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*Editor in Chief*

Dr. Swapnesh Taterh

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# FOREWORD

I am pleased to put into the hands of readers Volume-5; Issue-11: 2018 (Nov, 2018) of “**International Journal of Advanced Engineering Research and Science (IJAERS) (ISSN: 2349-6495(P) | 2456-1908(O)**”, an international journal which publishes peer reviewed quality research papers on a wide variety of topics related to Science, Technology, Management and Humanities. Looking to the keen interest shown by the authors and readers, the editorial board has decided to release print issue also, but this decision the journal issue will be available in various library also in print and online version. This will motivate authors for quick publication of their research papers. Even with these changes our objective remains the same, that is, to encourage young researchers and academicians to think innovatively and share their research findings with others for the betterment of mankind. This journal has DOI (Digital Object Identifier) also, this will improve citation of research papers. Now journal has also been indexed in **Qualis (Interdisciplinary Area) (Brazilian system for the evaluation of periodicals, maintained by CAPES)**.

I thank all the authors of the research papers for contributing their scholarly articles. Despite many challenges, the entire editorial board has worked tirelessly and helped me to bring out this issue of the journal well in time. They all deserve my heartfelt thanks.

Finally, I hope the readers will make good use of this valuable research material and continue to contribute their research finding for publication in this journal. Constructive comments and suggestions from our readers are welcome for further improvement of the quality and usefulness of the journal.

With warm regards.

**Dr. Swapnesh Taterh**

Editor-in-Chief

Date: Dec, 2018

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# Comparative Study between Groin and T-Head Groin

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**Abstract**— This study conducted a comparative study between groin and T-groin. The study was done by developing stable coastline equation between groins and between T-Head groins. Stable coastline equation is the follow up of previous research by the same researcher. Meanwhile, stable equilibrium coastline equation between T-Head groins is the development of stable coastline between groins equations.

Comparison study in erosion on the downstream groin and the maximum erosion shows that T-groin provides better coastal protection than groin.

**Keywords**— stable coastline, groin, T-Head groin.

## I. INTRODUCTION

Van Rijn [1] has acquired that as a result of differences in wave height as a result of a diffraction, there is littoral current toward shadow zone and down drift groin at the coastline protected by groin (Fig.1). The littoral current carries littoral drift that is deposited at the down drift groin; therefore the presence of this littoral drift acts as protector of down drift groin against erosion, at least reducing erosion. Vadya[2], show that impact of groin length is less erosion on downdrift groin as the length of groin increases.

The longer the groin the greater the shadow zone, the larger the difference of water surface elevation and the greater the littoral drift, the greater the sedimentation at the downstream groin. In addition to extending the groin, the widening of the shadow zone can be done by constructing T-head at the groin. Groin with this T-head is called T-head Groin or T-Groin (Fig.2). With the presence of this phenomenon, it is estimated that T-Groin will provide better coastal protection than using groin.

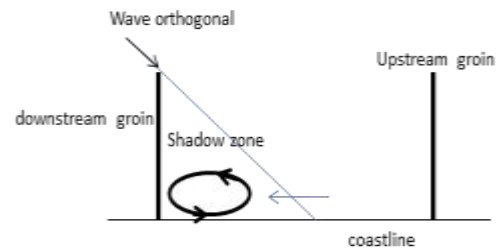


Fig.1: Coastal hydrodynamic at the coast between two groins

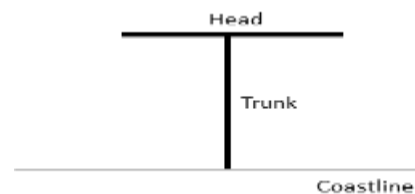


Fig.2: T-Head Groin or T-Groin

Even though there are not so many researches on T-groin, the result of the research shows that there is sedimentation at the downstream groin (Fig.3). The researches was done by among others, Bodge [3], Ozolcer [4], Elko [5], Ozolcer [6] Hanson [7] Frech, F.F [8], Ishihara [4] and Sato [9]. Those results of the researches strengthens the assumption that T-groin will provide a better coast protection than groin.

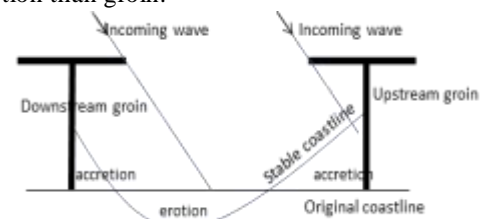


Fig.3: Erosion and accretion between T-groins

Hutahaean [10] has developed a method to build stable coastline equation between groins. In this research, the method is applied at T-groin to obtain stable coastline equation between T-groins. Then, a comparison is done to the phenomenon of erosion and sedimentation that occur at the formation of stable coastline between the two types of groin.

## II. STABLE COASTLINE EQUATION BETWEEN GROINS (REVIEW OF PREVIOUS STUDY)

Stable coastline between T-groins equation will be formulated the same way as the formulation of stable coastline between groins equation (Hutahaean [10]). Therefore, the next section will discuss first the formulation of stable coastline between groins equation.

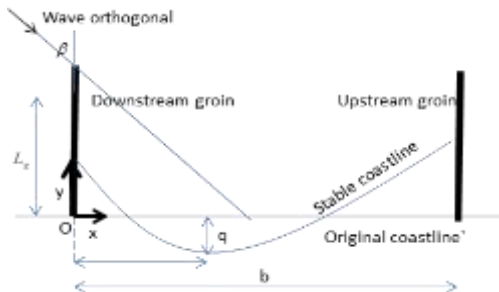


Fig.4: A Sketch of stable coastline between groins

Stable coastline between groins equation is approximated using quadratic polynomial equation, i.e.:

$$y(x) = c_0 + c_1x + c_2x^2$$

where  $c_0$ ,  $c_1$  and  $c_2$  are determined using conservation law of mass and stable coastline characteristics as on Fig.4, i.e.:

### 1. Conservation Law of Mass:

Conservation Law of Mass in this case is the volume of erosion is similar to the volume of accretion

By ignoring sand porosity, the conservation law of mass can be stated as:

$$\int_0^b y(x) dx = 0$$

By completing integration and dividing the integration with groin gap width  $b$ , the first equation is obtained, i.e.:

$$c_0 + \frac{c_1}{2}b + \frac{c_2}{3}b^2 = 0 \quad \text{.....(1)}$$

### 2. Boundary condition at the upstream groin

At the upstream groin, where  $x = b$  the boundary

condition is done  $\frac{dy}{dx} = \tan \beta$ ,

$$c_1 + 2c_2b = \tan \beta \quad \text{.....(2)}$$

### 3. At the minimum point, i.e. at $x = r$ , $\frac{dy}{dx} = 0$

and  $y = -q$

$$a. \quad \frac{dy}{dx} = 0$$

$$c_1 + 2c_2r = 0$$

$$r = -\frac{c_1}{2c_2}$$

$$b. \quad y = -q$$

$$-q = c_0 + c_1r + c_2r^2$$

$$\text{Substitute } r = -\frac{c_1}{2c_2}$$

$$c_0 + c_1\left(-\frac{c_1}{2c_2}\right) + c_2\left(-\frac{c_1}{2c_2}\right)^2 = -q$$

$$c_0c_2 - \frac{c_1^2}{4} + qc_2 = 0 \quad \text{.....(3)}$$

### 4. Approximation for $r$ , $r = (\alpha L_g - q) \tan \beta$

This approximation is a hypothesis, as an effort to incorporate the role of the length of groin  $L_g$  where  $\alpha$  is a coefficient with a set value, i.e.  $\alpha > 1.0$  for increasing the influence of  $L_g$ , whereas  $\alpha < 1.0$  for decreasing the influence of  $L_g$ . This value of  $\alpha$  can be obtained by conducting a calibration to the test result of physical model in the laboratory. In this research  $\alpha = 1$  is used.

$$-\frac{c_1}{2c_2} = (\alpha L_g - q) \tan \beta$$

$$(\alpha L_g - q) \tan \beta + \frac{c_1}{2} = 0 \quad \text{.....(4)}$$

The four equations, i.e. equations (1), (2), (3) and (4) can be completed using Newton-Raphson iteration method for non-linear equations system with  $c_0$ ,  $c_1$ ,  $c_2$  and  $q$  as the unknown. The initial value for the iteration is  $c_0 = -p$ , where  $p$  is determined randomly with a value around -1.0 or +1.0,  $c_1 = -\tan \beta$ ,  $c_2 = \frac{3 \tan \beta}{2b}$ .

Whereas, the estimation of initial value of  $q$ , the following equations are used,

$$r = -\frac{c_1}{2c_2} \quad \text{and}$$

$$-q = c_0 + c_1\left(-\frac{c_1}{2c_2}\right) + c_2\left(-\frac{c_1}{2c_2}\right)^2$$

Example of equation result

The equation is done at groins gap  $b = 100\text{m}$ , length of groin  $L_g = 30\text{ m}$  with the angle of the incoming wave  $\beta$ :  $10^\circ$ ,  $20^\circ$  and  $30^\circ$ . Influence Coefficient  $L_g$ , i.e.  $\alpha = 1$ .

Table.1: Polynomial Coefficient of Equation Result

$\beta^0$	$c_0$	$c_1$	$c_2$
10	-2.641	-0.009	0.001
20	-4.853	-0.036	0.002
30	-6.718	-0.087	0.003

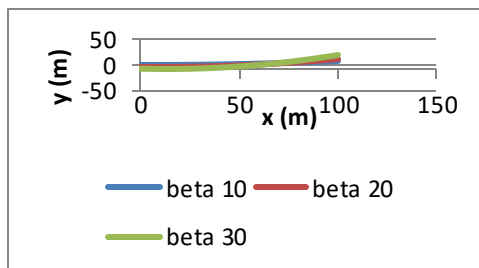


Fig.5: Stable coastline between groins, equation result

(Fig. 6) presented stable coastline graphs for varied groin length of  $L_g$ , i.e. 30 m, 50 m, and 70 m, with groins spacing 100 m and incoming wave angle  $30^\circ$ . The result of the equation shows that the longer the length of the groin, the smaller the erosion groin will be, where for groin with a length of 70 m, there is an accretion at the downstream groin. This represents the presence of longshore current effect toward downstream groin as the result of the study Van Rijn [1] and agree with Vadya's study [2].

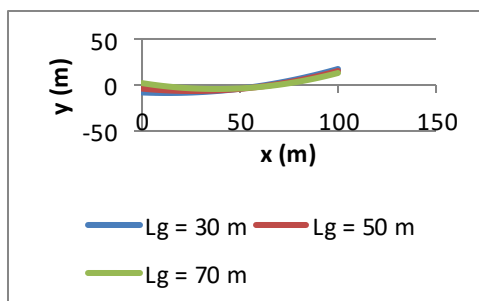


Fig.6: Stable coastline with varied length of groin  $L_g$

### III. STABLE COASTLINE BETWEEN TWO T-GROINS EQUATION

Equation for stable coastline between T-groins is formulated using the same method with the previous part, by incorporating the role of arm T where the length of half of the arm is  $t$  (Fig.7), as follows:

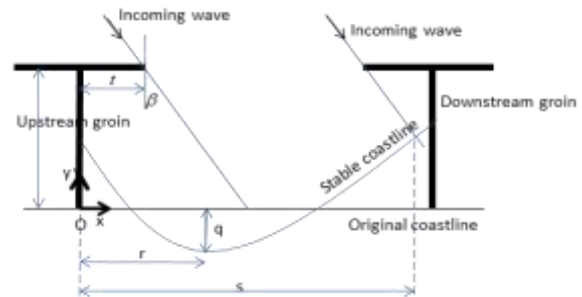


Fig.7: Sketch of stable coastline between two T-Groin

- Boundary condition of  $\frac{dy}{dx} = \tan \beta$  is done at the point with abscissa  $x = s$ , therefore (2) becomes,  

$$c_1 + 2c_2s = \tan \beta \quad \dots\dots(5)$$

- Equation for  $s$   

$$(c_0 - a_0) + (c_1 - a_1)s + c_2s^2 = 0 \quad \dots\dots(6)$$

This is an equation of point intersection between non diffracted wave originated at the left arm of upstream groin with stable coastline (Fig 7), where the wave ray equation is:

$$y(x) = a_0 + a_1x, \quad \text{where} \quad a_1 = t \theta, \quad \theta = -(90 - \beta) \quad \text{and} \quad a_0 = L_g - a_1(b-t).$$

- Incorporating the role of arm T downstream at  $r$ .  

$$r = (\alpha L_g - q)\tan \beta + \alpha t$$

Therefore (4) becomes,

$$(\alpha L_g - q)\tan \beta + \alpha t + \frac{c_1}{2} = 0 \quad \dots\dots\dots(7)$$

Similar to the equation for groin,  $\alpha$  at equation (7) is a coefficient that is obtained through calibration with the result of physical model, where in this research  $\alpha = 1$  is used.

Using equations (1), (5), (3), (7) and (6), unknowns  $c_0$ ,  $c_1$ ,  $c_2$ ,  $q$  and  $s$  are calculated using Newton-Rhapson's iteration method.

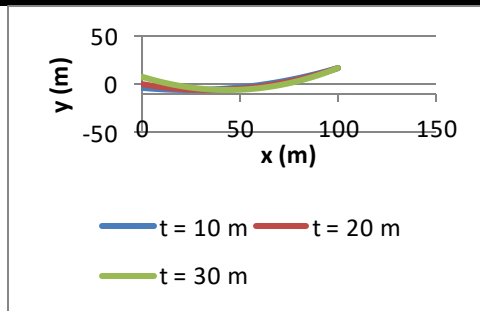


Fig.8: Stable coastline between T-groins, varied  $t$

(Fig. 8) presented equation result for incoming wave angle  $\beta = 15^\circ$ ,  $L_g(\text{Trunk}) = 30$  m, groins gap (distance between trunk)  $b = 100$  m, whereas the length of half head  $t$  varies, 10, 20, and 30 m. The figure shows that the longer the half head  $t$ , the smaller the erosion at the downstream oin will be, and when the half head long enough, the downstream groin accreted. Therefore, head also protect the coast around downstream groin against erosion, and protect against outflanked (Fig.9).



Fig.9: Outflank groin

#### IV. COMPARISON BETWEEN GROIN AND T-GROIN

Table (1) show erosion at the downstream (Erd) and maximum erosion (Ermax) at groin and T-groin. Angle of incoming wave  $\beta = 15^\circ$ , groin gap width (trunk to trunk) 100 m. The length of groin  $L_g$  varies from 40 m up to 80 m. The length of trunk ( $L_g$ ) at T-groin is 30m with the length of half T-head varies, i.e.  $t = 10$  m up to 50m. By considering T-groin as L-groin, the same total length between groin and L-groin, i.e. for groin length of  $L_g$ , 40 m, can be compared with L-groin with the length of trunk 30 m + 10 m half T-head, etc.

Table (1) shows that for the same length of structure, Erd and Ermax at T-groin are always smaller than Erd and Ermax groin. And the additional length of head at T-groin is more effective than the additional length of groin in reducing Erd and Ermax.

Table.1: Comparison between groin and T-groin

Groin		
$L_g$ (m)	Erd (m)	Ermax (m)
40	-8,14	-8,19
50	-7,87	-7,96
60	-7,59	-7,73
70	-7,3	-7,5
80	-7	-7,29
T-Groin $L - \text{trunk} = 30$ m		
$t$ (m)	Erd (m)	Ermax (m)
10	-7,64	-7,84
20	-6,47	-7,02
30	-5,15	-6,27
40	-3,65	-5,62
50	-1,94	-5,07

#### V. CONCLUSION

The method that is developed is quite simple to be applied and can reproduce the features of stable coastline between groins or between T-groins, and erosion and sedimentation that occur. However, a calibration is still needed to the physical model.

Even though the equation that is produced still requires physical model test, but considering the same method is used, it can still be concluded that coastal protection using T-groin is more effective than using groin.

#### REFERENCES

- [1] Van Rijn, L.C. (2014). A simple general expression for longshore transport of sand and gravel. Coastal Engineering Vol.90, 23-29.
- [2] Vadya, A.M., Kori, Santosh K. And Kudale, M.D. (2015). Shoreline Response to Coastal Structures, International Conference on Water Resources, Coastal And Ocean Engineering (ICWRCOE 2015) . Aquatic Procedia 4 (2015), 333-340. [www.sciencedirect.com](http://www.sciencedirect.com).
- [3] Bodge, K.R. (2003). Design Aspect of Groin and Jetties. In : Advances in Coastal Structure Design. Ed.R. Mohan, O. Magoon, M.Pirello. American Society of Civil Engineers (ASCE). Reston, VA. ISBN 0-7844-0689-8. Pp. 181-199
- [4] Ozolcer, I.H., I.K. Birben, A.R. Yusek. O., Karasu, S., (2006). Effect of T- Shapes of Groins Parameters on Beach Accretion, Journal of Ocean Engineering 33 pp 382-403.
- [5] Elko, N.A., W.Mann, Douglas P.E. (2007), Implementation of Geotextile T-Groins in Pinellas County, Florida. Shore & Beach Vol. 75 no.2 Spring 2007.

- [6] Hanson, H., and Kraus, N.C. (2001), Chronic beach erosion adjacent to inlets and remediation by composite T-head groins, ERDC/DHL CHETN IV-36 U.S. Army Engineer Research and Development Center, Vicksburg, MS. <http://chl.wes.army.mil/library/publications/chetn>.
- [7] Frech, F.F. (1949), Report to the XVIII International Navigation Congress, S II, C I, 45-62.
- [8] Ishihara, T., and Sawaragi, T. (1964), Stability of beaches using groins, *Proceeding 9<sup>th</sup> Coastal Engineering Conference*, ASCE, 299-309.
- [9] Sato, S., and Tanaka, N. , (1974). Field and model study on the protection of recreational beach against wave action. *Proceeding 14<sup>th</sup> Coastal Engineering Conference*, ASCE, 1432-1450.
- [10] Hutahaeon, S. (2018). Stable Coastline Between Two Groins Equation. *International Journals of Advance Engineering Research and Science (IJAERS)*. (Vol.-5, Issue-8, Aug. 2018). ISSN: 2349-6495 (P)/2456-1908 (O). <http://dx.doi.org/10.22161/ijaers.5.8.28>.



# The Effect of Bitumen Stabilized Subgrade on Cost of the Flexible Pavement

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**Abstract**— In countries where freight transportation is mostly done by highway, the increasing load carrying capacity of heavy vehicles creates the need for strengthening the road pavements. In this study, the effects of stabilized subgrade with asphalt emulsion on flexible pavement thickness and pavement cost were determined. Consequently, the optimum emulsion content and the CBR value has been determined. As a result, it was seen that the thickness of the asphalt pavement and thus the cost of pavement decreased.

**Keywords**— Bitumen Emulsion, Stabilization, CBR, Flexible pavement, AASHTO 86.

## I. INTRODUCTION

Increased traffic volume, environmental and external factors, and flaws incurring during construction phase cause early deterioration of the road pavement [1,2,3,4]. Subgrade stability in road pavements significantly affects the superstructure. Because the subgrade should be able to resist the stresses caused by the traffic loads [5]. Soil improvement can be done by many different methods. One of these methods is to ensure the soil stabilization by adding additives. Cement, lime, fly ash, bitumen etc. Additives such as stabilizers are the most preferred stabilization methods to provide soil stabilization. In the literature, there were many studies on the effects of different materials on the California Bearing Ratio (CBR) or superstructure for different soil types. [6-10].

Kök et al. [6] investigated the relationship between the cost of flexible pavements and the cost of stabilization to be built on soils with cement stabilization. As a result, for the low, medium and high traffic values, the cost of the pavement decreased to 15% CBR, then gradually decreased and the stabilization cost increased with the increase in CBR amount.

Kolias et al. [7] investigated the effectiveness of stabilization with high calcium-containing fly ash and cement on clayey soils.

Çalışıcı et al. [8] have investigated the effects of CBR on the infrastructure on bitumen reinforced soil and found that there is a significant decrease in the superstructure thickness.

Şenol et al. [9] have investigated the effects of high volatility of carbon as well as fly ash containing CaO and carbon from different plants on the stabilization of soft soils. They found that CBR value and compressive strength increased significantly compared to the soil types with the increase in the ash content, and the highest increase was in the CL class in the fly ash content.

Eren and Filiz [10] In their study, they examined the CBR values of cement and lime added soil in different ratios. In the study, it was determined that the lime ratio could increase the CBR value up to a certain value, but also found that the lime added soil was more resistant to swelling.

## II. MATERIAL AND METHODS

In this study, the soil is stabilized by bitumen emulsion and the bearing capacity is increased. The effects on the flexible pavement are determined by using the 2015 traffic data for Adana – Mersin highway using the AASHTO 86 pavement design method. The viscosity of the emulsion used in stabilization was 46 sec and the specific gravity was 1.0125 gr / cm<sup>3</sup>.

Soil sample used in stabilization was prepared to meet Turkish State Highway Specification and AASHTO specification limits. (Table 1).

Table.1: Sample gradation before and after oven

Sieve No	Specification Limits % passing	Before oven % passing	After oven % passing
4	50-100	85.00	89.50
40	35-100	55.00	56.90
200	10-50	20	21.50

Modified Proctor Tests was performed on the soil sample and maximum dry unit weight and optimum water content values were found in Figure 1.

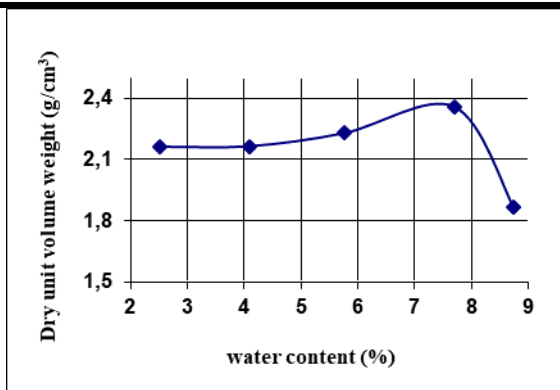


Fig. 1: Dry unit volume weight - water content relationship of soil

The sample prepared in optimum water content was mixed with bitumen emulsion at 1,2,3,4% and 5% by weight and subjected to Marshall Stability Test. As a result of the Marshall stability test, the optimum bitumen emulsion ratio for stabilization was 4% (Fig. 2)

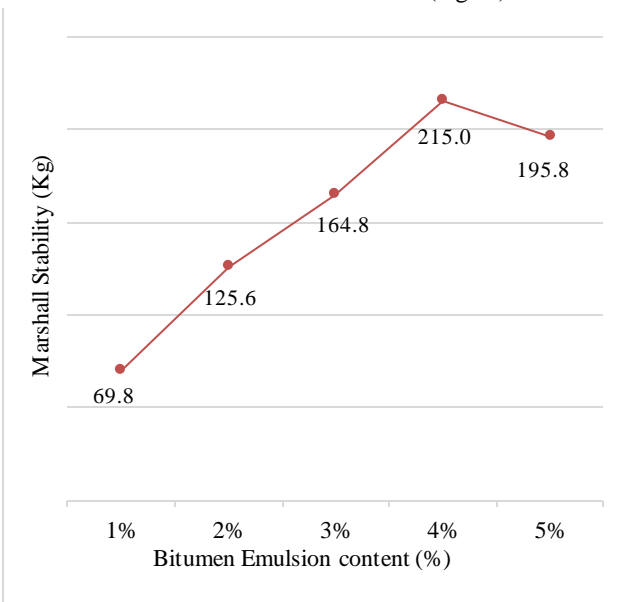


Fig. 2: The Marshall Stability Test Results

As a result of the CBR test performed before stabilization to the soil, the CBR value was found to be 18.09, the CBR of the sample stabilized with 4% bitumen emulsion was 24.05. According to this result, stabilization with bitumen emulsion resulted in an increase of 33% in the soil bearing strength.

**III. RESULTS AND DISCUSSION**

The CBR value obtained at the end of the experimental studies was selected as 24. Considering AASHTO 86 flexible pavement design criteria, Mersin and Adana state highway traffic data and environmental data values in Turkey were used the pavement design. The traffic data used in the design is presented in Table 2.

Table.2: Adana - Mersin highway annual average daily traffic data for 2015 [11].

Vehicle Type	Annual Average Daily Traffic	Annual increase rate (%)
Truck	3555	3
Trailer	3920	
Bus	450	5
Car	26000	

The  $M_R$  value used in the design can be calculated with the equation in Equation 1 depending on the CBR [12].

$$M_R = 1500 \times CBR \tag{1}$$

The planned route between Adana and Mersin is 4 lanes, the pavement width is 13 m and the base width is 20 m. Stabilization of the soil was adopted at a thickness of 10 cm. Service capability of road ( $P_t$ ) = 2.6 and Area factor  $R = 1.0$

**IV. CONCLUSION**

In this study, the effects of soil stabilization on the thickness of asphalt pavement were investigated. In addition, the cost reduction to be obtained by decreasing the pavement thickness is calculated. The layer thicknesses calculated before and after stabilization are given in Table 3 and Table 4.

Table.3: Pavement thickness before stabilization

5 cm	Surface Course	79 cm
8 cm	Binder Course	
66 cm	Base Course	
	Subgrade (CBR % 18)	

Table.4: Pavement thickness after stabilization

5 cm	Surface Course	65 cm
8 cm	Binder Course	
52 cm	Base Course	
10 cm	Stabilized Subgrade (CBR % 24)	
	Subgrade (CBR % 18)	

Table 3 and Table 4 showed that the base course after stabilization decreased by 14 cm. With the increasing CBR after stabilization of the soil, the decrease in the base layer is an expected result. It can be calculated that the layer thickness of the base course is reduced by about 21.2%.

Although the base layer has been reduced in the

calculated pavement for the stabilized subgrade, the economic gain should be calculated by taking into account the 10 cm stabilized subgrade cost. The distance between the cities of Adana and Mersin is 86 km. After the cost calculations, it was calculated that the road construction cost per kilometer has decreased by 5.3 % after stabilization.

#### REFERENCES

- [1] Mustafa Çalışıcı, Metin Gürü, M. Kürşat Çubuk, Ömer Faruk Cansız, Improving the aging resistance of bitumen by addition of polymer based diethylene glycol, Construction and Building Materials, Volume 169, 2018, Pages 283-288, ISSN 0950-0618, <https://doi.org/10.1016/j.conbuildmat.2018.03.018>.
- [2] Mustafa Çalışıcı, (2009), “Bitümün Sentetik Metal ve Polimer Katkı Maddeleriyle Yaşlanma Direncinin Arttırılması”, Doktora tezi, Gazi Üniversitesi, Fen Bilimleri Enstitüsü, Ankara.
- [3] Çalışıcı, M., Cansız, Ö.F., Ünsalan, K., Koç, E., (2017), “Katyonik Asfalt Emülsiyon Stabilizasyonlu Zeminin Esnek Üstyapı Maliyetine Etkisi”, Proceedings of the 3. International Soil-Structure Interaction Symposium İzmir/Turkey, 676-681
- [4] Çalışıcı, M., Cansız, Ö.F., Ünsalan, K., Koç, E., (2017), “Zeminin Bitümle Stabilizasyonunun Yol Üstyapısına Etkisi”, 2. International Congress on Engineering Architecture and Design, 591-592
- [5] Uzuner, B.A., 1995. Temel Mühendisliğine Giriş, Derya Kitabevi, Trabzon, 139.
- [6] Kök, B. V, Yılmaz, M., Geçkil, A., 2012. Çimento Stabilizasyonlu Zeminin Esnek Üstyapı Maliyetine Etkisi, Pamukkale Üniversitesi Mühendislik Bilimleri Dergisi, 165-172.
- [7] Koliass, S., Kasselouri-Rigopoulou, V., Karahalios, A. 2005. Stabilisation of Clayey Soils With High Calcium Fly Ash and Cement. Cement & Concrete Composites. 27, 301–313.
- [8] ÇALIŞICI, M , KOÇ, E , CANSIZ, Ö . (2017). Katyonik Asfalt Emülsiyon Stabilizasyonlu Zeminin Esnek Üstyapı Tabaka Kalınlığına Etkisi. Çukurova Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi, 32 (2), 231-238. DOI: 10.21605/cukurovaummfd.358427
- [9] Şenol, A., Edil, T.B., Bin-Shafique, M.S., Acosta, H.A., Benson, C.H. 2006. Soft Subgrades’ Stabilization by Using Various Fly Ashes. Resources, Conservation and Recycling. 46, 365–376
- [10] Eren, S., Filiz, M. 2009. Comparing the Conventional Soil Stabilization Methods To The Consolid System Used as an Alternative Admixture Matter in Isparta Dandere Material. Construction and Building Materials. 23, 2473–2480
- [11] KGM, 2016. 2015 Trafik ve Ulaşım Bilgileri, Trafik Güvenliği Dairesi Başkanlığı, Ankara
- [12] Tunç, A., 2004. Kaplama Mühendisliği ve Uygulamaları, Asil Yayın Dağıtım, Ankara, 279.

# Identification of Clusters of the Scientific Production on Business Incubators

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**Abstract**—Business incubators are increasingly important institutions in the economic scenario and focus of countless scientific researches. The objective of this work was to identify the clusters of the international scientific production on business incubators, through bibliometric analysis. We analyzed publications from the period 1984 to 2017, through a systematic mapping in periodicals and annals of congresses. Four clusters on the subject were identified: (i) implementation and management of incubators; (ii) management of companies served by incubators; (iii) incubation, knowledge transfer and competitiveness at the regional level; and, (iv) entrepreneurial education and culture in the context of higher education institutions. The cluster construction of scientific publications on business incubators points to technology scenarios, business models, and innovation strategies.

**Keywords**—Business incubation, bibliometrics, scientific clusters.

## I. INTRODUCTION

Business incubators are mechanisms developed around the world to implement policies to support innovation and business growth, especially in technology-oriented companies. They constitute dynamic processes for the formation of entrepreneurs and enterprises, financed by investments of various natures and supported by the intellectual and technological assets of training and research. Incubator activities involve a variety of services and infrastructure that support startup ventures, greatly increasing the chances of success [1], [2].

The role of incubators in the development, growth and consolidation of companies has attracted the attention of researchers in the field of economics and management in the last 35 years [3], [4]. For this reason, a significant number of scientific works have been published, at the international level, on the various particularities that involve these institutions.

Most incubator studies are financed by governments, through universities or research centers [5], showing a proactive position in promoting the ideal conditions for regional economic development. In fact, in a knowledge-based economy, universities become the base elements of the innovation process [6].

In this context, the objective of the present study was to identify the clusters of the international scientific production on business incubators, from 1984 to 2017. The choice of bibliometric approach is justified by the fact that an analysis of academic production in a longitudinal way allows the incorporation of several theoretical perspectives and their relations over time, constituting a useful format to understand the evolution of a certain area of knowledge.

## II. BUSINESS INCUBATORS: ORIGIN AND DEFINITION

The United States pioneered enterprise incubation programs because of three simultaneously developed processes: (i) corporate condos; (ii) various investments in new technology companies; and, (iii) focus on entrepreneurship programs. These initiatives were implemented by the National Science Foundation, which,

in partnership with the largest universities in the country, developed actions to stimulate the generation of innovation in research centers by students and teachers, as well as the transfer of knowledge and technologies produced in the academic field to society [7], [8].

The literature on business incubators contains a large number of similar definitions. One of the most commonly cited definitions of business incubators in scientific work is the definition of the International Business Innovation Association (InBIA). According to this association, a business incubator is a means of business support, which effectively accelerates the development of small enterprises, providing entrepreneurs with resources and services in the initial period in which they are more vulnerable [9], that is, is an entity with technical, managerial, administrative and infrastructure capacity to provide the small entrepreneur with mechanisms for growth[10].

Incubators are created with the objective of providing, during the incubation period, the necessary capacities so that, after incubation, companies are more likely to adapt to the market, generating competitive advantages over other companies in the sector, through innovation and application of technology, supporting local and regional economic development. In addition, it seeks to support the entrepreneur himself, preparing him for the management of his business. In this way, the incubation process results in a key factor so that competences are acquired in an adequate way, fulfilling the objective for which the incubators were created[11], [12].

### III. METHODOLOGY

In the present bibliometric analysis, we used data from the scientific production on Business Incubators based on articles published in periodicals and congress annals indexed in the Web of Science. The study was carried out in six stages: (a) definition of the research theme; (b) choice of database; (c) elaboration of the search protocol; (d) search performance; (e) identification of clusters of scientific production on the subject; and, (f) analysis of identified clusters.

The keywords "Business Incubator" and "Business Incubation" were used, considering only the publication in which at least one of them was present in the title, abstract and / or keywords of the work. This research methodology is especially used in the area of technology and information science. The data were processed using *VosViewerSoftware*.

### IV. RESULTS AND DISCUSSION

After the application of the search criteria defined in the methodology, 473 works were identified with the keyword *Business Incubators* and 121 works with the keyword *Business Incubation* in the period from 1984 to 2017. Subsequently, we excluded duplicate papers, obtaining a total of 534 papers, covering the two keywords defined for the study. It was observed that the first publications on business incubators occurred in 1984, as shown in Figure 1.

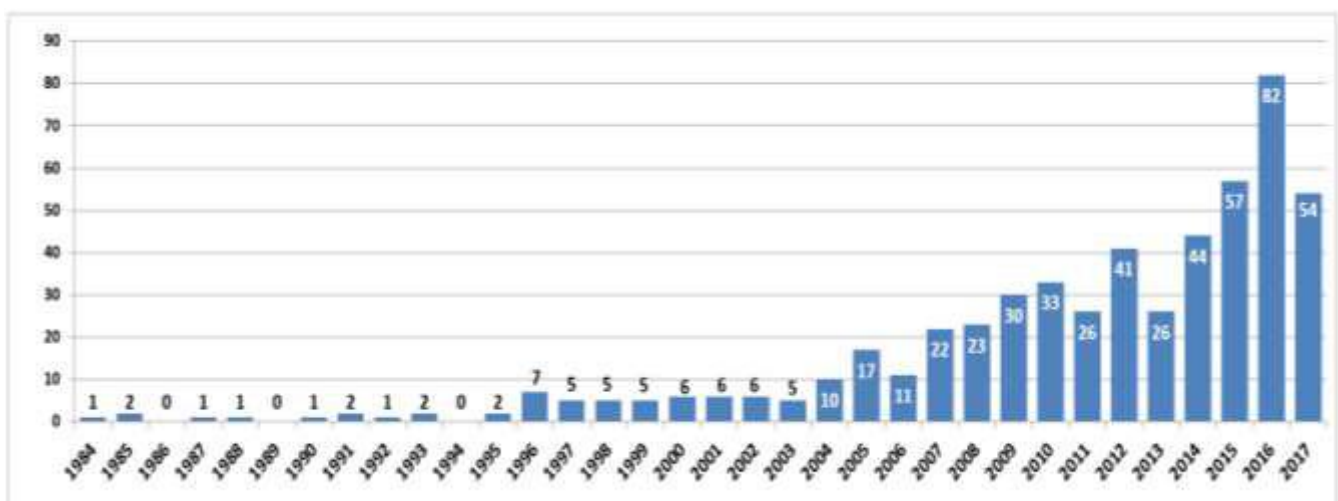


Fig. 1: Number of publications on business incubators, 1984-2017

In Figure 2, it is presented a network of occurrence of common terms in the set of works analyzed, which resulted in the formation of clusters of the main research areas. In the network visualization, the terms are represented by their label and by a circle, whose size

determines the weight of each of them, in relation to the number of linked works and the number of times these have been cited. The color determines the cluster to which the term belongs and the lines between them represent links (cocitation). The distance between two terms in the

visualization indicates the relationship between the content of the works to which they are linked, in what concerns cocitation.

For the construction of the network, the following criteria were established: (a) the terms were extracted from the title and of the summary of each article; and (b) the minimum occurrence of each term in the work set should be 20. In total, the incidence of 9,181 terms was identified in the 534 papers analyzed, of which only 138 met the criteria established above. The network was structured in four clusters, identified in Figure 1 by the colors red, blue, green and yellow.

The first cluster (red) are topics related to the management and operation of incubators, such as incubation process, management models etc. The second cluster (blue) is related to the management of companies linked to incubators, with emphasis on terms such as performance, relationship and managerial effectiveness. The third cluster (green) includes terms related to regional aspects, including the name of countries such as Germany, Russia, etc. Finally, the fourth cluster (yellow) is related to entrepreneurship in the academic sphere, focusing on topics such as creativity, entrepreneurial culture, among others.

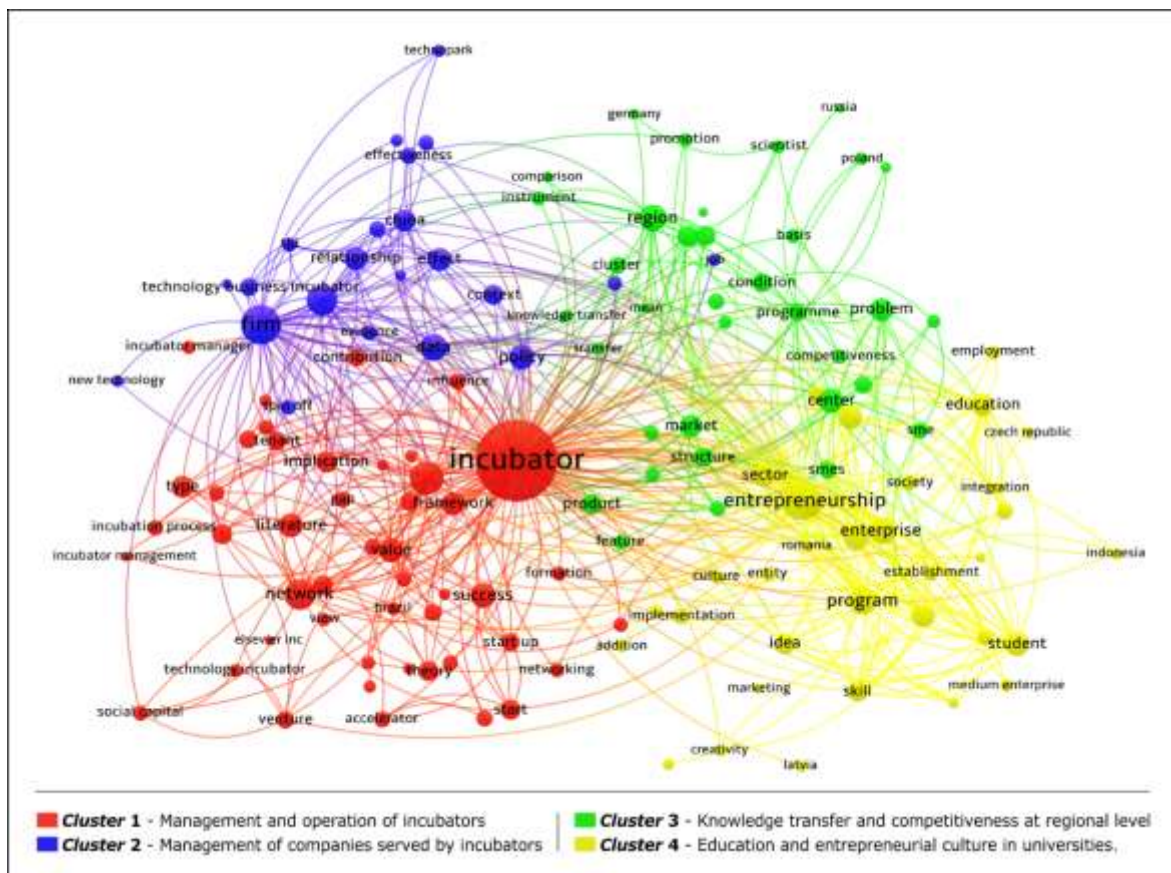


Fig. 2: Clusters of scientific production on business incubators

In the period from 1984 to 2003 - the first 20 years of the historical series analyzed - only 58 publications, developed almost exclusively in the United States and whose thematic focus was directed to the implantation and management of incubators of companies. From 2004, however, there is a gradual increase in the number of published works, with a focus on the dissemination of the entrepreneurial culture in the academic scope and management of companies resident in incubators. In addition, a broader geographic coverage is observed in the research focus, strengthening the growth and consolidation of the other clusters characterized in the

present study.

V. CONCLUSION

The analysis of clusters of the scientific production related to the incubator of companies highlights research related to the management and operationalization of these institutions, incubation process, management models, management of resident companies, transfer of knowledge and competitiveness in the regional scope (results of governmental policies) and works with focus on entrepreneurship, specifically related to the creativity and entrepreneurial culture in the academic scope, the

identification of publications on the subject of business incubators on a scientific basis points to possible scenarios of technology, business model and innovation strategies. In addition to highlighting the characteristics and directions of studies already published, it allows the understanding of the gaps for specific studies, in order to contribute to the definition of a research agenda in the area.

pp. 254–267, May 2007.

- [12] N. Roth, A. Brem, and N. Kreusel, “European business venturing in times of digitisation - an analysis of for-profit business incubators in a triple helix context,” *Int. J. Technol. Manag.*, vol. 76, no. 1/2, p. 104, 2018.

## REFERENCES

- [1] J. M. Shepard, “When incubators evolve: new models to assist innovative entrepreneurs,” *Int. J. Entrep. Innov. Manag.*, vol. 21, no. 1/2, p. 86, 2017.
- [2] H. Zhang, W. Wu, and L. Zhao, “A study of knowledge supernetworks and network robustness in different business incubators,” *Phys. A Stat. Mech. its Appl.*, vol. 447, pp. 545–560, Apr. 2016.
- [3] S. Mian, W. Lamine, and A. Fayolle, “Technology Business Incubation: An overview of the state of knowledge,” *Technovation*, vol. 50–51, no. 4, pp. 1–12, Apr. 2016.
- [4] M. Schwartz and C. Hornych, “Cooperation patterns of incubator firms and the impact of incubator specialization: Empirical evidence from Germany,” *Technovation*, vol. 30, no. 9–10, pp. 485–495, Sep. 2010.
- [5] Á. R. Vázquez-Urriago, A. Barge-Gil, and A. M. Rico, “Which firms benefit more from being located in a Science and Technology Park? Empirical evidence for Spain,” *Res. Eval.*, vol. 25, no. 1, pp. 107–117, Jan. 2016.
- [6] M. Ranga and H. Etzkowitz, “Triple Helix Systems: An Analytical Framework for Innovation Policy and Practice in the Knowledge Society,” *Ind. High. Educ.*, vol. 27, no. 4, pp. 237–262, Aug. 2013.
- [7] N. Mahmood, C. Jianfeng, F. Jamil, J. Karmat, M. Khan, and Y. Cai, “Business Incubators: Boon or Boondoggle for SMEs and Economic Development of Pakistan,” *Int. J. u-and e-Service, Sci. Technol.*, vol. 8, no. 4, pp. 147–158, Apr. 2015.
- [8] M. P. Rice, “Co-production of business assistance in business incubators: an exploratory study,” *J. Bus. Ventur.*, vol. 17, no. 2, pp. 163–187, Mar. 2002.
- [9] International Business Innovation Association (InBIA), “Business Incubation,” 2018. [Online]. Available: <https://inbia.org>.
- [10] D. Săvescu, “Research for Business—a New Concept and a Case Study,” in *2nd International Conference on Applied Social Science - ICASS*, 2012, pp. 339–344.
- [11] K. Aerts, P. Matthyssens, and K. Vandenbempt, “Critical role and screening practices of European business incubators,” *Technovation*, vol. 27, no. 5,

# Calculation of the Heat Transfer Surface Area of Heat Exchangers for Waste Heat Recovery with the Kalina Cycle

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**Abstract**— The purpose is to calculate the heat transfer surface area of the shell and tube heat exchanger aiming recovery to waste heat with Kalina cycles. The procedure for calculating the area was implemented in software Engineering Equation Solver (EES), where the calculation of the LMTD was held with the existing functions in EES for the correction factor calculation, and additional correlations were implemented in the EES to calculate the thermodynamic properties of  $\text{NH}_3\text{-H}_2\text{O}$  mixture and to determine the transport properties of the phase change regions. As input data for the calculations were employed geometry (internal and external diameters of the tubes, the exchanger arrangement, geometrical arrangement of the tubes) and the heat balance of the heat exchanger (temperature, concentration of  $\text{NH}_3\text{-H}_2\text{O}$  mixture, etc.) obtained by simulation of the Kalina cycle. As an example of the results that were obtained for the evaporator, the overall heat transfer coefficient was found to be  $108,5 \text{ W/m}^2\text{K}$  and the heat transfer surface area of  $1170 \text{ m}^2$ . This value of the overall heat transfer coefficient is within the ranges reported in the literature by other researchers.

**Keywords**—heat exchanger, waste heat recovery, Kalina cycle.

## I. INTRODUCTION

The waste heat from production processes are usually at low temperature. Hence, it is necessary a good heat exchanger design for recovery and produce power in thermodynamic cycles. The Kalina cycle [1-4] is excellent choice for waste heat recovery from production process. This cycle has as working fluid an ammonia-water ( $\text{NH}_3\text{-H}_2\text{O}$ ) mixture that offers a better efficient on other cycles such as Rankine cycle. The use of  $\text{NH}_3\text{-H}_2\text{O}$  mixture is a complicating factor in determining the convective coefficient of heat transfer, the calculation of which has a certain complexity. Empirical correlations are used to find the convective coefficients the cold and hot

side, and so determine the overall heat transfer coefficient. The determination of the heat transfer surface area is linked to the overall coefficient of heat transfer intrinsically. In this context the purpose in the design of shell and tube heat exchangers is to calculate the heat transfer surface area implemented in software Engineering Equation Solver (EES), aiming recovery to waste heat with Kalina cycles for power generation from waste heat of cement production process.

## II. LITERATURE REVIEW AND PROPOSED CYCLE

The determination of the heat transfer coefficient for mixtures is complex, particularly when the process involves phase change. Rivera and Best [5] found experimentally that the heat transfer coefficient in boiling  $\text{NH}_3\text{-H}_2\text{O}$  mixture is 2 to 3 times higher than that of the ammonia-lithium nitrate mixture. Khir et al [6] reported that heat and mass flow strongly influences the heat transfer coefficient in the  $\text{NH}_3\text{-H}_2\text{O}$  mixture, but the concentration of the mixture does not have great influence. Araújo et al [7] studied the behavior of the coefficient of heat transfer of various fluids in the evaporation process, and fluid from the studies, R717 (ammonia) presented a more efficient heat transfer. Shah [8] modified correlation shape to be applied in mixtures, and validated using the comparison with other correlations in literature.

The  $\text{NH}_3\text{-H}_2\text{O}$  mixture has a boiling point below than pure water and boiling temperature variable promoting the reduction of losses in heat transfer, according Mirolli [9], this provides an efficient use for waste heat recovery from exhaust gases in cement process. Kalina et al [10] found a large ratio between the exchange surface of the evaporator and the power generated by the cycle. And in thermodynamic cycle for waste heat recovery is known that the heat exchangers are devices that influence over the initial investment cost and the amount of power



generated by the system, hence the importance of a proper sizing of this equipment second Arrieta et al. [11].

The Kalina cycle proposed by Arrieta et al. [11], for the recycling of waste gases from a fictitious plant cement production is presented in Fig. 1. The thermodynamic calculation results of this cycle were used as a basis for the development of the employed method of calculation the determination of the convective heat transfer coefficient for heat exchangers which phase shift occurring NH<sub>3</sub>-H<sub>2</sub>O mixture, boiling process in the evaporator and condensation process in the condenser.

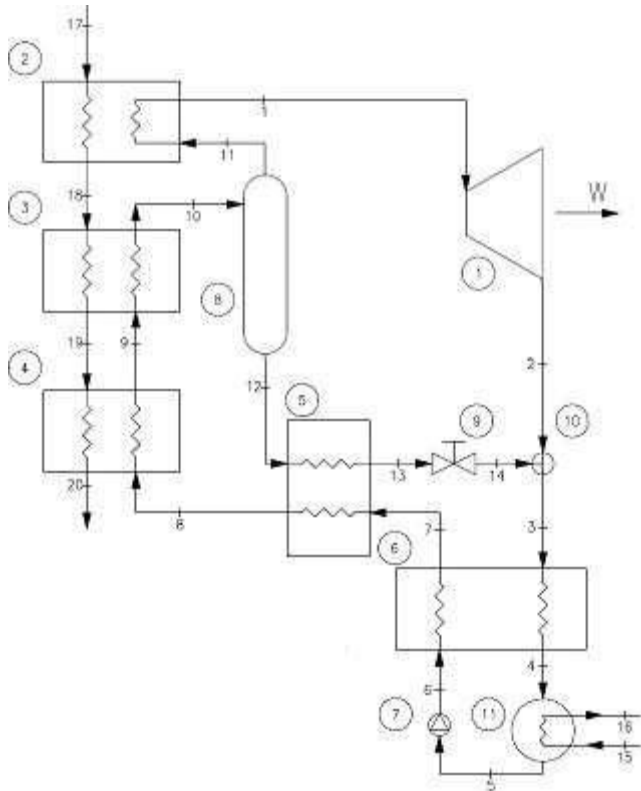


Fig. 1: Kaline cycle used for heat exchanger sizing

In Fig. 1 each number corresponds to an equipment, being:

- 1 turbine,
- 2 superheater,
- 3 evaporator,
- 4 economizer,
- 5 high temperature regenerator,
- 6 low temperature regenerator,
- 7 pump,
- 8 separator,
- 9 valve,
- 11 condenser.

### III. INPUT DATA IN EES

The calculations in EES were started with the input data related to thermodynamic and transport properties of each

state involved presented in Table 1 and Table 2. This data come from the thermodynamic calculation of the cycle performed by Arrieta et al. [11].

Table 1: Input data for evaporator

Property	Evaporator		
	Inlet	Outlet	
Temperature (K)	557.76	401.94	
Residual Gas	Pressure (kPa)	101.32	101.32
	Mass flow (Kg/s)	47.747	47.747
	Fluid	379.68	431.45
NH <sub>3</sub> -H <sub>2</sub> O mixture	Pressure (kPa)	6375	6375
	Mass flow (Kg/s)	0.8677	0.8677

Table 2: Input data for condenser

Fluid	Property	Condenser	
		Inlet	Outlet
Water	Temperature (K)	295.15	303.15
	Pressure (kPa)	250.00	250.00
	Mass flow (Kg/s)	265.034	265.034
NH <sub>3</sub> -H <sub>2</sub> O mixture	Temperature (K)	340.28	300.15
	Pressure (kPa)	902.62	902.62
	Mass flow (Kg/s)	0.8677	0.8677

### IV. INTERNAL HEAT TRANSFER COEFFICIENT

The methodology for calculating the convective transfer coefficient for the process of change of phase mixtures, both boiling as condensation, was presented by Shah [8] and is based on the addition of the two parameters, the nucleate boiling of the heat transfer mechanisms and effects of the forced convection.

$$h_{MIX} = h_{NB} + h_{FC} \quad (1)$$

$$h_{NB} = h_l F_{TS} (230Bo)^{0.5} \quad (2)$$

Where:

$$h_l = 0.023 Re_l^{4/5} Pr_l^n \left( \frac{k_l}{D_{in}} \right) \quad (3)$$

$$F_{TS} = \left\{ 1 + \left( \frac{h_{PB}}{q} \right) (T_{DP} - T_{BP}) \left[ 1 - \exp \left( \frac{-Bo}{\rho_l h_{lg}} \right) \right] \right\}^{-1} \quad (4)$$

Where in equations 1 to 4 the  $h_{MIX}$  is the convective heat transfer coefficient of the mixture;  $h_{NB}$  is convective heat transfer coefficient of the nucleate boiling;  $h_{FC}$  is convective heat transfer coefficient of the forced convection;  $h_l$  is convective heat transfer coefficient of the liquid phase;  $F_{TS}$  correction factor of the Thome and Shakir;  $Bo$  is boiling number;  $Re$  is Reynolds number;  $Pr$  is Prandtl number;  $k_l$  is thermal conductivity of the liquid phase;  $D_{in}$  is inside diameter;  $h_{PB}$  is heat transfer coefficient of the pool boiling;  $q''$  is heat flux,  $T_{DP}$  is dew point temperature of mixture;  $T_{BP}$  is bubble point temperature of mixture;  $\rho_l$  is density of the liquid phase;  $h_{lg}$  is latent heat of vaporization.

The second installment of the convective heat transfer coefficient of the mixture on the forced convection is:

$$h_{FC} = \left( \frac{Co^{0.8}}{1.8h_l} + \frac{Y}{h_v} \right)^{-1} \quad (5)$$

$$Co = \left( \frac{1}{x-1} \right)^{0.8} \left( \frac{\rho_v}{\rho_l} \right)^{0.5} \quad (6)$$

$$Y = x C_{p,v} \frac{dT_{PO}}{dH} \quad (7)$$

Where in equations 5 to 7 the  $Co$  is Convection number;  $Y$  is factor in Bell-Ghaly method;  $h_v$  is convective heat transfer coefficient of the vapor phase;  $x$  is vapor quality;  $\rho_l$  is density of the vapor phase;  $C_{p,v}$  specific heat of vapor at constant pressure;  $H$  is specific enthalpy.

## V. EXTERNAL HEAT TRANSFER COEFFICIENT

The staggered arrangement of circular tubes with fins is applied to the evaporator. Thulukkanam [12] proposes the following correlation for external heat transfer coefficient:

$$h_{out} = 0.134(Re_D)^{0.681} (Pr)^{1/3} \left( \frac{s_a}{h_a} \right)^{0.2} \left( \frac{s_a}{\delta_a} \right)^{0.1134} \quad (8)$$

For staggered and smooth tubing used in the condenser, Bejan [13] presents a number of correlations for the definition of convective heat transfer coefficient for the outside dependent on the Reynolds number. For Reynolds number between 1000 and 20,000, Nusselt number is calculated as:

$$\overline{Nu_D} = 0.35(Re_D)^{0.6} (Pr)^{0.36} \left( \frac{Pr}{Pr_w} \right)^{1/4} \quad (9)$$

Where in equations 8 and 9 the  $h_{out}$  is convective heat transfer coefficient of the outside;  $s_a$  is spacing between fins;  $h_a$  is fin height;  $\delta_a$  is thickness fin;  $Nu_D$  is Nusselt number;  $Pr_w$  is Prandtl number in the wall temperature.

## VI. CALCULATION OF THE AREA OF THE HEAT TRANSFER

The LMTD method was applied for specification of the thermal exchange area to each heat exchanger. The correction factor is calculated using proper function of the ESS software.

$$q = U_o A \Delta T_{lm} F \quad (10)$$

The overall heat transfer coefficient ( $U_o$ ) for smooth or finned tubes was used the formulation of Incropera et al. [14], which was modified to meet the particularities of the exchangers studied.

$$U_o = \left\{ \frac{1}{h_{in}} + R_{d,c} + R_w A_c + \frac{R_{d,h} A_c}{\eta_a A_h} + \frac{A_c}{\eta_a h_{out} A_h} \right\}^{-1} \quad (11)$$

Where in equation 11 the  $R_{d,c}$  is resistance to deposition of cold fluid;  $R_w$  is thermal resistance of the wall,  $A_c$  is area of the cold side;  $R_{d,h}$  is resistance to deposition of hot fluid;  $\eta_a$  is Fin efficiency;  $A_h$  is area of the hot side.

And  $\Delta T_{lm}$  given by:

$$\Delta T_{lm} = \frac{\Delta T_I - \Delta T_{II}}{\ln \left( \frac{\Delta T_I}{\Delta T_{II}} \right)} \quad (12)$$

$$\Delta T_I = T_{h,in} - T_{c,out} \quad (13)$$

$$\Delta T_{II} = T_{h,out} - T_{c,in} \quad (14)$$

Where in equations 10 to 14 the  $q$  is heat rate;  $U_o$  is overall heat transfer coefficient;  $A$  is area of heat transfer;  $\Delta T_{lm}$  is mean logarithmic temperature difference;  $F$  is factor correction;  $T_{h,in}$  is the inlet temperature of the hot fluid;  $T_{c,out}$  is the outlet temperature of the cold fluid;  $T_{h,out}$  is the outlet temperature of the hot fluid;  $T_{c,in}$  is the inlet temperature of the cold fluid.

## VII. RESULTS

The overall heat transfer coefficient is found within the range specified by Walas [16], for condenser type shell and tube of the overall coefficient of heat transfer is between 283.5 and 1134.9 W/m<sup>2</sup>K. In the evaporator, the specified range is 141.75 to 340.47 W/m<sup>2</sup>K. Table 3 and Table 4 shows the values found for internal heat transfer coefficient, external heat transfer coefficient, overall heat transfer coefficient and area of the heat transfer for the evaporator and condenser, respectively.

Table 3: Results for Evaporator

Parâmetro	Values
Internal heat transfer coefficient (W/m <sup>2</sup> K)	584.8
External heat transfer coefficient (W/m <sup>2</sup> K)	681.5
Overall heat transfer coefficient (W/m <sup>2</sup> K)	108.4

Area of the heat transfer (m <sup>2</sup> )	1170.0
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Table 4: Results for Condenser

Parâmetro	Values
Internal heat transfer coefficient (W/m <sup>2</sup> K)	943.9
External heat transfer coefficient (W/m <sup>2</sup> K)	3538.0
Overall heat transfer coefficient (W/m <sup>2</sup> K)	660.3
Area of the heat transfer (m <sup>2</sup> )	889.2

The parametric studies performed in EES show the influence on global heat transfer coefficient, heat transfer surface area and average convective heat transfer coefficient inside and outside the tubes with the variation of the outer diameter ( $0.0761 \leq D_{out} \leq 0.108$  m). Note that the outer diameter was connected such to the inner diameter so as to keep constant the thickness of the tube wall, that is the variation in the outer diameter of the inner diameter also varies.

### VIII. CONCLUSION

The overall heat transfer coefficient and heat transfer area to the evaporator were found 108.4 m<sup>2</sup> and 1170.0 W/m<sup>2</sup>K respectively. In the condenser, the overall heat transfer coefficient and area were found to 660.3 W/m<sup>2</sup>K and 889.2 m<sup>2</sup> respectively. For the parametric analysis, it is concluded that the external diameter of the tube has a strong influence on the overall heat transfer coefficient. In the evaporator, the increased outer diameter provides an increase in the overall coefficient of heat transfer, since the reverse occurs in the condenser, mainly caused by construction differences of the two heat exchangers. It is suggested as a future study the optimization of the evaporator and condenser that are used in the Kalina cycle, as in the case study found in Saldanha et al. [16] for shell and tube heat exchanger with single phase flow.

### ACKNOWLEDGEMENTS

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### REFERENCES

[1] Zhang, X., HE, M., Zhang, Y., (2012). A review of research on the Kalina cycle. Renewable and sustainable energy reviews, vol. 16, No. 7, pp. 5309-5318.

[2] Shankar, R., Srinivas, T., (2016). Options in Kalina Cycle Systems. Energy Procedia, vol. 90, pp. 260-266.

[3] Wall, G., Chuang, C., Ishida, M., (1989). Exergy study of the Kalina cycle. Analysis and design of

energy systems: analysis of industrial processes, vol. 10, No. 3, pp. 73-77.

- [4] Khankari, G., Munda, J., Karmakar, S., (2016). Power generation from condenser waste heat in coal-fired thermal power plant using Kalina cycle. Energy Procedia, vol. 90, pp. 613-624.
- [5] Rivera, W.; Best, R., (1999). Boiling heat transfer coefficients inside a vertical smooth tube for water/ammonia and ammonia/lithium nitrate. International Journal of Heat and Mass Transfer, No. 42, pp. 905–921.
- [6] Khir, Tahar et al., (2005). Experimental study on forced convective boiling of ammonia–water mixtures in a vertical smooth tube. Arabian Journal for Science and Engineering, Jeddah, Vol. 30, No. 1B, pp. 47–63.
- [7] Araújo, J.J. P., Santos, C.A.C., Duarte, J.B.F., Holanda, C.A.M., (2013). Calculation of the coefficient of heat transfer for Evaporation convective in saturated stream for cooling Fluids: R-12, R-22, R-134a, R-600 and R-717. International Congress of Mechanical Engineering, No. 22, pp. 8347–8356.
- [8] Shah, M.M., (2015). A method for predicting heat transfer during boiling of mixtures in plain tubes. Applied Thermal Engineering, No. 89, pp. 812–821.
- [9] Mirolli, Mark D., (2006). Cementing Kalina cycle effectiveness. Industry Applications Magazine - IEEE, California, Vol. 12, pp. 60–64.
- [10] Kalina, A. et al., (1995). Recent development in the application of Kalina cycle for geothermal plants. Proceedings of World Geothermal Congress, Florence, pp. 2093-2096.
- [11] Arieta, F.R.P., Irokawa, G.N.F., Júnior, E.P.B. and Santos, J.S., (2015). Avaliação termoeconômica de um ciclo Kalina para a recuperação de calor residual. Congress on Computational Methods in Engineering, No. 35.
- [12] Thulukkanam, K., (2013). Heat exchanger design handbook. CRC press.
- [13] Bejan, A., (2013). Convection heat transfer. 4 Ed., Wiley.
- [14] Incropera, F.P., Dewitt, D.P, Bergman, T.L., Lavine, A.S., (2008). Fundamentos de transferência de calor. 6 Ed., LTC.
- [15] Walas, S.M., (1990). Chemical Process Equipment: Selection and Design. Butterworth-Heinemann Series in Chemical Engineering.
- [16] Saldanha, W. H. et al., (2017). Choosing the best evolutionary algorithm to optimize the multiobjective shell and tube heat exchanger design problem using PROMETHEE. Applied Thermal Engineering, vol. 127, pp. 1049-1061.

# Pigmented Oral Lesion Associated with Root Canal Sealers: A diagnostic Dilemma

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**Abstract**— *The mucosa exogenous pigmentation may occur in consequence of dental materials contact, such as amalgam pigmentation. Aim: This paper reports a rare case of oral pigmentation due to extrusion of N-Rickert root canal sealer from a pre-existing fistula associated with a lateral canal in a 47-year-old female patient. Subjects and Methods: The clinical presentation was a well-defined grayish macule of about 3 mm located in the attached gingiva close to the maxillary left central incisor. Analysis Used and Results: Upon identification of endodontic treatment and a mesial lateral canal, a CT scan was requested. According to the endodontist that performed the prior treatment the tooth was filled with Rickert Pulp Canal Sealer™ (Sybron Endo) and there was a material extrusion through a fistula associated with the infected lateral canal at the time. Conclusion: The knowledge of exogenous pigmentations caused by dental materials is necessary to proper diagnosis.*

**Keywords**— *exogenous pigmentation, melanoma, oral mucosa pigmentation, root canal filling materials, root canal sealers.*

## I. INTRODUCTION

Melanin, one of the responsible for oral mucosa pigmentation, is synthesized by melanocytes present in the basal layer of the epithelium and its amount is determined genetically. However, exogenous stimuli, such as trauma, inflammation, medications, hormones and radiation, may increase melanin production [1], originating pigmented oral

lesions. In addition, endogenous factors like reactive, neoplastic, systemic, physiological and idiopathic processes can make the diagnosis of these lesions more challenging [2].

Oral pigmentations are common and can be either focal or diffuse. Melanoma is the most concerning pigmented lesion and should always be included as a differential diagnosis in all cases. The most common solitary pigmented oral lesion is amalgam tattoo, caused by amalgam restorations [3-10]. However, other dental materials can produce tattoos, such as N-Rickert root canal sealer [11].

Commonly used in endodontics, N-Rickert sealer has a high antimicrobial action and excellent flow and sealing ability. Its composition includes oil of cloves, aristol and silver [12]. Silver might cause pigmentation of tissues in an exposed mucosal site.

In the literature search, no other case reports of oral pigmentation due to extrusion of N-Rickert sealer were found. It is likely that dentists dealing with black or bluish macules in the mucosa without contacting amalgam restorations would not consider pigmentation caused by the root canal sealer and only suspect of a malignant lesion or other options. It is therefore important to publish cases like this one and disseminated information among clinicians and researchers in order to increase the chances of establishing an accurate diagnosis.

This paper reports a rare case of oral pigmentation due to extrusion of N-Rickert root canal sealer from a pre-

existing fistula associated with a lateral root canal in a maxillary central incisor.

## II. CASE REPORT

A 47-year-old female Asian patient sought care with a general dentist complaining of a lesion on her gingiva that appeared 1 year before. The intraoral examination revealed a grayish macule with approximately 3 mm on the attached gingiva close to the maxillary left central incisor (Fig. 1). The patient was referred to an oral diagnosis specialist, who requested a radiograph. Upon identification of endodontic treatment and a mesial lateral canal (Fig. 1 B and C), the professional recommended monitoring the lesion and requested a CT scan (Fig. 2A and 2B) for diagnostic investigation. It was suggested that the patient returned to the endodontist that performed the treatment for a reevaluation. According to the endodontist's records the tooth had been filled with thermoplasticized gutta-percha and Rickert Pulp Canal Sealer™ (Sybron Endo) and there had been extrusion of material through a fistula associated with the infected lateral canal at the time. Therefore, a diagnostic hypothesis of an oral pigmented lesion caused by the silver-containing N-Rickert sealer was formulated. Since the patient did not have esthetic complaints, a decision was made not to remove the tattoo and monitor the lesion closely. The patient has been under follow-up for 8 years without alteration.

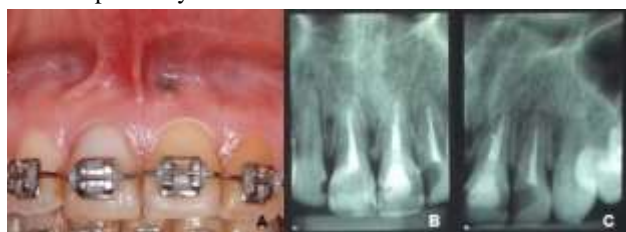


Fig. 1: Clinical and radiographic features: A. Grayish macule on the attached gingiva above the maxillary left central incisor. B. Radiographic image of the maxillary central incisor region. C. Radiographic image of the region of the maxillary anterior teeth on the left side.

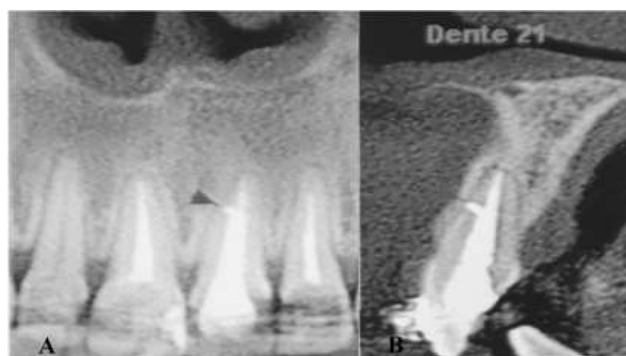


Fig. 2: Computed tomography scan. A. CT image of the anterior maxilla region B. CT image of the maxillary left central incisor 21 (sagittal view).

## III. DISCUSSION

Although it is not a frequent subject in the literature, it is known oral pigmentation of exogenous origin can be caused by the deposition of metal from some dental materials, such as amalgam [3], silver cones [13] or silver-containing root canal sealers [11]. Figueiredo et al. [14] compared root canal sealers with and without silver (N-Ricket and Rickert, respectively) and concluded that the silver present in the chemical composition of the sealer could produce oral mucosa tattoos.

However, there is only one clinical report of oral pigmentation caused by a root canal sealer, AH-26, an epoxy resin-based sealer containing silver [15], which reinforces the relevance of our case report. It is important to consider this hypothesis in cases of pigmented lesion close to endodontically treated teeth without history of apical surgery. In cases of apicoectomy, amalgam tattoo remains a possibility since the amalgam used to be indicated as retrofilling material and could pigment hard and soft tissues, especially in mucosal regions distant from the apical root third [16].

Regarding the prevalence of oral pigmentations, Hassona et al. [9] evaluated the oral mucosa of 1,275 patients and found that 386 (30.2%) of them presented pigmented oral lesions, 18.9% of which being amalgam tattoo. Although the oral pigmentations were frequent, the authors did not consider silver-containing root canal sealers as possible etiological agents of these tattoos. Likewise, in clinical practice, amalgam restorations are the primary hypothesis when these lesions are identified and, in the absence of amalgam restorations, dentists usually do not consider other dental materials, like root canal sealers, as the source of pigmentation.

Amalgam tattoos are relatively common lesions that appear clinically isolated bluish, grayish or black macules and spots that may occur more frequently in the gingiva or other sites as the buccal mucosa, palate, or tongue [7]. They are harmless and asymptomatic lesions [6]. In lesions with incorporation of large particles, the diagnosis can also be established radiographically as the metal particles appear as radiopaque granules inside the lesion [4]. In this case report, the tattoo was located in the gingiva and there were no amalgam restorations close to the region, which led us to assume that the silver-containing endodontic sealer could be the source of the pigmentation.

The diagnosis is often clinical, but, in non-typical cases, biopsy is necessary to exclude malignant lesions, such as melanoma. In the present case, the clinical history combined with intraoral and radiographic examination was sufficient to confirm the diagnosis, and a biopsy was not necessary.

Oral pigmentations should have a differential diagnosis with malignant lesions (Table 1), including oral melanoma. Although reports and occurrence are rare, with

a prevalence of 1.3 to 6.3% among all melanomas [17], oral melanoma is one of the most aggressive malignancies [18, 19, 20], and its etiology is still unknown [21, 22]. Clinically, oral melanomas present as black or brown macules or nodules with blackish, brownish, grayish, reddish tonalities, or as nonpigmented lesions. The alveolar gingiva and the hard palate are the most common locations [21, 22]. Thus, dentists must be careful with pigmented lesions located on the hard palate and gingiva, and a biopsy should be done if there is any alteration, even if minimal, because these sites are the most frequently affected by nevi and oral melanomas [10].

Table.1: Clinical features and etiology of major pigmented oral lesions found on oral mucosa.

	Etiology	Clinical features
<b>Melanocytic nevi</b>	Congenital or developmental disorder	Well-demarcated dark black / brown /blue macule or papule (0.1-3.0 cm in diameter)
<b>Melanotic macules</b>	Racial/smoking/ drug induced/post inflammatory	Single / multiple (lower frequency) brownish, well-demarcated macule (<1cm in diameter)
<b>Melanoma</b>	Unknown	Pigmented mass with irregular borders, color variation, and rapid growth
<b>Systemic disease associated</b>	Endocrinopathies (Addison's, Nelson's, Albright, pregnancy, Graves Genetic disorders (Peutz-leghers, Laugier-Hnuziker, Carney Others (HIV, hemochromatosis, Wilson disease	Diffuse brown pigmentation on tongue, lips and mucosae Brown circum-oral macules, mucosal brown patches Brown-blue pigmented patches
<b>Oral melanoacanthoma or melanoacantosis</b>	Reactive process Increased dendritic melanocytes	Dark brown macule, usually solitary

The majority of patients with pigmented lesions on the oral mucosa seek treatment due to esthetic reasons and an excisional biopsy is the most common form to eliminate amalgam tattoos [5]. Alternatively, if esthetics is not a complaint, clinical and photographic follow-up every 3 to 6 months can be done, as performed in the present case.

It has been shown that the histopathological features of sealer and amalgam tattoos are, consisting of granular, thin, sharp, reticular fibers around the blood vessel walls, with rare larger black metal particles. Mononuclear inflammatory cell infiltrate is a frequent

finding, while giant cells are uncommon [4]. Figueiredo et al. [23] compared the histopathological response to four root canal sealers and found that N-Rickert produced the greatest amount of granulation tissue, followed by Fillcanal, Sealer 26 and AH-26 sealers. All materials induced the migration of a large number of macrophages and giant cells. Only the silver-containing sealers exhibited a visible deposition on the vessel walls. Fillcanal was the most aggressive sealer, causing severe irritation, followed by N- Rickert and AH-26, which caused moderate irritation, and Sealer 26 which caused only mild irritation. Oral pigmentations produced by root canal sealers seems to cause a more intense granulomatous chronic inflammatory response compared with amalgam tattoos, which could be attributed to the greater amount of silver in the sealer.

Although N-Rickert can cause pigmentation of oral tissues, it has highly desirable properties for an endodontic sealer, including excellent sealing ability [24], and good antimicrobial activity [12], which justifies its widespread use in endodontics.

Ricket sealer can be considered as an etiological agent of pigmented oral lesions, especially when there are no amalgam restorations at the lesion region. In addition, as a primary rule, any oral pigmented lesion that does not fulfill the clinical criteria to establish a diagnosis or present alterations over time must be biopsied to exclude other lesions, especially oral melanoma. As all dental professionals, endodontists must maintain proper patient records and documentation, including the root canal filling material and technique used in each case. In patients that present with oral pigmentations, having this information is essential to make an accurate differential diagnosis with malignant lesions.

#### IV. CONCLUSION

The presented case emphasizes the need of the correct differential diagnosis of exogenous pigmentations of the mucosa caused by dental materials, that due to its clinical appearance, they may resemble melanocytic and melanocytic lesions.

#### REFERENCES

- [1] Feller L, Masilana A, Khammissa RA, Altini M, Jadwat Y, Lemmer J. Melanin: the biophysiology of oral melanocytes and physiological oral pigmentation. *Head Face Med* 2014; 10: 1–7.
- [2] Meleti M, Vescovi P, Mooi WJ, van der Wall I. Pigmented lesions of the oral mucosa and perioral tissues: a flow-chart for the diagnosis and some recommendations for the management. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2008; 105: 606–16.

- [3] Eley BM. The fate of amalgam implanted in soft tissues – na experimental study. *Journal of Dental Research* 1979; 58: 1146–52.
- [4] Eisen D. Disorders of pigmentation in the oral cavity. *Clinics in Dermatology* 2000; 18: 579–87.
- [5] Gojkov-Vulkelec M, Hadzic S, Pasic E. Laser Treatment of Oral Mucosa Tatto. *Acta Inform Med* 2011;19: 244-6.
- [6] Lundin K, Schmidt G, Bonde C. Amalgam Tatto Mimicking Mucosal Melanoma: A diagnostic Dilemma Revisited. *Case Reports in Dentistry* 2013; 2013: 1-3.
- [7] Longo C, Scope A, Lallas A, Zalaudek I, Moscarella E, Gardini S et al. Blue Lesions. *Dermatol Clin* 2013; 31: 637-47.
- [8] Baden LR. Oral Amalgam Tatto Mimicking Melanoma. *The New England Journal of Medicine* 2016; 374: e21.
- [9] Hassona Y, Sawair F, Al-Karadsheh O, Scully C. Prevalence and Clinical Features of Pigmented Oral Lesions. *International Journal of Dermatology* 2016; 55: 1005-13.
- [10] Lambertini M, Patrizi A, Fanti PA, Melotti B, Magnoni C, Misciali C et al. Oral melanoma and other pigmentations: whan to biopsy? *J Eur Acad of Dermatol Venereol* 2017; 1-6.
- [11] Orban B, Wentz F. *Atlas of Clinical Pathology of the Oral Mucous Membrane*. St. Louis, MO, USA: Mosby, 121–2; 1955.
- [12] Miyagak DC, Carvalho EMOF, Robazza CRC, Chavasco JK, Levorato GL. In vitro evaluation of the antimicrobial activity of root canal sealers. *Braz Oral Res* 2006; 20:303-6.
- [13] Kehoe JC. Intracanal corrosion of a silver cone producing a localized argyria-scanning electron microscope and energy dispersive x-ray analyser analyses. *Journal of Endodontics* 1984; 10: 199-01.
- [14] Figueiredo MAZ, Lorandi CS, Figueiredo JAP. Oral mucosal tattoo induced by root canal sealers. *Brazilian Endodontic Journal* 1996;1: 11–4.
- [15] Dayan D, Buchner A, Moskona D, Sperling I. Pigmentation of the oral mucosa after root canal filling with AH-26. A light and electron microscopic study. *Clinical and Preventive Dentistry* 1983; 5: 25–9.
- [16] Dorn SO, Gartner AH. Retrograde filling materials: a retrospective success-failure study of amalgam, EBA, and IRM. *J Endodont* 1990; 16:391–393.
- [17] Warszawik-Hendzel O, Słowinska M, Olszewska M, Rudnicka L. Melanoma of the oral cavity: pathogenesis, dermoscopy, clinical features, staging and management. *J Dermatol Case Rep* 2014; 8: 60–66.
- [18] Seetharamu N, Ott PA, Pavlick AC. Mucosal melanomas: a case-based review of the literature *Oncologist* 2010; 15: 772–81.
- [19] Gavriel H, McArthur G, Sizeland A, Henderson M. Review: Mucosal melanoma of the head and neck. *Melanoma Research* 2011; 21: 257-66.
- [20] Shuman AG, Light E, Olsen SH, Pynnonen MA, Taylor JM, Johnson TM et al., Mucosal melanoma of the head and neck: predictors of prognosis. *Archives of Otolaryngology, Head and Neck Surgery* 2011; 137: 331-337.
- [21] Patrick RJ, Fenske NA, Messina JL. Primary mucosal melanoma. *J Am Acad Dermatol* 2007; 56: 828–834.
- [22] Williams MD. Update from the 4th edition of the world health organization classification of head and neck tumours: mucosal melanomas. *Head Neck Pathol.* 2017; 11: 110–117.
- [23] Figueiredo JAP, Pesce HF, Gioso MA, Figueiredo MAZ. The histological effects of four root canal sealers implanted in the oral mucosa: submucous injection versus implant in polyethylene tubes. *International Endodontic Journal* 2001; 34: 377-85.
- [24] Medina FV, Sousa-Neto MD, Carvalho-Júnior JR, Santos HSL, Mezzena MA, Garcia LFR. In vitro study of the effect or ER:YAG laser irradiation on the apical sealing of different root canal sealers. *J Appl Oral Sci* 2006; 14: 260-3.

# Oil and Gas on the Brazilian Coast

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**Abstract**— *The study of behavioral finance is characterized by analyzing the volatility of financial markets, however, in a contemporary view, one can also apply it in other fields such as commerce and factories, and its dislike to be able to invest or not its financial capital. The objective of this work is to present foreign reflections on a new branch in financial theory, Behavioral Finance, which aims to adhere the psychological and sociological aspects of the individuals in the decision making process at the time of making an investment, as well as their applications through incorporation evidence of the investor's irrationality. This new segment aims to review and improve the current economic-financial model. The association with behavioral finances provides both the understanding of the psychological process that motivates the investments, helping in the construction of a more adequate decision-making model, and in the hiring of its managers who must possess adequate technical and psychological skills in order to avoid cognitive bias as overconfidence*

**Keywords**— *behavioral finance, cognitive, Rio de Janeiro.*

## I. INTRODUCTION

The present work begins with a brief history of the Brazilian sea exploration related to the activities of oil extraction in the high seas in the Brazilian coast exploited in its vast majority by oil operators. From the first research for oil exploration in the high seas, through exploration in deep waters and arriving to the present day with the discovery of the zone of the Pre-Salt and the respective evolution of the logistic support to this activity.

Oil exploration is the main economic activity of the country and the predictions of the scarcity of this resource that haunts not only the Brazilian economy but the world economy has made the country search for alternative ways of exploiting this resource. The recently discovered Pre-Salt is one of these alternatives and the exploration challenges that have already begun in Brazil made it necessary to evolve both in the technological apparatus of production and support linked to it and of innovative models of administration of these resources.

Exploitation of oil in the Pre-salt zone is not an easy task, since it is located 300 km off the coast, twice as far as the Campos Basin, and these wells are drilled more than 7000 meters deep. This would require more resilient pipelines and pipelines where at that depth the aggressiveness of the environment due to pressure and corrosive agents are more severe [1] [2].

Given these scenarios, the need to overcome technological challenges and find the best way to transport not only oil and gas, but also support materials for the entire production chain and workers.

The bibliographical research aims at the theoretical basis for understanding the functioning of logistics in the Pre-salt zone. It will be searched books, articles and dissertations, selection of books, magazines, newspapers, chapter that address the main factors that influence the main characteristics of the modes of transport used and the systems of production flow. A case study was also analyzed in the Tupi Oilfield, which will serve as the main source of study of this work.

The purpose of this article is to analyze the oil logistics in the Tupi Oil Field, located in the Pre-salt zone. For this,



the article will contemplate initial concepts about logistics and their modalities that will contribute to the study, thus permeating the main logistic challenges of the Pre-salt and the oil logistics of the Tupi field.

## II. THE LOGISTICS OF PETROLEUM IN THE FIELD OF TUPI

In 2006 was discovered the largest oil field is natural gas of the country in the oilfield of Tupi in the basin of Santos. This discovery has revolutionized the national oil industry. It is the beginning of oil exploration in the pre-salt layer [3]. To reach this discovery were years of geological studies that indicated possible existence of oil in these layers, in 2004 initiated the seismic tests, data collection and exploration of exploratory wells for the purpose of estimating the amount of petroleum, analyze the viability of operating costs and production sustainability. Since the production of oil from the pre-salt would require a very high cost due to the difficulty of extracting the oil from that layer, it was necessary to know the size of these reservoirs, as can be seen in Figure 1 [3].



Fig. 1: pre-salt Explanatory figure. Source: PETRONOTÍCIAS (2013)

The scenario is quite positive, if the estimates of the first findings are confirmed, Brazil will make a leap and both in the ranking of the countries with the highest reserves, getting among the first (BERTO, MENDES and NOGUEIRA, 2012). The production from pre-salt to 2020 is estimated at 47% of the total produced by Petrobrás in Brazil [3].

It is estimated that the total area of the Tupi evaluation plan is 1,974 km<sup>2</sup> and is located in waters of about 2,200 m of water blade, with layers of salt of 2,000 m thick [1]. The wells initially tested in Tupi indicated potential flows of 15 to 20000 barrels of oil per day and good quality of the oil with API degree from 28th to 30th considered a light oil of better quality and easier to refine than the national average In addition to natural gas [1].

### 2.1 MAIN LOGISTICAL CHALLENGES OF PRE-SALT

One of the major challenges awaiting Petrobras in oil exploration in the pre-salt layer is the logistics area. The distance from the coast that lies around 300 km is one of the main factors contributing to the high degree of difficulty of pre-salt logistics [1].

The constant flow of people, which today revolves around 40,000 to 60,000 people who are moved from the coast towards the platforms should double, since in 2017 Petrobras announced that it wants to build 11 more platforms only in the Holy Spirit in the area of Salt [3].

The naval sector will also need changes due to the volume of investments applied by Petrobras in the construction of new platforms and technologies that contribute to the increasing increase in production. The emergence of new naval and Offshore industries, new refineries, change in shipments and increase in autonomy, among others will be elements that would bring opportunities for bold and prepared logistics companies, those that are not Will certainly not be able to enjoy this universe.

The scenario allied with the acceleration of the area of infrastructure and pre-salt, will unleash a new cycle of mergers and acquisitions in the transport chain and storage of the country, increasing the range of services of the logistics companies that enter this market.

The individual evolution of the transport modals and the intermodal relationship should be adopted as a premise for the main logistics companies able to join airport, port and storage in solutions without enriching the tariffs.

With the installation of new platforms and the constant growth of the pre-salt infrastructure, it becomes increasingly complex and challenging to flow of production, reuse of surpluses and an effective and efficient distribution of the pipelines.

#### 2.1.1 THE TRANSPORT MODAL OF TUPI

The Tupi oil field following the premises imposed by the operator is in the process of establishing its infrastructure. Although it is already a commercially productive field of pre-salt, Tupi is still at the beginning of phase 1a, beginning in 2013 and forecast of ending in 2017, at that stage will be used technologies already dominated or that can be quickly absorbed [3].

Following the strategy adopted by the operator, the field of Lula as was baptized, as soon as the commerciality of the field was disseminated, it is still a test area, study of behavior of new installations and behavior of production [3].

The arrival of FPSO (Floating Production Storage and Offloading) City of Paraty Day 07 June 2013 with a maximum capacity of 120,000 barrels of oil per day elevates the capacity of the field to 220 mbopd (220 a thousand barrels of oil a day) [4].

The movement of the modal transport of the Lula field in general is of vessels that assist in the construction of the entire infrastructure of production. Construction of pipelines, drilling wells, auxiliary vessels of such installations as operators of ROVs (Remotely operated underwater vehicle), among others. There is also the presence of relief ships that drain the production of the present FPSOs Direct to the terminals on terra firma which is still the only means of draining the production of the production of the pre-salt, as can be seen in the figure 2 [4].



Fig. 2: PLSV – Vessel for launching ducts [4].

The volume of these vessels tends to increase further, the development plan of the Lula-Iracema fields includes the installation of eight FPSO Additional to 2018, year in which the total capacity of the fields will reach 1,400 mbopd-thousand barrels per day [4].

### 2.1.2 MODAL PIPELINE

The transport of petroleum derivatives by pipelines remains timid in the oilfield oil field, the set of flexible tubes, umbilicals and other installations, in almost its entirety are concentrated only in the movement of the oil extracted from the well towards the exploration platforms (FPSOs), passing through umbilicals and risers [5].

Based on the information disseminated by petrobras, there are several challenges in this follow-up, it will be necessary to improve the rise pipe (riser), taking into account the high pressures arising from the depth, the high corrosive power due to the high concentration of CO<sub>2</sub>, are new situations requiring pipes with new rigid materials and line-type conformations in “s” – lazy wave; It should also improve the thermal insulation of the pipes considering the depth in water slides of 2,200 m. and pipes for injection of gas at high pressures [1].

From these challenges presented it is concluded that Petrobras will have to invest in other areas besides logistics, such as engineering, in order to develop new materials capable of mitigating the effects of pressure and corrosion.

Petrobras has established long-term contracts and defined an early approach to the market as fundamental to the strategic purchasing Process. In addition, it defined basic guidelines that include the increase of local content, support of the increase in Brazilian manufacturing capacity, equipment standardization and easing of these

contracts to enable the incorporation of new technologies [6].

Adaptations are already being made in parts of production lines and equipment, as well as in pipeline launch craft, with the view that the exploitation of this new oil frontier requires more resistant materials because of the worsening conditions corrosive, depending on the increase in Pressure [7].

On the other hand, the Squid-mussel pipeline put into operation since September 19, 2011 is an unprecedented milestone for Brazilian engineering: with capacity to seep up to 10 million cubic meters, 216 kilometers long, 18 inches in diameter, is the pipeline wWith greater depth and length of submarine rigid duct already installed in Brazil [3] [8].

At the level of drainage through the ducts, the Squid-mussel pipeline presents high flow Capacity. Due to its extension, it has been found that Petrobras is able to build new lines starting from the pre-salt, connecting wells and platforms until the arrival of the gas to the coast.

It is part of a water depth of 2,200 meters, where it is interconnected to the FPSO city of Angra dos Reis, in the field of Lula, until it reaches 180 meters, where it is connected to the mussel platform, owned by petrobras, situated in shallow waters in the basin of Campos , as can be seen in the Figure 3 [9].



Fig. 3: Squid-Mussel pipeline line [10].

This project will also contribute to the disposal of the natural gas of the platforms intended for the development of the first phase of the pre-salt of the Santos basin, as can be seen in Figure 4.



Fig. 4: Detailed view of the Squid-Mussel pipeline line [11].

The Squid-Mussel pipeline has been linked to the following installations of the Petrobras system: to the mussel field to the gas treatment unit (UTGCA) Monteiro Lobato, which is located in Caraguatatuba (SP), with the objective of enabling the arrival of the gas to the Caraguatatuba-state pipeline, which connects the gas processed in that unit to the distribution mesh of natural gas to the national market [12].

### 2.1.3 MODAL AIR – THE LOGISTICS OF PEOPLE IN PRE-SALT

Currently in the Campos basin, Petrobras carries an impressive volume of passengers from the mainland to the platforms, about 40,000 people a month, in more than 6,000 flights [3]. This number tends to double with the development of pre-salt, which would effectively be unfeasible due to the volume of people who are transported incompatible with the quantity and current structures of the existing aerodromes.

Another challenge is the long distance of the pre-salt installations of the Brazilian coast, which is around 300 km, in some situations the triple in comparison of the distance that is the basin of Campos of the Brazilian Coast. This distance is above the limit of flight autonomy of most aircraft operating in the field basin of Campos [3]. In addition, transport operations are subject to greater climatic instability.

“The aircraft need to be large, able to face the harsh weather conditions on the high seas and have autonomy to fly for 300 kilometers and return” [13].

“The EC225 Super Puma helicopter has transport capacity for up to 19 passengers plus two riders, depending on the configuration, "as can be seen in Figure 5 [14].



Fig. 5: EC225 SUPER PUMA helicopter [15].

The large aircraft that only a few years ago had higher costs than the mid-sized, are now becoming financially Competitive. Another important advantage of large aircraft is the transport management and Aerodrome capacity, because its use provides a transport of more passengers with fewer flights and in this way fewer

helicopters and vacancies are needed Parking at aerodromes, In addition to facilitating the process of air traffic management.

### III. REVOLUTION IN PRE-SALT BUSINESS LOGISTICS

The final phase of consolidation of Brazilian pre-salt, phase 1b, to be initiated after 2017, will serve as a field laboratory for the development of new technologies [3].

In this period, unconventional technological innovations in High-scale will be incorporated to complete the definitive development of pre-salt production areas, focusing on cost reduction and the optimization of deposits 'recovery rates, as can be seen in Figure 6 [3].



Fig. 6: Major technological developments in evaluation [2].

It can be seen in Figure 06 the main projects of Petrobras for the technological development of the Pre-salt. Explain in this chapter how some of these projects will work when they are deployed.

One of these proposals for the development of Petrobras is the construction of floating bases midway between the coast and the productive fields of the pre-salt of the Santos basin, seen the difficulty of logistical support due to the distance already cited in this work. "it would be an outlet for the logistical problems we will face due to the distance" [16].

It can be observed that the distribution system present in the basin of Campos and also today in the basin of Santos is the direct, where the coast (airports, airfields and ports) is the central terminal and the platforms located in the fields in the high seas, the destination" [16].

Hubs are floating bases that will function as distribution centers for people and loads in the middle of the ocean. Workers will be transported in high-capacity passenger craft, between 150 and 300 people up to those bases that are installed at a point closer to the coast, from that point would set off to the platforms through flights in smaller helicopters, which run shorter distances, reflecting on time and fuel economy [17].

In spite of the improvement of pipeline transport, a solution studied by the operator is the geological capture, transport and storage systems of carbon dioxide (CO<sub>2</sub>), through the technology development program for CO<sub>2</sub> (PRO-CO<sub>2</sub>) [3]. This project aims to study the possibility of reinjecting carbon dioxide into reservoirs with the aim of increasing the recovery of reserves; Storage of gas in saline aquifers under the seabed; Reinjection into gas reservoirs already depleted and storage in caves in the salt layer, with which emissions would be avoided in the earth's atmosphere [3]. Among other benefits this technology aims to reduce the corrosive effects in the ducts, materials and equipment by the presence of CO<sub>2</sub>.

The operator is still studying the best alternatives to enable the pre-salt logistics, because it is a complex process, it needs to carefully treat the implementation of each alternative of technological development studied.

#### IV. FINAL CONSIDERATIONS

The study of the business logistics carried out in this work proposed to synthesize the knowledge newly with the new experience of the exploration and production of the Brazilian pre-salt.

It is observed that the operator had a history of successive hits and that the prospecting of the Brazilian sea provided a great incentive to develop new technologies, but there is still a long way to go.

The theory as to the location of the facilities addressed were addressed to reflect on the main characteristics that involve the installations of the sedimentary basins in the sea.

The analysis of the modals previously made by these authors is also crucial to verify the characteristics of each of them, as well as, the intermodal relations and in this work serves as support for the understanding of the business logistics of the pre-salt, since, the modals used in the Pre-salt business logistics have environmental influences and varied technological interventions which makes a complex subject of being studied.

The exploration and production of Brazilian oil has achieved excellent results in recent years, the discovery of the pre-salt boosted the investments in logistics and caused that not only the operator as all logistical support companies directed their resources in technology and innovation.

Although the investments are high, the results obtained with the first tests are increasingly encouraging and the effective production of pre-salt will make Brazil become not only one of the main producers of world oil, but the holder of the major logistics technologies.

#### REFERENCES

- [1] Ferro, F., & Teixeira, P. (2009). Os desafios do Pré-Sal. Brasília. Câmara dos Deputados, Edições Câmara, 2009. 78 p. Série cadernos de altos estudos; n. 5.
- [2] Hayashi, M. Y. (2010). Desenvolvimento do Pré-sal. In: CURSO DE ENERGIA PARA JORNALISTAS, Rio de Janeiro: Agência Petrobras de Notícias, CD ROM.
- [3] Moraes, J. M. (2013). Petróleo em águas profundas: uma história tecnológica da Petrobras na exploração e produção offshore. – Brasília: Ipea: Petrobras.,p. 424.
- [4] GALP ENERGIA. (2018). Entrada em operação da segunda FPSO no campo Lula-Iracema duplica capacidade de produção instalada naquela área. Lisboa: Galp Press, p. 1. Disponível em: <<http://www.galpenergia.com>>. Acesso em: 23 out. 2018.
- [5] Rodrigues, R. C. (2010). Pré-sal: desafios tecnológicos. Conhecimento & Inovação, Rio de Janeiro: ANPEI, abr-jun 2010. Disponível em: <<http://www.conhecimentoeinovacao.com.br/materia.php?id=360>>. Acesso em: 123 out. 2018.
- [6] Almeida, N. E., Alonso, P. S. R., Rosseto Filho, I. J., & Serpa, F. G. (2009). Pre-Salt Cluster Long Term Supply Strategy. Offshore Technology Conference. OTC 20100.
- [7] Cardoso, D. ENTREVISTA: Technip faz 1o navio brasileiro para lançar dutos. Estadão, [S.l.], 22 out. 2009. Notícias, p. 1. Disponível em: <<http://www.estadao.com.br/noticias/geral,entrevista-technip-faz-1o-navio-brasileiro-para-lancar-dutos,454915,0.htm>>. Acesso em 23 out. 2018.
- [8] Schutte, G. R. (2012). Panorama do Pré-sal: Desafios e Oportunidades. Brasília: IPEA, p. 76. ISSN 1415-4765.
- [9] Schüffner, C. (2008). Entrevista - José Formigli. Valor Econômico, [S.l.], 23 mai. 2008. Resenha Eletrônica, p. 1. Disponível em: <<http://www.fazenda.gov.br/resenhaeletronica/MostraMateria.asp?page=&cod=463767>>. Acesso em: 23 out. 2018.
- [10] Rosa, B. (2012). Pré-sal: Brasil tem potencial para explorar 55 bilhões de barris. O Globo, Rio de Janeiro., Economia. p. 1 Disponível em: <<http://oglobo.globo.com/economia/pre-sal-brasil-tem-potencial-para-explorar-55-bilhoes-de-barris-6097763>>. Acesso em: 23 out. 2018.
- [11] O ESTADO DE SÃO PAULO. Petrobrás define logística do pré-sal. Estadão, São Paulo, 12 jun. 2010. Economia&Negócios, p. 1. Disponível em: <<http://www.estadao.com.br/noticias/impreso,petrob>>

- ras-define-logistica-do-pre-sal,565469,0.htm>.  
Acesso em: 23 out. 2018.
- [12] GASODUTO Lula-Mexilhão começa a operar na Bacia de Santos. Petrobras, Rio de Janeiro, 19 set. 2011. Relacionamento com Investidores, p. 1-2. Disponível em: <<http://www.bmfbovespa.com.br/empresas/consbov/ArquivosExibe.asp?site=B&protocolo=305220>>. Acesso em 23 out. 2018.
- [13] Caetano, R., & Velluto, L. (2013). A cadeia bilionária de negócios do pré-sal. Isto é Dinheiro. São Paulo, n. 804. Disponível em: <[http://www.istoedinheiro.com.br/noticias/114181\\_A+CADEIA+BILIONARIA+DE+NEGOCIOS+DO+PRE+RESAL](http://www.istoedinheiro.com.br/noticias/114181_A+CADEIA+BILIONARIA+DE+NEGOCIOS+DO+PRE+RESAL)>. Acesso em: 23 out. 2018.
- [14] Fraiha, D. (2013). Setor offshore deve demandar 100 novos helicópteros nos próximos sete anos. Petronotícias. [S.l.], 7 mai. 2013. p. 1. Disponível em: <<http://www.petronoticias.com.br/archives/27959>>. Acesso em: 23 out. 2018.
- [15] EUROCOPTER O produto. Disponível em <http://www.helibras.com.br/> acesso em 20/03/2014,
- [16] Goy, L., & Lima, K. (2008). Blocos terão bases flutuantes: Objetivo é reduzir as dificuldades com o transporte. O Estado de São Paulo, [S.l.], p. 1. Disponível em: <<http://www.fazenda.gov.br/resenhaeletronica/MostraMateria.asp?page=&cod=489760>>. Acesso em: 23 out. 2018.
- [17] Pamplona, N. (2009). Petrobrás planeja ilha artificial para apoiar exploração do pré-sal. Estadão, São Paulo. Economia&Negócios, p. 1. Disponível em: <<http://www.estadao.com.br/noticias/impreso,petrobras-planeja-ilha-artificial-para-apoiar-exploracao-do-pre-sal,394141,0.htm>>. Acesso em: 23 out. 2018.

# Evaluation of Risk Reduction for Portfolio in Islamic Investment Using Modern Portfolio Theory

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**Abstract**— *Main objective of this study is to maximize expected return and in the same time lowering investment risk. The methodology implemented in this study is modern portfolio theory through diversification assets that has low or negative correlation factor. This study tried to discover the portfolio expected risk and portfolios risk for 3 stocks namely Top Glove Corporation Berhad, AirAsia X Berhad and Axiata Group Berhad. Data for the analysis is selected from June 2015 until September 2018 involving 40 monthly observations. Result indicates the correlation factor between Top Glove and Airasia X is negative; meanwhile other correlation is not significant. Therefore, the selection of these three stocks is complying with the requirement of modern portfolio theory. Result indicates there are nine optimal combinations that calculated in this study which are suitable to develop non-linear line of efficient frontier. Data shows with the increment weightage in Top Glove stock, the expected average return will be increase. This is because the mean average return for share price of Top Glove 3.65%. This is the highest return comparing to other two stocks. However the risk of share price of Top Glove is 8.6 %, which is on the risky side. In addition, this study concludes the portfolio can attained lower risk by combining three stocks. The important implication of this study is it will help investors to develop optimal investment to attain maximum expected return based on a given level of market risk.*

**Keywords**— *Investment, Modern Portfolio Theory, Three stock combination, Portfolio Risk, Portfolio Expected Return*

## I. INTRODUCTION

Portfolio optimization is one of the most interesting researches in the financial area. It was attracted most investors to get high return from the selection of portfolio at a pre-specified level of risk. In the global economy, portfolio optimization has become an important issue in

generate high return and reduce the level of investment risk. Therefore, diversification of investment is looking as one of the alternative in generating high return.

Diversification is a portfolio strategy that is designed to reduce the overall risk exposure by combining a variety of assets into one basket of portfolio. Small capital stocks tend to produce a higher return since these stocks are far less accessible to international investors due to the high transaction costs associated with their limited liquidity, capital rationing and information availability (Bin and Yuan, 2016).

Recent evidence suggests that diversification of investment can reduce the level of risk. Study by Abu Bakar and Rosbi (2018) regarding Modern Portfolio Theory found the optimal combination of securities was generated maximizes return for any given level of risk.

In recent years, there has been an increasing interest in *shariah*-compliant companies industry. Investors are not only concerned about what is profitable but also what makes their investments ethical (Mohd-Sanusi, et, al., 2015; Ulrich and Marzban, 2008). Therefore, Malaysia Stock Exchange was established a *shariah* board in 1997 in order to fulfill the ethical investments in *shariah* law. Since *shariah* board was established, out of 693 companies from 901 was *shariah*-complaint companies (Securities Commission Malaysia, 2018). Thus, investors have many choices to choose an optimal investment either in *shariah*-compliant companies or non *shariah*-compliant companies.

Thus, this main objective of this study is to discover the relationship between portfolios expected return with respect to portfolio risk using combination of three stocks namely Top Glove Corporation Berhad, AirAsia X Berhad and Axiata Group Berhad. This study was evaluating risk reduction for portfolio in Islamic investment using Modern Portfolio Theory. Modern Portfolio Theory has become the backbone of finance as it

gives better understanding of the best possible investment portfolio for financial assets (Mohd Ali, 2006).

diversified portfolio under certain conditions peculiar to this market.

## II. LITERATURE REVIEW

A considerable amount of literature has been published on the portfolio optimization (Deng, 2018; Jothimani, et al., 2017; Fabozzi, 2002) and performance of *shariah*-compliant companies (Abu Bakar and Rosbi, 2017; Abu Bakar and Rosbi, 2016). The first serious discussions and analyses of diversification of investment emerged during 1952 by Harry Markowitz (Markowitz, 1952). Before Modern Portfolio Theory was developed, most of the investment are followed Theory of Investment that stated it was enough looking into only one stock (Kazan and Uludag, 2014). But, Markowitz suggested the benefits of diversification and explores how risk-averse investors construct portfolios to optimize expected returns against market risks (Bin and Yuan, 2016).

Therefore, several studies have used Modern Portfolio Theory in measuring the performance of stock market (Azizan and Sorooshian, 2014; Alrabadi, 2016; Chen and Pan, 2013). Study that focus on the Modern Portfolio Theory regarding asset allocation found Modern Portfolio Theory are more intuitively appropriate for decision making in international and direct real estate investing (Ho, et al., 2010). Study regarding the benefits of further diversifying a global portfolio of financial assets in New Zealand farm real estate found that the risk reduction benefits of diversifying with farm real estate are larger than the risk enhancement benefits (Nartea and Eves 2010). Giannotti, et al., (2011) provides in-depth analysis of Markowitz diversification approach and found that the standard geographic and sector diversification allow for a good results and more efficient portfolios.

A large and growing body of literature has investigated the performance of *shariah*-compliant companies. Bahlous and Mohd. Yusof (2014) investigates the benefits of international diversification among Islamic funds, suggests that investors can reduce risk even more substantially if they hold an internationally diversified fund as globally diversified portfolios among Islamic funds only. Abu Bakar and Rosbi (2018) develop an efficient frontier line for investment portfolio in Malaysia market. Each point on the efficient frontier line represents an optimal combination of securities that maximizes the return for any given level of risk (standard deviation).

Numerous studies have attempted to explain the performance of Malaysian stock market. Zainal Abidin, et al., (2004) provide evidence whether international portfolio diversification gain exists in equity investment from a Malaysian perspective and it is feasible for Malaysian investors to construct a purely domestic portfolio which is more superior to an internationally

## III. RESEARCH METHODOLOGY

This study try to discover the relationship between portfolios expected return with respect to portfolio risk using combination of three stocks. The methodology implemented in this study involved with data selection process, correlation diagnostics and evaluation of Markowitz theory of diversification approach.

### 3.1 Data selection process

This study involved with share prices from three companies namely Top Glove Corporation Berhad, AirAsia X Berhad and Axiata Group Berhad. Data of share price is collected in daily basis from database of Datastream Thomson Reuters. The collected data is starting from 1<sup>st</sup> June 2015 until 30<sup>th</sup> September 2018. Then, this study calculated average monthly value for share price.

The calculation for share price is described in Equation (1).

$$Re_{i,n} = \left( \frac{SP_{n+1} - SP_n}{SP_n} \right) \times 100\% \dots\dots\dots$$

(1)

where,

$Re_{i,n}$  = return for stock  $i$  at period  $n$ ,

$SP_n$  = monthly share price for stock  $i$  at period  $n$ ,

$SP_{n+1}$  =monthly share price for stock  $i$  at period  $n+1$ .

### 3.2 Correlation diagnostics

Next, this study performed the calculation for correlation between share price return among three selected companies. This study implemented Pearson correlation for statistical approach. The type of data in Pearson correlation analysis should be interval or ratio.

Pearson correlation coefficient between two variables (stocks) is defined as covariance of the two variables divided by the product of their standard deviations. Pearson correlation coefficient is represented as  $\rho$  in Equation (2) for population .

$$\rho_{X,Y} = \frac{\text{cov}(X,Y)}{\sigma_X \sigma_Y} = \frac{E[(X - \mu_X)(Y - \mu_Y)]}{\sigma_X \sigma_Y} \dots(2)$$

where,

cov is covariance,

$\sigma_X$  is standard deviation of X,

$\sigma_Y$  is standard deviation of Y,

$\mu_X$  is mean of X,  $\mu_Y$  is mean of Y,

The sample of Pearson correlation coefficient is represented as  $r$  in Equation (3).

$$r_{XY} = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^n (X_i - \bar{X})^2} \sqrt{\sum_{i=1}^n (Y_i - \bar{Y})^2}} \dots\dots\dots(3)$$

3.3 Evaluation of Markowitz theory in diversification approach for investment portfolio.

Modern portfolio theory is a theory of finance that attempts to maximize portfolio expected return for a given amount of risk, or minimize risk for a given level of expected return (Markowitz, 1952). Modern portfolio theory is an investment theory based on the idea that risk-averse investors can construct portfolios to optimize or maximize expected return based on a given level of market risk, emphasizing that risk is an inherent part of higher reward (Fabozzi et al., 2002)

The Markowitz portfolio theory is based on the risk in a portfolio of diverse individual stocks will be less than the risk inherent in holding any one of the individual stocks. There are two concepts that underlying for Markowitz portfolio theory:

- (a) The objective of investor is to develop investment portfolio that contributes maximum return for any given level of risk.
- (b) Investors are risk-averse and thus have a preference for expected return and dislike for risk.

The expected return for a portfolio consist of three stocks is represented by Equation (4).

$$E(r_p) = w_A E(r_A) + w_B E(r_B) + w_C E(r_C) \dots\dots\dots(4)$$

where

$E(r_p)$  is expected return for portfolio,

$E(r_A)$  is expected return for stock A,

$E(r_B)$  is expected return for stock B,

$E(r_C)$  is expected return for stock C,

$w_A$  is stock A weigthage,  $w_B$  is stock B weigthage and

$w_C$  is stock C weigthage.

The variance of rate of return for two type of stocks in a portfolioi is described in Equation (5).

$$\begin{aligned} \sigma_P^2 = & (w_A \sigma_A)^2 + (w_B \sigma_B)^2 + (w_C \sigma_C)^2 \\ & + 2(w_A \sigma_A)(w_B \sigma_B) \rho_{AB} \\ & + 2(w_A \sigma_A)(w_C \sigma_C) \rho_{AC} \\ & + 2(w_B \sigma_B)(w_C \sigma_C) \rho_{BC} \end{aligned} \dots\dots\dots(5)$$

where,  $\sigma_A$  is stock A standard deviation,  $\sigma_B$  is stock B standard deviation,  $\rho_{AB}$  is correlation coefficient between stock A and B,  $\rho_{AC}$  is correlation coefficient between stock A and C, and  $\rho_{BC}$  is correlation coefficient between stock B and C.

IV. RESULT AND DISCUSSION

The objective of this study is to evaluate the effectiveness of the investment portfolio using modern portfolio theory. Three stocks are selected in the analysis namely Top Glove Corporation Berhad, AirAsia X Berhad and Axiata Group Berhad. All three selected companies are listed in main market of Bursa Malaysia in Malaysia.

4.1 Data selection and analysis

The first company that selected in this study is Top Glove Corporation Berhad. Figure 1 shows the dynamic behavior of share price for Top Glove Corporation Berhad. Monthly data is collected using database of Datastream Thomson Reuters. The monthly observation started from June 2015 until September 2017. The total observations are 40 months. The initial value of share price in June 2015 is MYR 3.006. The maximum value of share is MYR 11.233 in June 2018.

Figure 2 shows the return rate for Top Glove Corporation Berhad. The maximum value of share price return is 25.5753 % on January 2018. Meanwhile, the minimum value of share price is -15.734 % on February 2016.

The second selected company is AirAsia X Berhad. Figure 3 shows the dynamic behavior of share price for AirAsia X. The initial share price is MY 0.2318 in June 2015. The maximum value of share price is MYR 0.4743 on May 2017. Meanwhile, the minimum value is MYR 0.1810 on August 2015.

Figure 4 shows the return rate for AirAsia X Berhad. The maximum value of share price return is 22.25 % on February 2016. Meanwhile, the minimum value of AirAsia X share price is -21.14 % on June 2015.



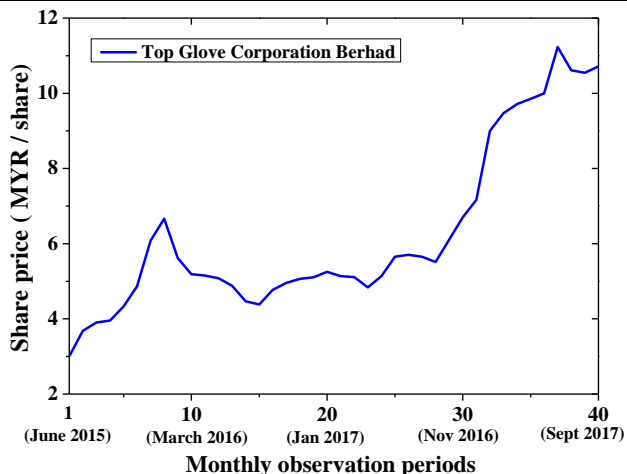


Fig. 1: Dynamic behavior of share price (Top Glove)

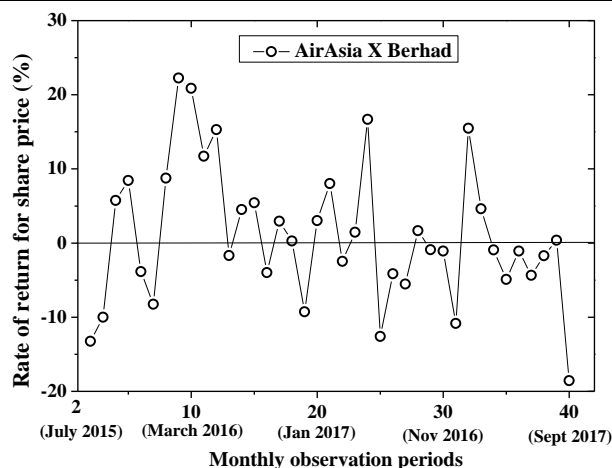


Fig. 4: Rate of return for share price (AirAsia X Berhad)

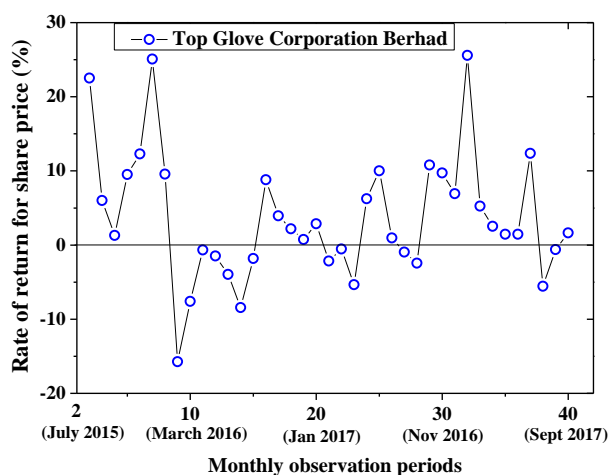


Fig. 2: Rate of return for share price (Top Glove Corporation Berhad)

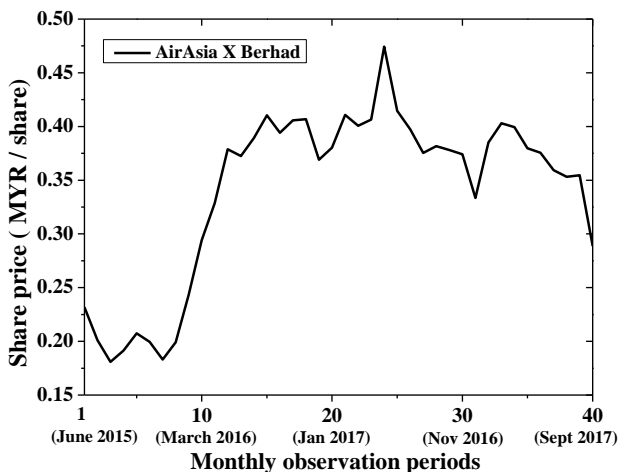


Fig. 3: Dynamic behavior of share price (AirAsia X Berhad)

The third selected company is Axiata Group Berhad. Figure 5 shows the dynamic behavior of share price for Axiata Group Berhad. The initial share price is MY 6.441 in June 2015. The minimum value of share price is MYR 4.225 on July 2018. The value of share price at the end of the last observation period (September 2018) is MYR 4.605. Figure 5 indicates there are decrements of share price value from the June 2015 until September 2018.

Figure 6 shows the return rate of share price for Axiata Group Berhad. The maximum value of share price return is 6.993 % on August 2018. Meanwhile, the minimum value of return for Axiata Group Berhad share price is -10.996 % on November 2016.

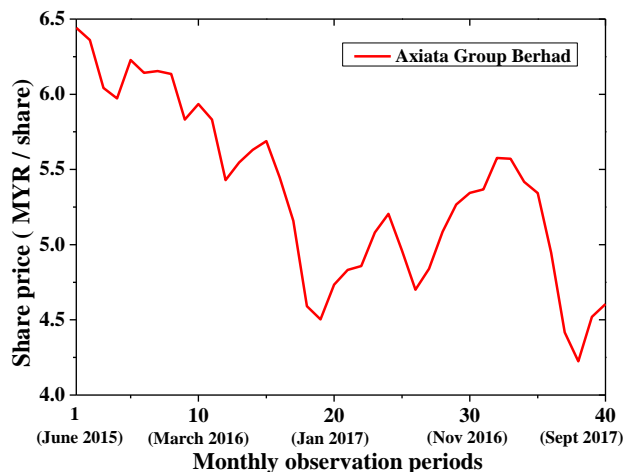


Fig. 5: Dynamic behavior of share price (Axiata Group Berhad)

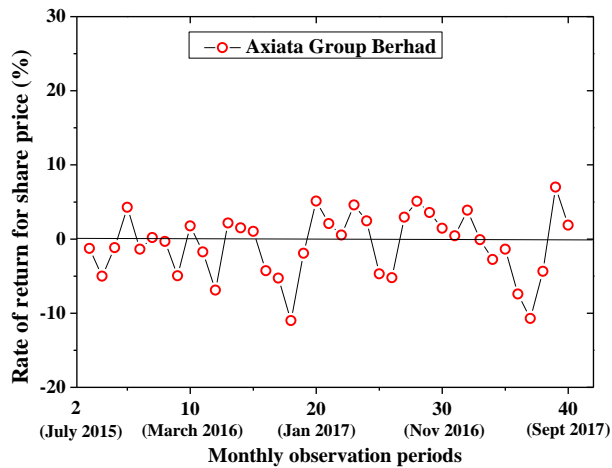


Fig. 6: Rate of return for share price (Axiata Group Berhad)

#### 4.2 Pearson product moment correlation analysis

This section describes the correlation analysis between the share price return of selected companies. The analysis carried out using graphical analysis, including statistical analysis.

Figure 7 shows the correlation diagram between two share price returns namely Top Glove and AirAsia X. The red line indicates linear relationship between two share prices. The analysis shows there is negative slope of liner line.

Next, the statistical test performed to validate the linear relationship between two share price returns of Top Glove and AirAsia X. Table 1 shows the value of Pearson correlation value and significant level of correlation. The Pearson correlation value is -0.326 that indicates there is weak negative correlation. The significant value is 0.045 which is less than 0.05. That indicates this study reject null hypothesis of Pearson correlation statistical analysis. Therefore, Table 1 indicates there is significantly weak and negative correlation between two share price returns ( $r = -0.326$ ,  $n = 39$ ,  $p = 0.045$ ).

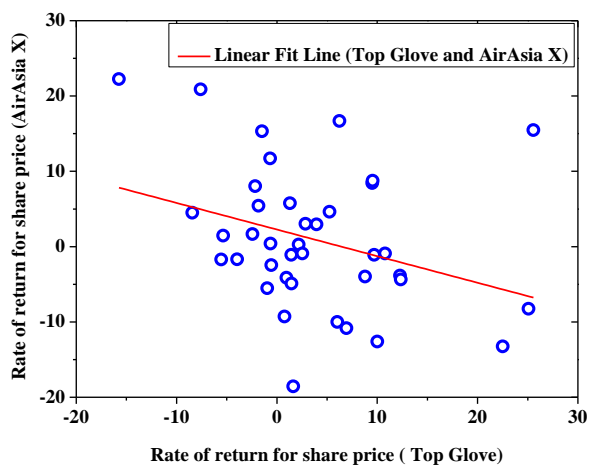


Fig. 7: Correlation diagram between share prices (Top Glove and AirAsia X)

Table 1: Statistical test for correlation analysis (Top Glove and AirAsia X)

Pearson correlation	-0.326
Significant level (two-tailed statistics)	0.043

Figure 8 shows the correlation diagram between two share price returns namely Top Glove and Axiata Group. The red line indicates linear relationship between two share prices. The analysis shows the slope is near to zero value.

Next, the statistical test performed to validate the linear relationship between two share price returns of Top Glove and Axiata Group. Table 1 shows the value of Pearson correlation value and significant level of correlation. The Pearson correlation value is 0.002 that indicates there is very weak positive correlation. The significant value is 0.992 which is larger than 0.05. That indicates this study failed to reject null hypothesis of Pearson correlation statistical analysis. Therefore, Table 2 indicates there is very weak positive correlation between two share price returns and the correlation is not significant ( $r = 0.002$ ,  $n = 39$ ,  $p = 0.992$ ).

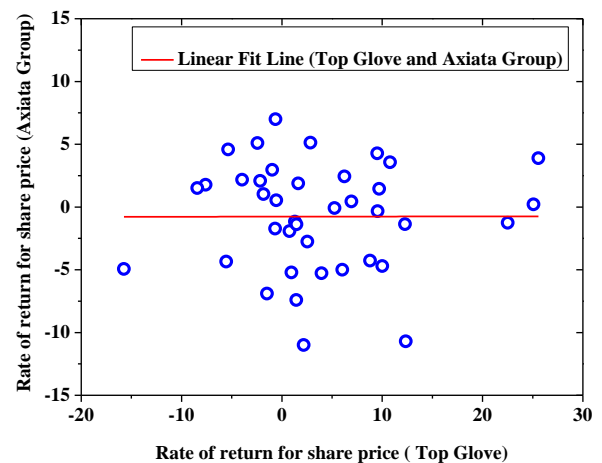


Fig. 8: Correlation diagram between share prices (Top Glove and Axiata Group)

Table 2: Statistical test for correlation analysis (Top Glove and Axiata Group)

Pearson correlation	0.002
Significant level (two-tailed statistics)	0.992

Figure 9 shows the correlation diagram between two share price returns namely AirAsia X and Axiata Group. The red line indicates linear relationship between two share prices. The analysis shows the slope is positive value.

Next, the statistical test performed to validate the linear relationship between two share price returns of AirAsia X and Axiata Group. Table 3 shows the value of Pearson correlation value and significant level of correlation. The Pearson correlation value is 0.126 that indicates there is very weak negative correlation. The significant value is 0.443 which is larger than 0.05. That indicates this study failed to reject null hypothesis of Pearson correlation statistical analysis. Therefore, Table 3 indicates there is very weak positive correlation between two share price returns and the correlation is not significant ( $r = 0.126$ ,  $n = 39$ ,  $p = 0.443$ ).

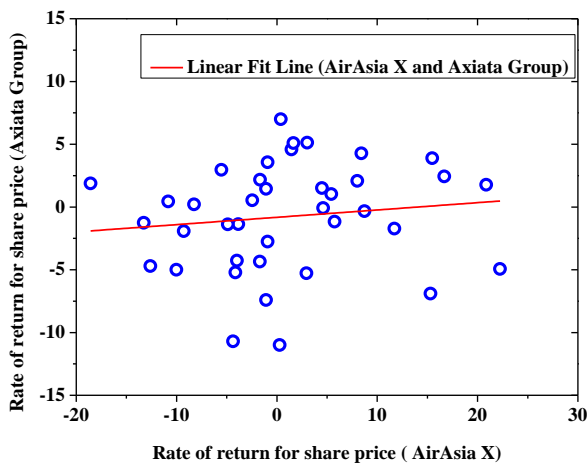


Fig. 9: Correlation diagram between share prices (AirAsia X and Axiata Group)

Table 3: Statistical test for correlation analysis (Airasia X and Axiata Group)

Pearson correlation	0.126
Significant level (two-tailed statistics)	0.443

#### 4.3 Evaluation of correlation for portfolio risk and portfolio return using Modern Portfolio Theory

The main objective of this paper is to evaluate the risk of portfolio investment with correlation to expected return. Modern Portfolio Theory is an investment theory based on the idea that risk-averse investors can construct portfolios to optimize or maximize expected return based on a given level of market risk, emphasizing that risk is an inherent part of higher reward. It is one of the most important and influential economic theories dealing with finance and investment.

Modern portfolio theory emphasized about the selected of stocks that is important to reduce risk at expected return setting by investor.

Figure 10 shows the correlation between portfolio risk and portfolio return for investment portfolio consists of combination with three share prices namely Top Glove Corporation Berhad, AirAsia X Berhad and Axiata Group

Berhad. The weightage of investment for each of share price is adjusted to find better portfolio expected return for given portfolio risk.

This study adjusted the value of contribution for each of the stocks with reference to Top Glove Corporation Berhad as the main contributors for portfolio expected return. Figure 10 illustrates red dots that represented the combination of portfolio between three stocks. Figure 10 concludes for a same value portfolio risk (x-axis value), there a few combination of portfolio that contributes to different value of expected return (y-axis value).

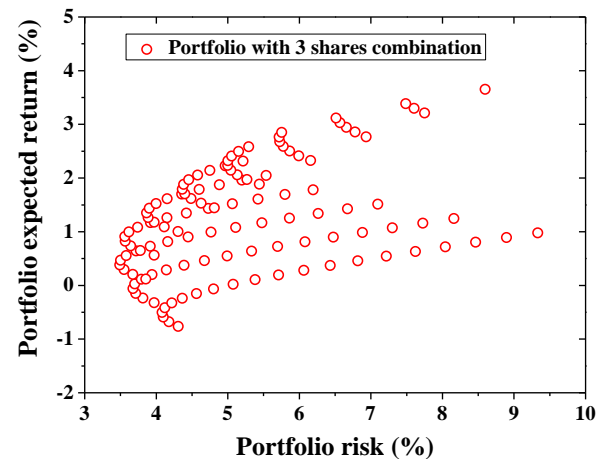


Fig. 10: Correlation between portfolio risk and portfolio return for investment portfolio consists of 3 share prices

Next, this study developed the optimal combinations of portfolio investment using efficient frontier analysis. Figure 11 shows the efficient frontier for portfolio investment of 3 stocks combination namely Top Glove Corporation Berhad, AirAsia X Berhad and Axiata Group Berhad.

There are nine optimal combinations that calculated in this study to develop non-linear line of efficient frontier. Table 4 shows the combinations of 3 stocks for efficient frontier development. Data shows with the increment weightage in Top Glove stock, the expected average return will be increase. This is because the mean average return for share price of Top Glove 3.65%. This is the highest return comparing to other two stocks. However the risk of share price of Top Glove is 8.6 %, which is on the risky side. The portfolio can attained lower risk by combining three stocks.

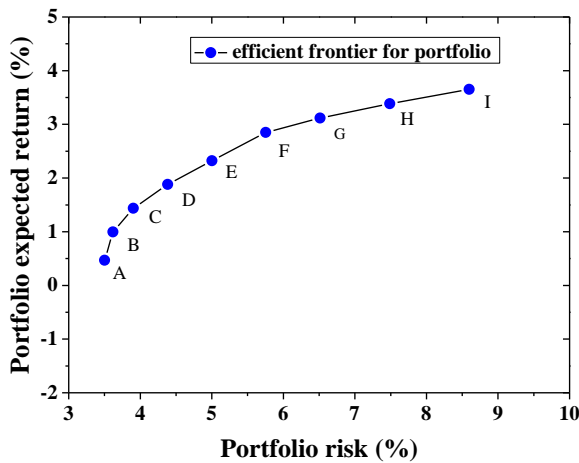


Fig. 11: Efficient frontier for portfolio investment of 3 stocks combination

Table 4: The combinations of 3 stocks for efficient frontier development

Combination	Combination stocks weightage		
	Top Glove	AirAsia X	Axiata Group
A	0.2	0.2	0.6
B	0.3	0.25	0.45
C	0.4	0.25	0.35
D	0.5	0.25	0.25
E	0.6	0.25	0.15
F	0.7	0.3	0
G	0.8	0.2	0
H	0.9	0.1	0
I	1	0	0

**V. CONCLUSION**

The main objective of this study is to evaluate the correlation of portfolio risk and portfolio expected return by combining 3 share prices namely Top Glove Corporation Berhad, AirAsia X Berhad and Axiata Group Berhad. Method implemented in this study is using Markowitz portfolio theory approach. The main findings of this study are:

- (a) The mean expected return for Top Glove share price is 3.65% with standard deviation is 8.6%. Next, the mean expected return for Airasia X is 0.98 % with standard deviation is 9.33%. The third selected share price is Axiata Group Berhad with mean expected return is -0.76% and standard deviation is 4.31% .
- (b) The correlation value for share price return of dynamic movement between Top Glove and Airsia X is -0.326. Negative correlation is preferable in Modern portfolio Theory because negative correlation will reduce the portfolio risk. Therefore negative value is supporting the theory of diversification in Markowitz approach.

The correlation value between Top Glove and Axiata Group is 0.002. Next, the correlation value between AirAsia X and Axiata Group is 0.126.

- (c) There are nine optimal combinations that calculated in this study to develop non-linear line of efficient frontier. Data shows with the increment weightage in Top Glove stock, the expected average return will be increase. This is because the mean average return for share price of Top Glove 3.65%. This is the highest return comparing to other two stocks. However the risk of share price of Top Glove is 8.6 %, which is on the risky side. This study concludes the portfolio can attained lower risk by combining three stocks.

The significant of this study is it will help investors to attain required expected return for a given investment risk using diversification of investment portfolio. The combination of 3 stocks will help investors to achieve higher return on lower risk.

The further study of this analysis can be extending to increase of number of assets in order to achieve better expected return with lower risk. In the same time, the implementation of artificial intelligent is crucial to find optimal weightage of portfolio in developing efficient frontier of optimal investment portfolio.

**REFERENCES**

- [1] Abu Bakar, N. and Rosbi, S. (2018) Efficient frontier analysis for portfolio investment in Malaysia stock market, *Science International*, Vol. 30 (5), pp. 723-729
- [2] Abu Bakar, N. and Rosbi, S. (2017) Dynamic Forecasting method for Shariah-compliant Share Price of Healthcare sector in Malaysian Stock Exchange, *International Journal of Advanced Engineering, Management and Science*, Vol. 3 (8), pp. 855-863
- [3] Abu Bakar, N. and Rosbi, S. (2016) Error diagnostic for weighted moving average to forecast Sharia-compliant securities in Malaysian Stock Exchange, *International Academic Research Journal of Business and Technology*, Vol. 2 (2), pp. 29-37
- [4] Alrabadi, D.W.H. (2016) Portfolio optimization using the generalized reduced gradient nonlinear algorithm: An application to Amman Stock Exchange, *International Journal of Islamic and Middle Eastern Finance and Management*, Vol. 9 (4), pp. 570-582
- [5] Azizan, N.A. and Sorooshian, S. (2014) Stock Market performance and modern portfolio theory: Case on Malaysian stock market and Asian Indices, *WSEAS Transactions on Business and Economics*, Vol. 11, pp. 303-313

- [6] Bin, R.L.L. and Yuan, C.J. (2016) Portfolio Diversification Strategy in the Malaysian Stock Market, *Capital Markets Review*, Vol. 24 (1), pp. 38-67
- [7] Bahlous, M. and Mohd. Yusof, R., (2014) International diversification among Islamic investments: is there any benefit, *Managerial Finance*, Vol. 40 (6), pp. 613-633
- [8] Chen, L. and Pan, H. (2013) A dynamic portfolio theory model based on minimum semi-absolute deviations criterion with an application in the Chinese stock markets, *China Finance Review International*, Vol. 3(3), pp. 284-300
- [9] Drake, P.P. and J.F. Frank (2010) *The Basics of Finance*. New Jersey: John Wiley & Sons, Inc.
- [10] Deng, Q. (2018) A generalized VECM/VAR-DCC/ADCC framework and its application in the Black Litterman model: Illustrated with a China portfolio, *China Finance Review International*, Vol. 8 (4), pp. 453-467
- [11] Fabozzi, F.J., Gupta, F. and Markowitz, H.M. (2002) The Legacy of Modern Portfolio Theory, *The Journal of Investing*, pp. 7-22
- [12] Giannotti, C., Mattarocci, G. and Spinelli, L. (2011) The role of portfolio diversification in the hotel industry: Evidence from the Italian market, *EuroMed Journal of Business*, Vol. 6 (1), pp. 24-45
- [13] Hin/David Ho, K., Hui, E.C.M. and Su, H., (2010) Examining fuzzy tactical asset allocation (FTAA) as an alternative to modern portfolio theory (MPT) asset allocation for international and direct real estate investment, *Journal of Financial Management of Property and Construction*, Vol. 15 (1), pp. 71-94
- [14] Jothimani, D., Shankar, R. and Yadav, S.S. (2017) A PCA-DEA framework for stock selection in Indian stock market, *Journal of Modelling in Management*, Vol. 12 (3), pp. 386-403
- [15] Kazan, H. and Uludag, K., (2014) Credit Portfolio Selection According to Sectors in Risky Environments: Markowitz Practice, *Asian Economic and Financial Review*, Vol. 4 (9), pp. 1208-121
- [16] Mohd Sanusi, Z., Ismail, R., Hidayati A. and Harjito, D.A. (2015) Screening Process of Shariah-Compliant Companies: The Relevance of Financial Risk Management, *International Journal of Economics and Management*, Vol. 9 (1), pp. 177-195
- [17] Mohd Ali, H. (2006) Modern Portfolio Theory: Is There Any Opportunity for Real Estate Portfolio?, *Malaysian Journal of Real Estate*, Vol. 1 (1), pp. 14-26
- [18] Markowitz, H. (1952) Portfolio Selection, *Journal of Finance*, Vol. 7(1), pp. 77-91
- [19] Nartea, G. and Eves, C., Role of farm real estate in a globally diversified asset portfolio, *Journal of Property Investment & Finance*, Vol. 28 (3), pp. 198-220
- [20] Securities Commission Malaysia (2018) available at: [https://www.sc.com.my/wp-content/uploads/eng/html/icm/sas/sc\\_syariahcompliance\\_180525a.pdf](https://www.sc.com.my/wp-content/uploads/eng/html/icm/sas/sc_syariahcompliance_180525a.pdf)
- [21] Ulrich, D., and Marzban, S. (2008) Review and Analysis of Current Shariah-Compliant Equity Screening Practices, *International Journal of Islamic and Middle Eastern Finance and Management*, Vol. 1(4), pp. 285-303.
- [22] Zainal Abidin, S., Ariff, M., Md. Nassir, A. and Mohamad, S. (2004) International Portfolio Diversification: A Malaysian Perspective, *Investment Management and Financial Innovations*, Vol. 1(3), pp. 51-68

# Remote Sensing Satellites Planning System

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*Abstract— A Remote Sensing Satellites Planning system (RSSP) for satellite constellations is responsible for managing these satellites by assigning the imaging tasks to each satellite in the constellation such that the loads are balanced and the resources are well used. The proposed system can be used with heterogeneous constellations that consist of satellites whose different specifications, different orbits' types and/or different payload types. This problem is a combinatorial optimization NP-hard problem modeled in this paper as a Constraint Satisfaction Problem using the Constraint Programming Technique. The output plan is obtained using one of three objective functions (gain maximization, area maximization, and image quality maximization) using four search algorithms (simulated annealing, hill climbing, tabu search and late acceptance) and different planning horizons (one track, one day and one month).*

**Keywords— Agile satellites, remote sensing, planning, constraint satisfaction problem, heterogeneous constellation.**

## I. INTRODUCTION

The output plans from a RSSP system should satisfy the customers by performing the maximum number of their requests in addition to optimize the usage of the constellation's resources taking into consideration all the system and operational constraints to assure obtaining a feasible output plan.

The paper introduces the related work in Section(II). Then the proposed RSSP system formulation in Section(III) is discussed. The system architecture is introduced in Section(IV). Section(V) clarify the system performance and introduces some comparisons with other systems from CPU time point of view. The final Conclusion and recommendations for future work are introduced in Section(VI).

## II. RELATED WORK

The constraint programming technique were used by two references, in 2015 Erik Demeulemeester et al [1] used non-agile earth observing satellites in their system. The used planning horizons were multiple tracks and one day. They

used branch and price search algorithm and column generation heuristics. While in 2002 M., Verfaillie, G., Jouhaud, F., Lachiver, J., & Bataille and N. Lemaitre [2] used single agile satellite with the Greedy search algorithm and the simulated annealing. They describe their system for the illuminated half of the track.

## III. PROBLEM FORMULATION

The problem model can be partitioned into the following four parts:

### 1) Input Data

For the set of input requests  $R$ , there exists  $r \in R$ , whose gain  $G_r$  and surface area  $A_r$ . Let  $I$  be the set of images obtained from  $R$  by the geometric cutting up process. For each image  $i \in I$ :

$E_i$  : earliest shooting time,  $L_i$  : latest shooting time,  $D_i$  : duration of shooting,  $A_i$  : surface area. For each possible pair of images  $(i, j)$ ,  $M_{ij}$  is defined as the transition time between shooting the two images consecutively.  $B$  is defined as the set of pairs of images  $(i, j)$  such that  $i$  and  $j$  are images for the same strip with opposite pitch angles and  $S$  be the set of pairs of stereoscopic images.

### 2) Decision Variables

- $X_i \dots$  is One if the image  $i \in I$  is selected, and Zero otherwise.
- $t_i \dots$  the shooting start time of image  $i$  if selected.

### 3) Constraints

The following constraints have been implemented in the proposed system:

- Observation Time Window Constraint:  $\forall i \in I$  :  
 $(X_i = 1) \Rightarrow (E_i \leq t_i \leq L_i)$  (1)
- Transition Time Constraint:  $\forall (i, j) \in I$  :  $(X_i, X_j = 1) \Rightarrow (t_i + D_i + M_{ij} \leq t_j)$  (2)
- Request End Time Constraint:  $\forall i \in I, I \subset r, r \in R$  :  $(X_i = 1) \Rightarrow (t_i < \text{end}_r)$  (3)
- Mono Image is Shot Once Constraint:  $\forall (i, j) \in B$  :  
 $X_i + X_j \leq 1$  (4)
- Stereo Image Constraint:  $\forall (i, j) \in S$  :  $X_i = X_j$  (5)

- f) The Stereo Pair Pitch Angles Constraint:  $\forall (i, j) \in S : \text{Pitch}_i = -\text{Pitch}_j$  (6)
- g) The Stereo Pair Roll Angles Constraint:  $\forall (i, j) \in S : \text{Roll}_i = \text{Roll}_j$  (7)
- h) The Stereo Pair Satellite Constraint:  $\forall (i, j) \in S : \text{Satellite}_i = \text{Satellite}_j$  (8)
- i) Onboard Memory Constraint:  $\forall$  planning horizon,  $\forall i \in I : \sum_i X_i \leq N_{\max}$  (9)  
Where  $N_{\max}$  is the maximum allowable number of selected images for this planning horizon.
- j) Payload Duty Cycle Constraint:  $\forall (i, j) \in I : t_j - (t_i + D_i + M_{ij}) \geq t_p$  (10)  
Where  $t_p$  is the payload duty cycle or the so called technological break.

- 4) Objective Functions  
The three objective functions implemented in the proposed system are defined as follows:
  - a) Gain Maximization function:  $\forall i \in I : f(x) = \max(\sum_i G_i * X_i)$  (11)
  - b) Area Maximization function:  $\forall i \in I : f(x) = \max(\sum_i A_i * X_i)$  (12)  
Where  $A_i = D_i * W_s$  (13) and  $W_s$ ... is satellite's swath.
  - c) Image Quality Maximization function:  $\forall i \in I : f(x) = \max(\sum_i (R_{\text{worst}} - R_i) * X_i)$  (14)  
 $R_i$ ... is the resolution of image  $i \in I$  and  $R_{\text{worst}}$ ... resolution at maximum roll and pitch angles.

#### IV. PROPOSED SYSTEM ARCHITECTURE

The operation through the proposed system architecture in Fig. 1 is explained as follows:

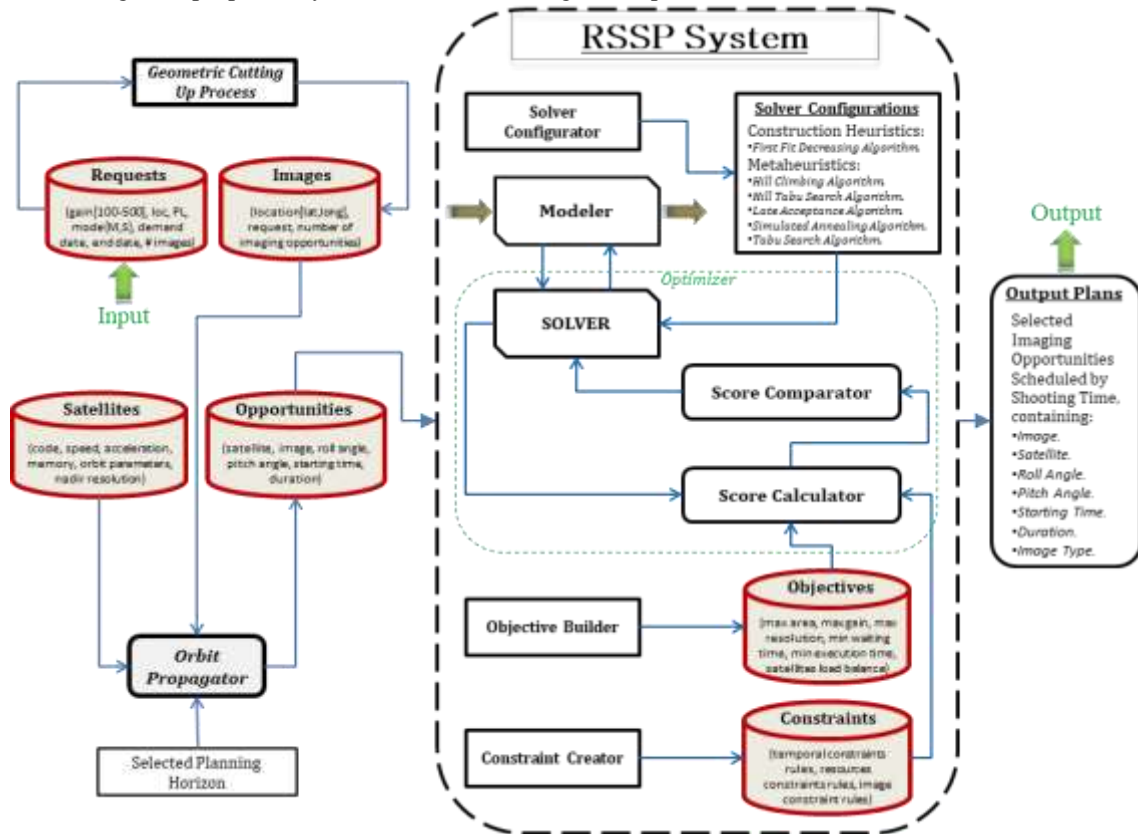


Fig.1: Proposed System Architecture

Requests database will contain the input requests with their data. The Geometric cutting up process will produce images in Images database that is fed to the Orbit Propagator with the satellites in Satellites database and the selected planning horizon. The Orbit Propagator outputs the imaging

opportunities for each image. The Opportunities database will contain all the imaging opportunities for all the images with all the satellites. The operation in the RSSP system begins with modeling the input via the Modeler to be sent to the SOLVER that is configured using a Solver Configurator. To build the

Constraints database and the Objectives database, the Constraint Creator and the Objective Builder is used respectively. The Score Comparator takes the created constraints and the built objectives as inputs. The SOLVER searches for solutions in the search space and selects feasible solutions during the algorithm-running lifetime. Each time, the selected solution is score calculated via the Score Calculator. This score is compared with the previous scores via the Score Comparator until reaching the optimum score.

V. TESTS AND RESULTS ANALYSIS

To determine the system's performance, it is tested for three case studies with different problem sizes and measure the CPU time (efficiency) and the Normalized Score (quality). The first case study consists of (1) satellite, (1) track planning horizon and (25) targets while the second is (2) satellites, (1) day and (120) targets and the third one uses (3) satellites, (1) month planning horizon and (2500) targets. Fig. 2 illustrates the system's behavior in the (3) objectives using the (4) search algorithms and measures the (2) metrics.

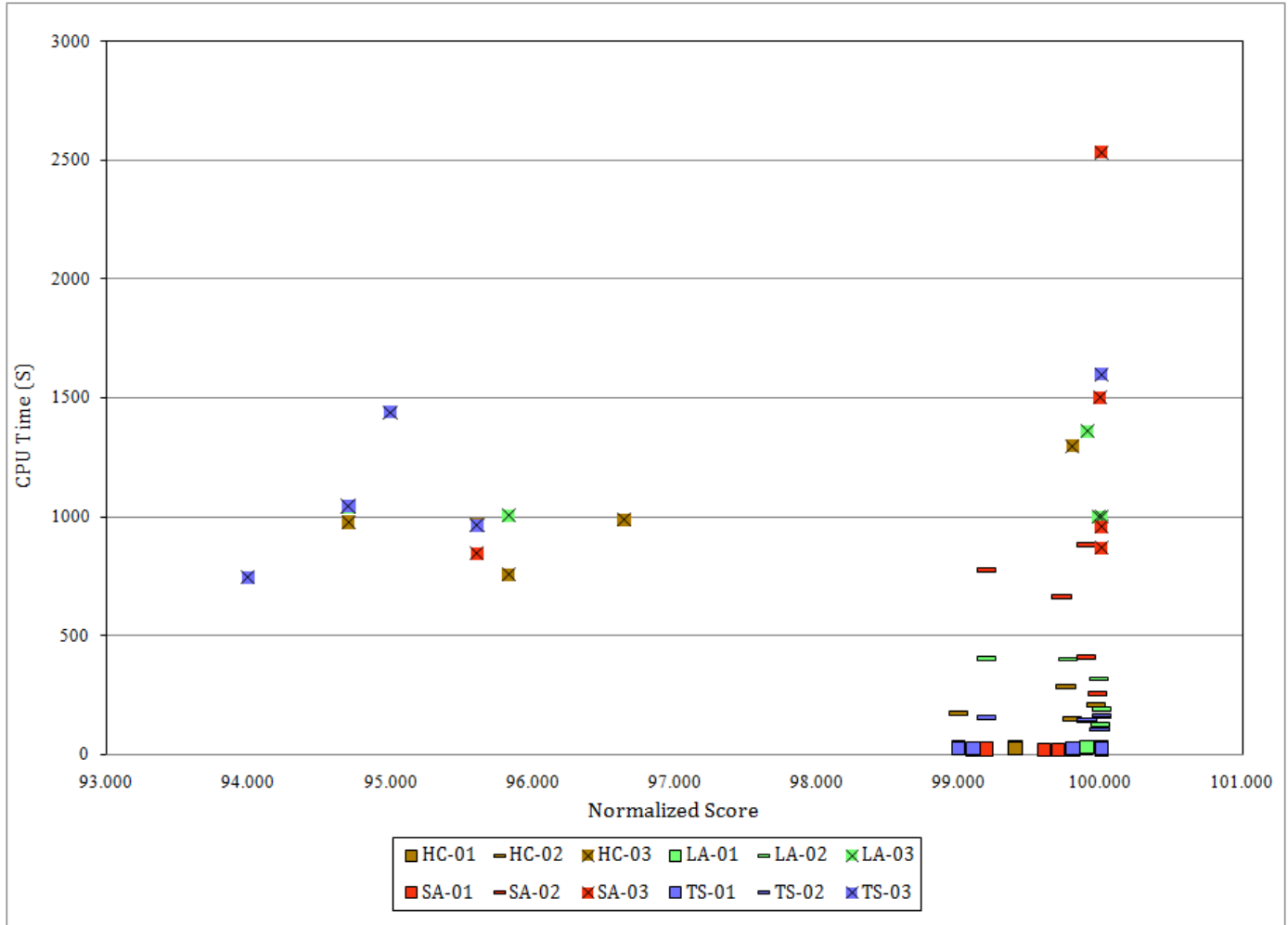


Fig.2: System Performance in the Three Objectives

It is clear from the figure that almost all the results lie in the left bottom part of the graph which means that these results has high normalized score and low CPU time. This emphasizes that the system is qualified and efficient. We compared our results, from the CPU time point of view, with

those published for similar systems according to the problem size.

The comparison introduced in TABLE I clarifies that the proposed system performs very well compared with the listed references.



TABLE I  
 COMPARISON WITH OTHER SYSTEMS

# Serial	Sat's no.	The Reference Results			Proposed System Results	
		Ref.	# of Targets/ Imaging Opportunity	CPU Time (seconds)	# of Targets/ Imaging Opportunity	CPU Time (seconds)
1	1	[3]	30	153.2	25	32 (Max)
2	2, 3	[1]	100 (3 Satellites)	486.12	120 (2 Satellites)	304 (Average)
3	3	[4]	250 Imaging Opportunities	2995.5	86195 Imaging Opportunities (2500 Targets)	2532 (Max)

## VI CONCLUSION AND FUTURE WORK RECOMMENDATIONS

The proposed system is implemented and tested to be used with different target types, different planning horizons and different constellation types. The system is designed with many constraints and four search algorithms. Three different objectives for creating the output plan are used. The tests results are relatively good compared with some other similar systems.

It is recommended for the future work to include more objectives and use other search algorithms.

## REFERENCES

- [1] Erik Demeulemeester, Dishan Qiu Jianjiang Wang, "Proactive scheduling algorithms for multiple earth observation satellites under uncertainties of clouds," p. 25, Sep 2015.
- [2] M., Verfaillie, G., Jouhaud, F., Lachiver, J., & Bataille, N. Lemaitre, "Selecting and scheduling observations of agile satellites," Aerospace Science and Technology, vol. 6(5), pp. 367–381, 2002.
- [3] Hongfei, Xuzhi Li, Yurong Liu, and Bing Zhou. Wang, "Summary of intelligent algorithms in planning & scheduling of Earth observation satellite," in Intelligent Computing and Intelligent Systems (ICIS), IEEE International Conference, on. Vol. 3, 2010, pp. 480-483.
- [4] Christiaan Vermaak. Oberholzer, Time-window optimization for a constellation of earth observation satellite, 2009, PhD diss.

# Proposal of a Reference Model in BPMN Notation for an MRP System

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**Abstract** — Companies are progressively investing in practices aimed at improving the quality of management, with the main purpose of enabling them to operate competitively in the present market. For this, it is necessary to document the activities and information of the existing business processes in the organization, aiming at reducing time and cost in the elaboration of the particular model. In this context, the objective of this work is to develop a reference model of the Manufacturing Resource Planning (MRP) processes, an important module of production planning and control (PPC). The research methodology used in this work was divided into the following stages: study of MRP and business process modeling, definition of reference model processes, choice of methodology and process modeling tool, development of reference model and prototype of the software and, finally, analysis of results. The modeling notation used was the BPMN, since it is considered a standard language in the field of process modeling. The prototype was developed through the Delphi interface in order to apply the model to support the implementation of business management programs. As results, from a formal documentation, the model proved to be a useful mechanism in the understanding of the processes raised and appropriate in the support to the implantation of production management tools.

**Keywords** — Reference Model. Production Planning and Control. Manufacturing Resource Planning. BPMN.

## I. INTRODUCTION

Organizations are progressively investing in business quality practices such as: reengineering processes, adoption of an integrated management system (ERP), ISO certifications, lean production, costing by activities, among others. However, most of the high-investment and long-term investment actions, for example, in the adoption of ERP (BREMER; LENZA, 2000; CORREA; SPINOLA, 2015).

Quality management and process management units that are carried out, which are raised and documented Existing Business Processes in the organization.

However, a business process modeling activity is still not a common issue among organizations (THURER; FILHO, 2012), which is responsible for increasing the cost and time of implementation of the system or projects to improve the development of new models related to Business Processes (BREMER; LENZA, 2000). As a company already had a reference model, this activity would not be necessary. According to Scheer (2000), case studies using reference models can reduce the cost and pace of deployment of organizational projects by up to 30%.

In the business context, Business Processes are important for the expansion process, such as Brazil, where production activities are more pronounced than product development, and Production Planning and Control (PPC). This process is done by surveying demand, planning production, planning capacity, producing

materials, scheduling production, etc. (FERNANDES; GODINHO FILHO, 2010; MUKHOPADHYA Y, 2013).

The basic exercises of the PPC hierarchy, related to Material Planning, are the Manufacturing Resource Planning (MRP). According to Girotti et al. (2016), the MRP model determines the quantity and timing of the modules, components and raw materials needed to produce a given quantity of final products considering inventory levels and delivery times.

According to Thurer and Filho (2012), most companies, especially small and medium-sized companies, have a science that their PPC activities can be closed and that "processing time" and "work in progress" higher operating energy. However, the authors, as they simply do not know how to do this, are a vast majority of research and solutions for the PPC is focused on large and complex companies.

Therefore, it is important and growing attention, both the academic environment and not to undertake, there is no development of models that support any planning of entrepreneurial resources (CORREA; SPINOLA, 2015). However, these studies were designed to investigate PPC models and are mostly focused on industrial purposes and that address modules of specific production management activities.

In order to become companies, especially small and medium enterprises, in the development and implementation of business management actions, the present work aims to develop a reference model that addresses the related Business Processes as MRP activities.

In addition, this work also aims to develop a software prototype through the Delphi interface (Object-Pascal language), in order to apply the reference model to support the implementation of business management systems.

The article is organized as follows: a section 2 addresses a literature review on model reference and MRP; a section 3 presents the methodological procedures used in this study; a section 4 presents results obtained; and finally a section 5 presents as final endings.

## II. LITERATURE REVIEW

### 2.1 REFERENCE MODEL

Reference modeling is defined as the process of formally documenting a problematic domain in order to understand and communicate stakeholders (SIAU, 2004; SIAU; ROSSI, 2011).

The reference models, which can be developed in real situations or in theoretical studies, document the various aspects of a business process (BREMER; LENZA, 2000). According to Scheer (2000), one can distinguish between procedural models or standard software implementation,

and business models such as models for production management and product development.

According Vernadat (1996), a reference model must contain a certain degree of generality and be customizable. Therefore, it should serve as a basis for discussion, a formal or semiformal suggestion for the elaboration of specific models, bringing information regarding the design of a business process. Keller and Teufel (1998) understand that reference models can be applied in cases of accumulated experience in a business type, and in business process solutions implemented and executed in business management software.

Vojislav and Leon (2000) propose that choosing the right reference models helps to minimize possible errors in the early stages of modeling and deploying management systems. This allows the design of a process or system to begin with the appropriate choice of requirements and also with the establishment of appropriate characteristics given by the reference model.

According to Bremer and Lenza (2000), the objective of the reference model is to provide the company with an initial solution for its Business Processes, so that, through this, the particular model of the company can be specified and detailed. According to Climent, Mula and Hernández (2009), reference models are useful in the description and graphical representation of the important aspects of a particular process, distinguishing, for example, people, departments and the connection between them. Additionally, Vergidis, Turner, and Tiwari (2008) models adequately portray and represent processes, emphasizing those aspects that need to be communicated and addressed.

Bolloju and Leung (2006) suggest that during the analysis phase of an information system development, the conceptual model can be used to capture and represent the development and deployment requirements of such technologies. For Scheer (2000), the use of reference models can reduce the cost and time of implementation of organizational projects, for example in the adoption of ERP.

In a review elaborated by Hernandez, Mula and Ferriols (2008), it was proposed that a reference model describe the social and physical aspects of the world in order to understand and communicate. In addition, it was also described that the reference model should go beyond the terms "specifications" and "requirements" and apply three linguistic concepts (syntax, semantics and pragmatics) to four aspects of modeling: language, domain, model and participants.

In summary, according to Vernadat (2003), the advantages of adopting reference models are to reduce time and cost in the development of the particular model; comparing the activities of the company with the

activities proposed in the model, that is, best practices; and better support in deploying integrated enterprise management systems.

The model to be developed in this work will give greater emphasis to the information and activities that compose the PPC process, because its main objective is support in the implementation of organizational improvements, such as business management systems (Figure 1).

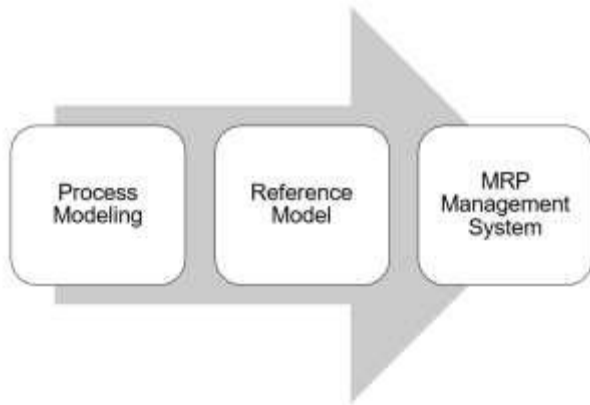


Fig. 1: Process of elaboration of the reference model

## 2.2 MATERIALS REQUIREMENTS PLANNING

A decision is made on the basis of the information available. Many of the material management decisions of a company are made with the help of the MRP (Materials Requirements Planning).

The MRP, created in the 1960s, is a logical system of calculation that converts demand forecasting into programming of the necessity of its components, being predominant present in PPC systems in manufacturing processes (MENDES, FILHO, 2017)

The MRP model determines the quantity and timing of the modules, components and raw materials needed to produce a given quantity of final products, as specified in the MPS, considering inventory levels and delivery times (GIROTTI et al. , 2016).

In addition, according to Favaretto (2012), MRP performs detailed production planning, which releases production orders and purchases the product components according to expected demand and available inventories. The fulfillment of delivery times and the production costs of the companies depend in part on the good result of this planning. For the author, the main information used in the decisions of this planning stage is related to the following variables: demand, inventory levels and spare times. If these variables are uncertain, the planning result may show errors.

Guerra, Schuster and Tondolo (2014) reiterate that through MRP, it is possible for companies to better manage and monitor inputs, raw materials, components, products under preparation and finished products. Due to the great complexity of some products (large number of items, components, parts and accessories), the PPC area frequently uses MRP, aiming at reducing inventories, obtaining greater predictability of receiving materials and inputs, reducing time of processing of the product, as well as fulfillment of the deadlines of delivery of the final product to the clients.

Therefore, the purpose of the MRP is to perform the material requirements planning activity computationally, thus enabling the determination of the priorities of the purchase and manufacturing orders. For Carvalho, Silva Filho & Fernandes (1998), the main objective of the MRP is to preset the raw materials (or supplies) according to the time (or factory capacity), which will be necessary to produce the order book of a organization.

MRP is based on requirements planning according to the Master Production Plan, which is prepared according to customer demand, Bill of Materials (BOM) (YENISEY, 2006), and quantities in inventories of the BOM items (NEELY; BYRNE, 1992). Figure 2 graphically shows the inputs required in the MRP system and what outputs such a system provides.

According to Figure 2, MPS provides for MRP which products will be produced within the planning horizon for which the resource requirements will be calculated. The BOM provides the "parent" and "child" items to be produced according to the MPS, the gross demand for each item and the production and delivery lead time of the suppliers. Finally, the stock situation file provides the quantity in stock of each item to be subtracted from the gross need and found the need for material to be produced during the planning horizon adopted (YENISEY, 2006).

The MRP model is characterized as a "pushed" production system, which generates orders of production and purchase according to the master production program, material lists and stock levels. From the production and purchase lead times, the instants in which the orders are to be released are determined, applying a programming logic to "behind" (GIACON; MESQUITA, 2011).

Godinho Filho & Fernandes (2006), supported by Gaither & Frazier (2005), highlight the main benefits of MRP are: to improve customer service, with greater attention to deadlines and deliveries; reduce inventory investments; and improve the operational efficiency of the manufacturing organization.

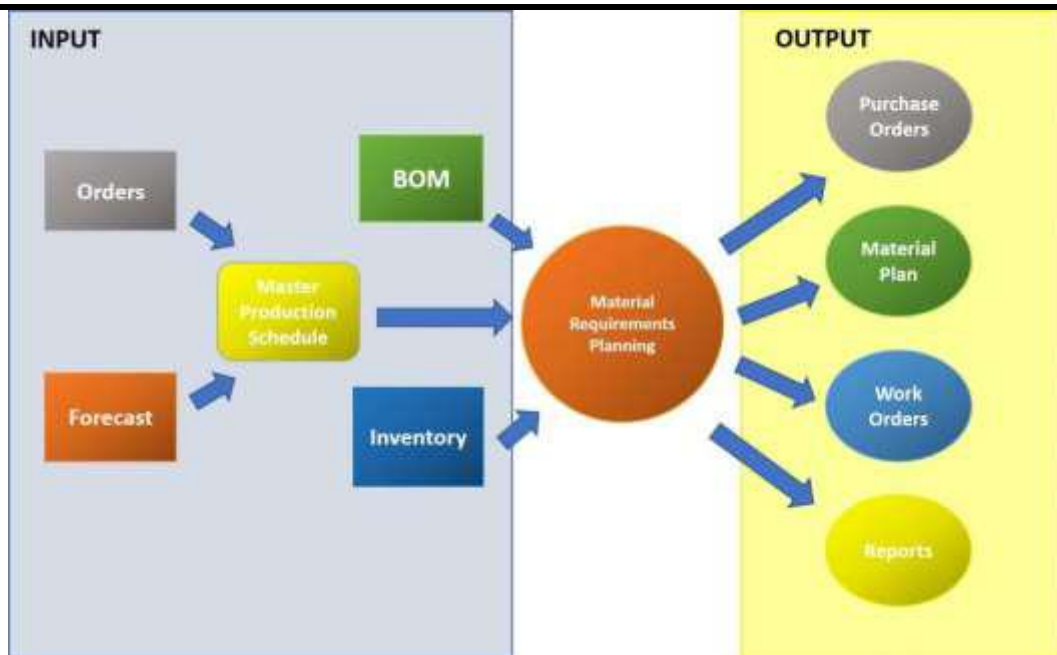


Fig. 2: Outline of MRP implementation

However, Sagbansua (2010) emphasizes that information accuracy plays a vital role in MRP as the benefits of this system depend heavily on the availability of the use of computers that will keep data up to date on the needs of a certain component of production. Errors in the inventory or bill of materials records would result in missing parts, oversupply of some products and lack of others, deviations from the production schedule, all of which cause poor results, such as poor customer service, inefficient use of resources and deliveries to customers. Therefore, companies planning to use this system must carefully evaluate the benefits and needs of MRP.

According to a survey by Jonsson & Mattsson (2006), 75% of manufacturing companies used MRP as the main material planning method. As noted by Ornek & Cengiz (2006), Pandey, Yenradee & Archariyapruak (2000) and Taal & Wortmann (1997), the relative simplicity of MRP systems makes them preferred by many approaches to mathematical programming.

For Milne, Mahapatra and Wang (2015), users understand MRP logic and develop a good understanding of the relationships between inputs and outputs of this system. For authors, this understanding allows users to identify which input data is in error and which needs to be improved for best results. Because MRP users understand these input/output relationships, they tend to be more confident in the results of production plans by MRP than the production plans issued by mathematical programs of unknown source codes.

An additional reason to use MRP is that many large corporations have licenses for software in which MRP modules are integrated with other corporate functions.

Due to this integration and relative simplicity, MRP systems offer managerial flexibility that can be difficult to obtain in material planning systems based on mathematical programming (MILNE; MAHATMA; WANG, 2015).

Capacity Requirements Planning (CRP) aims to support the decisions of the detailed planning of production and materials, MRP (MUKHOPADHYAY, 2013). This planning, according to Corrêa et al. (2009), has as main objectives the anticipation of resource needs that require a few weeks to mobilize and also the generation of a detailed plan of purchases and production that is viable, through adjustments made in the original plan suggested by MRP, so that it can be released for execution by the factory.

At this level, it is not necessary that the calculation of capacity be fast, since assuming that the RCCP (Rough Cut Capacity Planning) was well done, there should not have been many problems to be analyzed, which must be solved by small adjustments in the orders of production. In addition, the MRP calculation itself is relatively time-consuming and does not, as a rule, allow for many simulations. The important thing is that the calculation is as accurate as possible, assuming, of course, the typical inaccuracies of the infinite capacity planning logic (CORRÊA; GIANESI; CAON, 2009).

The typical planning horizon is a few weeks, and the limit is given by the MPS (Master Production Schedule) horizon, which defines the maximum MRP horizon. Thus, the short-term capacity planning period is one week, such as RCCP (CORRÊA; GIANESI; CAON, 2009).

### III. RESEARCH METHODOLOGY

#### 3.1 DEFINING THE SEARCH METHOD

The reference model was developed from theoretical studies. Thus, this research uses the procedures of bibliographic research, since it was developed from previous works such as dissertations, articles and books on the subject matter. In this way, the future work can be based on the conclusions presented in this article, and elaborate hypotheses aiming to deepen the study on the subject or related specific aspects.

On the other hand, this research can also be classified as experimental, since it is based on the creation of a reference model of a MRP system, modeled through software. Thus, with the objective of developing a reference model and exposing the way it was developed from the analysis of the activities involved in the processes, allow this work to be classified as a descriptive research.

#### 3.2 SCOPE OF RESEARCH

The phase of process identification and hierarchization

levels is considered the key step in process modeling, aiming to identify all existing Business Processes in a particular activity of an organization.

Figure 3 presents the model of the PPC Process hierarchy relating the planning of the capacity of its resources with the planning of the needs of its materials. The hierarchical decomposition of the PPC function starts from understanding the basic concepts related to material planning levels, namely: Sales & Operations Planning (S&OP) and Aggregate Planning (AP); Master Production Planning (MPS); Material Requirements Planning (MRP) and Production Scheduling (PS) (CORRÊA; CORRÊA, 2012; MUKHOPADHYAY, 2013). This work will be limited in the development of the MRP reference model and its respective capacity planning. The modules of the Production Planning and Control function related to Capacity Planning are Resource Requirements Planning (RRP), Rough Cut Capacity Planning (RCCP) and Capacity Requirements Planning (CRP).

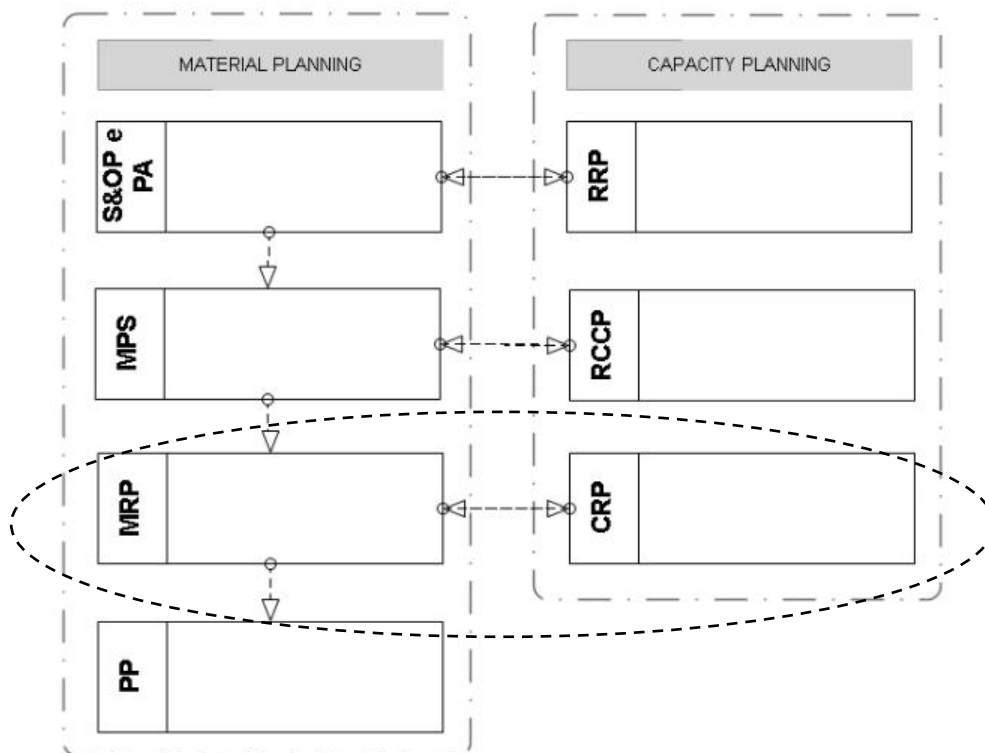


Fig. 3: Hierarchy of production planning and control

#### 3.3 STAGES OF THE RESEARCH METHODOLOGY

The methodology used for the elaboration of this work was divided into eight sequential stages, as shown in Figure 4.

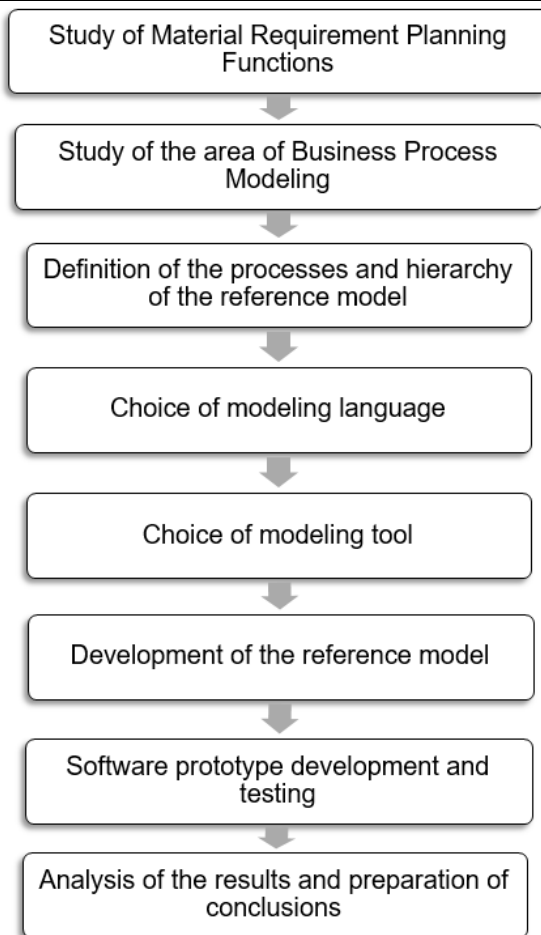


Fig. 4: Stages of the research methodology

- *Step I* - Study of Production Planning and Control Functions: In this stage, according to bibliographical references related to the topic of study, concepts, activities and information and functions of a typical production planning hierarchy were raised and studied;
- *Step II* - Study of the Business Process Modeling area: In the second stage, the concepts and languages regarding process modeling, as well as reference models, were studied and analyzed from the scientific literature;
- *Step III* - Definition of the processes and hierarchy of the reference model: In this third step, after the phases of the bibliographic review, the processes and hierarchy that will make up the reference model of a PPC system were defined;
- *Step IV* - Choice of the modeling language: In this fourth stage, the modeling language used for the development of the reference model was defined. The modeling notation selected was BPMN;
- *Step V* - Choice of the modeling tool: In this step, the modeling tool was defined, in order to provide facilities in the understanding and visualization of the

model, that is, the full understanding of the functions of a system. The modeling tool selected was Bizagi Process Modeler version 3.1.0.011;

- *Step VI* - Development of the reference model: In this step, based on the language and defined modeling tools, the reference model of a PPC system was developed based on BPMN theory and notation;
- *Step VII* - Development of application software and tests: In the seventh stage, once the reference model of the PPC system was elaborated, a software prototype was developed with the purpose of applying and validating the model, from the Delphi version interface 7.0, which used the Object-Pascal language;
- *Step VIII* - Analysis of the results obtained and conclusions drawn: In the last step, the results presented in the previous phases were analyzed and discussed, as well as the conclusions obtained and suggestions for future work

IV. RESULTS AND DISCUSSION

4.1 MRP MODELING

MRP, in short, is a logical calculation system that converts demand forecasting into requirements programming for its components. From the knowledge of all the components of a given product and the times of obtaining each of them, one can, based on the future vision of the needs, calculate how much and when to obtain of each item, so that there is no shortage or surplus in the supply of production needs.

The input and output information required to prepare the reference model of the MRP module are shown in Table 1.

Table 1: MRP information

Input	Output
Bill of Materials (BOM)	Gross material requirements
Short-term planning period	Projected Stocks of Materials
Gross demand for materials	Planned Receipts of Materials
Scheduled component receipts	Orders released from materials
Initial Stocks of Components	Material requirements plan
Levels of safety stocks of components	
Component batch sizes	
Batch sizes rules for components	

The activities related to this module of the MRP are presented, with their respective theoretical references, in Table 2.

Table 2: Sequence of MRP activities

#	Activity	Theoretical Framework
1	Definition of BOMs for the final products from the production master plan.	Girotti et al. (2016), Corrêa & Corrêa (2012), Moreira (2008), Gaither & Frazier (2005), Yenisey (2006) and Neely & Byrne (1992).
2	Definition of the short-term planning period.	Corrêa & Corrêa (2012).
3	Calculation of gross requirements.	Girotti et al. (2016), Corrêa & Corrêa (2012), Moreira (2008), Gaither & Frazier (2005) and Carvalho, Silva Filho & Fernandes (1998).
4	Calculation of projected inventories.	
5	Calculation of planned receipts.	
6	Release of planned orders.	Girotti et al. (2016), Favaretto (2012), Corrêa & Corrêa (2012) and Moreira (2008).
7	Verification of the need to analyze another component of the BOM.	Girotti et al. (2016), Corrêa & Corrêa (2012), Gaither & Frazier (2005), Yenisey (2006) and Neely & Byrne (1992).
8	Issue of the material requirement plan.	Corrêa & Corrêa (2012).
9	Review the material requirements plan if necessary.	

The reference model of the proposed Material Requirements Planning initially includes the definition of BOMs, a structured list of all components of the final product to be planned. Information about final products is taken from the MPS stage, which determines which products will be made and on which dates.

Next, the definition of the planning period (short term) is carried out, and this time period must come from the period that was established in the previous planning stage, that is, in the MPS.

For the calculation of gross requirements, it is necessary to extract information from the BOM regarding the structure of the components at each level of production,

as well as the quantity required to be produced for each unit of production of the component (gross demand), according to the master plan of production of the final products. For each planned level of materials required for the production of the final product, information on the orders released from the lower level materials is required in order to calculate the required quantity (gross requirement).

After calculating the gross requirements, the projected inventories are calculated. For this, it is necessary to take into consideration, in addition to the gross requirements, inventories from the previous planning period to the current, scheduled receipts, if any, and also the level of security stock. If the current planning period has a production request to be made (planned receipts), according to the gross requirements, the projected inventory is recalculated.

For the calculation of the planned receipts, it must be verified if the inventory level meets the gross requirements of the planning period, always respecting the security stock level established in the previous step. If the level does not meet the needs, this value is calculated taking into consideration the lot size and lot size. At this stage, the establishment of MPS production levels takes into account information from the CRP regarding short-term productive capacity.

After setting the planned receipts, the planned order release is established according to the delivery time of each material and the assembly time of the planned final product.

Once the release of orders for a particular component has been defined, it is verified whether there is a need to analyze other BOM material, since, as already mentioned, the bill of materials has planning levels, so that quantities of materials (demand) are dependent on others.

After the completion of the planned order release of all items that make up the BOM of the final product, the material requirement plan is issued. In case of need, it is possible to carry out a review of this plan elaborated. After review, the consolidated MRP plan is issued.

This information is required for the calculation of the CRP, and also for the analysis and definition of the PS of the components and final product.

The reference model, in BPMN notation, for the MRP module is shown in Figure 5.



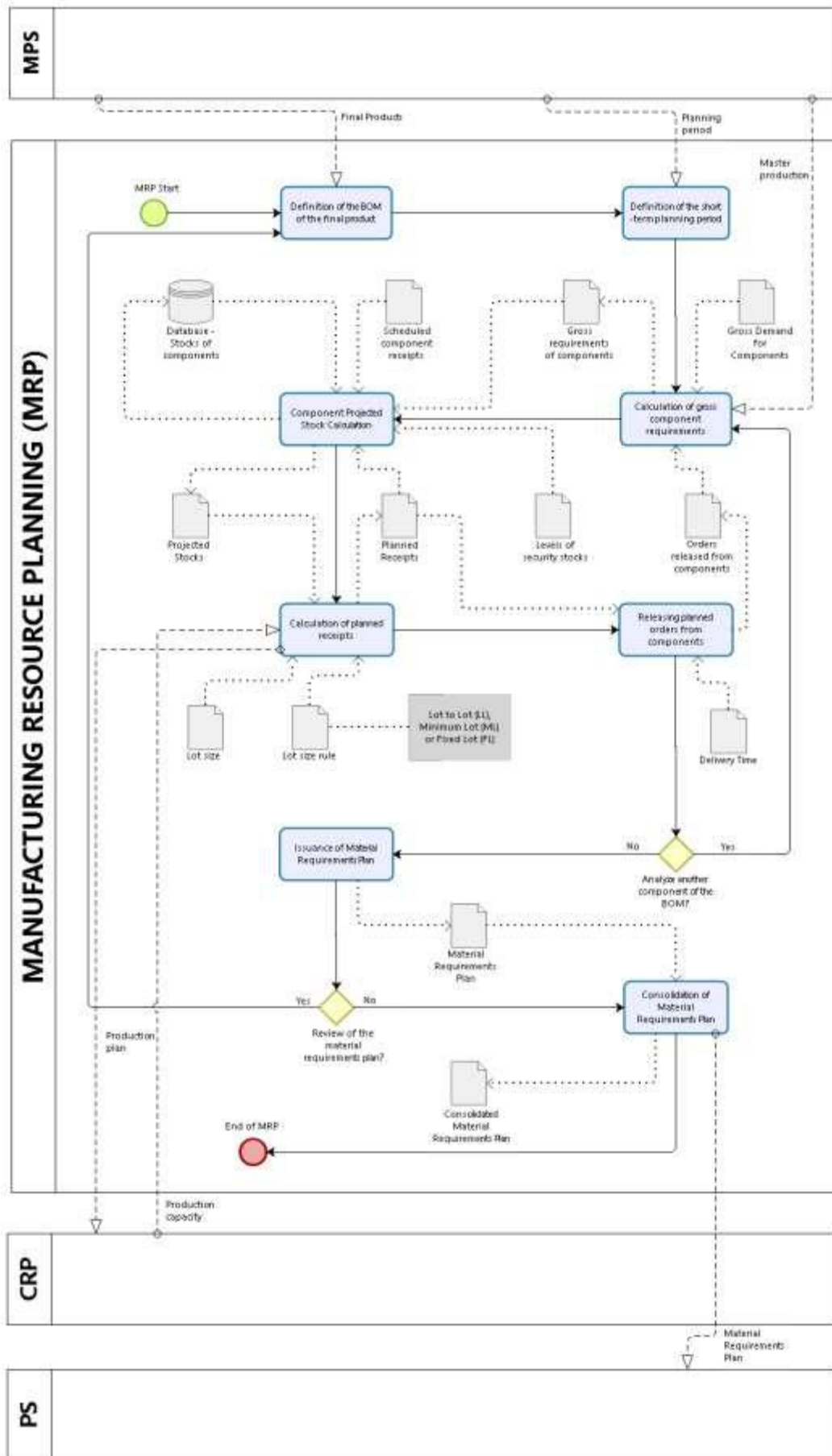


Fig. 5: Modeling of MRP in BPMN notation

**4.2 CRP MODELING**

The CRP aims to subsidize the decisions of the detailed planning of the production and materials. This planning has the objective of calculating resource needs that require a few weeks to mobilize and also the generation of a detailed production plan that is viable, through adjustments made in the original plan suggested by MRP, so that this can be released for execution.

The input and output information required for the elaboration of the reference model of the CRP module are shown in Table 3.

*Table 3: CRP information*

<b>Input</b>	<b>Output</b>
List of materials of the final products	Capacity required
Short-term planning period	Capacity installed
Working days	Charging rate
Daily working day	Short-term production capacity plan
Amount of labor	
Quantity of subcontracted labor	
Overtime of daily work	
Setup times	

The activities related to this module of the PPC planning are presented, with their respective theoretical references, in Table 4.

*Table 4: Sequence of CRP activities*

<b>#</b>	<b>Activity</b>	<b>Theoretical Framework</b>
1	Definition of the BOM of the final products specified in MRP.	Girotti et al. (2016), Corrêa & Corrêa (2012), Moreira (2008), Gaither & Frazier (2005), Yenisey (2006) and Neely & Byrne (1992).
2	Definition of the planning period specified in MRP.	Corrêa & Corrêa (2012).
3	Survey of the following information regarding productive capacity: quantity of labor (normal and subcontracted).	Corrêa & Corrêa (2012), Corrêa, Giansesi & Caon (2009), and Mukhopadhyay (2013).
4	Survey of the following information regarding production time: daily working day, overtime and working days of each planning period.	

5	Survey of the production rate of final product components.	
6	Calculation of the necessary production capacity of the components.	Corrêa and Corrêa (2012).
7	Calculation of installed production capacity.	
8	Calculation of the loading rate.	Corrêa & Corrêa (2012) and Vollmann (2005).
9	Elaboration of the short-term production capacity plan.	Martins & Laugeni (2009).
10	Review of the short-term production capacity plan, if necessary.	Mukhopadhyay (2013) and Corrêa, Giansesi & Caon (2009).
11	Definition of the BOM of the final products specified in MRP.	

In the CRP model, as shown in Figure 6, the short-term planning time is initially defined, according to what was established by the MRP.

Next, the total setup time for all BOM materials present in the production process is calculated.

For calculating the required production capacity, account is taken of the quantity of materials of the final product to be planned that are described in the receipts planned in the material requirements plan. In order to make this calculation, it is necessary to have information on two variables relevant to the production process: the production rate of these materials, the amount of labor available (normal and subcontracted), the production plan specified in the MRP, and total times calculated in the previous step.

Following the description of this stage of the model, the production capacity is consolidated, which for calculation should take into account the following variables: working days, working hours and overtime, the latter if there is .

Finally, for the calculation of the loading rate of the production process related to the MRP, which is performed by the ratio between the total required production capacity and the installed production capacity. After the completion of this last stage, the short-term capacity plan, necessary for the consolidation of the MRP, is issued. In case of need, it is possible to carry out a review of this plan elaborated. After the review, then, the consolidated plan of the CRP is issued. This

information, as previously seen, is required for MRP analysis and definition.

The reference model, in BPMN notation, for the MRP module is shown in Figure 6.

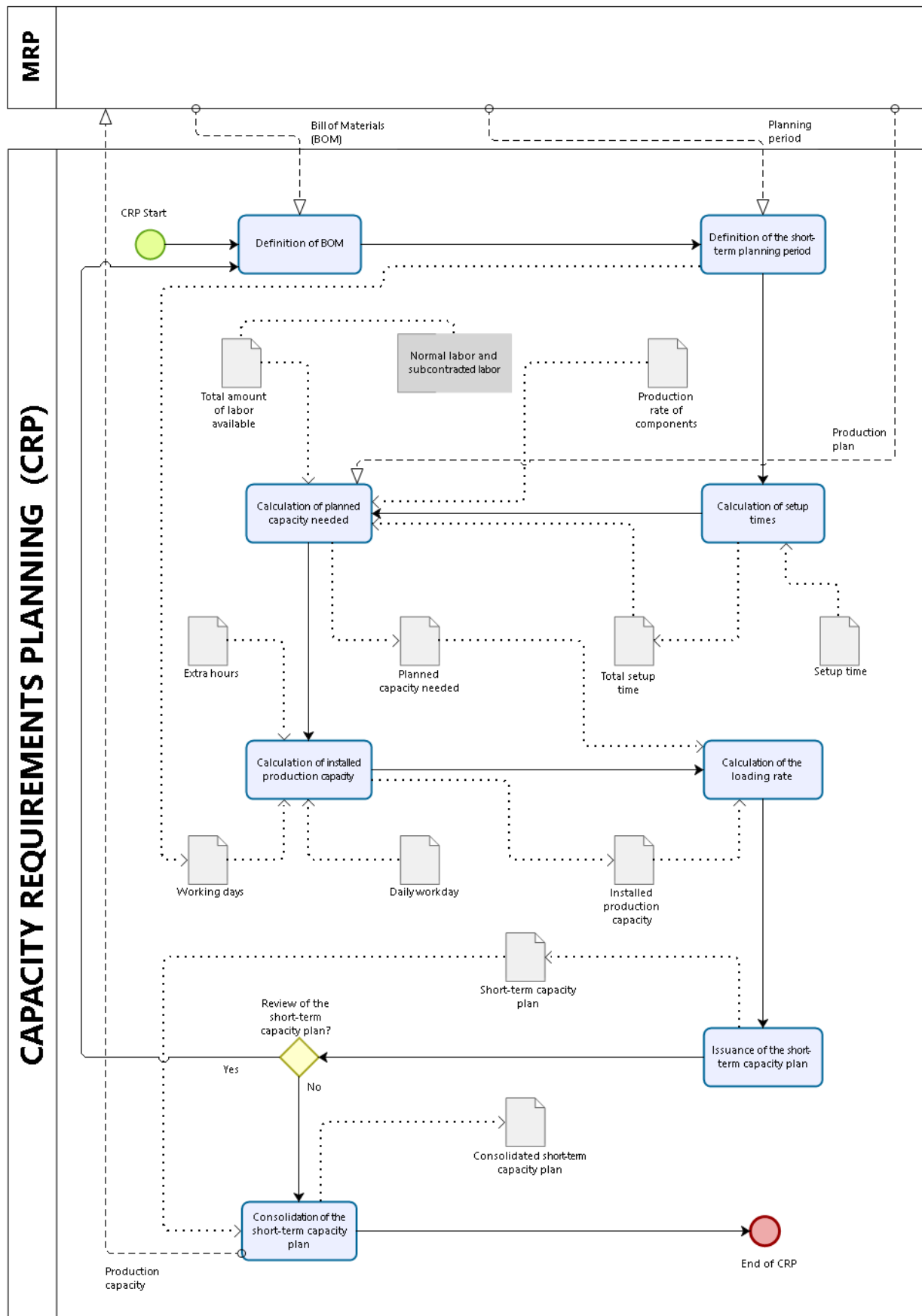


Fig. 6: Modeling of CRP in BPMN notation

### 4.3 SOFTWARE PROTOTYPE

After the elaboration of the production planning system module for MRP and CRP, a software prototype was developed through the Delphi interface, with the intention of generating a greater consistency between the abstraction of the reference model and its application in

the support of implementation and development of enterprise management tools, a software prototype was developed through the Delphi interface.

The first screen of the prototype for MRP and CRP is being shown in Figure 7.

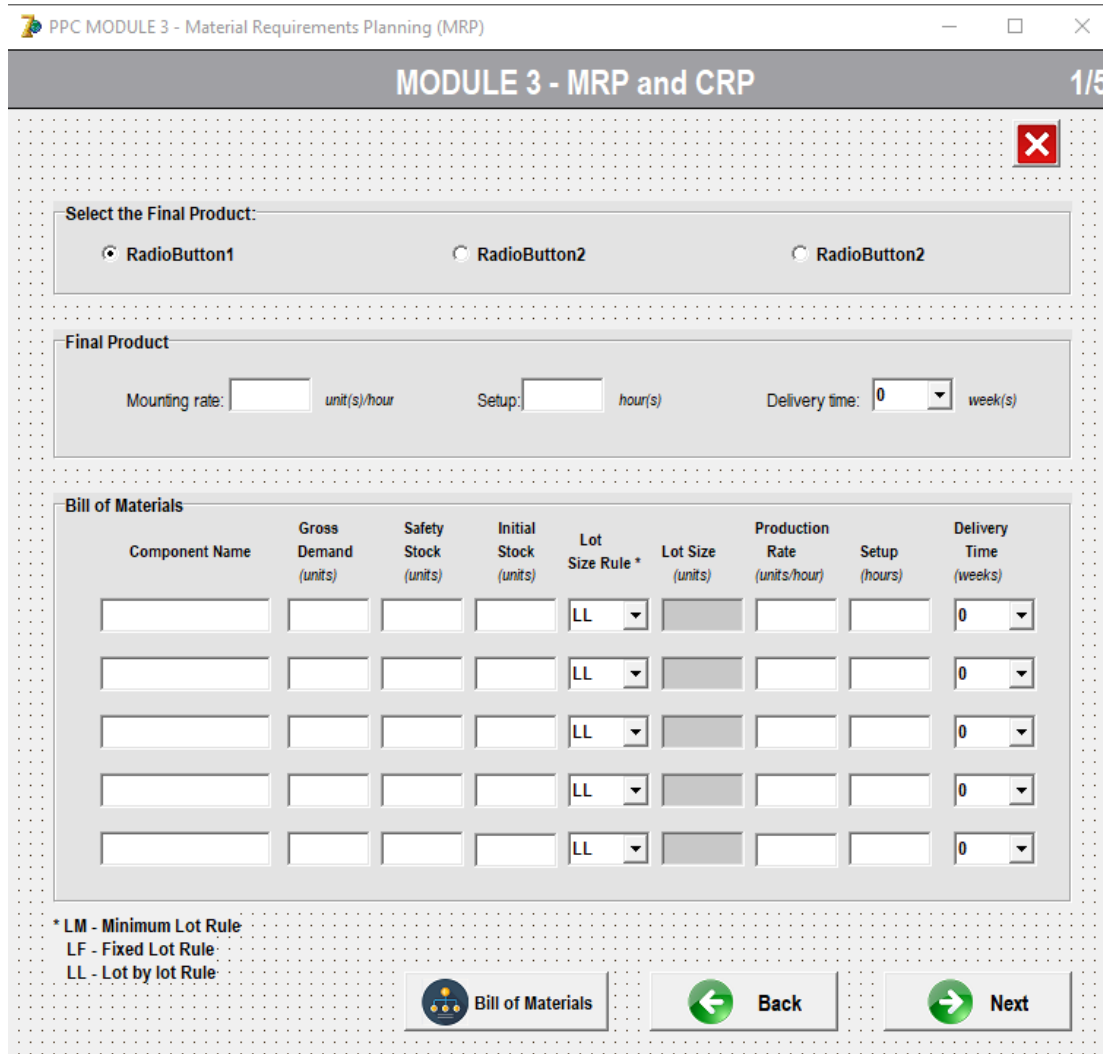


Fig. 7: First screen of the computational program of the MRP and CRP module

In order to validate the software prototype, several tests were carried out, with different planning scenarios and production strategies, in order to verify the activities, information, accuracy and precision of the calculations used to prepare the final master plan.

The results obtained by the computational program were compared with the results extracted manually and in electronic spreadsheets. Thus, the software prototype developed from the developed reference model proved to be reliable and apt to be used for the preparation of production material requirements plans.

### V. CONCLUSION

Currently, we are seeing increasing attention in the support to the development and implementation of actions

of improvements of the business management. However, most research and solutions for production planning are focused on large and complex organizations, highlighting an academic gap regarding work to support the implementation of management systems, especially for small and medium-sized enterprises. Therefore, the reference model developed in this work may provide these companies with an initial solution for their business processes, in order to specify and detail the particular model with a reduction in cost and implementation time. Thus, this work sought the development of a reference model, in BPMN notation, that addresses the business processes related to MRP, as well as to CRP, one of the modules inherent in the PPC. In addition, we also aimed to develop a software prototype with the aim of applying

this model in systems and management tools.

As a result, from a formal documentation, the reference model proved to be a useful tool in understanding and communicating the existing processes in MRP and CRP. It was also verified that this developed model is able to support the implantation of production management systems in real situations. However, for use in corporate environments, such as ERP adoption, these processes should receive the expertise and the users should have knowledge of the terms and variables involved in the reference model.

It is worth mentioning that the reference model has been configured as an important tool for knowledge management, since it is capable of storing and documenting existing knowledge in the business processes and serves as a basis for planning the development of new knowledge, always being guided by the strategic objectives of the company.

As a continuation of this work, a model is being developed that approaches in a holistic and hierarchical way the other modules of the Business Processes related to the PPC. Thus, this reference model seeks to fill gaps in the scientific literature and to advance in relation to international models, since there is a lack of work on reference models for the activities of the PPC.

For the purposes of validation and evaluation, it is suggested the dissemination and application of the software, developed from the reference model, in small and medium-sized enterprises with activities focused on production planning.

#### REFERENCES

- [1] BOLLOJU, N.; LEUNG, F. S. K. Assisting Novice Analysts in Developing Quality Conceptual Models with UML. *Commun. ACM*, v. 49, n. 7, p. 108–112, jul. 2006.
- [2] BREMER, C. F.; LENZA, R. DE P. A reference model for production management in assembly to order: ato production systems and its multiple applications. *Gestão & Produção*, v. 7, n. 3, p. 269–282, dez. 2000.
- [3] CARVALHO, M. F.; SILVA FILHO, O. S.; FERNANDES, C. A. O. O planejamento da manufatura: práticas industriais e métodos de otimização. *Gestão & Produção*, v. 5, n. 1, p. 34–59, abr. 1998.
- [4] CLIMENT, C.; MULA, J.; HERNÁNDEZ, J. E. Improving the business processes of a bank. *Business Process Management Journal*, v. 15, n. 2, p. 201–224, 17 abr. 2009.
- [5] CORRÊA, H. L.; CORRÊA, C. A. Administração de produção e operações: manufatura e serviços - Uma abordagem estratégica. 2. ed. São Paulo: Atlas, 2012.
- [6] CORRÊA, H. L.; GIANESI, I. G. N.; CAON, M. Planejamento, programação e controle da produção: MRP II/ERP: conceitos, uso e implantação: base para SAP, Oracle Applications e outros Softwares integrados de gestão. 5. ed. São Paulo: Atlas, 2009.
- [7] CORREA, J.; SPINOLA, M. DE M. Adoção, seleção e implantação de um ERP livre. *Production*, v. 25, n. 4, p. 956–970, dez. 2015.
- [8] FAVARETTO, F. Impacto das incertezas da previsão da demanda no planejamento detalhado da produção. *P&D em Engenharia de Produção*, v. 10, n. 1, p. 101–108, 2012.
- [9] FERNANDES, F. C. F.; GODINHO FILHO, M. Planejamento e controle da produção: dos fundamentos ao essencial. São Paulo: Atlas, 2010.
- [10] GAITHER, N.; FRAZIER, G. Administração da produção e operações. 8a. ed. São Paulo: Pioneira Thomson Learning, 2005.
- [11] GIACON, E.; MESQUITA, M. A. DE. Levantamento das práticas de programação detalhada da produção: um survey na indústria paulista. *Gestão & Produção*, v. 18, n. 3, p. 487–498, 2011.
- [12] GIROTTI, L. J. et al. Production Planning and Control: a survey of teachers in Production Engineering. *Production*, v. 26, n. 1, p. 176–189, mar. 2016.
- [13] GODINHO FILHO, M.; FERNANDES, F. C. F. MRP system: nervousness reduction and performance improvement. *Production*, v. 16, n. 1, p. 64–79, abr. 2006.
- [14] GUERRA, R. M. DE A.; SCHUSTER, J. V.; TONDOLO, V. A. G. Implantação de um modelo de MRP em uma empresa de médio porte do setor moveleiro. *Revista Gestão Industrial*, v. 9, n. 4, 20 fev. 2014.
- [15] HERNANDEZ, J. E.; MULA, J.; FERRIOLS, F. J. A reference model for conceptual modelling of production planning processes. *Production Planning and Control*, v. 19, n. 8, p. 725–734, 2008.
- [16] JONSSON, P.; MATTSSON, S. A longitudinal study of material planning applications in manufacturing companies. *International Journal of Operations & Production Management*, v. 26, n. 9, p. 971–995, 1 set. 2006.
- [17] KELLER, G.; TEUFEL, T. SAP R/3 process-oriented implementation: iterative process prototyping. Harlow, England; Reading, Ma: Addison Wesley Longman, 1998.
- [18] MARTINS, P. G.; LAUGENI, F. P. Administração da produção. São Paulo: Saraiva, 2009.
- [19] MENDES, M. R.; FILHO, L. C. DE B. A Experiência da Elaboração de um PCP: um Caso de

- uma Indústria de Alimentos. Revista de Engenharia e Pesquisa Aplicada, v. 2, n. 2, 27 jul. 2017.
- [20] MILNE, R. J.; MAHAPATRA, S.; WANG, C.-T. Optimizing planned lead times for enhancing performance of MRP systems. *International Journal of Production Economics*, v. 167, p. 220–231, 1 set. 2015.
- [21] MOREIRA, D. A. Administração da produção e operações. São Paulo: Cengage Learning, 2008.
- [22] MUKHOPADHYAY, S. K. Production planning and control: text and cases. 2. ed ed. Delhi: PHI Learning, 2013.
- [23] NEELY, A. D.; BYRNE, M. D. A simulation study of bottleneck scheduling. *International Journal of Production Economics*, v. 26, n. 1, p. 187–192, 1 fev. 1992.
- [24] ORNEK, A. M.; CENGIZ, O. Capacitated lot sizing with alternative routings and overtime decisions. *International Journal of Production Research*, v. 44, n. 24, p. 5363–5389, 15 dez. 2006.
- [25] PANDEY, P. C.; YENRADEE, P.; ARCHARIYAPRUEK, S. A finite capacity material requirements planning system. *Production Planning & Control*, v. 11, n. 2, p. 113–121, 1 jan. 2000
- [26] SAGBANSUA, L. Information Technologies and Material Requirement Planning (MRP) in Supply Chain Management (SCM) as a Basis for a New Model. *Bulgarian Journal of Science and Education Policy*, v. 4, n. 2, p. 236–247, 1 nov. 2010.
- [27] SCHEER, A.-W. ARIS - Business Process Frameworks. 3. ed. Berlin, Heidelberg: Springer Berlin Heidelberg, 2000.
- [28] SIAU, K. Informational and Computational Equivalence in Comparing Information Modeling Methods. *Journal of Database Management (JDM)*, v. 15, n. 1, p. 73–86, 1 jan. 2004.
- [29] SIAU, K.; ROSSI, M. Evaluation techniques for systems analysis and design modelling methods – a review and comparative analysis. *Information Systems Journal*, v. 21, n. 3, p. 249–268, 1 maio 2011.
- [30] TAAL, M.; WORTMANN, J. C. Integrating MRP and finite capacity planning. *Production Planning & Control*, v. 8, n. 3, p. 245–254, 1 jan. 1997.
- [31] THURER, M.; FILHO, M. G. Redução do lead time e entregas no prazo em pequenas e médias empresas que fabricam sob encomenda: a abordagem Worload Control (WLC) para o Planejamento e Controle da Produção (PCP). *Gestão & Produção*, v. 19, 2012.
- [32] VERGIDIS, K.; TURNER, C. J.; TIWARI, A. Business process perspectives: Theoretical developments vs. real-world practice. *International Journal of Production Economics, Special Section on Competitive Advantage through Global Supply Chains*. v. 114, n. 1, p. 91–104, 1 jul. 2008.
- [33] VERNADAT, F. Enterprise modeling and integration: principles and applications. London ; New York: Chapman & Hall, 1996.
- [34] VERNADAT, F. B. Enterprise Modelling and Integration. In: KOSANKE, K. et al. (Eds.). . Enterprise Inter- and Intra-Organizational Integration. Boston, MA: Springer US, 2003. p. 25–33.
- [35] VOJISLAV, B.; LEON, J. Evaluating the Quality of Reference Models. *Conceptual Modeling — ER 2000. Anais...: Lecture Notes in Computer Science*. In: INTERNATIONAL CONFERENCE ON CONCEPTUAL MODELING. Springer, Berlin, Heidelberg, 9 out. 2000Disponível em: <[https://link.springer.com/chapter/10.1007/3-540-45393-8\\_35](https://link.springer.com/chapter/10.1007/3-540-45393-8_35)>. Acesso em: 12 dez. 2017
- [36] VOLLMANN, T. E. (ED.). Manufacturing planning and control for supply chain management. 5th ed ed. Boston: McGraw-Hill/Irwin, 2005.
- [37] YENISEY, M. M. A flow-network approach for equilibrium of material requirements planning. *International Journal of Production Economics*, v. 102, n. 2, p. 317–332, 1 ago. 2006.

# WEKA for Reducing High -Dimensional Big Text Data

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**Abstract**— In the current era, data usually has a high volume, variety, velocity, and veracity, these are known as 4 V's of Big Data. Social media is considered as one of the main causes of Big Data which get the 4 V's of Big Data beside that it has high dimensionality. To manipulate Big Data efficiently; its dimensionality should be decreased. Reducing dimensionality converts the data with high dimensionality into an expressive representation of data with lower dimensions. This research work deals with efficient Dimension Reduction processes to reduce the original dimension aimed at improving the speed of data mining. Spam-WEKA dataset; which entails twitter user information. The modified J48 classifier is applied to reduce the dimension of the data thereby increasing the accuracy of data mining. The data mining tool WEKA is used as an API of MATLAB to generate the J48 classifiers. Experimental results indicated a significant improvement over the existing J48 algorithm

**Keywords**— Dimension Reduction; J48; WEKA; MATLAB.

## I. INTRODUCTION

In the current era, data usually has a high volume, variety, velocity, and veracity, these are known as 4 V's of Big Data. Social media is considered as one of the main causes of Big Data which get the 4 V's of Big Data beside that it has high dimensionality. To manipulate Big Data efficiently; its dimensionality should be decreased. Reducing dimensionality converts the data with high dimensionality into an expressive representation of data with lower dimensions. Reducing high dimensional text is really hard, problem-specific, and full of tradeoffs. Simpler text data, simpler models, smaller vocabularies. You can always make things more complex later to see if it results in better model skill. Machine learning is frequently characterized by a singular focus on model selection. Be it logistic regression, random forests, Bayesian methods, or artificial neural networks, machine learning practitioners are often quick to express their preference. The reason for this is mostly historical. Though modern third-party machine learning libraries

have made the deployment of multiple models appear nearly trivial.

Dimension reduction (DR) is a pre processing step for reducing the original dimensions. The aims of dimension reduction strategies are to improve the speed and precision of data mining. The four main strategies for DR are: Supervised-Feature Selection (SFS), unsupervised feature selection (UFS), Supervised Feature Transformation (SFT), and Unsupervised Feature Transformation (UFT). Feature selection emphasizes on finding feature subsets that better describes the data, as good as the original data set, for supervised or unsupervised learning tasks [Kaur & Chhabra, (2014)]. Unsupervised implies the re-learner, in the form of class labels. It is important to note that DR is but a preprocessing stage of classification. In terms of performance, having data of high dimensionality is problematic because (a) it can mean high computational cost to perform learning and inference and (b) it often leads to over fitting when learning a model, which means that the model will perform well on the training data but poorly on test data. Dimensionality reduction addresses both of these problems while trying to preserving most of the relevant information in the data needed to learn accurate, predictive models.

## II. J48 ALGORITHM

Classification the process of building model of classes from a set of records that contain class labels. Decision Tree Algorithm is of no doubt the way the attribute-vector behaves for a number of instances. Also on the basis of the training instances, the classes for the newly generated instances are being found. This algorithm generates the rules for the prediction of the target variable. With the help of a tree classification algorithm, the critical distribution of the data is easily understandable.

J48 is an extension of ID3. The additional features of J48 are accounting for missing values, decision trees pruning, continuous attribute value ranges, derivation of rules, etc. In the WEKA data mining tool, J48 is an open source Java implementation of the C4.5 algorithms. The

WEKA tool provides a number of options associated with tree pruning. In case of potential over fitting, pruning can be used as a tool for pruning. In other algorithms the classification is performed recursively until every single leaf is pure, that is the classification of the data should be as perfect as possible. This algorithm generates the rules from which particular identity of that data is generated. The objective is progressive generalization of a decision tree until it gains equilibrium of flexibility and accuracy. The following shows the basic steps in the algorithm

- In case the instances belong to the same class the tree represents a leaf so the leaf is returned by Labeling with the same class.
- The potential information is calculated for every attribute, given by a test on the attribute. Then the gain in information is calculated that would result from a test on the attribute.
- Then the best attribute is found on the basis of the present selection criterion and that attribute selected for branching.

### 2.1 Counting Gain

This procedure uses the "ENTROPY" which is a measure of the data disorder. Entropy of  $\bar{y}$  is calculated as

$$Entropy(\bar{y}) = -\sum_{j=1}^n \frac{|y_j|}{|\bar{y}|} \log\left(\frac{|y_j|}{|\bar{y}|}\right) \quad (1)$$

$$Entropy(j|\bar{y}) = -\sum_{j=1}^n \frac{|y_j|}{|\bar{y}|} \log\left(\frac{|y_j|}{|\bar{y}|}\right) \quad (2)$$

### Making Gain

$$Gain(\bar{y}, j) = Entropy(\bar{y}) - Entropy(j|\bar{y}) \quad (3)$$

### 2.2 Pruning

The outliers make this a very significant step to the result. Some occurrences are present all data sets which are not well defined and also differ from the occurrences in its neighborhood. The classification is done on the instances of the training set and tree is formed. The pruning is done for decreasing errors in classification which are produced by specialization in the training set. Pruning is achieved for the generality of the tree.

### 2.3 Features of the Algorithm

- Both discrete and continuous attributes are handled by this algorithm. A threshold value is decided by C4.5 for managing continuous attributes. This value splits the data list into those who have their attribute value below the threshold and the remaining more than or equal to it.
- This algorithm also takes care of missing values in the training data.
- After the tree is fully built, this algorithm does the pruning of the tree. C4.5 after its building drives back through the tree and challenges to eliminate branches that

are not helping in reaching the leaf nodes.

## III. RELATED WORK

Decision tree classifiers are widely used supervised learning approaches for data exploration, resembling or approximation of a function by piecewise constant regions, also does not necessitate preceding information of the data distribution [Mitra & Acharya, (2003)]. Decision trees models are usually used in data mining to test the data and induce the tree and its rules that will be used to make predictions [Two Crows Corporation, (2005)]. The actual purpose of the decision trees is to categorize the data into distinctive groups that generate the strongest of separations in the values of the relevant variables [Parr Rud (2001)], being superior at identifying segments with the desired compartment such as activation or response, hence providing an easily interpretable solution.

The concept of decision trees was advanced and refined over many years by J. Ross Quinlan starting with ID3 [Interactive Dichotomize 3 (2001)]. A method based on this approach uses an evidence theoretic measure, such as entropy, for assessing the discriminatory power of every attribute [Mitra & Acharya (2003)]. Major decision tree algorithms are clustered as [Mitra & Acharya (2003)]: (a) classifiers from the machine learning community: IDS, C4.5, CART; and (b) classifiers for large databases: SLIQ, SPRINT, SONAR, Rain Forest.

Weka is a very effective assemblage of machine learning algorithms to ease data mining tasks. It holds tools for data preparation, regression, classification, clustering, association rules mining, as well as visualization. Weka is used in this research to implement the most common decision tree construction algorithm: C4.5 known as J48 in weka. It is one of the more famous Logic Programming methods, developed by Quinlan [Quinlan JR (1986)], an attribute-based machine learning algorithm for creating a decision tree on a training set of data and an entropy measure to build the leaves of the tree. C4.5 algorithms are based on the ID3, with supplementary programming to address ID3 problems.

## IV. PROPOSED TECHNIQUE AND FRAMEWORK

The WEKA tool has emerged with innovative and effective as well as relatively easiest data mining and machine learning solutions. Since 1994, this tool was developed by the WEKA team. WEKA contains many inbuilt algorithms for data mining and machine learning. It is an open source and freely available platform. People with little knowledge of data mining can also use this software very easily since it provides flexible abilities for scripting experiments. As new algorithms appear in the



research literature, these are updated in the software. WEKA has also gained some reputation which makes it one of the favorite tool for data mining research and assisted to progress it by making numerous powerful features available to all.

**4.1 The following are steps performed for data mining in WEKA:**

- Data pre-processing and visualization
- Attribute selection
- Classification (Decision trees)
- Prediction (Nearest Neighbor)
- Model evaluation
- Clustering (Cobweb, K-means)
- Association rules

**4.2 J48 Improvement**

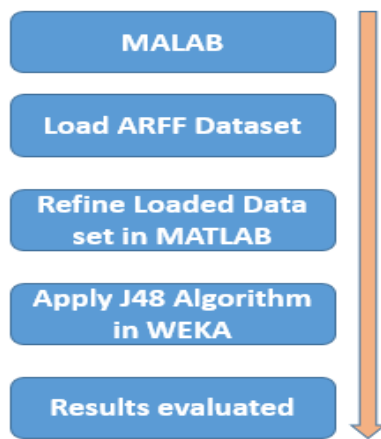


Fig.1: Flow Chart and Set-Up

**V. EXPERIMENTATION**

This section shows results and how performance was evaluated; the J48 algorithm is also compared to other algorithms.

The formula employed for calculating the accuracy is

$$TA = \frac{TP+TN}{TP+TN+FP+FN} \tag{4}$$

$$RA = \frac{(TP+FP)*(TN+FN)*(FN+TP)*(FP+TP)}{(Total*Total)} \tag{5}$$

In the equation (4)TA = Total Accuracy ,TP=True Positive, TN=True Negative ,FP = False Positive and FN= False Negative. In equation(5) RA represents Random Accuracy.

Fig 2, shows the tested negative and positive values of spammers with respect to the various attributes. It shows the total number of classified spammers and non-spammers per the dataset in WEKA environment.

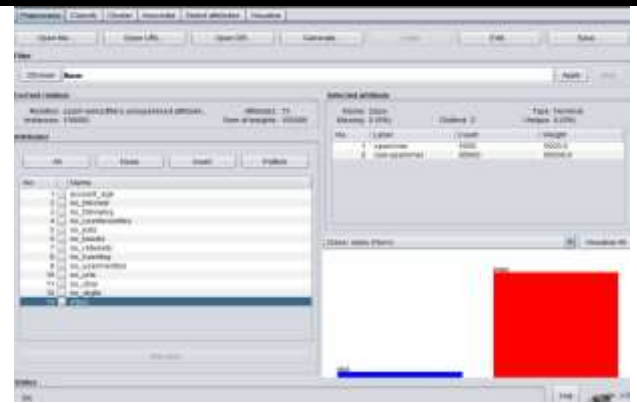


Fig.2: Data representation by class in Weka environment

Table 1, indicates the output of classification represented in the following confusion matrix for spammers and non-spammers.

Table.1: Confusion matrix

a	b	classified as
2316	2684	a=spammer
720	94280	b=non-spammer

Table 2 shows the results of various algorithms against the performance of the proposed improved technique.

Table.2: Performance comparison of other algorithms

Algorithm	Accuracy %	Error %
Naive Bayes	54.46	45.54
Multi Class Classifier	94.999	5.001
Random Tree	94.98	5.02
REP Tree	96.347	3.653
Random Forest	96.962	3.038
J48	96.596	3.404
Improved J48	98.607	1.393

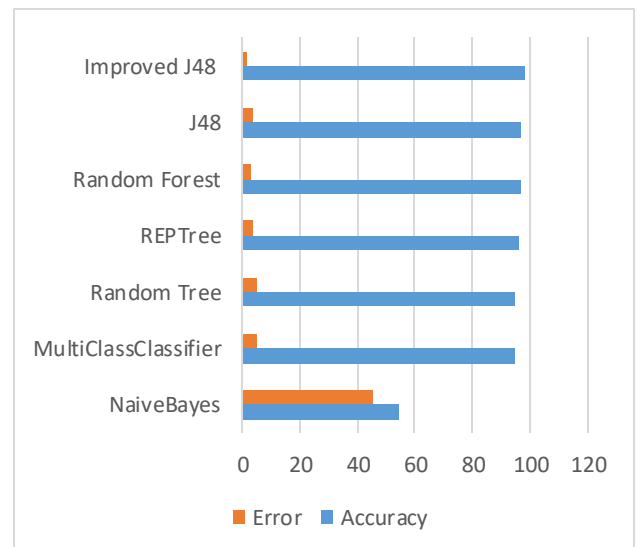


Fig.3: Results of algorithms in percentage

Fig 3 shows the comparison graph of the various algorithms on accuracy and error rate. It clearly shows how the improved technique performs better than the others with its accuracy rate of 98.607 %.

## VI. CONCLUSIONS AND FUTURE TREND

This research proposes an approach for efficient prediction of spammers from records of Twitter users. It is able to correctly predict spammers and no-spammers with up to 98.607% accuracy rate. The improved technique makes use of the data mining tool WEKA, which is used together with MATLAB for generating an improved J48 classifier. The experiment results speak for itself.

In the near future, some more datasets will be used to validate the proposed algorithm. Only 100000 instances were used for this research work, a larger and more dynamic dataset should be considered in order to test the effectiveness of this algorithm.

## ACKNOWLEDGMENT

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## REFERENCES

- [1] Acharya, T; Mitra, S. (2003). Data Mining: Concept and Algorithms from Multimedia to Bioinformatics, John Wiley & Sons, Inc. New York.
- [2] Aggarwal, C. C; Zhai C. (2012). An introduction to text mining in Mining Text Data, Springer, pp. 1–10.
- [3] Cunningham, P.(2008). Dimension reduction, Machine learning techniques form multimedia, vol. 13pp.91–112.
- [4] Council,N.(2016).Future directions forms f advanced computing infra structure to support. science and engineeringin,pp.2017-2020:Interimreport,The National Academies Press Washington, DC.
- [5] Flach , A.; Wu, S. (2002).Feature selection with labelled and unlabelled data, in ECML/PKDD,vol.2,pp.156–167.
- [6] Gao, L.;Song, J.;Liu,X.;Shao,J.; Liu, J.; Shao,J. (2017). Learning in high- dimensional multimedia data: the state of the art, Multimedia Systems, vol.23, pp.303–313.
- [7] Hüllermeier, E. (2011).Fuzzysetsinma chine learning and data mining, Applied Soft Computing,vol.11, no.2,pp.1493–1505.
- [8] Karami, A. (2015).Fuzzy Topic Modeling for Medical Corpora, University of Maryland, Baltimore County.
- [9] Karami, A.;Gangopadhyay, A. (2014).Afuzzy feature transformation method for medical documents, in

Proceedings of the Conference of the Association for Computational Linguistics(ACL),vol.128, pp 16-22.

- [10] Karami, A.; Gangopadhyay, A; Zhou,B. and H.Kharrazi,“Flatm: A fuzzy logic approach topic model for medical documents,” in Proceed- ings of the Annual Meeting of the North American Fuzzy Information Processing Society(NAFIPS). IEEE,2015.
- [11] Karami, A.; Yazdani, H.;Beiryaie, R.; Hosseinzadeh, N. (2010).A riskbased model foris out sourcing vendor selection, in Proceedings of the IEEE International Conference on Information and Financial Engineering(ICIFE). IEEE,pp.250–254.

# The Crime Scene: Considerations about the State of Rondônia, Brazil

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**Abstract**— *This article presents the crime scenario in the state of Rondônia using as the time frame of 2010 to 2016. The overall objective of the research is to analyze the levels of crime in the state of Rondônia (Brazil), comparing it with other federal units have similar prison population. As a research problem seeks to answer: Investments in public safety have reflected in decreasing rates of crime and violence? The research has to approach nature with quantitative and qualitative use of secondary data through bibliographical and documentary studies. The research results it was found that Rondônia is among Brazilian states, one that dedicates part of their income to totalitarian public safety segment.*

**Keywords**— *Crime. Resocialization. Rondônia. Development.*

## I. INTRODUCTION

It is very current state that the prison system crisis is a concern that affects our country. In narrower scenario, the North is in evidence because of this conflict, motivated by numerous echoes issues in riots and massacres that highlight the interference of a delicate area of Brazil. Delicate because it deals with the ability to punish

those who broke the law and caused damage of all kinds. Gentler yet, would discuss this punitive capacity and compare it with the ideals of justice, which, due to its subjectivity generate contrary discussions and often unsolvable. It is too inconclusive to define if it's just the application of a shame, since the place where it is fulfilled not only generates the deprivation of liberty, but in many cases also the deprivation of fundamental rights.

This article presents the crime scenario in the state of Rondônia using as the time frame of 2010 to 2016. The overall objective of the research is to analyze the levels of crime in the state of Rondônia, comparing it with other federal units that have prison population similar. The study also adopts the variable comparison of investments in public safety in the Brazilian states in order to answer the following question: Investments in public safety have reflected in decreasing rates of crime and violence? The answer to this question is relevant to allow the construction of strategies for rehabilitation, watching as a tool for fighting crime.

## II. THEORETICAL

### 2.1 Crime and crime

According to Pastore (2011, p. 41) the crime "is human behavior that violates the law and subject the author to penalties of deprivation of liberty, suspension or interdiction of rights, alternative social provision and fine." According to the author, in Brazil there are the "death sentences, in perpetuity, forced labor, banishment or cruel." About this statement to raise two main issues: the first is the end of the sentence, that is, regardless of which system the condemnation is given, the criminal, which no longer will be so designated, will return to social life; the other issue is humanitarian bias, where he discusses how cruel is worth, given that Brazil is characterized by the prison system crisis, overpopulation in prisons and subhuman conditions, considering basic rights such as health,

Decree-Law No. 3,914 / 41 establishes that crime is a criminal offense in which the law confers in isolation, cumulative or alternative to imprisonment or detention with a fine. This is the legal concept of crime (BRAZIL, 1941st).

At the crime field of study has criminology which is regarded as the science that investigates and seeks to explain the legal violation, as well as the means by which society deals with crime, care for the victim and the focus on the criminal (SHECAIRA, 2012, p. 35). Means the criminal offense as a genre that makes up the species crime and misdemeanor. The concept of crime is already clear on the punishment by imprisonment and detention, and such imprisonment be cumulated with a fine. Already the misdemeanor is understood as the fact that less potential offensive to society, assuming maximum simple imprisonment and may provide application only fine (BRAZIL, 1941b).

Silva (2014, p. 16) to the handle on the inability of the penal state with the growing crime says that "the issue of combating the crime by coercion is intertwined with authoritarianism characteristic that has always been voiced by the elites." The author explains that this model generates an expansive conflict, where the state punishes the violence that consequently generates more violence through crime.

The prison system is the meeting of administrative actions and equipment used for the execution of custodial sentences. Its existence is related to the fact that the

individual who broke the law, given the nature of the crime, should be separated from society, suffering so, punishment and retribution for the offense committed, and also that system, the function of re-socialize the offending individual (IBAIXE JR, 2010).

As for crime prevention, Pebble (2009) distinguishes three types of interventions, which were the primary, secondary and tertiary. At first the author explains that prevention is oriented to the root of the problem, working to create conditions that allow citizens to solve social conflicts without the adoption of violent conduct. This is achieved through the provision of education, quality of life, work and social welfare.

In secondary prevention action is aimed at areas that have the highest rates of violence, such as poor communities occupied by drug trafficking. Such action is guided by a penal policy and focused police action, taking place at the moment in which violence manifests itself and where it outsources. Already tertiary prevention, heavily criticized by the author in the face of their inefficiency, involves late initiatives that seek to reduce criminal recidivism rates. Such policies are expressed by the rehabilitation of shares tendered during and post-prison (CALHAU, 2009). Although the fact resocializing policy does not present high efficiency and effectiveness, it is necessary, therefore, discuss it and improve it. This is because the complexity and financial costs demanded by primary prevention in conjunction with the difficulties of the country to provide welfare to its citizens, exposes how delicate and difficult is the resolution of the problem. Not stated, however, that primary prevention is not the best solution, but it is argued that even if it is fully functioning, the prison reality needs to be worked for the social reintegration of that already outsourced violence socially.

**2.2 Types of crime**

Criminal typologies presented in this research consider the crimes listed in official reports on crime in the country, the main one being the Brazilian Yearbook of Public Security issued by the Brazilian Forum on Public Security (FBSP, 2013, 2015 and 2017). In the classification are mentioned crimes against life, sexual freedom, equity and personal injury, as descriptive of Table 1.

Table.1: Types of crime

TYPE	RANKING	STANDARD	LEGAL DEFINITION
<b>MURDER</b>	Crime against life; You can integrate the list of heinous crimes	Art. 121 Decree-Law No. 2,848 / 1940	Kill someone;
<b>ROBBERY</b>	Crime against property; Integrates the list of	Art. 157 § 3 Decree-Law No. 2,848 / 1940	Variant of crime theft; It occurs when the violence used to the consummation of theft because the victim's death.

heinous crimes			
<b>ASSASSINATION ATTEMPT</b>	Crime against life	Art. 121 combined with Art. 14 Decree-Law No. 2,848 / 1940	Variant of homicide crime; occurs when after started running crime, this will not be consumed by others to the criminal.
<b>BODILY INJURY</b>	Crime injury; You can integrate the list of heinous crimes	Art. 129 Decree-Law No. 2,848 / 1940	Offend the body or health of others.
<b>THEFT</b>	Crime against property	Art. 155 Decree-Law No. 2,848 / 1940	Subtract mobile alien thing
<b>THEFT OF VEHICLE</b>	Crime against property	Art. 155 Decree-Law No. 2,848 / 1940	Subtract mobile alien thing
<b>THEFT</b>	Crime against property	Art. 157 Decree-Law No. 2,848 / 1940	Subtract thing others through violence or serious threat to the victim
<b>VEHICLE THEFT</b>	Crime against property	Art. 157 § 2 IV Decree-Law No. 2,848 / 1940	Variant of crime theft; if the stolen property is transported to another state or country will be increased penalty of one third to one half.
<b>RAPE</b>	Crime against sexual freedom; Integrates the list of heinous crimes;	Art. 213 Decree-Law No. 2,848 / 1940	Embarrass someone by violence or serious threat to have sexual intercourse or engaging in any other lewd acts.
<b>DRUG TRAFFICKING</b>	trafficking crime; Equated to heinous crimes	Art. 33 Law No. 11.343 / 2006.	Carry, facilitate the transport, produce, market, having in possession and supply, even for free, unauthorized substances capable of causing addiction.

Source: BRAZIL (1940, 2006).

Some of the crimes listed in Table 1 are or may be classified as heinous crimes, which are those that cause high censorship by society and commotion for hurting human dignity. Listed by Law No. 8,072 / 1990 such criminal acts are not susceptible of amnesty, grace, pardon or bail, whether were tempted or consummated crimes (CNJ, 2018).

The crime of murder is considered heinous crime when committed: (a) with the use of torture; (B) a futile motivation; (C) to ensure that go unpunished another crime or (d) for extermination group (BRAZIL, 1990). Law No. 13,142 / 2015 added to the list of heinous crimes very grave bodily injury and / or killing of members of the prison system and the National Public Security Force or against your spouse, partner or relative within the third degree consanguineous (BRAZIL, 2015). It is also cast as crime heinous femicide, which is the murder of women by their gender.

Trafficking in narcotics is considered a crime equivalent to heinous. This is because the Law No. 8,072 / 1990 not

directly typifies as a crime of this nature, as you do with the crimes of robbery and rape. However in art. 2 of the said legal regulation is indicated that, as the crimes considered heinous, the practice of torture, terrorism and illicit trafficking in narcotics and similar drugs are not amenable to forgiveness (grace, amnesty and pardon) and surety (BRAZIL, 1990 ).

### 2.3 Resocialization

Falconi (1998, p. 122) in his studies conceptualizes social reintegration as an institute of criminal law, which "falls within the own space of Criminal Policy (post-prison), facing the reintroduction of *former believes* in the social context, aiming to create a *modus vivendi* between it and society." The cited author adds that social reintegration is "the crowning achievement of good work to be held in re-education or rehabilitation."

In the absence of a life sentence in Brazil for to highlight the role of rehabilitation that is taken by Julian (2012, p. 57) as socializing again, a concept used primarily within the prison system, which means "the idea that the internal

return to society willing to accept and follow social norms and rules." The rehabilitation is the set of attributes able to create opportunities to humans become useful to yourself, your family and society. In this regard, penalties should offer conditions for individuals to be effectively reintegrated into the social environment, through actions that can reduce recidivism levels and contribute to the recovery of the detainee, his education, vocational training and psychological and social awareness (Figueiredo Neto et al., 2009). Silva (2014, p.

### III. METHODOLOGY

The research has quantitative and qualitative approach with use of secondary data obtained from the article published by Lessa and Silva (2015) that characterized the crime in the state of Rondônia in the period 2010 to 2014. The data for 2015 were collected the Brazilian Yearbook of Public Security (FBSP, 2017) and those relating to the years 2016 and 2017 are statistical publications held by the State Security Department, Defense and Citizenship - SESDEC (RONDÔNIA, 2017).

For the research were also carried out bibliographical and documentary research. In the quantitative analysis we used the MsExcel program. The comparative analysis occurred in two scenarios, the first considered the period from 2010 to 2016 in years; the second aiming to translate latest context used for comparing the first half of 2016 and 2017, since the study was conducted in August 2017. As a criterion of demarcation of the research, were selected for comparative design states with prison population similar to that of Rondônia, allowing the analysis of investments in public safety, size and population of these states.

### IV. RESULTS

#### 4.1 Characterization of the crime in the state of Rondônia

In the survey was conducted survey on the number of criminal incidents in the state of Rondônia. Table 1 shows the classification of the crime and the number of occurrences per year in the period 2010 to 2016.

Table.1: Crime in the State of Rondônia 2010-2016

RONDÔNIA	PERIOD							TOTAL
	2010	2011	2012	2013	2014	2015	2016	
<b>Murder</b>	550	427	484	470	530	503	545	<b>3.509</b>
<b>Robbery</b>	27	16	11	7	17	15	35	<b>128</b>
<b>Assassination Attempt</b>	782	916	866	925	881	908	867	<b>6.145</b>
<b>Bodily injury</b>	10.998	11.524	10.875	11.477	10.640	10.354	10.054	<b>75.922</b>
<b>Theft</b>	30.894	32.654	35.221	44.643	40.655	-	44.231	<b>228.298</b>
<b>Theft of vehicle</b>	1.576	1.782	1.984	2.681	2.571	3.304	3.555	<b>17.453</b>
<b>Theft vehicle theft</b>	6.951	7.210	9.405	14.501	16.844	-	26.418	<b>81.329</b>
<b>Rape</b>	675	731	806	822	753	692	790	<b>5.269</b>
<b>Narcotics trafficking</b>	1405	1.475	1.180	1.051	1.041	1.004	1.019	<b>8.175</b>
<b>TOTAL</b>	54.720	57.683	62.083	77.819	75.082	18.575	89.422	<b>435.384</b>

Source: FBSP (2017); RONDÔNIA (2017); LESSA and Silva (2015).

2015 data were collected in the Brazilian Yearbook of Public Security that does not use in his classification the occurrence of theft and robbery, as occurs in the data published by the Rondonia organs. Given this distinction, the information on the occurrence of theft and robbery for

the year 2015 are not mentioned in Table 1. For the perception of crime rate of evolution elaborated the Table 2 presents the annual and total growth for the period by type of crime.

Table.2: Evolution rate calculation crime 2010-2016

RONDÔNIA	PERIOD						
	10/11	11/12	12/13	13/14	14/15	15/16	10/16
<b>Murder</b>	-22,36%	13,35%	-2,89%	12,77%	-5,09	8,35	-0,91%
<b>Robbery</b>	-40,74%	-31,35%	-36,35%	142,86%	-11,76%	133,33%	29,63%
<b>Assassination Attempt</b>	17,14%	-5,46%	6,81%	-4,76%	3,06%	-4,52%	10,87%

<b>Bodily injury</b>	4,78%	-5,63%	5,54%	-7,29%	-2,69%	-2,90%	-8,58%
<b>Theft</b>	5,70%	7,86%	26,75%	-8,93%	(*)	(*)	43,17%
<b>Theft of vehicle</b>	13,07%	11,34%	35,13%	-4,10%	28,51%	7,60%	125,57%
<b>Theft</b>	3,73%	30,44%	54,18%	16,16%	(*)	(*)	280,06%
<b>vehicle theft</b>	9,98%	31,96%	-0,72%	-7,41%	56,09%	6,30%	121,35%
<b>Rape</b>	8,30%	10,26%	1,99%	-8,39%	-8,10%	14,16%	17,04%
<b>Narcotics trafficking</b>	4,98%	-20,00%	-10,93%	-0,95%	-3,55%	1,49%	-27,47%

(\*) Amounts not calculated due to the lack of data for the year 2015.

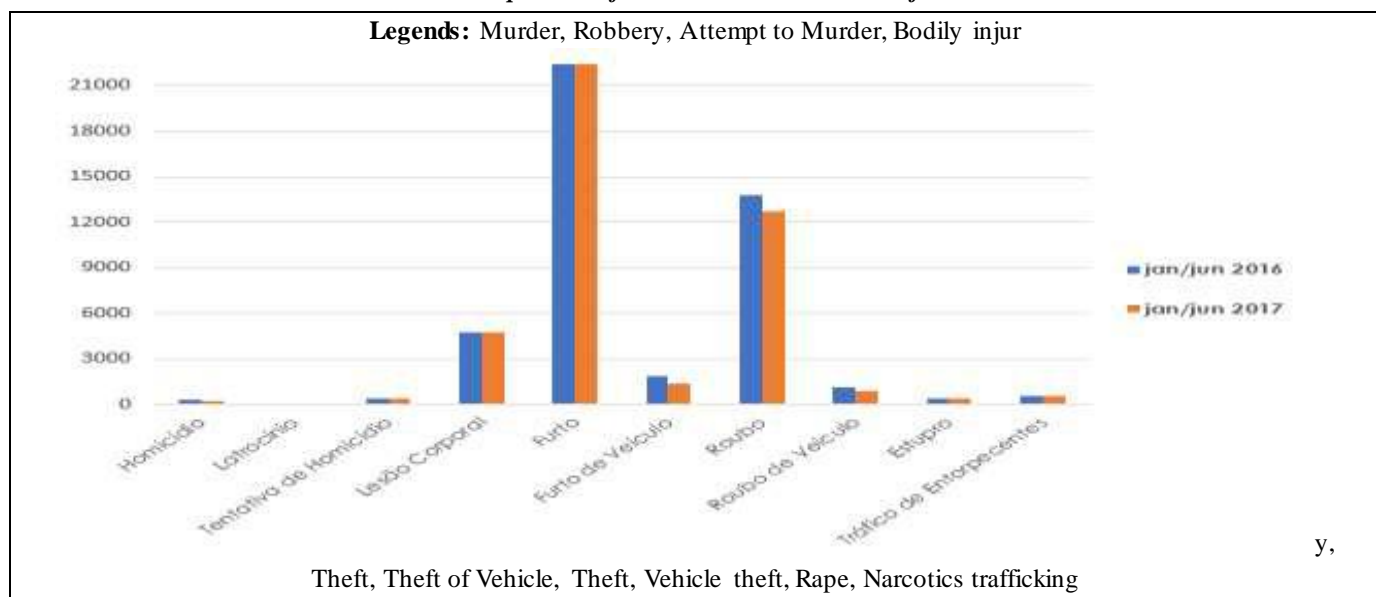
Source: FBSP (2017); RONDÔNIA (2017); LESSA and Silva (2015).

Of the 11 criminal types analyzed, only the crimes of murder (-0.91%), bodily injury (-8.58%) and drug trafficking (-27.47%) had a reduction in the crime rate between 2010 and 2016. in contrast stands the significant increase in theft crimes (280.06%), vehicle theft (125.57%), vehicle theft (121.35%), drug trafficking (63.42%) and theft ( 43.17%). Disturbing to realize that in analyzing the crime rate presents a shy decrease in contrast to the high growth, now that the reduced numbers

reach a maximum of 27.47% (drug trafficking), while the percentage of increase in crime as well as represent most types grow at least 10.87% (attempted murder) and reach alarming 280.06% (theft).

For the preparation of the latest study, we compared the occurrence number of the first and second half of the years 2016 and 2017, obtaining the results shown in Figure 1 and described in Table 3.

Chart.1:- Comparison of occurrences in the State of Rondônia



Source: Prepared based on RONDÔNIA (2017).

Table.3: Criminality in the State of Rondônia - January to June 2016/2017

RONDÔNIA	Período: 1º semestre		%	TOTAL
	2016	2017		
Murder	287	248	-13,6	535
Robbery	12	7	-41,7	19
Attempt to Murder	434	369	-15,0	803
Bodily injury	4.747	4.741	-0,1	9.488
Theft	22.422	22.392	-0,1	44.818
Theft of Vehicle	1.892	1.383	-26,9	3.275
Theft	13.737	12.678	-7,7	26.415

Vehicle theft	1.104	882	-20,1	1.986
Rape	382	433	13,4	815
Narcotics trafficking	539	569	5,6	1.108
<b>TOTAL</b>	45.556	43.702	<b>-4,1</b>	<b>89.258</b>

Source: Prepared based on RONDÔNIA (2017).

According to the data presented in Figure 1 and Table 3 it can be seen the reduction in most types of crimes, however this is the increase in rape crimes and drug trafficking. The main highlights are as reductions for robbery crimes, car theft, vehicle theft, attempted murder and murder.

It conducted further survey of the general population, estimated and prison in order to compare the percentage of incarcerated for state of the federation. Data from general and estimated population were obtained from the latest census conducted in 2010 by the Brazilian Institute of Geography and Statistics (IBGE) and those relating to

the prison population were collected from the National Survey of Penitentiary Information (BRAZIL, 2014).

Based on the prison population of 27 units, Rondônia occupies the 17th position with 7,631 inmates (BRAZIL, 2014). The states with similar prison population include the Amazon (7,455 inmates), Rio Grande do Norte (7081) and Maranhão (6098). Table 4 identifies the relationship between prison and general population of the federated units that occupy the top positions in the national ranking and those with close prison population of the State of Rondonia.

Table.4: Ranking of the prison population

Position / Federative Unit	Prison population - 2014	State's population - 2010	Estimated population - 2016	% Population in 2010 <sup>1</sup>	% 2016 Population <sup>2</sup>
1° São Paulo	219.053	41.262.199	44.749.699	0,53%	0,49%
2° Minas Gerais	61.286	19.597.330	20.997.560	0,31%	0,29%
3° Rio de Janeiro	39.321	15.989.929	16.635.996	0,25%	0,24%
[...] <sup>3</sup>	-	-	-	-	-
15° Mato Grosso	10.357	3.035.122	3.305.531	0,34%	0,31%
16° Paraíba	9.596	3.766.528	3.999.415	0,25%	0,24%
17° Rondônia	7.631	1.562.409	1.787.279	0,49%	0,43%
18° Amazonas	7.455	3.483.985	4.001.667	0,21%	0,19%
19° Rio Gr. do Norte	7.081	3.168.027	3.474.998	0,22%	0,20%
20° Maranhão	6.098	6.574.789	6.954.036	0,09%	0,09%
21° Alagoas	5.785	3.120.494	3.358.963	0,19%	0,17%
22° Sergipe	4.307	733.559	816.687	0,48%	0,43%
23° Acre	3.486	2.068.017	2.265.779	0,21%	0,19%
24° Tocantins	3.233	1.383.445	1.532.902	0,23%	0,21%
25° Piauí	3.224	3.118.360	3.212.180	0,10%	0,10%
26° Amapá	2.654	669.526	782.295	0,40%	0,34%
27° Roraima	1.610	450.479	514.229	0,36%	0,31%

1 Percentage of the prison population compared with the general population in 2010

2 Percentage of prison population with respect to population of 2016;

3 Data hidden by not showing significant for analysis of the state of Rondônia.

Source: Prepared based on BRAZIL (2014); IBGE (2017).

It is relevant to point out, as recorded in Table 4, when observed the population recorded in the 2010 census, Rondônia has the second highest percentage of prisoners with regard to their general population, surpassing even

federal units that occupy the top ranking. In the same analysis, when considering the estimated population for 2016, Rondonia state still has the second highest



percentage of imprisoned, sharing the lead with the state of Sergipe.

We note also that the 10 states having lower prison population that Rondônia 6 have the general population and higher estimated, and the state of Maranhao 4 times more populous; Amazon and Rio Grande do Norte have

more than double the rondonian population; Alagoas and Piauí come close twice and Sergipe is 24% more populous. To understand the spatial dimension of the states with lower prison population Rondônia was prepared an infographic (Figure 1).

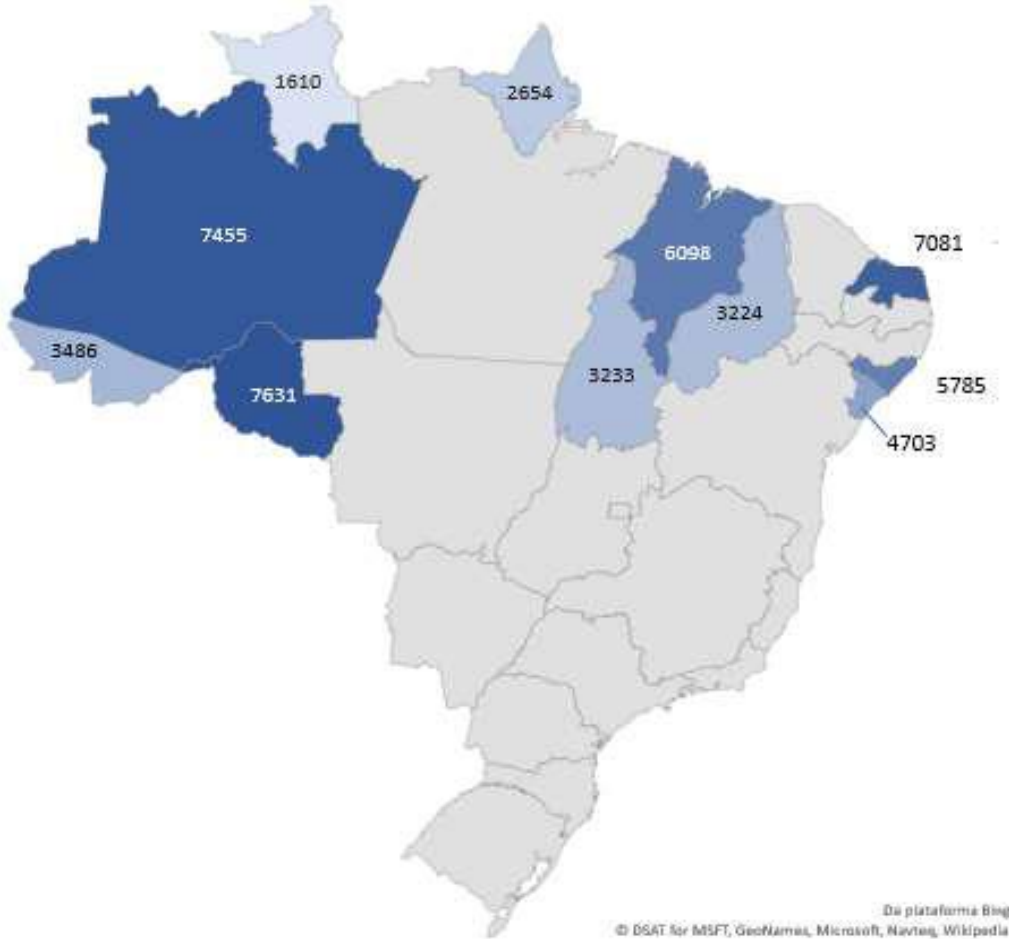


Fig.1: States with prison population less than Rondônia

Source: Prepared based on BRAZIL (2014).

Advancing research, data were collected on costs of these federal units (Table 4) for public safety function. We conducted a survey of expenditures for public safety

function compared to the total expenses of each state. For this classification was taken as basis the period from 2010 to 2015, obtaining the results presented in Table 5.

Table.5: Percentage of share of costs incurred for the public safety function in the total expenditure of the federal unit  
LINK Excel.Sheet.12

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\* MERGEFORMATX

Position <sup>1</sup> / Federative Unit	2010	2011	2012	2013	2014	2015	Avarage
1º São Paulo	5,5	7,7	5,6	5,2	4,9	5,8	5,8
2º Minas Gerais	13,4 (1º)	13,6 (1º)	9,1	9,4	13,3 (2º)	17,7 (1º)	12,8 (3º)
3º Rio de Janeiro	8	8,4	9,3	10,3	10,2	14 (3º)	10,0
[...]²	-	-	-	-	-	-	-
15º Mato Grosso	9,4	9,8	8	9	8,2	11,2	9,3
16º Paraíba	9,9	10,6	10,4	10,5	9,2	10	10,1

17° Rondônia	13,2 <sup>(2°)</sup>	13,3 <sup>(2°)</sup>	13,6 <sup>(1°)</sup>	13,1 <sup>(2°)</sup>	13,8 <sup>(1°)</sup>	16,1 <sup>(2°)</sup>	13,9 <sup>(1°)</sup>
18° Amazonas	7,2	7,6	8,7	7,8	8,7	9,7	8,3
19° Rio Grande do Norte	7,9	8,2	9,6	7,7	7,4	7,8	8,1
20° Maranhãoas	8,9	7,3	7,6	6,4	8	8,3	7,8
21° Alagoas	13,4 <sup>(1°)</sup>	12,4 <sup>(3°)</sup>	12,3 <sup>(2°)</sup>	14,1 <sup>(1°)</sup>	13 <sup>(3°)</sup>	13,5	13,1 <sup>(2°)</sup>
22° Sergipe	11,7	12,2	11,9 <sup>(3°)</sup>	10,8 <sup>(3°)</sup>	10	11,3	11,3
23° Acre	7,3	7,7	7,7	7,7	7,8	8,7	7,8
24° Tocantins	9,4	10,8	10,1	9,5	7,8	9,1	9,5
25° Piauí	5,2	4,1	3,8	1,4	0,8	3,2	3,1
26° Amapá	9,5	10,6	1	1,2	1,3	11,7	5,9
27° Roraima	6,9	5,9	5,6	4,7	8,8	9,9	7,0

<sup>1</sup> Position in the ranking of the prison population of 27 units.

<sup>2</sup> hidden data not prove significant for analysis of the state of Rondônia.

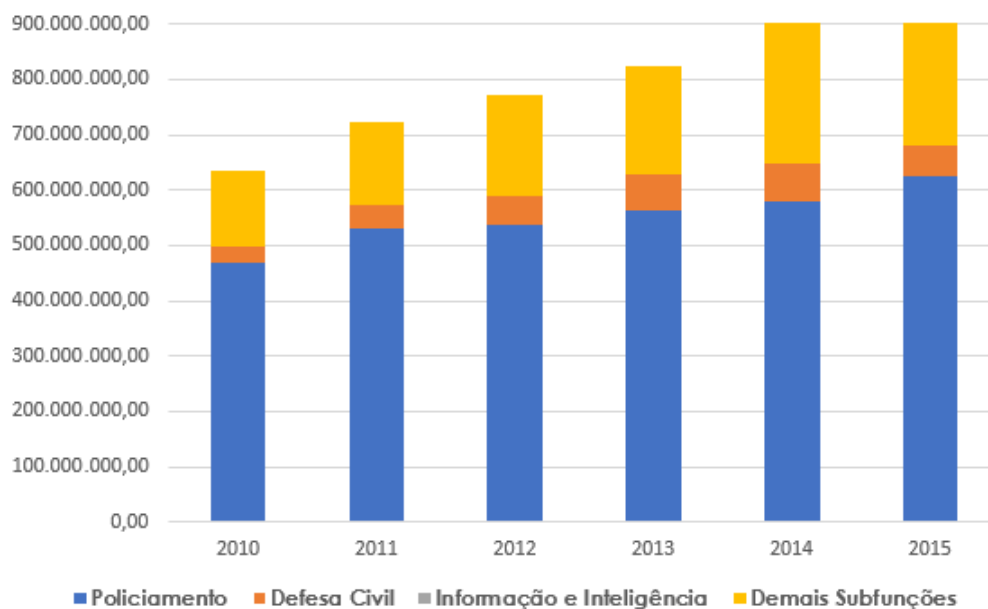
Source: Prepared based on FBSP (2015) (2017);

In Table 5 was highlighted in orange color the highest percentage recorded each year during the period. it makes clear that the hidden data does not hurt the study, since all temporal interval, Rondonia, Alagoas and Minas Gerais disputed the lead with the largest holdings of government revenue dedicated to public safety in this regard have been identified at the top of the data three highest percentages per year and the three highest averages at end of period (1, 2 and 3).

It also points out that the overall assessment made by the analysis of 27 units in the period 2010 to 2015, Rondônia

held in the years 2012 and 2014 the first position and in the years 2010, 2011, 2013 and 2015 the second position. Another significant fact is that the national average for the period (2010-2015) rondonian the state is the leader in this comparative scale with 13.9% of revenue dedicated public safety function, followed by Alagoas occupying the second position (13.1 %) and Minas Gerais (12.8%). Further integrating the research, had classified the type of spending within the public safety function, as shown in Chart 2.

Chart.2:- Expenditure incurred with public safety function in the state of Rondônia by subfunctions



Legends: Policing. Civil defense. Information and Intelligence. Other subfunctions

Source: Prepared based on FSBP (2013) (2015) (2017 ).

For this issue for the highlights the lack of revenue to information and intelligence as well as the gradual increase of investment for the policing sub-function. In this scenario one has to question whether the lack of

investment in intelligence actions justify the high percentage of resources devoted to public security of the state, now that the strengthening of information provision and intelligence is a strategy for the reduction of crime,

enabling deconstitution criminal organizations. This practice is also essential for the police action as it will allow the public security manager to decide how, where and what tools need to promote the protection of society. So we have an inverted spiral where rising crime requires more investment

One has to question even if the decrease in criminal typology trafficking of drugs is not associated with lack of investment in intelligence and information actions, now that generally trafficking is combated with strategic actions since they are organized networks that have financial capital, personnel and military in large proportions.

## V. FINAL CONSIDERATIONS

The research allowed to draw picture of crime in the state of Rondônia, also realizing factors such as investment and population in the analysis. It was found that Rondônia is among Brazilian states, one that dedicates part of their income to totalitarian public safety segment. In general, the Rondonia state invested increasingly in the public security and such application of resources not reflected in the reduction of crime. Add the significant increase in crimes of theft and robbery, characterizing the state as insecure and prevalent in property damage, a fact that disseminates the impediment of power have yet to be allowed to have, it prevents you enjoy. Regarding the relationship of the prison and general population, Rondônia again occupies the top as second state more imprisoned population.

The study showed relevant to detail the crime of the State of Rondônia, as in the national ranking holds the 17th position on the prison population, a factor that first investigation would show little significant, considering states with most populous prison systems. As suggestions to the development of new studies, it is cited rehabilitation as an alternative to fighting crime, this because it acts on the reintegration of the convict into society through education, work and citizenship.

Integrated rehabilitation for development projects and contribute to the reduction of crime, can generate benefits for the implementation of the labor force and productive in the face of reduced government costs. In this perspective, the cost savings would occur by reducing recidivism rates, labor integration prisoner in providing useful services to society and also by the use of goods and services arising from production systems in prisons.

## REFERENCES

[1] BRAZIL. Presidency. (1940). **Decree-Law No. 2848 of December 7, 1940.** Criminal

Code. Brasilia. Available in [www.planalto.gov.br/legislacao](http://www.planalto.gov.br/legislacao).

- [2] \_\_\_\_\_. Presidency. (1941). **Decree-Law No. 3914 of 09 December 1941** introduction of the Penal Code (Decree-Law No. 2,848 / 40) and the Law of Criminal Offenses (Decree-Law No. 3,688 / 41). Brasilia, 1941st. Available in [www.planalto.gov.br/legislacao](http://www.planalto.gov.br/legislacao).
- [3] \_\_\_\_\_. Presidency. (1941). **Decree-Law No. 3,688, of October 03, 1941.** Law of Misdemeanor Criminal. Brasilia, 1941b. Available in [www.planalto.gov.br/legislacao](http://www.planalto.gov.br/legislacao).
- [4] \_\_\_\_\_. Presidency. (1990). **Law No. 8072 of 25 July 1990.** Provides for the heinous crimes under art. 5, item XLIII of the Federal Constitution, and addresses other matters. Brasilia. Available in [www.planalto.gov.br/legislacao](http://www.planalto.gov.br/legislacao).
- [5] \_\_\_\_\_. Presidency. (2006). **Law No. 11.343, of 23 August 2006.** Creates the National System of Public Policies on Drugs - SISNAD; prescribes measures to prevent abuse, attention and social reintegration of drug users and dependents; It sets standards for crackdown on unauthorized production and illicit drug trafficking; defines crimes and other measures. Brasilia. Available in [www.planalto.gov.br/legislacao](http://www.planalto.gov.br/legislacao).
- [6] \_\_\_\_\_. Justice ministry. National Penitentiary Department - Depen. (2014). **National Survey of Information Penitentiary - InfoPen.** Brasilia. Available in [www.planalto.gov.br/legislacao](http://www.planalto.gov.br/legislacao).
- [7] \_\_\_\_\_. Presidency. (2015). **Law No. 13,142, of July 6, 2015.** Changes the arts. 121 and 129 of Decree-Law No 2848 of 7 December 1940 (Penal Code), and art. 1 of Law No. 8,072, of July 25, 1990 (Law of Heinous Crimes). Brasilia. Available in [www.planalto.gov.br/legislacao](http://www.planalto.gov.br/legislacao).
- [8] CALHAU, Lélío Braga. (2009). **Summary of Criminology.** 4. Ed Rio de Janeiro: Impetus.
- [9] CNJ, National Council of Justice. (2018). **CNJ Service: What are heinous crimes?** Available at: <<http://www.cnj.jus.br/noticias/cnj/86048-cnj-servico-o-que-sao-crimes-hediondos>>. Accessed on 20 March 2018.
- [10] FALCONI, Romeu. (1998). **Prison system: social reintegration?** Sao Paulo: Icone.
- [11] FBSP, Brazilian Forum on Public Security. (2013). **Brazilian Yearbook of Public Security in 2012.** Sao Paulo: FBSP.
- [12] \_\_\_\_\_. (2015). **Brazilian Yearbook of Public Security in 2014.** Sao Paulo: FBSP.

- [13] \_\_\_\_\_. (2017). **Brazilian Yearbook of Public Security in 2016**. Sao Paulo: FBSP.
- [14] IBAIXE JR, João. (2010). Prison system: some concepts to understand the statistics. In.: **Revised Final Appeal**. Posted: 15 January 2010. Available at:  
<<http://ultimainstancia.uol.com.br/conteudo/colunas/2765/sistema+prisional+alguns+conceitos+para+compreender+estatisticas.shtml>>. Accessed on 15 January 2017.
- [15] IBGE. Brazilian Institute of Geography and Statistics. (2017). **States@**. Available at:  
<<http://www.ibge.gov.br/estadosat/perfil.php?sigla=m>>. Access: 18 July 2017.
- [16] JULIÃO, Elionardo Fernandes. (2012). **Brazilian penitentiary system: criminal enforcement policy**. Petropolis: In Petus et al; Rio de Janeiro: Faperj.
- [17] LESSA, Sávio Antiógenes Borges; SILVA, Layde Lana Borges da. (2015). Public Safety agencies of the State of Rondônia and combating transnational crimes. In.: **1st International Seminar of Political Science**. State and Democracy in Change in the XXI Century. Porto Alegre: UFRGS, 9 to 11 September 2015.
- [18] PASTORE, José. (2011). **Work for ex-offenders**. São Paulo: Saraiva.
- [19] RONDÔNIA. Secretary of State for Security, Defense and Citizenship. (2017). **Quantitative Events Monthly 2016/2017**. Publications. Statistics. Available at:  
<<http://www.rondonia.ro.gov.br/sesdec/publicacoes/estatisticas/>>. Access: 19 July 2017.
- [20] SILVA, André Luiz Augusto da. (2014). **Retribution and history: for a critique of the Brazilian penitentiary system**. Rio de Janeiro: Lumen Juris.

# Reference Model in BPMN Notation for a Production Scheduling System

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**Abstract** — Companies are progressively investing in practices aimed at improving the quality of management, with the main purpose of enabling them to operate competitively in the present market. For this, it is necessary to document the activities and information of the existing business processes in the organization, aiming at reducing time and cost in the elaboration of the particular model. In this context, the objective of this work is to develop a reference model of the Production Scheduling (PS) processes, an important module of production planning and control (PPC). The research methodology used in this work was divided into the following stages: study of PS and business process modeling, definition of reference model processes, choice of methodology and process modeling tool, development of reference model and prototype of the software and, finally, analysis of results. The modeling notation used was the BPMN, since it is considered a standard language in the field of process modeling. The prototype was developed through the Delphi interface in order to apply the model to support the implementation of business management programs. As results, from a formal documentation, the model proved to be a useful mechanism in the understanding of the processes raised and appropriate in the support to the implantation of production management tools.

**Keywords** — Reference Model. Production Planning and Control. Production Scheduling. BPMN.

## I. INTRODUCTION

Organizations are progressively investing in business quality practices such as reengineering processes, adoption of an integrated management system (ERP), ISO certifications, lean production, costing by activities, among others. However, most of the high-investment and long-term investment actions, for example, in the adoption of ERP (BREMER; LENZA, 2000; CORREA; SPINOLA, 2015).

Quality management and process management units that are carried out, which are raised and documented Existing Business Processes in the organization.

However, a business process modeling activity is still not a common issue among organizations (THURER; FILHO, 2012), which is responsible for increasing the cost and time of implementation of the system or projects to improve the development of new models related to Business Processes (BREMER; LENZA, 2000). As a company already had a reference model, this activity would not be necessary. According to Scheer (2000), case studies using reference models can reduce the cost and pace of deployment of organizational projects by up to 30%.

In the business context, Business Processes are important for the expansion process, such as Brazil, where production activities are more pronounced than product development, and Production Planning and Control (PPC). This process is done by surveying demand, planning production, planning capacity, producing

materials, scheduling production, etc. (FERNANDES; GODINHO FILHO, 2010; MUKHOPADHYA Y, 2013).

The basic exercises of the PPC hierarchy, related to Material Planning, are the Production Scheduling (PS). PS is an important decision-making process in a PPC system, widely used in industrial production, management and computing (SETHY; BEHERA, 2017). The PS aims to distribute the tasks to the resources over time, in order to meet all agreed deadlines at an acceptable cost (SILVA; MORABITO; YAMASHITA, 2014).

According to Thurer & Filho (2012), most companies, especially small and medium-sized companies, have a science that their PPC activities can be closed and that "processing time" and "work in progress" higher operating energy. However, the authors, as they simply do not know how to do this, are a vast majority of research and solutions for the PPC is focused on large and complex companies.

Therefore, it is important and growing attention, both the academic environment and not to undertake, there is no development of models that support any planning of entrepreneurial resources (CORREA; SPINOLA, 2015). However, these studies were designed to investigate PPC models and are mostly focused on industrial purposes and that address modules of specific production management activities.

In order to become companies, especially small and medium enterprises, in the development and implementation of business management actions, the present work aims to develop a reference model that addresses the related Business Processes as PS activities. In addition, this work also aims to develop a software prototype through the Delphi interface (Object-Pascal language), in order to apply the reference model to support the implementation of business management systems.

The article is organized as follows: a section 2 addresses a literature review on model reference and PS; a section 3 presents the methodological procedures used in this study; a section 4 presents results obtained; and finally a section 5 presents as final endings.

## II. LITERATURE REVIEW

### 2.1 REFERENCE MODEL

Reference modeling is defined as the process of formally documenting a problematic domain in order to understand and communicate stakeholders (SIAU, 2004; SIAU; ROSSI, 2011).

The reference models, which can be developed in real situations or in theoretical studies, document the various aspects of a business process (BREMER; LENZA, 2000). According to Scheer (2000), one can distinguish between procedural models or standard software implementation,

and business models such as models for production management and product development.

According Vernadat (1996), a reference model must contain a certain degree of generality and be customizable. Therefore, it should serve as a basis for discussion, a formal or semiformal suggestion for the elaboration of specific models, bringing information regarding the design of a business process. Keller & Teufel (1998) understand that reference models can be applied in cases of accumulated experience in a business type, and in business process solutions implemented and executed in business management software.

Vojislav & Leon (2000) propose that choosing the right reference models helps to minimize possible errors in the early stages of modeling and deploying management systems. This allows the design of a process or system to begin with the appropriate choice of requirements and with the establishment of appropriate characteristics given by the reference model.

According to Bremer & Lenza (2000), the objective of the reference model is to provide the company with an initial solution for its Business Processes, so that, through this, the particular model of the company can be specified and detailed. According to Climent, Mula & Hernández (2009), reference models are useful in the description and graphical representation of the important aspects of a particular process, distinguishing, for example, people, departments and the connection between them. Additionally, Vergidis, Turner, & Tiwari (2008) models adequately portray and represent processes, emphasizing those aspects that need to be communicated and addressed.

Bolloju & Leung (2006) suggest that during the analysis phase of an information system development, the conceptual model can be used to capture and represent the development and deployment requirements of such technologies. For Scheer (2000), the use of reference models can reduce the cost and time of implementation of organizational projects, for example in the adoption of ERP.

In a review elaborated by Hernandez, Mula & Ferriols (2008), it was proposed that a reference model describe the social and physical aspects of the world in order to understand and communicate. In addition, it was also described that the reference model should go beyond the terms "specifications" and "requirements" and apply three linguistic concepts (syntax, semantics and pragmatics) to four aspects of modeling: language, domain, model and participants.

In summary, according to Vernadat (2003), the advantages of adopting reference models are to reduce time and cost in the development of the particular model; comparing the activities of the company with the

activities proposed in the model, that is, best practices; and better support in deploying integrated enterprise management systems.

The model to be developed in this work will give greater emphasis to the information and activities that compose the PPC process, because its main objective is support in the implementation of organizational improvements, such as business management systems (Figure 1).

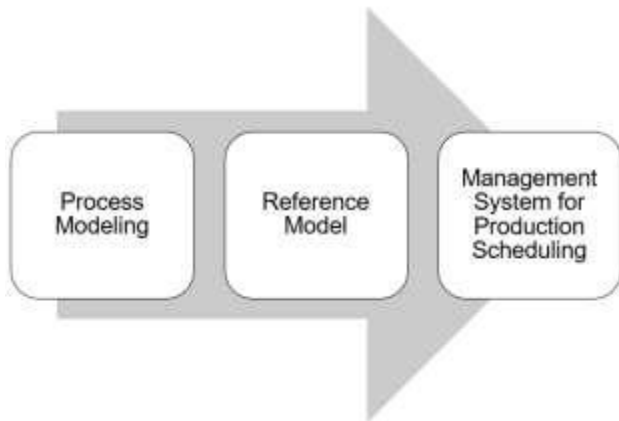


Fig. 1: Process of elaboration of the reference model

## 2.2 PRODUCTION SCHEDULING

Production Scheduling is an important decision-making process in a PPC system, widely used in industrial production, management and computing (SETHY; BEHERA, 2017). This process seeks to define (PLITSOS et al., 2017):

- i. What productive tasks to perform (or orders / work instructions);
- ii. Where to process the production tasks and in what sequence; and
- iii. When to carry out productive activities.

Usually, these decisions are strongly coupled and, ideally, are taken simultaneously (HARJUNKOSKI et al., 2014). The PS aims to distribute the tasks to the resources over time, in order to meet all agreed deadlines at an acceptable cost (SILVA; MORABITO; YAMASHITA, 2014). Its level of aggregation of information is about product components and its planning horizon is very short term, usually in weeks, in productive environments with a great mix of products and many alternatives of roadmaps (GLACON; MESQUITA, 2011). In this scenario, companies, through tools that can assist them in this task, seek to increase productivity, reduce inventories, reduce costs and achieve greater flexibility.

In addition, Muthiah & Rajkumar (2017) affirm that the objectives of the Production Schedule are:

- iv. Deliver the products on the agreed date;
- v. Minimize stock in process;
- vi. Decrease delivery time;
- vii. Minimize the use of resources; and

- viii. Maximize operational efficiency.

For Sethy & Behera (2017), PS is a typically operational activity, which can reduce costs and material handling time by optimizing the procedure. Its scope is restricted in the time horizon, contemplating from hours to a few weeks, due to the dynamism in the production environment (LUSTOSA; MESQUITA; OLIVEIRA, 2008). Thus, developing good programming for particular production order sets can help the organization to effectively control workflows and provide solutions for job sequencing (SETHY, BEHERA, 2017).

Several classic formulations and different approximate methods have been used to address the problems of production scheduling in various industrial contexts, such as in the beverage industry (FERREIRA; ALMADA-LOBO; MORABITO, 2013); in the animal nutrition industry (AUGUSTO; ALEM; TOSO, 2016); in the packaging industry (MARTÍNEZ et al., 2016); in the metalworking industry (LOEBLEIN et al., 2013); in the textile industry (RAYMUNDO; GONÇALVES; RIBEIRO, 2015); among others.

Silva, Morabito & Yamashita (2014) carried out a study of a practical case of production scheduling in the aeronautical industry. The computational experiments showed that there is potential for productivity gains when using these models to optimize the assembly schedule. Compared with company practice, the results indicate that it is possible to reduce labor costs by up to 30%, without significantly jeopardizing compliance with the established deadlines

It is worth noting that, depending on the complexity of the production system, the area of production management or operation management will have greater difficulty in managing it (FUCHIGAMI et al., 2015). Thus, the internal performance of an industry, in turn, conditions the external performance of the company (that perceived by the customer).

Plitsos et al., (2017) point out that due to the complexity and the increase in production volumes, decisions taken from PS can not be approached without automated optimization support. This functionality is generally considered part of a Manufacturing Execution System (MES) and is usually supported by an ERP system (HARJUNKOSKI et al., 2014), usually of high cost mainly for small and medium enterprises.

Novas & Henning (2010), in a review of existing knowledge-based techniques for Production Scheduling, have found that the inherent presence of uncertainties on the shop floor creates the need to constantly adjust schedules through operational control.

Thus, Framinan & Ruiz (2010), to address this problem, affirm that these systems should include support for a series of activities, such as: monitoring and execution of

planned schedules; accurate representation of the shop floor model, including all of its restrictions; use of adequate techniques to solve the problem of generation of schedule, that is, the algorithm; assessment of the proposed solution, which should satisfy all possible constraints; ability to be reactive and respond to events that could prevent the completion or feasibility of the schedule; capacity analysis; and ability to integrate with various existing information systems within the company. Therefore, PS is in practice a dynamic activity in which information gathering and constant monitoring occur before and during the generation and execution of the schedule (ROMERO-SILVA; SANTOS; HURTADO, 2015).

Priority rules, also known as sequencing rules, are extremely important procedures in practice. They are technically simple, easy to understand and require little effort to be applied. Generally, the use of priority rules is sufficient for programming in multiple production

environments. Moreover, such rules are easy to code in modern programming languages and their calculations are quite fast (Fuchigami et al., 2015). For some specific problems, these rules generate optimal solutions, but in general, they are heuristic methods that in their simplicity do not guarantee the complete optimization of the PS problem (LUSTOSA; MESQUITA; OLIVEIRA, 2008)

The need to define a sequence of tasks is most evident in pushed production systems, where predetermined criteria are used to issue purchase, manufacturing and assembly orders. In the pull systems, kanbans are usually implemented to manage production (FUCHIGAMI et al., 2015). For these reasons, research with priority rules for such complex production scheduling problems is an important topic and requires careful attention.

Table 1 presents some of the more usual rules. It is worth remembering that in the attempt to obtain better results inside the factory floor, it is possible to apply more than one rule simultaneously.

Table 1: Common rules for task sequencing.

Initial	Specification	Description	Priority of Production Orders
FIFO	First in first out	On the same order of arrival on the machine.	Priority to orders that will arrive first. It seeks to minimize the variance of the machine's dwell time.
LIFO	Last in first out	In the reverse order of arrival of the machine.	Priority to orders that will arrive last. It seeks to minimize the variance of the machine's dwell time.
LPT	Lower manufacturing/ processing time	In increasing order of processing time in the resource.	Priority to orders of shorter time, leading to reduced queues and increased flow.
LDD	Lowest delivery date	In ascending order in promised delivery period.	Priority to the most urgent orders, aiming to reduce arrears.
LTO	Less time off	In ascending order of clearances (promised date less total processing time).	Priority to the most urgent orders, aiming to reduce arrears.

It should be noted that the Gantt Chart is widely used for the graphical representation of a schedule of tasks to be performed in a previously established period of time. It is used to represent several types of tasks, such as a production program, an event planning or the stages of a project (LORENZI et al., 2015).

This graph consists of a graph where the rows represent the tasks to be performed and the columns the execution time of the tasks. They usually also provide other information such as: who or where each operation will be performed, total and partial operation time, critical process points, follow-up lines, etc.

### III. RESEARCH METHODOLOGY

#### 3.1 DEFINING THE SEARCH METHOD

The reference model was developed from theoretical studies. Thus, this research uses the procedures of

bibliographic research, since it was developed from previous works such as dissertations, articles and books on the subject matter. In this way, the future work can be based on the conclusions presented in this article, and elaborate hypotheses aiming to deepen the study on the subject or related specific aspects.

On the other hand, this research can also be classified as experimental, since it is based on the creation of a reference model of a PS system, modeled through software. Thus, with the objective of developing a reference model and exposing the way it was developed from the analysis of the activities involved in the processes, allow this work to be classified as a descriptive research.

#### 3.2 SCOPE OF RESEARCH

The phase of process identification and hierarchization



levels is considered the key step in process modeling, aiming to identify all existing Business Processes in a particular activity of an organization.

Figure 2 presents the model of the PPC Process hierarchy relating the planning of the capacity of its resources with the planning of the needs of its materials. The hierarchical decomposition of the PPC function starts from understanding the basic concepts related to material planning levels, namely: Sales & Operations Planning (S&OP) and Aggregate Planning (AP); Master Production

Planning (MPS); Material Requirements Planning (MRP) and Production Scheduling (PS) (CORRÊA; CORRÊA, 2012; MUKHOPADHYAY, 2013). This work will be limited in the development of the PS reference model and its respective capacity planning. The modules of the Production Planning and Control function related to Capacity Planning are Resource Requirements Planning (RRP), Rough Cut Capacity Planning (RCCP) and Capacity Requirements Planning (CRP).

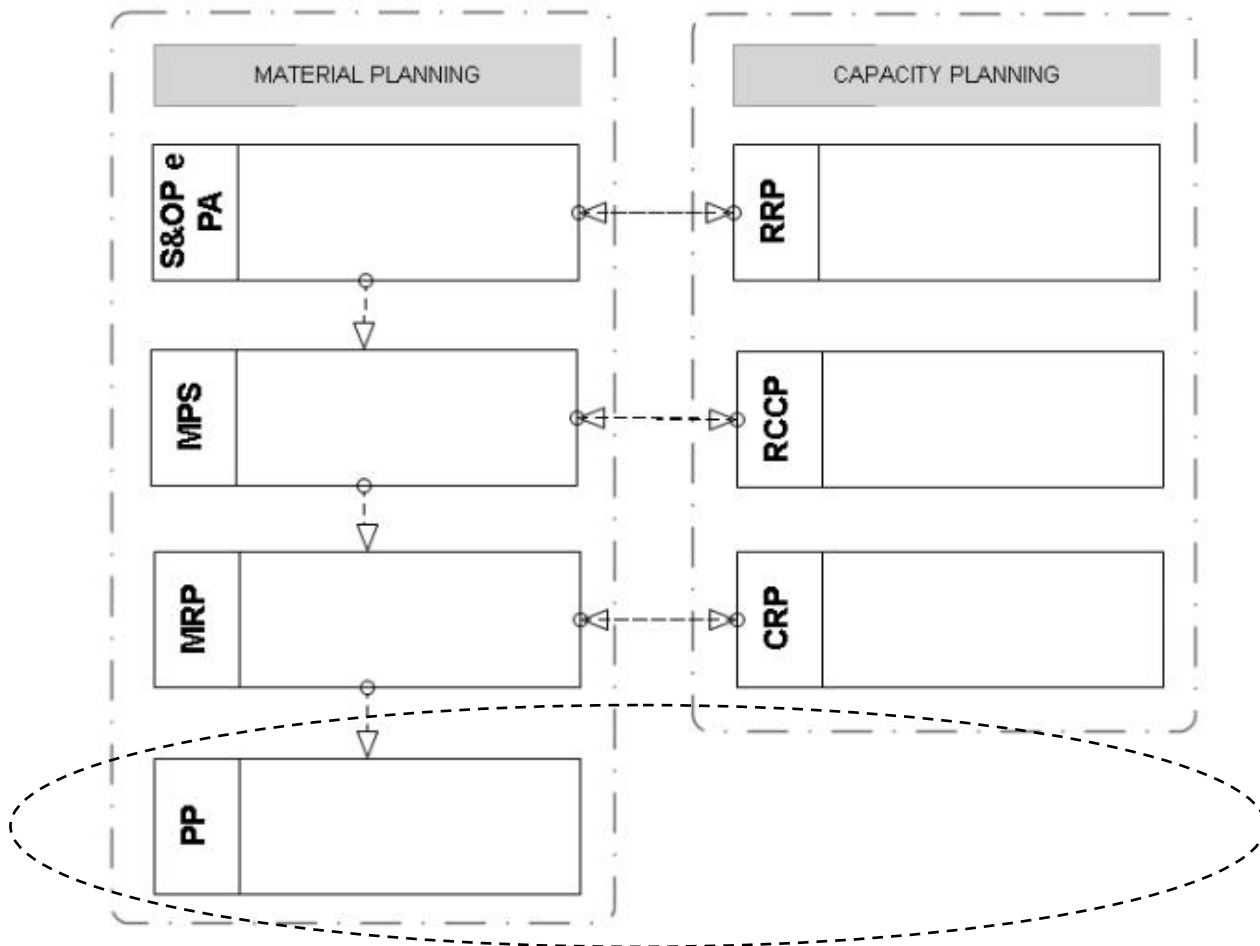


Fig..2: Hierarchy of production planning and control

### 3.3 STAGES OF THE RESEARCH METHODOLOGY

The methodology used for the elaboration of this work was divided into eight sequential stages, as shown in Figure 3.

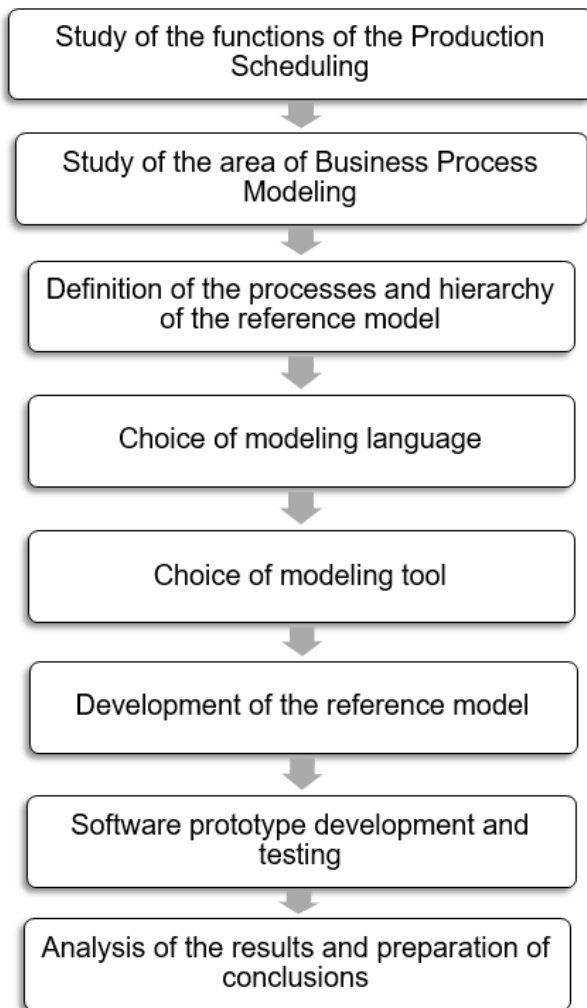


Fig. 3: Stages of the research methodology

- *Step I* - Study of Production Planning and Control Functions: In this stage, according to bibliographical references related to the topic of study, concepts, activities and information and functions of a typical production planning hierarchy were raised and studied;
- *Step II* - Study of the Business Process Modeling area: In the second stage, the concepts and languages regarding process modeling, as well as reference models, were studied and analyzed from the scientific literature;
- *Step III* - Definition of the processes and hierarchy of the reference model: In this third step, after the phases of the bibliographic review, the processes and hierarchy that will make up the reference model of a PPC system were defined;
- *Step IV* - Choice of the modeling language: In this fourth stage, the modeling language used for the development of the reference model was defined. The modeling notation selected was BPMN;
- *Step V* - Choice of the modeling tool: In this step, the

modeling tool was defined, in order to provide facilities in the understanding and visualization of the model, that is, the full understanding of the functions of a system. The modeling tool selected was Bizagi Process Modeler version 3.1.0.011;

- *Step VI* - Development of the reference model: In this step, based on the language and defined modeling tools, the reference model of a PPC system was developed based on BPMN theory and notation;
- *Stage VII* - Development of application software and tests: In the seventh stage, once the reference model of the PPC system was elaborated, a software prototype was developed with the purpose of applying and validating the model, from the Delphi version interface 7.0, which used the Object-Pascal language;
- *Step VIII* - Analysis of the results obtained and conclusions drawn: In the last step, the results presented in the previous phases were analyzed and discussed, as well as the conclusions obtained and suggestions for future work

#### IV. RESULTS AND DISCUSSION

##### 4.1 PS MODELING

PS is a typically operational activity that aims to reduce material handling time by optimizing the procedure, and consequently reduces costs. In this way, it seeks to deliver the final product at the right time, minimizing delivery delays to the maximum. Its scope is restricted in the horizon of very short time, contemplating from hours to few weeks, due to the dynamism in the production environment. As the orders arrive at the same time in the work centers, decisions about the sequence in which they will be executed become very important. The input and output information needed to construct the reference model of the PS module are shown in Table 2.

Table 2: PS information

Input	Output
Material Requirements Plan	Production Sequencing
Very short-term planning period	End time of production
Production time of components	Production delay time
Delivery time of components	Gantt Chart
Production sequencing rules	Production scheduling

The activities related to this module of the PS are presented, with their respective theoretical references, in Table 3.

Table 3: Sequence of PS activities

#	Activity	Theoretical Framework
1	Product definition and production scheduling component, as specified in MRP.	Corrêa e Corrêa (2012).
2	Definition of the short-term planning period of production scheduling.	Corrêa e Corrêa (2012), Giacom e Mesquita (2011) e Lustosa, Mesquita e Oliveira (2008).
3	Calculation of the production time of each component or product, according to the required capacity specified in the MRP.	Muthiah e Rajkumar (2017) e Tubino (2007).
4	Definition of the delivery time of each component or product.	
5	Sequencing the components or products in the production line according to the adopted rule.	Framinan e Ruiz (2010), Lustosa, Mesquita e Oliveira (2008) e Tubino (2007).
6	Calculation of the final production times for each sequencing rule.	Muthiah e Rajkumar (2017), Sethy e Behera (2017) e Silva, Morabito e Yamashita (2014).
7	Calculation of production delays for each sequencing rule.	
8	Select the sequencing method according to company objectives.	Lustosa, Mesquita e Oliveira (2008), Tubino (2007) e Metaxiotis, Psarras e Ergazakis (2003).
9	Elaboration of the Gantt chart and emission of the production schedule.	Plitsos et al. (2017), Sethy e Behera (2017), Lorenzi et al. (2015), Silva, Morabito e Yamashita (2014) e Framinan e Ruiz (2010).

The reference model for the Production Scheduling module proposed firstly identifies the components of the final products specified in the MRP stage.

Then, according to the proposed model, the definition of the planning period (very short term) is carried out, and this period must come from the period that was established in the material requirements plan.

From the computation of the necessary capacity calculated in the planning stage prior to this, the production time of each of the components relating to a final product is calculated, which includes the final assembly of the product. Likewise, from the installed capacity specified in MRP, the final delivery time of these components is defined.

Once the production and delivery time of each of the components is defined, possible production schedules are performed according to each sequencing rule adopted by the organization. In this model, the following rules were specified: FIFO, LIFO, LPT, LDD and LTO. For the definition of the LDD sequencing, it is necessary to calculate the clearance times before this step.

For each production sequence established according to the rules, the final production time and the total production delay time are calculated, with the purpose of supporting the decision making of the best production-sequencing rule to be adopted by the organization.

After selecting the sequencing method, the Gantt chart is drawn. Then the production schedule is issued, thus finalizing this last stage of the planning.

The reference model, in BPMN notation, referring to the PS module is shown in Figure 4.

#### 4.2 SOFTWARE PROTOTYPE

After the elaboration of the production planning system module for PS, a software prototype was developed through the Delphi interface, with the intention of generating a greater consistency between the abstraction of the reference model and its application in the support of implementation and development of enterprise management tools, a software prototype was developed through the Delphi interface.

The first screen of the prototype for PS is being shown in Figure 5.

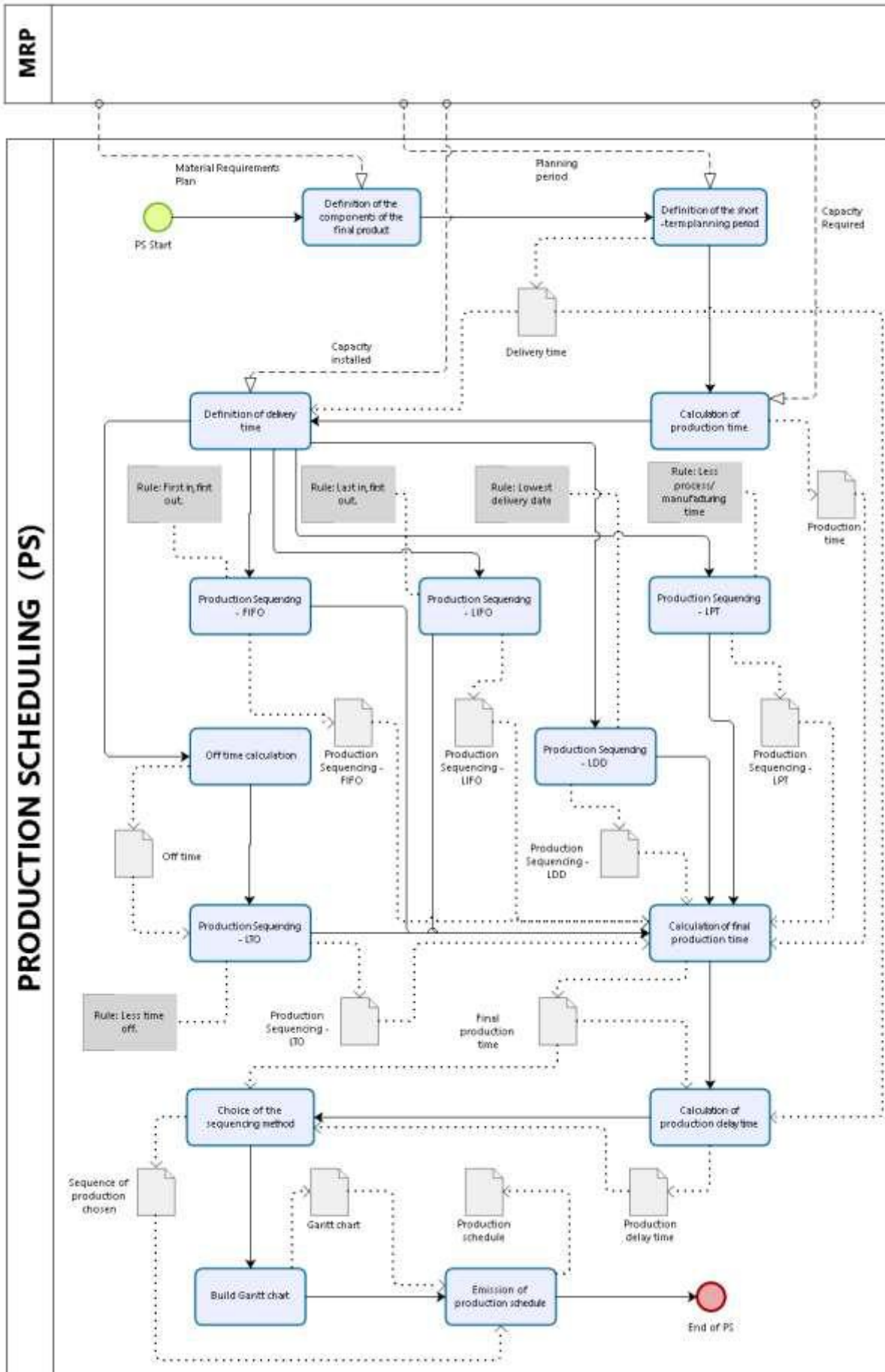


Fig. 5: Modeling of MRP in BPMN notation

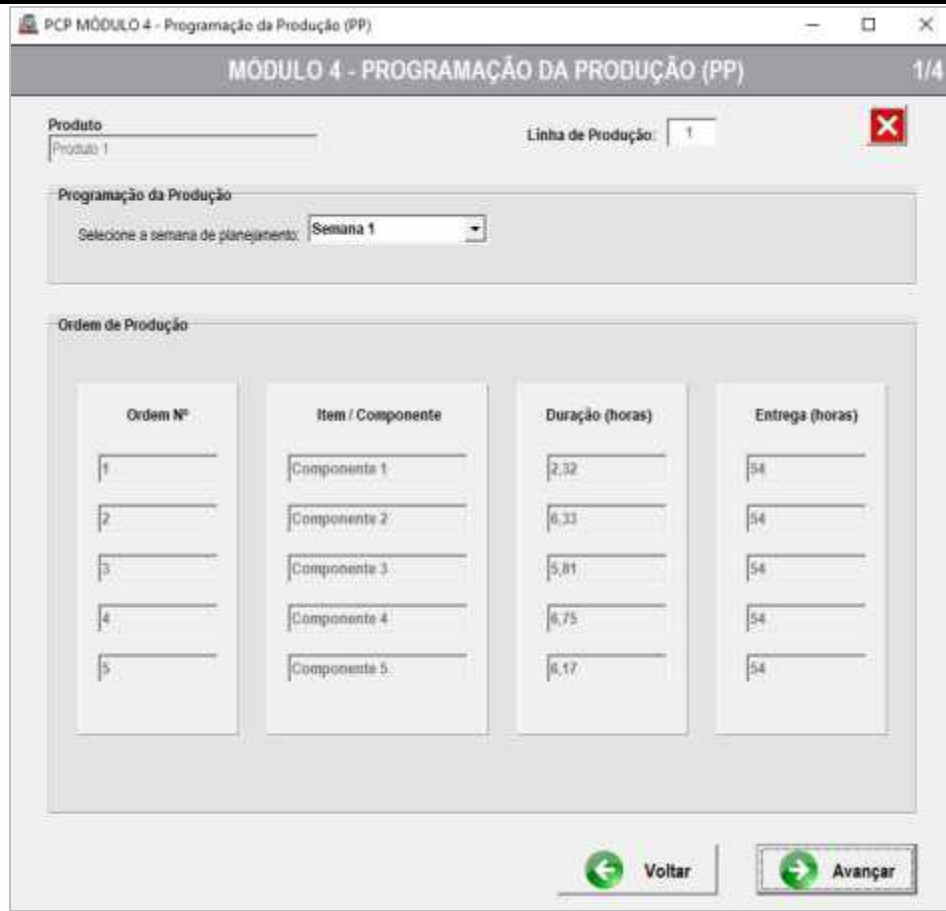


Fig. 5: First screen of PPC software prototype of PS module.

In the developed software, one must choose the week of production scheduling (very short term planning) of the components and the final product that was selected in the MRP stage. As a limitation in the development of the software prototype, in order to facilitate programming, only 1 production line was pre-established.

In the first screen (Figure 6), the production orders, identified by numbers and component names, are also shown, as well as the production duration and delivery time in hours.

When you click on forward, the calculations of the total manufacturing time and delivery delay for each of the sequencing rules are started.

In the second screen the results of the calculation of the total manufacturing time and delivery delay for the FIFO and LIFO sequencing rules are displayed.

In the third screen (Figure 7) the results of the calculation of the total manufacturing time and delivery delay for the LPT e LDD sequencing rules are displayed. From the

form table, as in the previous screen, the calculations of the total manufacturing time and delivery delay are also exposed.

In the fourth and last screen of the prototype PPC software for the PS module is shown in Figure 8. For the sequencing of the production orders of the components for the LTO rule, it is necessary to calculate the time off, in hours, in order to order them more and more.

In order to assist the user in choosing the best sequencing rule for production scheduling, a graph comparing total manufacturing times and total delays is presented in the fourth screen of the PPC prototype of the PS module. With this, the user must select the desired sequencing, according to the company's goals and strategies, to create the Gantt chart for a better visualization of the schedule. Figure 9 shows the prototype screen of the PPC software with the Gantt chart for the PS module.

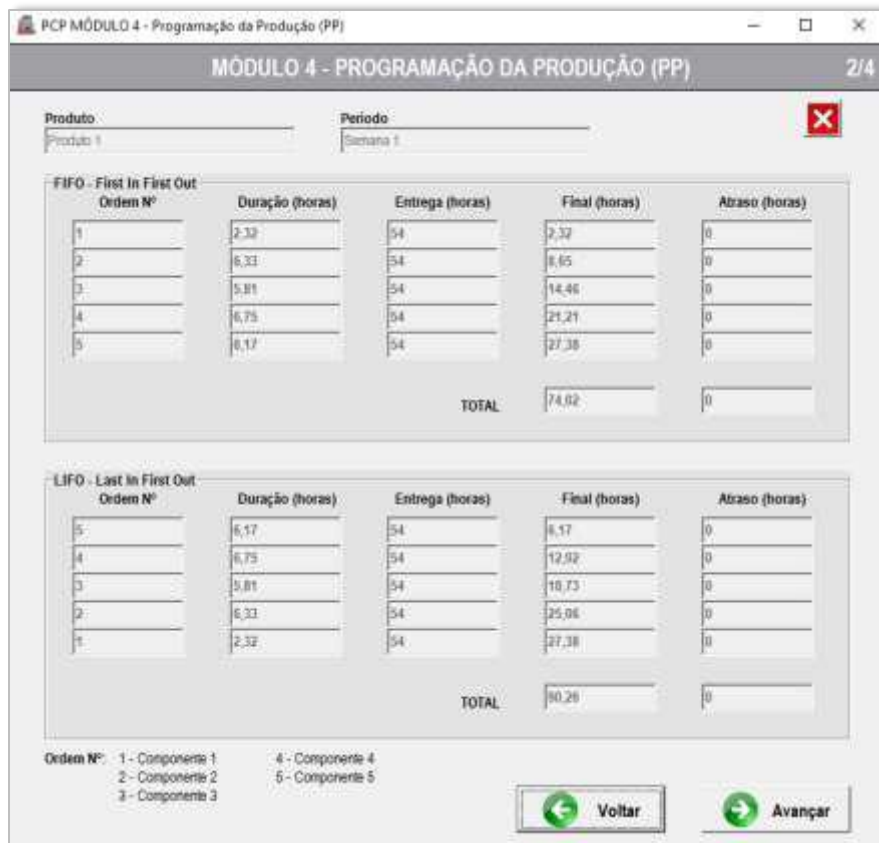


Fig. 6: Second screen of PPC software prototype of PS module.

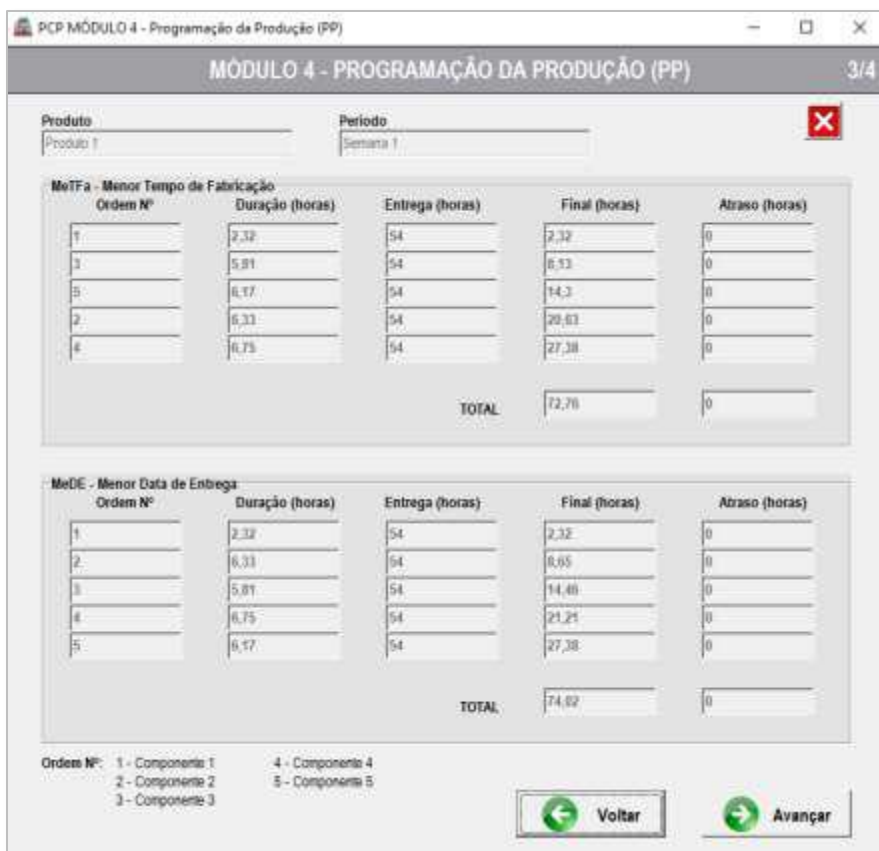


Fig. 7: Third screen of PPC software prototype of PS module.



Fig. 7: Fourth screen of PPC software prototype of PS module.

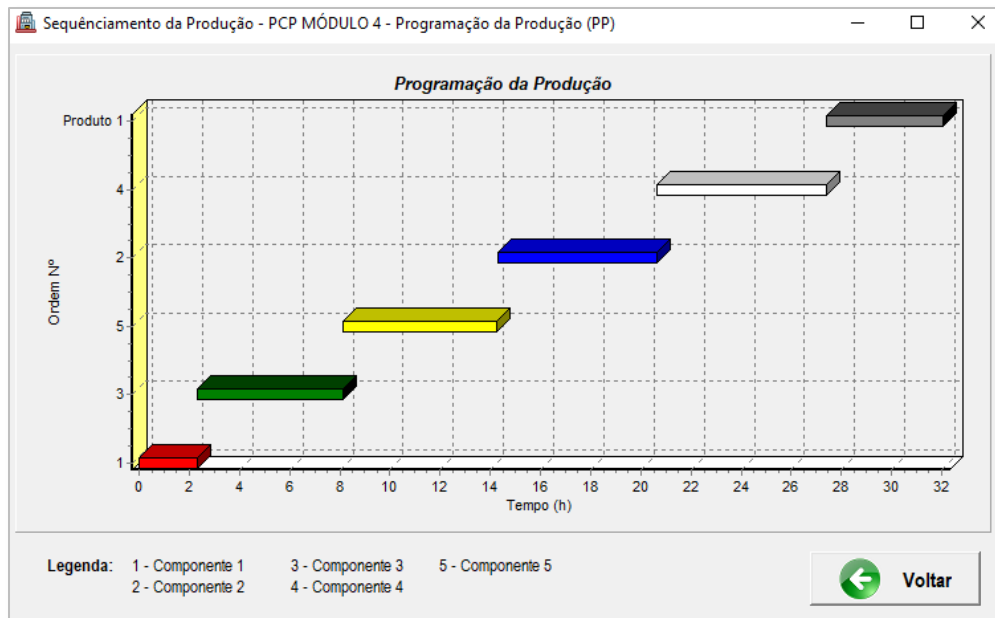


Fig. 8: Screen of the PCP software prototype with the Gantt chart for the PS module.

In order to validate the software prototype, several tests were carried out, with different planning scenarios and production strategies, in order to verify the activities, information, accuracy and precision of the calculations used to prepare the final master plan. The results obtained by the computational program were

compared with the results extracted manually and in electronic spreadsheets. Thus, the software prototype developed from the developed reference model proved to be reliable and apt to be used for the preparation of production material requirements plans.

## V. CONCLUSION

Currently, we are seeing increasing attention in the support to the development and implementation of actions of improvements of the business management. However, most research and solutions for production planning are focused on large and complex organizations, highlighting an academic gap regarding work to support the implementation of management systems, especially for small and medium-sized enterprises. Therefore, the reference model developed in this work may provide these companies with an initial solution for their business processes, in order to specify and detail the particular model with a reduction in cost and implementation time.

Thus, this work sought the development of a reference model, in BPMN notation, that addresses the business processes related to PS, one of the modules inherent in the PPC. In addition, we also aimed to develop a software prototype with the aim of applying this model in systems and management tools.

As a result, from a formal documentation, the reference model proved to be a useful tool in understanding and communicating the existing processes in PS. It was also verified that this developed model is able to support the implantation of production management systems in real situations. However, for use in corporate environments, such as ERP adoption, these processes should receive the expertise and the users should have knowledge of the terms and variables involved in the reference model.

It is worth mentioning that the reference model has been configured as an important tool for knowledge management, since it is capable of storing and documenting existing knowledge in the business processes and serves as a basis for planning the development of new knowledge, always being guided by the strategic objectives of the company.

As a continuation of this work, a model is being developed that approaches in a holistic and hierarchical way the other modules of the Business Processes related to the PPC. Thus, this reference model seeks to fill gaps in the scientific literature and to advance in relation to international models, since there is a lack of work on reference models for the activities of the PPC.

For the purposes of validation and evaluation, it is suggested the dissemination and application of the software, developed from the reference model, in small and medium-sized enterprises with activities focused on production planning.

## REFERENCES

- [1] AUGUSTO, D. B.; ALEM, D.; TOSO, E. A. V. Planejamento agregado na indústria de nutrição animal sob incertezas. *Production*, v. 26, n. 1, p. 12–27, mar. 2016.
- [2] BOLLOJU, N.; LEUNG, F. S. K. Assisting Novice Analysts in Developing Quality Conceptual Models with UML. *Commun. ACM*, v. 49, n. 7, p. 108–112, jul. 2006.
- [3] BREMER, C. F.; LENZA, R. DE P. A reference model for production management in assembly to order: ato production systems and its multiple applications. *Gestão & Produção*, v. 7, n. 3, p. 269–282, dez. 2000.
- [4] CLIMENT, C.; MULA, J.; HERNÁNDEZ, J. E. Improving the business processes of a bank. *Business Process Management Journal*, v. 15, n. 2, p. 201–224, 17 abr. 2009.
- [5] CORRÊA, H. L.; CORRÊA, C. A. Administração de produção e operações: manufatura e serviços - Uma abordagem estratégica. 2. ed. São Paulo: Atlas, 2012.
- [6] CORREA, J.; SPINOLA, M. DE M. Adoção, seleção e implantação de um ERP livre. *Production*, v. 25, n. 4, p. 956–970, dez. 2015.
- [7] FERNANDES, F. C. F.; GODINHO FILHO, M. Planejamento e controle da produção: dos fundamentos ao essencial. São Paulo: Atlas, 2010.
- [8] FERREIRA, D.; ALMADA-LOBO, B.; MORABITO, R. Formulações monoestágio para o problema de programação da produção de bebidas dois estágios com sincronia. *Production*, v. 23, n. 1, p. 107–119, mar. 2013.
- [9] FRAMINAN, J. M.; RUIZ, R. Architecture of manufacturing scheduling systems: Literature review and an integrated proposal. *European Journal of Operational Research*, v. 205, n. 2, p. 237–246, 1 set. 2010.
- [10] FUCHIGAMI, H. Y. et al. New priority rules for the flexible flow line scheduling problem with setup times. *Production*, v. 25, n. 4, p. 779–790, dez. 2015.
- [11] GIACON, E.; MESQUITA, M. A. DE. Levantamento das práticas de programação detalhada da produção: um survey na indústria paulista. *Gestão & Produção*, v. 18, n. 3, p. 487–498, 2011.
- [12] HARJUNKOSKI, I. et al. Scope for industrial applications of production scheduling models and solution methods. *Computers & Chemical Engineering*, v. 62, n. Supplement C, p. 161–193, 5 mar. 2014.
- [13] HERNANDEZ, J. E.; MULA, J.; FERRIOLS, F. J. A reference model for conceptual modelling of production planning processes. *Production Planning and Control*, v. 19, n. 8, p. 725–734, 2008.
- [14] KELLER, G.; TEUFEL, T. SAP R/3 process-oriented implementation: iterative process prototyping. Harlow, England; Reading, Ma: Addison Wesley Longman, 1998.



- [15] LOEBLEIN, L. C. et al. Aplicação da Programação Linear para Minimização de Perdas em Indústria Metal Mecânica. *Revista Gestão Industrial*, v. 8, n. 4, 8 fev. 2013.
- [16] LORENZI, R. S. et al. Utilização de Gráfico de Gantt para a Programação da Produção. *Revista Global Manager*, v. 15, n. 1, p. 55–68, 22 set. 2015.
- [17] LUSTOSA, L. J.; MESQUITA, M. A. DE; OLIVEIRA, R. J. DE. *Planejamento e controle da produção*. 1. ed. [s.l.] Elsevier, 2008.
- [18] MARTINEZ-OLVERA, C. Reference model of the manufacturing execution activity in make-to-order environments. *International Journal of Production Research*, v. 47, n. 6, p. 1635–1659, 2009.
- [19] METAXIOTIS, K. S.; PSARRAS, J. E.; ERGAZAKIS, K. A. Production scheduling in ERP systems: An AI-based approach to face the gap. *Business Process Management Journal*, v. 9, n. 2, p. 221–247, abr. 2003.
- [20] MUKHOPADHYAY, S. K. *Production planning and control: text and cases*. 2. ed ed. Delhi: PHI Learning, 2013.
- [21] MUTHIAH, A.; RAJKUMAR, R. Scheduling problem solving using genetic and greedy algorithms. *International Journal of Computer Aided Engineering and Technology*, v. 9, n. 2, p. 207, 2017.
- [22] NOVAS, J. M.; HENNING, G. P. Reactive scheduling framework based on domain knowledge and constraint programming. *Computers & Chemical Engineering*, 10th International Symposium on Process Systems Engineering, Salvador, Bahia, Brasil, 16-20 August 2009. v. 34, n. 12, p. 2129–2148, 9 dez. 2010.
- [23] PLITSOS, S. et al. Energy-aware decision support for production scheduling. *Decision Support Systems*, v. 93, n. Supplement C, p. 88–97, 1 jan. 2017.
- [24] RAYMUNDO, E. A.; GONÇALVES, L. W. N.; RIBEIRO, N. S. Pesquisa Operacional na Tomada de Decisão: Modelo de Otimização de Produção e Maximização do Lucro. *Journal of Management & Technology*, v. 3, n. 1, 20 abr. 2015.
- [25] ROMERO-SILVA, R.; SANTOS, J.; HURTADO, M. A framework for studying practical production scheduling. *Production Planning & Control*, v. 26, n. 6, p. 438–450, 26 abr. 2015.
- [26] SCHEER, A.-W. *ARIS - Business Process Frameworks*. 3. ed. Berlin, Heidelberg: Springer Berlin Heidelberg, 2000.
- [27] SETHY, N. K.; BEHERA, D. K. Intelligent production scheduling a case study. *International Journal of Mechanical Engineering and Technology*, v. 8, n. 2, p. 283–298, 2017.
- [28] SIAU, K. Informational and Computational Equivalence in Comparing Information Modeling Methods. *Journal of Database Management (JDM)*, v. 15, n. 1, p. 73–86, 1 jan. 2004.
- [29] SIAU, K.; ROSSI, M. Evaluation techniques for systems analysis and design modelling methods – a review and comparative analysis. *Information Systems Journal*, v. 21, n. 3, p. 249–268, 1 maio 2011.
- [30] SILVA, B. J. V. DA; MORABITO, R.; YAMASHITA, D. S. Otimização na programação de montagens na indústria aeronáutica. *Gestão & Produção*, v. 21, n. 1, p. 33–44, mar. 2014.
- [31] THURER, M.; FILHO, M. G. Redução do lead time e entregas no prazo em pequenas e médias empresas que fabricam sob encomenda: a abordagem Worload Control (WLC) para o Planejamento e Controle da Produção (PCP). *Gestão & Produção*, v. 19, 2012.
- [32] TUBINO, D. F. *Planejamento e controle da produção teoria e prática*. São Paulo: Atlas, 2007.
- [33] VERGIDIS, K.; TURNER, C. J.; TIWARI, A. Business process perspectives: Theoretical developments vs. real-world practice. *International Journal of Production Economics, Special Section on Competitive Advantage through Global Supply Chains*. v. 114, n. 1, p. 91–104, 1 jul. 2008.
- [34] VERNADAT, F. *Enterprise modeling and integration: principles and applications*. London ; New York: Chapman & Hall, 1996.
- [35] VERNADAT, F. B. Enterprise Modelling and Integration. In: KOSANKE, K. et al. (Eds.). . *Enterprise Inter- and Intra-Organizational Integration*. Boston, MA: Springer US, 2003. p. 25–33.
- [36] VOJISLAV, B.; LEON, J. Evaluating the Quality of Reference Models. *Conceptual Modeling — ER 2000. Anais...: Lecture Notes in Computer Science*. In: INTERNATIONAL CONFERENCE ON CONCEPTUAL MODELING. Springer, Berlin, Heidelberg, 9 out. 2000Disponível em: <[https://link.springer.com/chapter/10.1007/3-540-45393-8\\_35](https://link.springer.com/chapter/10.1007/3-540-45393-8_35)>. Acesso em: 12 dez. 2017

# Influence of Altitude on the indirect Analysis of $\alpha$ -amylase Content on Wheat Flours

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**Abstract**— *The objective of this study was to verify the influence of altitude on the indirect analysis of  $\alpha$ -amylase content on wheat flours. The experimental design used was completely randomized, with eight treatments and three repetitions. The treatments consisted of the analysis of the falling number from flours of four wheat classes (basic, domestic, bread and improver) on the elevations zero, 412, 540, 761, 934, 975, 1,040 and 1,095 meters. After the trial results, under the correction of the averages above 600 meters of elevation, it was verified that there was a significant difference between the results of distinct altitudes, for the four wheat classes. When a polynomial regression is applied, for the values without correction, it was obtained that a quadratic regression equation correlates the falling number values with altitude; however, the coefficient of determination was very low, highlighting the major influence of the different equipments that were used to measure the falling number instead of the different altitudes.*

**Keywords**— *falling number, food analysis, food composition, flours, wheat classes.*

## I. INTRODUCTION

Wheat (*Triticum aestivum*) is a major cereal crop worldwide. Wheat flour is the basic ingredient to produce many foods, including breads, pasta, biscuits/cookies, cakes, among others. Even though, with the estimated production of 4.6 million metric tons of wheat (2018 harvest season), Brazil is unable to supply its demand, standing as a huge importer country (CONAB, 2018).

Wheat flour is qualified by its physical, chemical, rheological, and nutritional characteristics, considering its large use in bakeries. The exigence on technological

attributes has been increasingly considered by the consumer markets when buying wheat and wheat flour. Therefore, reaching the required quality is a key-factor for the success of planting, commercializing and processing wheat (Pinnow et al., 2013; Finck et al., 2015).

In Brazil, the classification of wheat is ruled by the Normative Instruction n.º 38, from November 30, 2010. The wheat group II (destined to milling, and other ends) is divided into five classes according to the values obtained of gluten strength, stability and falling number. To be classified in the “Improver”, “Bread”, “Domestic”, “Basic, and Others Uses classes the falling number must present the minimum values of 250, 220, 220 and 200 s, respectively. For the “Other Uses” class, the falling number minimum value is not established (BRASIL, 2010).

Falling number is based on the  $\alpha$ -amylase capacity to hydrolyze the starch gel. The intensity of the activity of the  $\alpha$ -amylase enzyme in the wheat grain and in the wheat flour is estimated indirectly using the equipment called Falling Number<sup>®</sup>, which measures the starch paste (like a porridge) liquefaction of the grinded wheat grain suspension warmed in a boiling water bath, with the result being expressed in seconds (AACC, 2010; Mohler et al., 2014; Ral et al., 2015).

Starting from the assumption that at low atmospheric pressures the boiling temperature in the water bath will decrease, Lorenz and Wolt (1981) proved that the falling number determination method suffers from influence of altitude. Thus, the falling number values increase with the elevation of altitude; because of a lower temperature, the sample in the test tube will be cooler and the activity of the  $\alpha$ -amylase enzyme will be lower, therefore, increasing the falling number.

As the determination equipment of the falling number reproduces the method, the same suffers influence of the altitude. Thus, when the analysis is done from 600 m above the sea level, the operator programs the equipment to automatically perform the correction of the result (PERTEN INSTRUMENTS, 2016).

Examining the precision level of the replication of the procedure to determine the falling number, under controlled laboratory conditions, Delwiche et al. (2014) analyzed 24 wheat samples and found falling number values ranging from 168 to 404 s. The authors concluded that there was a variation of the values up to 16 s, between elevation at sea level and 800 m, with linear regression as best adjustment of data.

Due to the scarcity in the literature of experiments on altitude interference in the falling number, the objective of the present study was to verify the influence of altitude on the indirect analysis of  $\alpha$ -amylase content on wheat flours.

## II. MATERIALS AND METHODS

The experimental design utilized was completely random, with eight treatments and three repetitions. The treatments consisted of the analysis of the falling number on different altitudes related to the sea level, in selected Brazilian cities: Fortaleza – CE, sea level; Medianeira – PR, 412 meters; Campinas – SP, 540 meters; Campo Mourão – PR, 761 meters; Curitiba – PR, 934 meters; Ponta Grossa – PR, 975 meters; Castro – PR, 1,040 meters; and Guarapuava – PR, 1,095 meters. The analyses were carried out on different equipments from Perten® models FN 1500, FN 1700 and FN 1900. All the equipments were certified and were used for wheat flour analysis in public agencies and private companies.

Samples from four wheat classes were considered: “Basic”, “Domestic”, “Bread” and “Improver”. The wheat samples were granted by CONAB, Ponta Grossa – PR unity and classified according to the Normative Instruction nº 38, from November 30, 2010. They were used on the experiment with available samples that had falling number values that were the most discrepant.

The procedure to prepare the sample and to determine the falling number was the method ICC nº 107/1 – Approved in 1968 / Revised in 1995; and AACC nº 56-81B – Approved in 1972 / Revised in 1999 (AACC, 2010). The wheat was milled, and then collected 300 g to make the three repetitions on all the local above mentioned.

The samples were codified to keep the experiment secrecy, and then, sent the samples properly milled and sealed in plastic bags, avoiding external moisture in the bags. After the delivery of the samples to their proper research sites they stayed stored in a cool dry place and

protected from light, until the analysis date. All analyses were carried on the same day.

To perform the analyses, 7.0 g of each sample was put into the proper FN test tube and 25 mL of distilled water was added, then the tube was sealed with a stopper and shaken vigorously until a homogeneous mix was achieved. The stopper was removed, and replaced by a clean and dry viscometer stirrer that was plunged into the tube. After this process the viscometer stirrer and the tube connected to the equipment to start the analysis. All the procedures, from stirring up until putting the tubes in the equipment, has not taken more than 60 seconds.

All laboratories were oriented to manipulate the equipment and prepare the samples the same way, in order to avoid possible differences on the results. In accordance with the manufacturer’s recommendation of the equipment, it was applied a correction to values above 600 meters altitude using the the following formula:

$$\text{Log}_{10}(NQ_{nm}) = 1.0 \times \text{log}_{10}(NQ_{alt}), \text{ wherein}$$

NQ represents the falling number, nm represents the sea level and alt represents altitude.

The corrected results from altitude were submitted to Hartley tests, to verify the homoscedasticity of variances, and Kolmogorov-Smirnov to examine the normality of the data. The analysis of variance used the F test, and Scott-Knott test was used for mean comparison, with a confidence interval above 95% of probability. Thus, it was intended to verify the formula of correction between the results on the different altitudes.

Without correcting data with the formula for altitudes above 600 meters, it was applied the Hartley test, Kolmogorov-Smirnov, ANOVA, and polynomial regression. With the above tests, we aimed to verify the influence of altitude on the determination of the falling number, with defined equations, both linear or quadratic regression.

## III. RESULTS AND DISCUSSION

All the analyses had homoscedasticity and normality of variance, dispensing the transformation of data. When the wheat flours of different classes were analyzed, and the FN values were corrected for altitude above 600 meters, significant differences were found, with confidence interval above 95% of probability (Table 1).

Therefore, Lorenz and Wolt (1981) observations were confirmed, that altitude influences the falling number analysis. However, the correction factor was not sufficient to correct the different results with the altitudes,

contradicting the instructions of PERTEN INSTRUMENTS (2016).

Therefore, it is possible to observe that wheat of the “Basic” class has not presented statistic difference between altitude zero and 540 m. This tendency, however, did not repeat on the others wheat classes. On all the wheat analyses there was a significant difference between altitudes, however it was not established as a standard error for altitude.

When the falling number factor is analyzed by itself, through the Normative Instruction n.º 38 (BRASIL, 2010), the “Domestic”, “Bread” and “Improver” wheat classes fit on the “Improver” class on all altitudes. This demonstrates that, even though the significant discrepancy of the results and lack of standard error, the classification of wheat should not be affected by the variable under analysis.

However, it stands that the difference between values of altitudes were always higher than the parameters established to distinguish the wheat classes, which is the maximum of 30 seconds. The discrepancies of classes obtained were: “Basic” with 43, “Domestic” with 103, “Bread” with 166 and “Improver”, distancing 148 seconds between the lowest and highest values. The values obtained in the present study have more than doubled those determined by Delwiche et al. (2014), between the altitudes on the sea level and 800 m.

Considering the analyses performed without correction, the data obtained by the equation of polynomial regression demonstrated that the different altitudes have interfered on the falling number, for the distinct wheat flour classes. In the case of the “Basic”, “Domestic”, “Bread” and “Improver” wheat classes, the polynomial regression was significant, with confidence interval above 95% of probability, for the quadratic equation. Thus, it is confirmed that the recommendations of PERTEN INSTRUMENTS (2016) and Lorenz & Wolt (1981), that the altitude significantly influences the falling number analysis. However, the results are not in conformity with the formula purposed by PERTEN INSTRUMENTS (2016) and the linear regression indicated by Delwiche et al. (2014) to explain the relation between the falling number and altitude.

Nevertheless, the dispersion of data that varies in function of altitude had the phenomenon explained by 44% of the curve adjustment for the “Basic” wheat class (Fig. 1), 29% for the “Domestic” wheat class (Fig. 2), only 10% for the “Bread” wheat class (Fig. 3), and 31% for the “Improver” wheat class (Fig. 4). Therefore, due to the lack of a standard error, it is not advisable to use the equation of curves found on each class to correlate the influence of altitude on the falling number.

Lorenz and Wolt (1981) used the equipment FN<sup>®</sup> 1400, and the method AACC 56-81A (AACC 1969), both outdated. However, equipment models FN<sup>®</sup> 1500, FN<sup>®</sup> 1700, FN<sup>®</sup> 1800, FN<sup>®</sup> 1900, and method AACC 56-81B (AACC 2010) were used in the present study. Different equipments may be the cause of results variation.

However, Delwiche et al. (2014) utilized the same method to define the falling number (AACC, 2010), and the equipment (FN<sup>®</sup> 1700) that was used in this experiment; with discrepant results. That fact deserves attention to the equipment being certified and used on the commercial analysis of wheat flour.

#### IV. CONCLUSIONS

After performing all the analyses, with the correction of the average values above 600 meters of altitude, it was verified that there was a significant difference between the results of distinct altitudes; for the four wheat classes.

When applied the polynomial regression, to the values without correction, it was obtained that the quadratic equations correlated the falling number values with altitude; however, the coefficient of determination was very low, emphasizing the major influence of different equipment utilized to determine the falling number than the distinct altitudes.

#### REFERENCES

- [1] AACC - American Association of Cereal Chemists, 1969. Approved Methods of the AACC. Method 22-10, approved May 1960, and Method 56-81 A, approved 1969. St. Paul: AACC International.
- [2] AACC - American Association of Cereal Chemists, 2010. Approved Methods of Analysis. 11th ed. St. Paul: AACC International. Available in: <<http://methods.aaccnet.org/toc.aspx>>. Accessed on: May 13, 2017.
- [3] BRASIL - Ministério da Agricultura, Pecuária e Abastecimento, 2010. Instrução Normativa n<sup>o</sup> 38, de 30 de novembro de 2010. Brasília, Diário Oficial da República Federativa do Brasil, pp.2-4.
- [4] CONAB - Companhia Nacional de Abastecimento, 2018. Acompanhamento da safra brasileira de grãos. Conab, Brasília, Brasil. p. 129.
- [5] Delwiche, S.R., Vinyard B.T., Bettge A.D., 2014. Repeatability precision of the falling number procedure under standard and modified methodologies. Cereal Chemistry. 92, 177-184. <https://doi.org/10.1094/CCHEM-07-14-0156-R>
- [6] Fink, C., Santana, C., Oliveira, E.B., Weirich Neto P.H., Garcia, L.C., 2015. Expurgo de grãos de trigo

- em câmara de lona. *Ciência Rural*. 45, 2157-2160.<http://dx.doi.org/10.1590/0103-8478cr20141150>.
- [7] Lorenz, K., Wolt, M., 1981. Effect of altitude on falling number values of flours. *Cereal Chemistry*. 58, 80-82. ISSN : 0009-0352
- [8] Mohler, V., Albrecht, T., Mrva, K., Schweizer, G., Hartl, L., 2014. Genetic analysis of falling number in three bi-parental common winter wheat populations. *Plant Breeding*. 133, 448-453.<https://doi.org/10.1111/pbr.12177>.
- [9] PERTEN INSTRUMENTS, 2016. Falling number FN 1500. Available in: <<http://www.perten.com/Products/Falling-Number/Models-and-Accessories/FN-1500/>>. Accessed on: Nov 17, 2017.
- [10] Pinnow, C., Benin, G., Viola, R., Silva, C.L., Gutkoski, L.C., Cassol, L.C., 2013. Qualidade industrial do trigo em resposta à adubação verde e doses de nitrogênio. *Bragantia*. 72,20-28.<http://dx.doi.org/10.1590/S0006-87052013005000019>.
- [11] Ral, J.P., Whan, A., Larroque, O., Leyne, E., Pritchard, J., Dielen, A.S., Howitt, C.A., Morell, M.K., Newberry, M., 2015. Engineering high  $\alpha$ -amylase levels in wheat grain lowers falling number but improves baking properties. *Plant Biotechnology Journal*. 14, 364-376.<http://dx.doi.org/10.1111/pbi.12390>.

Table.1: Falling number (seconds) on different altitudes of wheat classes<sup>1</sup> (*Triticumaestivum*), with correlation values above 600 meters<sup>2</sup>.

Altitude (m)	Wheat classes			
	Basic	Domestic	Bread	Improver
Zero	214 b <sup>3</sup>	276 c	461 b	517 b
412	217 b	354 a	526 a	545 a
540	212 b	304 b	437 d	517 b
761	203 c	282 b	453 c	489 c
934	197 d	269 c	386 f	416 e
975	231 a	251 d	360 g	369 f
1,040	206 c	280 b	426 e	471 d
1,095	188 d	272 c	439 d	408 e
CV (%)	1.2	1.4	1.1	1.6

<sup>(1)</sup>Classified according to Normative Instruction n.º 38, from November 30 of 2010.

<sup>(2)</sup>Log<sub>10</sub> (NQ<sub>nm</sub>) = 1.0 x log<sub>10</sub> (NQ<sub>alt</sub>).

<sup>(3)</sup>Means with the same letter in the column do not differ significantly by Scott-Knott ( $p > 0.05$ ).

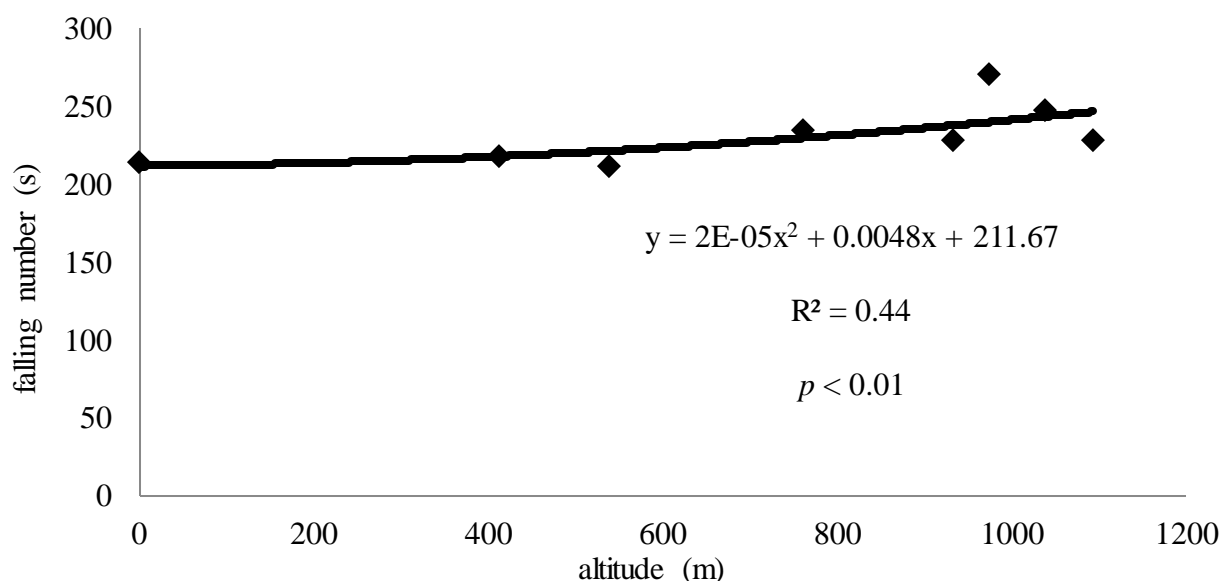


Fig.1: Falling number under different altitudes, without correction ( "Basic" class wheat sample).

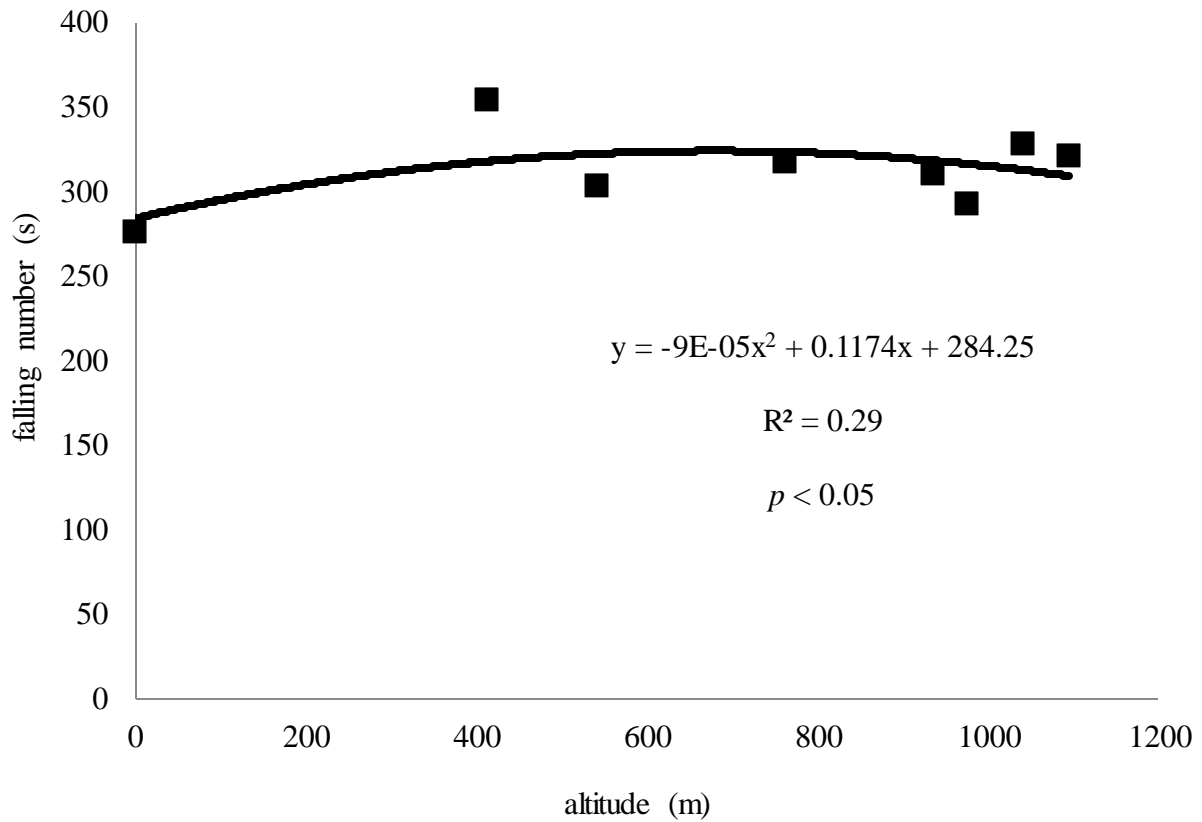


Fig. 2: Falling number under different altitudes, without correction ("Domestic" class wheat sample).

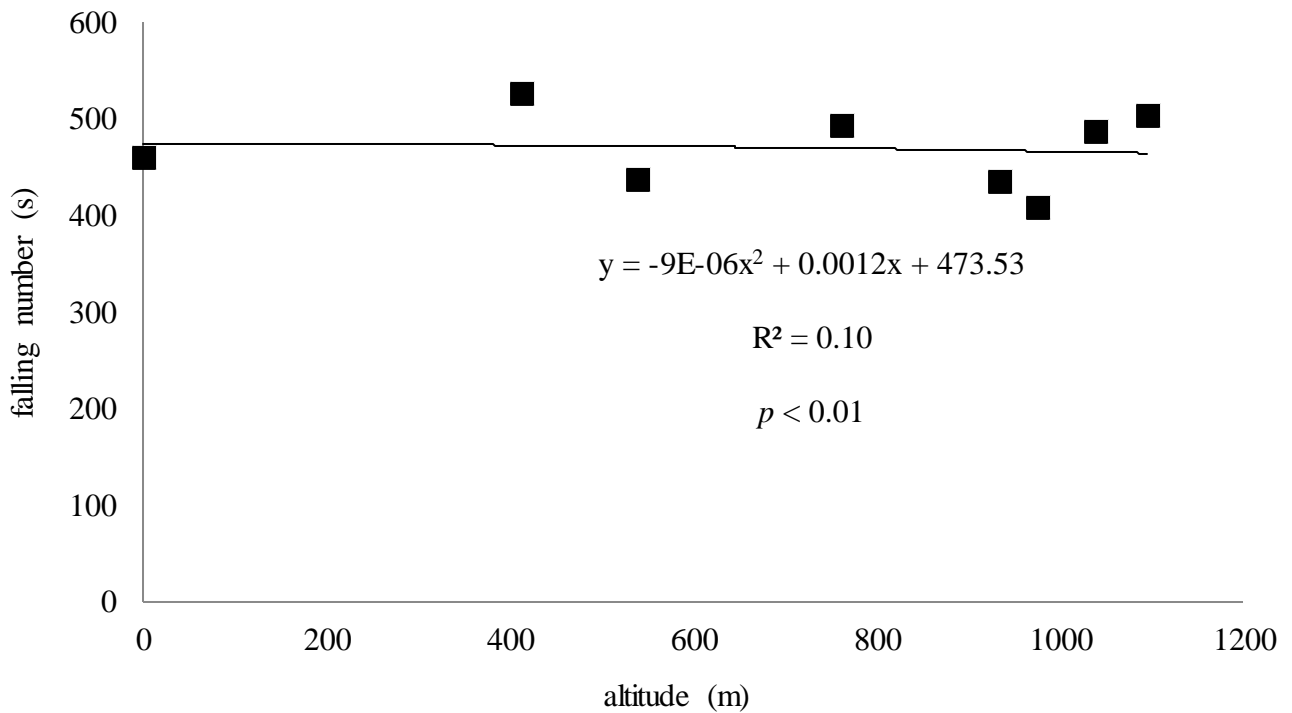


Fig. 3: Falling number under different altitudes, without correction ("Bread" class wheat sample).

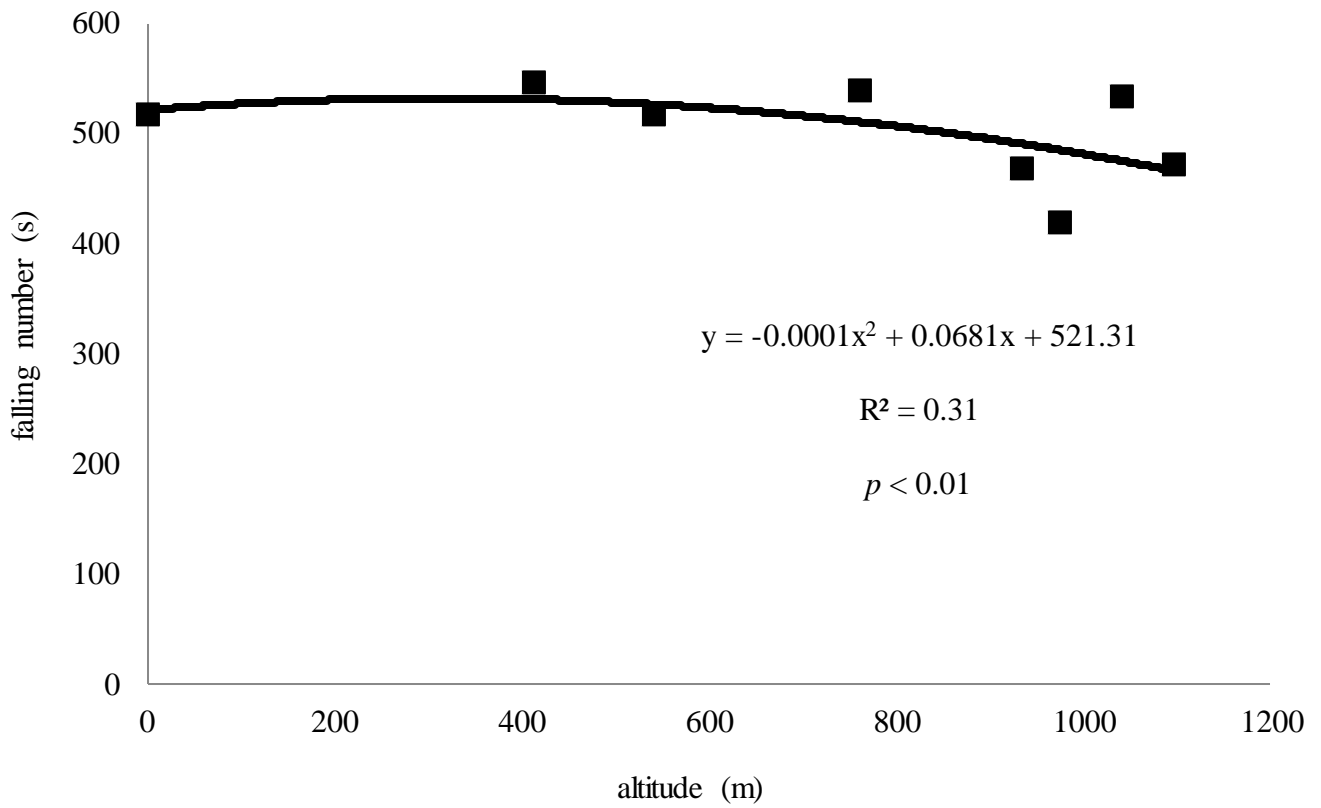


Fig. 4: Falling number under different altitudes, without correction ("Improver" class wheat sample).

# Behavioral Finance: A Different View in the State of Rio de Janeiro

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**Abstract** — *The objective of this work is to present the consolidation of foreign reflections of a new branch in the financial theory, behavioral finance, that it aims at to adhere to the psychological aspects and the sociological ones of the individuals in the process of taking of decision at the moment to carry through an investment, as well as its applications through the incorporation of evidences on the irrationality of the investor. This new segment has as objective the revision and the improvement of the economic-financial model used currently. Through this study it was verified presence of the effect of super valuation of the assets and the effect disposal, as well as of aversion to the risk, since in the occurred economic crisis in 2008 middle a bigger index in the closing of companies was evidenced, and a minor in the opening of companies in the state of Rio De Janeiro. The association to the behavioral finance in such a way provides the agreement of the psychological process that motivates the investments, assisting in the construction of a model of more adequate taking of decision, how much in the act of contract of its administrators who will have to possess abilities adequate psychological techniques and in intention to prevent cognitive bias as reliable excess. The regression for being static got errors in its forecast high thus was not an incisive method, being able to be applied the forecast of demand of products, not obtaining success thus in this model.*

**Keywords** — *Behavioral Finance, Forecast of demand, Model.*

## I. INTRODUCTION

Most of the traditional finance theories were built on pillars of neoclassical micro economy whose main paradigm is the rationality of economic agents. In them, through the Expected Utility Theory (EUT), it is argued that individuals make totally rational decisions, are risk averse and aim to maximize utility. However, several empirical evidence produced in recent decades reveals that these theories alone are not able to explain the various phenomena observed in the financial markets [1]. According to Barbedo & Silva [2], intelligent people make decisions seeking the maximization of utility that is the usefulness that something can produce of benefit. Even so, at all times, people lose money, whether in the stock market, in games, in sloppy purchases, in personal endeavors, and in activities involving decisions.

Behavioral finances are based on the combination of concepts from economics, finance, and psychology, with the aim of generating a specific and judicious model of human behavior in the financial markets, assuming that the Human agents are subject to behavioral determinants that, in many cases, push them away from a decision centered on rationality [3].

It is also worth mentioning the importance of authors Daniel Kahneman and Amos Tversky [4][5], Israeli psychologists and founders of this new study on finance, which in 1979 developed the theory of the prospectus in counterpoint to EUT. In their theory, risk aversion occurs only in the field of gains, because in the losses the



individual tends to be prone to risk, unlike what happens in the EUT. From this, these authors identified three distinct effects: the certainty, in which the individuals in the comparison between a certain event and a probable prefer the right, even if the probable is better; the reflection, which will demonstrate the search for people for safer gains and riskier losses; and isolation, which is linked to the ability to evaluate, presenting the difficulty of individuals to assume mistakes made.

Thus the study of behavioral finances arises as a way of predicting and modeling the said "irrational", but also systematic, of men and women in decision making, through their understanding, inducing them to a better decision, which will lead to the Reduction of money loss in simple everyday situations, consequently in a greater gain [6].

The objective of this article is to analyze the behavior of investors when trying to start a business in the state of Rio de Janeiro, on the optics of behavioral finance, glimpsing the motivations focused on entrepreneurship, using comparative analysis Static of a prediction through a linear regression and compared with the facts happened with the opening and closing of companies in the State. It is expected, through this presentation, to outline the process of analysis and to incite the study of financial behavior through theories from this alternative approach, emphasizing its usefulness for the understanding of important phenomena observed to this practice in the Rio de Janeiro market.

## II. THEORETICAL REFERENCE

### 2.1 MODERN FINANCE

For a long period, finance studies were basically related to financial instruments and their respective uses by economic agents, which aimed to control and minimize financial risks. However, as nothing in the financial market is static, financial theories have been influenced by political, economic and social facts, adapting to the conditions of the time [7] [8].

The traditional finance theory was pioneering, considered the market irrational and judged that it was not always correct. In it, investors were based on past information to design the future [7]. This assumption, however, contradicts the principle of temporal discontinuity which states that companies-corporations and markets-do not behave in the future in the same way they have behaved in the past. [7]. From this, the theory of modern finances has as the main characteristic the Efficient Market Hypothesis (EMH) founded on the EUT and rational expectations [8].

### 2.2 OPPORTUNITY FOR EFFICIENT MARKETS

An opportunity for efficient markets, according to Milanez [9], it is characterized by neoclassical economic tradition, and admits that human behavior is rational,

capable of maximizing the expected utility and optimally analyzing all the information that is Available. In this way, it is stated that the markets are driven by economic agents that act under an unlimited rationality, making decisions in the perspective of the expected utility theory, formulating expectations often precipitated.

However, with the advent of rational expectations theory, developed in the work of Milanez [9], individuals began to use all available information to improve their predictions, and to make more reasonable decisions. From this, it was found that these conditions imply the same result of the perfect market models, in which the price history of an asset does not influence its future price, because what has occurred in the past is not correlated with the future changes.

In this way, according to EMH, whenever the economic agents check some new information about a particular asset, they immediately adjust the asset prices given the new information available. In addition, a possible irrational behavior of a given agent, characterized as random, would be compensated by another individual, not impacting on the prices [10] [11].

Modern finance theory has its emphasis in the 80 with globalization, but in the 90 the expected utility theory had its rise with the analysis of emerging countries.

### 2.3 BEHAVIORAL FINANCE

In this new area of study concerning finance, the themes of psychology and economics were incorporated in order to clarify the decision-making process in this new scenario. Following this line of thought, the behavioral finances are based on the study of human action and their weaknesses and failures. These, in turn, are linked to the decision-making process, in which most of the decisions are influenced by the behaviors described by Barbedo & Silva [2] where there are effects on the certainty and uncertainty of investments tied to behavioral finance, analyzed and stated to follow.

This effect is characterized by the tendency of individuals to value more possibilities with greater likelihood of occurring. That is, people prefer events that give them absolute certainty of gain by the simple fact that they do not understand the meaning of the probable results and the notion of expected value [7] [12].

According to Ferreira et al. [7], this effect deals with the fact that individuals remember, most of the time, of events that occur more often, or those that have a greater likelihood of occurring. In this way, their respective behaviors would be influenced by the availability of events, as well as by the association of these to visibility, exposure and overhang.

In addition, Barbedo & Silva [2] it states that people are more dissatisfied with losses than they are satisfied with earnings. In this way, the investor tends to risk more in a loss situation in an attempt to minimize it, or even

eliminate it, recovering at least his initial investment initial. This attitude can lead to more drastic losses, to the point of not being able to bear it anymore and being forced to abandon the investment.

According to Bazerman [13] the rational decision-making model is based on elements that define the way in which the decision must be made, not as it really is. In this line of thinking, considering that managers process many decisions, many of them routine - requiring little mental effort - and other, however, strategic - require a special sensitivity, dealing with several aspects such as new directions, setting, winning the competition, and above of everything, to obtain profit - it is essential for the projection of the company that the latter are well defined. [14]. For this, we study some biases that are intrinsic to the individuals, so that the decision making is not biased. Some of these behaviors will be analyzed for a better understanding.

This status expression is defined by Samuelson and Zeckhauser [15] to demonstrate the tendency of people to cling to old rules or conditions. That is, when new relationships are presented to individuals, they tended to prefer pre-defined options. This phenomenon is tied to the idea of loss aversion relative to the reference point, that is, most people define and set a benchmark to follow, even if they offer better opportunities. One way of breaking this paradigm and following more patterns that are rational is the very knowledge of this bias.

According to Yoshinaga [1], people tend to make judgments from previously formed models. From this, individuals estimating a probability disregard sample size, taking into account only one representation for the entire population, selecting information that is more convenient to them than the relevant ones.

This behavior is known in the literature as the belief that there is a tendency to regress to the mean of the results. It occurs because of the inability of people to statistically analyze independent events - the occurrence of one does not statistically influence the occurrence of the other. One of the cases that can be cited is the multiple-choice test with 5 alternatives for each question, when you have a sequence of questions with the same alternative, consequently, individuals begin to doubt if that is really the correct template. This behavior is biased, because each question is an event independent of each other, that is, for each of them you would have a 20% chance of success [16].

The great challenge in the field of finance is in proving the predictability of behavioral anomalies, and whether these can actually determine changes in the market. The theory of perspectives based on the grounds of loss aversion and excessive self-confidence was one of the ways in which some of the types of behaviors were identified by the researchers Tversky and Kahneman [4].

However, there is not yet a single model that explains all the anomalies generated by human behavior, but for each one in particular. The following will describe some theories.

Tversky and Kahneman [4] conducted research at Stanford University and Columbia. In it they have found evidence that changing from a perspective to a specific situation can influence and bias the choice of alternatives. From this, it has been found that people, within certain gain events, are risk averse, while in choices involving losses, they are risk prone. Through the theory in question two basic concepts are analyzed: loss aversion, and excessive self-confidence.

### 2.3.1 LOSS AVERSION

This is a concept considered one of the pillars of Behavioral Finance, and states that the investor ponders both gains and losses, but from different perspectives. According to Tversky and Kahneman [4] investors feel much more the pain of loss than the satisfaction gained by an equivalent gain. According to Rogers et. al [8], it is observed that the fear of loss leads people to make irrational decisions, creating cognitive frames that make it difficult to analyze historical data and mainly statistical probabilities.

This theory contradicts the Theory of Utility, a precept integral to the Modern Model of Finance. Figure 1 assumes that the investor assesses the risk of an investment according to the change it provides to its level of wealth, the other in Figure 2 states that the investor assesses the risk from a will measure gains and losses.

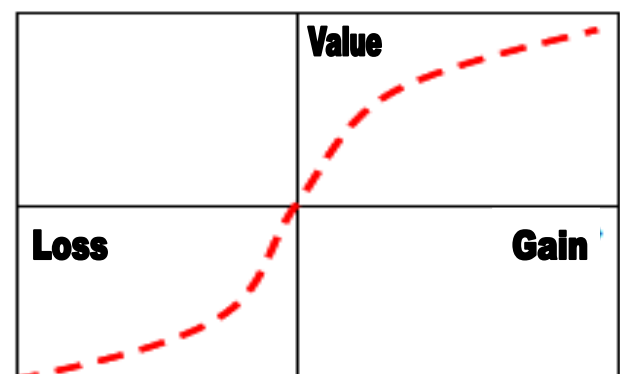


Fig. 1: Theory of Utility

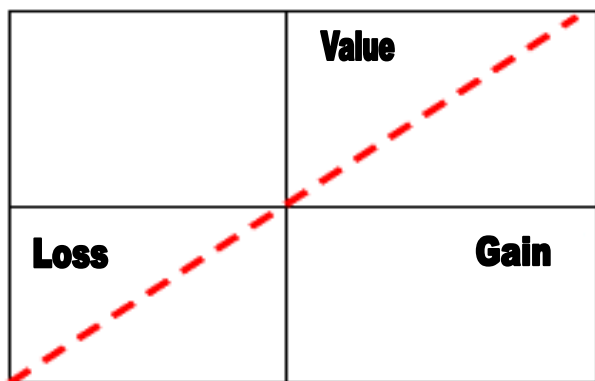


Fig. 2: The Prospect Theory

Another characteristic of this behavior is the fear of repentance. It is worth remembering that it is quite painful for an investor to make mistakes, and with this attitude, his profit is not maximized, contradicting once again the Theory of Utility.

### 2.3.2 EXCESSIVE SELF-CONFIDENCE

According to Milanez [9] overconfidence is a hallmark of most of the world's population. With investors, it is no different, since most consider themselves to be above average. This behavior makes sure that your information is better and more reliable than that of others who operate in the same market. Consequently, due to the incorrect understanding of reality, there is a tendency to achieve an excessive turnover, with a marked risk.

## III. COMPARATIVE ANALYSIS BETWEEN THE FINANCIAL MARKET AND A STATISTICAL FORECASTING METHOD

We then return to the discussion about the opening of companies in the state of Rio de Janeiro in 2007, being of great relevance in the study of behavioral finances in the line of temporal analysis, as shown in Figure 3 (relation from 2007 to 2008). According to Barbedo & Silva [2], there was emphatic entrepreneurial motivation in microsystems in the state of Rio de Janeiro in investments in entrepreneurial ventures.

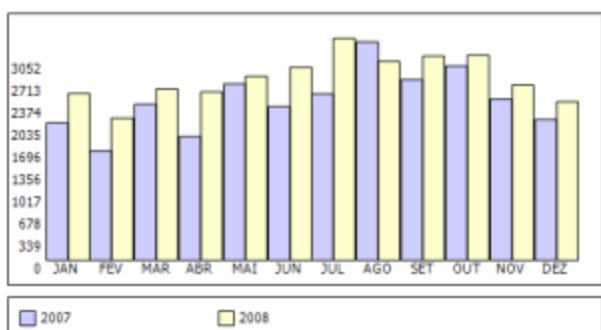


Fig. 3: Comparative Statistics of Companies Opening from 2007 to 2008. Source: Rio de Janeiro Trade Board, 2008.

In 2008 and 2009 there is another increase in the opening of companies in a few months, as shown in Figure 4, this can be noticed with greater emphasis as of May 2009, when the government initiated the reduction of IPI (Products Tax Industrialized).

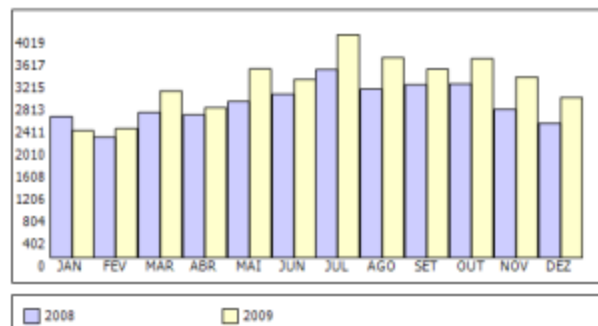


Fig. 4: Comparative Statistics of Companies Opening from 2008 to 2009. Source: Rio de Janeiro Trade Board, 2008.

Figure 5 shows the relation between the closures of companies from 2007 to 2008, as well as an increase in the second half.

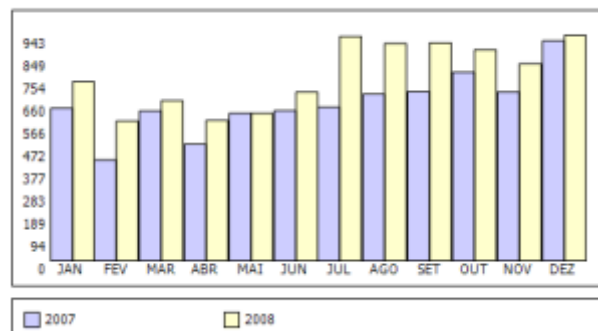


Fig. 5: Comparative Statistics of Closing Companies from 2007 to 2008. Source: Rio de Janeiro Trade Board, 2008.

Figure 6 shows the relation between the closures of companies from 2008 to 2009, as well as a comparative increase in all related months, due to the beginning of the world crisis.

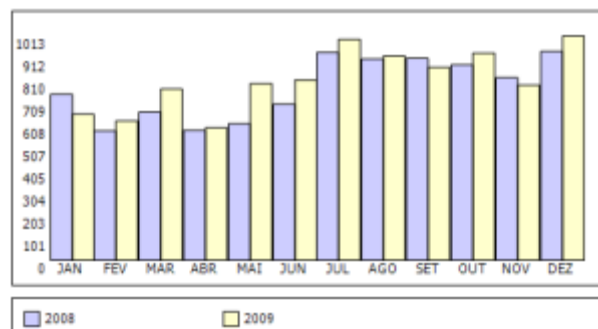


Fig. 6: Comparative Statistics of Companies Closing from 2008 to 2009. Source: Rio de Janeiro Commercial Board, 2009.

The analysis from the behavioral finance perspective of the relationship between opening and closing companies, according to Barbedo & Silva [2], is a consequence of the involvement of the emotions in the financial market as the tendency to exaggerate in front of new information. According to the Efficient Markets Hypothesis, new information should be reflected instantly in the asset price. Based on this, it can be correlated that during the crisis there was an increase in the closure of companies due to the fear it received in mid-2008.

Good news should raise the price of the asset, and it should not fall if no new information is given. The reality, however, tends to contradict the theory, since based on the theory of challenge and risk of it can be incited that even at the beginning of the crisis in 2008 people invested in the opening of companies for their entrepreneurial spirit. Sometimes financial market participants act exaggeratedly on new information, creating an asset overvaluation effect. According to the availability theory, people tend to give more weight to the latest information for decision-making. This happens all the time in our daily lives. For an analysis relating the behavior in the opening of companies applying the linear regression analysis and verifying the prediction and the real behavior simulating the year of 2008 and forecast for 2009 (Table 1 and Table 2).

Table 1: Linear Regression

X	2008 – Y	2009 – X.Y	X <sup>2</sup>
1	2548	2548	1
2	2173	4346	4
3	2621	7863	9
4	2576	10304	16
5	2816	14080	25
6	2949	17694	36
7	3391	23737	49
8	3039	24312	64
9	3119	28071	81
10	3135	31350	100
11	2678	29458	121
12	2424	29088	144
<b>78</b>	<b>33469</b>	<b>222851</b>	<b>650</b>

Table 2: Forecast and correlation of the deviation.

X	2008	Forecast	2009 Real	Deviation
1	2548	2816,83	2292	81,37
2	2173	2820,53	2328	82,54
3	2621	2824,23	3007	106,47
4	2576	2827,93	2705	95,65
5	2816	2831,63	3403	120,18
6	2949	2835,33	3215	113,39

7	3391	2839,03	4019	141,56
8	3039	2842,73	3606	126,85
9	3119	2846,43	3399	119,41
10	3135	2850,13	3588	125,89
11	2678	2853,83	3259	114,20
12	2424	2857,53	2888	101,07
<b>78</b>	<b>33469</b>	<b>34046,16</b>	<b>37709</b>	<b>110,76</b>

The correlation of the forecast and the opening of companies show that there is a margin of error above 10% that can be explained by the static forecast and by the variable behavior of the financial market. The forecast and behavior in Closing Companies.

Table 3: Linear Regression

X	2008 – Y	2009 – X.Y	X <sup>2</sup>
1	750	750	1
2	585	1170	4
3	670	2010	9
4	588	2352	16
5	617	3085	25
6	706	4236	36
7	939	6573	49
8	909	7272	64
9	912	8208	81
10	883	8830	100
11	825	9075	121
12	943	11316	144
<b>78</b>	<b>9327</b>	<b>64877</b>	<b>650</b>

For an analysis relating the behavior in the closing of companies applying the linear regression analysis and verifying the prediction and the real behavior simulating the year of 2008 and forecast for 2009.

Table 4: Forecast and correlation of the deviation

X	2008	Forecast	2009 Real	Deviation
1	750	1000,23	660	65,99
2	585	1029,96	630	61,17
3	670	1059,69	774	73,04
4	588	1089,42	599	54,98
5	617	1119,15	799	71,39
6	706	1148,88	815	70,94
7	939	1178,61	998	84,68
8	909	1208,34	923	76,39
9	912	1238,07	872	70,43
10	883	1267,80	937	73,91
11	825	1297,53	792	61,04
12	943	1327,26	1013	76,32
<b>78</b>	<b>33469</b>	<b>13964,88</b>	<b>9812</b>	<b>70,26</b>

The correlation of the forecast and the closure of companies show that there is a margin of error above 30% that can be explained by the static forecast and by the variable behavior of the financial market.

The study of this new branch, behavioral finance, came to aggregate to the analysis of the decision making in the investments made by the individuals, once the theory of modern finances was not enough to explain the anomalies occurred in the financial market.

#### IV. CONCLUSION

In the present work, this theme was used in a new perspective, that is, the studies found on behavioral finances, mostly, are focused on the financial market, but through this work can be analyzed, from a motivational point of view, the factors that drive and influence individuals at the time of making any investment. In the case in question, which leads them to open as well as to close a deal.

Through this study, we verified the presence of the effects of asset overvaluation and the disposition effect, Barbedo & Silva [2], risk aversion, advocated by Tversky and Kahneman [5], since in the economic crisis occurred in the middle of 2008 was evidenced a higher index in the closing of companies, and a lower in the opening of companies in the State of Rio de Janeiro.

As previously discussed by, it is known that, despite the EMH defend the rationality of investors, human behavior is influenced by several psychological factors that, most of the time, distort the rational decision-making process. From this, the association with behavioral finances provides a better understanding of the psychological process that drives investments, favoring the construction of a more adequate decision-making model, as well as in the selection and hiring of its managers who should have appropriate psychological and technical skills in order to avoid cognitive biases such as overconfidence. Regression, because it is static, has raised errors in its prediction. In this way, this was not an incisive method, because it was not successful. However, it can be applied to the demand forecast of products.

#### REFERENCES

- [1] Yoshinaga, C. E., Oliviera, R. F., Silveira, A. D. M., & Barros, L. A. B. de C. (2007). *Finanças Comportamentais: Uma Introdução*. São Paulo: Faculdade de Economia e Administração da Universidade de São Paulo (FEA/USP).
- [2] Barbedo, C. H. S., & Silva, E. C. (2008). *Finanças Comportamentais: Pessoas Inteligentes também perdem dinheiro na Bolsa de Valores*. São Paulo: Atlas.
- [3] Oliveira, E., Silva, S. M., & Silva, W. V. (2005). *Finanças Comportamentais: um estudo sobre o perfil comportamental do investidor e do propenso investidor*. Seminário de Gestão de Negócios. Curitiba.
- [4] Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, v.211, n. 4481. pp. 453-458.
- [5] Tversky, A., & Kahneman, D. (1979). Prospect theory: analysis of decision under risk. *Econometrica* 47.
- [6] Souza, C. A., Kayo, E. K., Pusch, A. C., & Yu, A. S. (2008). *Teoria Da Perspectiva (Prospect Theory) De Kahneman E Tversky: Estudo Empírico Com Alunos De Graduação Em Administração*. São Paulo: Faculdade de Economia e Administração da Universidade de São Paulo (FEA/USP).
- [7] Ferreira, J. K. F. S., Silva, R. F. M., & Guilherme H. F. (2009). Um panorama evolutivo das finanças e a aplicação das finanças comportamentais na análise de tomada de decisão dos Investidores no mercado de capitais. Seminário de UFPE de Ciências Contábeis III, Recife.
- [8] Rogers, P., Securato, J. R., Ribeiro, K. C. S., & Araujo, S. R. (2007). *Finanças Comportamentais no Brasil: um estudo comparativo*. São Paulo: Faculdade de Economia e Administração da Universidade de São Paulo (FEA/USP).
- [9] Milanez, Y. D. (2003). *Finanças Comportamentais no Brasil*. São Paulo: FEA. Dissertação de Mestrado - Economia das Instituições e do Desenvolvimento, Faculdade de Economia Administração e Contabilidade, São Paulo.
- [10] Lacerda, R. T. (2007). *Estratégias de Investimento para o Brasil baseadas em Finanças Comportamentais*. Rio de Janeiro: FGV. Dissertação de Mestrado - Finanças e Economia Empresarial, Escola de Pós-Graduação em Economia, Rio de Janeiro.
- [11] Heanton, J. B. (2002). Managerial Optimism and Corporate Finance. *Financial Management*, p. 33-45, Summer.
- [12] Thaler, R., & Barberis, N. (2003). A Survey of Behavioral Finance. In: CONSTANTINIDES, G., HARRIS, M., STULZ, R. (Eds.) *Handbook of the Economics of Finance*. New York: North-Holland.
- [13] Bazerman, M. (2004). *Processo decisório*. Rio de Janeiro. Campus.
- [14] Costa Neto, P. L. O. (2007). *Qualidade e Competência nas Decisões*. São Paulo: Edgarg Blücher LTDA.
- [15] Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of Risk and Uncertainty*.
- [16] Reina, D., Junior, J. S. M., Nunes, P., & Fritzen, F. (2009). *Finanças comportamentais: uma investigação acerca da tomada de decisão dos formandos em administração e ciências contábeis com base nas idéias de Higgins*, CONGRESSO UFSC: Controladoria e Finanças. Vol 3. Florianópolis.

# Professional Orientation: Proposals for a University of the Brazilian Western Amazon

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**Abstract**— This article deals with proposals on professional orientation for a Brazilian Western Amazon university based on a doctoral thesis entitled "Needs of vocational guidance of students at the Federal University of Rondônia." The objectives: (1) to know some characteristics of professional guidance received before your entry into the university and during your stay at the university; (2) identify the professional orientation received by the students of the Federal University of Rondônia; (3) identify the professional orientation needs of the students of the same university and (4) suggest proposals for the attention to the needs detected and adapted the characteristics of the university. In accordance with the investigated problem and the light, particularly, of the conducting objectives of the study, a line of descriptive inquiry was adopted. In addition to being one of the most used in educational research, it presents itself as the most suitable for the objectives that are proposed especially to describe the nature of the existing conditions. The conclusions are structured around three objectives: (1) characterization of the

orientation received and required in secondary education, (2) professional orientation received and needed in university education, and (3) discrepancies between orientation received and needs to receive. This study shows that the need for guidance in university education is considered very important by most students. Moreover, it provided a greater theoretical and practical knowledge on the subject of guidance and led to innovative reflections on instigating issues, opens new possibilities for research and interest to continue studying this theme, not only about the objectives proposed in this work, but also the inferences extracted with more general character, which we formulate as proposals to improve the situation analyzed. These are suggestions considered fundamental, that can serve as reference for effective implementation of a program of action with the High School (PROEM); the introduction of new content on the UFRO – Federal University of Rondonia website; a manual for the student and a tutorial plan at the university.

*Keywords— Professional Orientation. High school. University orientation proposals. Plan of Action Tutorial.*

## I. INTRODUCTION

One of the objectives of the research was the characterization of the professional orientation received in High School. According to the data obtained, the orientation received presents the traits or characteristics that are described in the continuation. Vocational guidance was little present in high school. In all the areas and in all the contents that are integrated in them, the received orientation is little valued with the category, which means the lower level of presence. In addition, in many of the themes of the different areas, the majority of the student stated that they had not received guidance. Within the low presence of professional orientation, the differences found radiate an essentially informative professional orientation, focused on the area of academic and professional information. The greater attention given to academic information also allows us to conclude that the orientation towards academic insertion has priority over the orientation towards labor insertion. In addition to the differences indicated between the areas studied, it should be noted, on the one hand, that the awareness about the influence of gender in academic and professional choices, one of the contents that we call orientation for transformation, is where the student appears to have received more guidance. The two main agents of orientation were the teaching staff and the family. Orientation professionals (educational counselor and psychologist) have played a more limited role, especially the educational counselor who is the one who has contributed least to the orientation of the student. This data abounds in the characterization and situation of the institutionalization of vocational guidance in secondary education. Vocational guidance is a one-off activity that takes place primarily at the end of high school. It lacks, therefore, the continuous character that defends itself at the conceptual level. Of the activities of professional orientation in which the student has participated more widely, was the consultation of sources of academic and professional information. The differences in ownership by schools that have studied high school indicate that the pupil who studied in private schools has generally been given more guidance, in addition to being more continuous and to be carried out to a greater extent by the psychologist. The student arrives at the university with little knowledge of the studies he will carry out, his demands and his domains of professional performance. Failure to provide guidance that integrates the different areas of intervention may lead to abandonment, locking or failure.

The passing of the university is a formative period with important consequences for social, personal and professional development. In the university course, the student faces changes of stage and new situations of integration of university life and of academic, professional and work decisions. Vocational guidance will provide them with knowledge, skills and attitudes that will help them to respond appropriately to new situations. Thus, vocational guidance in Higher Education acquires a significant importance in the formation of students, enabling assistance for integration in university life, for academic decision making and for insertion in the job market. In the same way, it was detected that the study done on the institutionalization of the orientation, shows that its institutional development is still incipient; the analysis of the data presented below will allow us to know the characteristics of the professional orientation received and the needs of its most direct beneficiaries: the student of the six Federal University of Rondônia - UFRO campuses. In the continuation, the characterization of both high school and university education is presented at the Federal University of Rondônia.

## II. CHARACTERIZATION OF MIDDLE SCHOOL

Vocational guidance in High School is especially important here. At the end of this educational stage the student has to make a decision about his academic and professional future. During high school, the student must receive the professional guidance that facilitates this moment and avoid future dissatisfaction with the academic choice and also some abandonment or even an exchange of university studies. Despite the importance and educational need of vocational guidance, its institutional development is rather precarious. In this item we present some of the data analyzed throughout this, which are presented below and allowed to know indirectly the situation of their institutionalization, in the opinion of their most direct beneficiaries: the former secondary school student who is currently a university student, besides of having made possible to know the orientation received and the necessary orientation in the following dimensions: Self-knowledge; Academic and professional information; Guidance for transition to the labor market; Orientation for transformation and professional project and individual counseling.

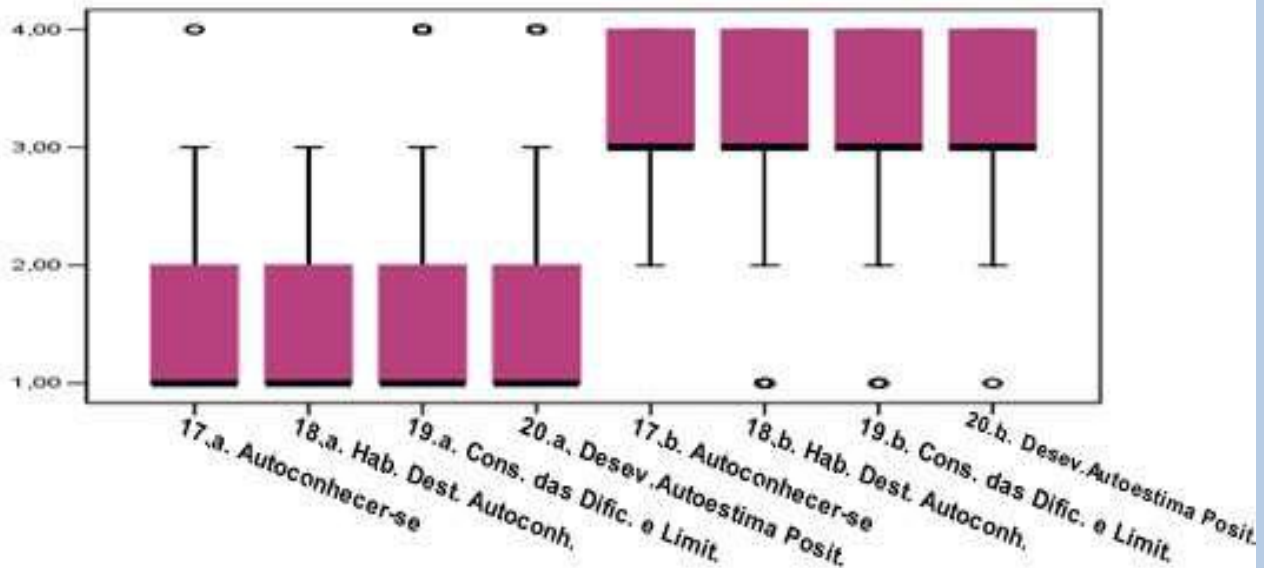
### 2.1 Self-knowledge

Self-knowledge refers to the possibility of the individual knowing himself in those aspects related to academic and professional decision-making. Self-knowledge seeks a dual purpose. On the one hand, to make available to the student a series of elements of reflection that give them a better knowledge of themselves. On the other hand, stimulate and improve those aspects that are required

through some planned intervention strategies (Álvarez and Isús, 1998). Self-knowledge needs to be worked on in order to identify the subject's personal history, in which the necessary reflections on his personality traits are made, which must be analyzed with the purpose of helping him to define his professional project, awareness

of their training and their occupational skills (Romero Rodríguez, 1996). In graph 1 will be presented the variables that approached contents, necessary for university students, in the Self-knowledge dimension. Comparison between the orientation received and the orientation you need.

Graph.1: Self-knowledge. Orientation received and what you need.



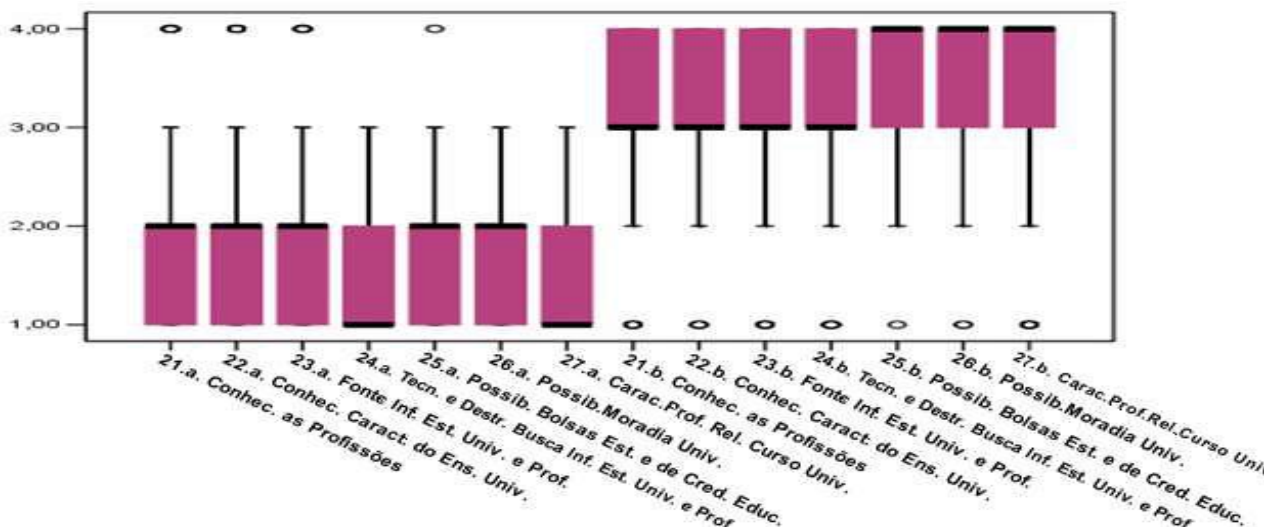
**Legends:** 17.self-knowledge; 18.Skills for self-knowledge; 19.Consciousness of the difficulties and limits; 20.Development of positive self-esteem;

2.2 Academic and professional information

Information is one of the essential components of career guidance. Its main contribution is to increase the knowledge of the academic options, the professions and the knowledge of the labor market. That is, diversify the knowledge of the educational, professional and labor world so that they can make a very informed decision

making. From the perspective of the orienting as an active person it is very important that they know the sources where to obtain this information and that they acquire the necessary skills to know how to seek and use this information. Graph 2 will present the variables that addressed contents, necessary for university students, in the dimension of academic and professional information.

Graph.2: Academic and professional information. Orientation received and guidance you need.



**Legends:** 21. Knowing the professions; 22. Knowing the characteristics of university education; 23. Source of information on university studies and professions; 24. Techniques and skills. Research Information University Studies and Professions; 25. Possibility of scholarship and educational credit; 26. Possibility of university housing; 27. Professional characteristics related to the university course

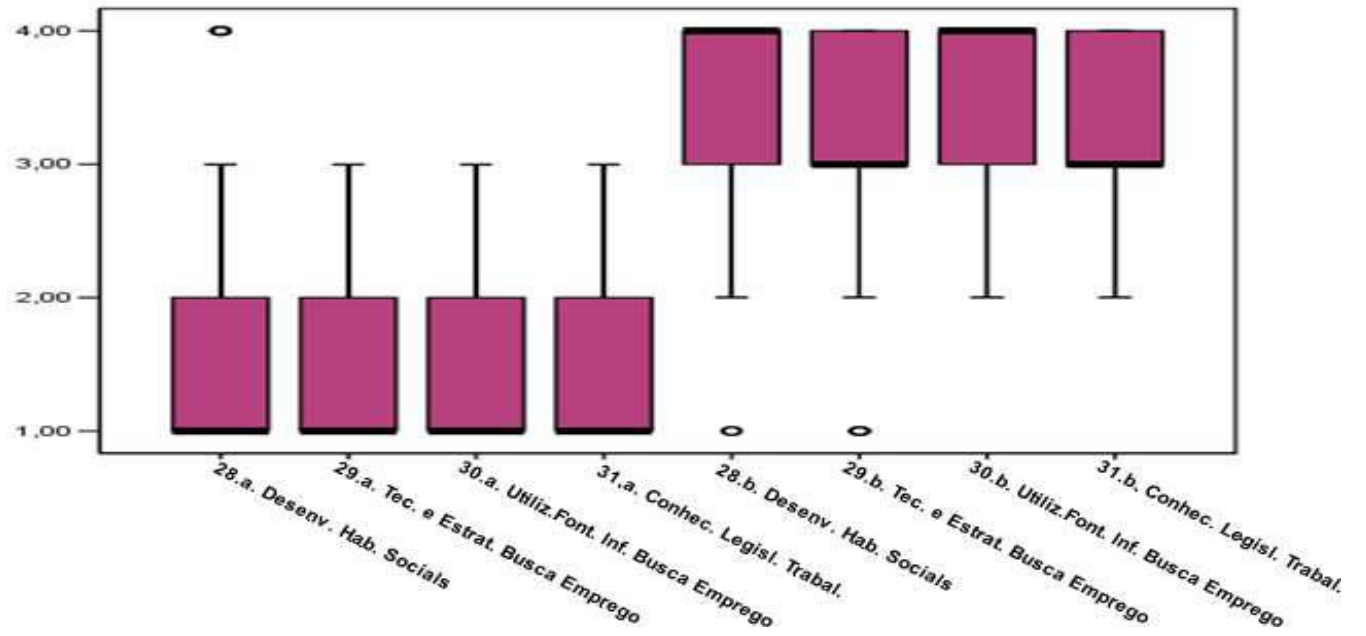


**2.3 Orientation for transition to the labor market**

The High School is an educational stage of transition to the labor market for a good part of the student. Not every student goes to college. Faced with this reality, the professional orientation takes on a special importance,

those contents or thematic ones that are of help to integrate itself in the labor market. Graph 3 will present the variables that addressed contents, necessary for university students, in the orientation dimension for transition to the labor market.

Graph.3: Orientation for transition to the labor market. Guidance received and guidance you needed.



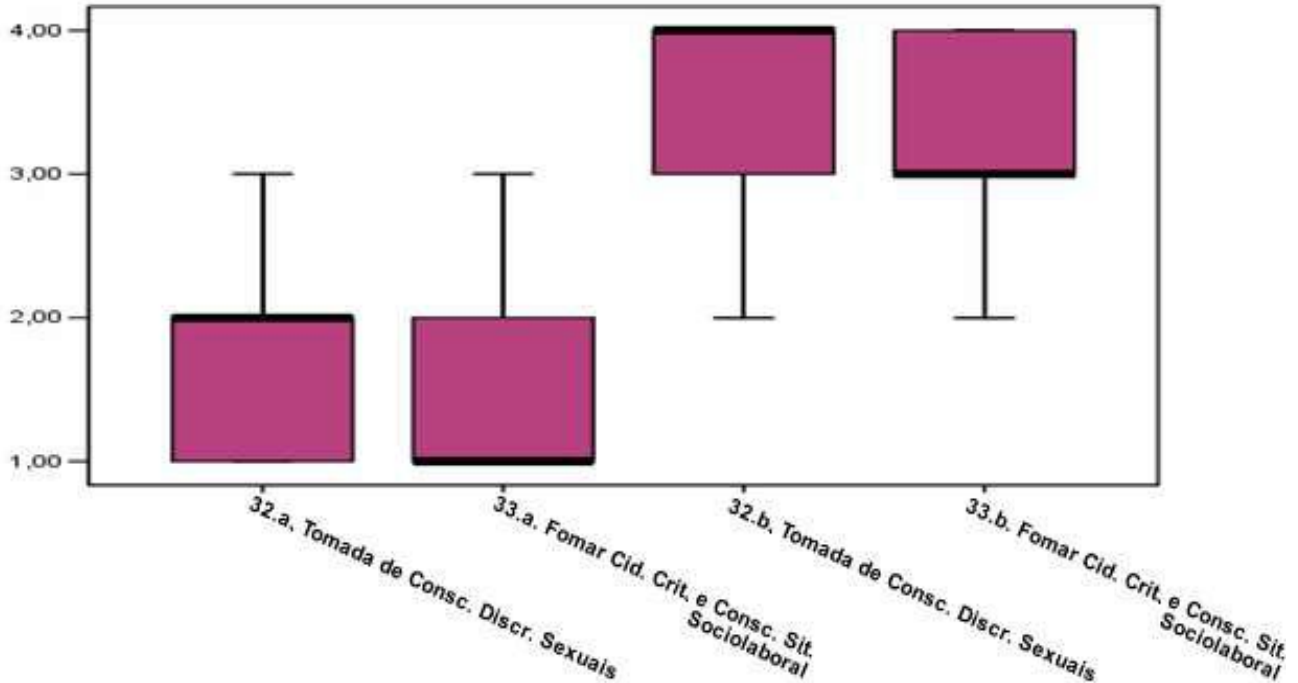
**Legends:** 28. Development of Social Skills; 29. Techniques and strategies for job search; 30. Use of sources of information in the search for employment; 31. Knowledge of labor legislation

**2.4 Orientation for transformation**

Vocational guidance should contribute to the formation of critical citizens aware of the socio-labor situation and its social meanings. It also has to promote decision making that is not influenced by gender. From this vision of professional orientation two questions are incorporated into the Guidance for transformation dimension. One is

about identifying and raising awareness about the gender factors that condition access to education and the world of work. The other is related to the formation of knowledgeable and critical citizens of the socio-labor situation. In graph 4 will be presented those variables that approached contents, necessary for the university student, in the dimension Orientation for transformation.

Graph.4: Orientation for transformation. Orientation received and what you need.



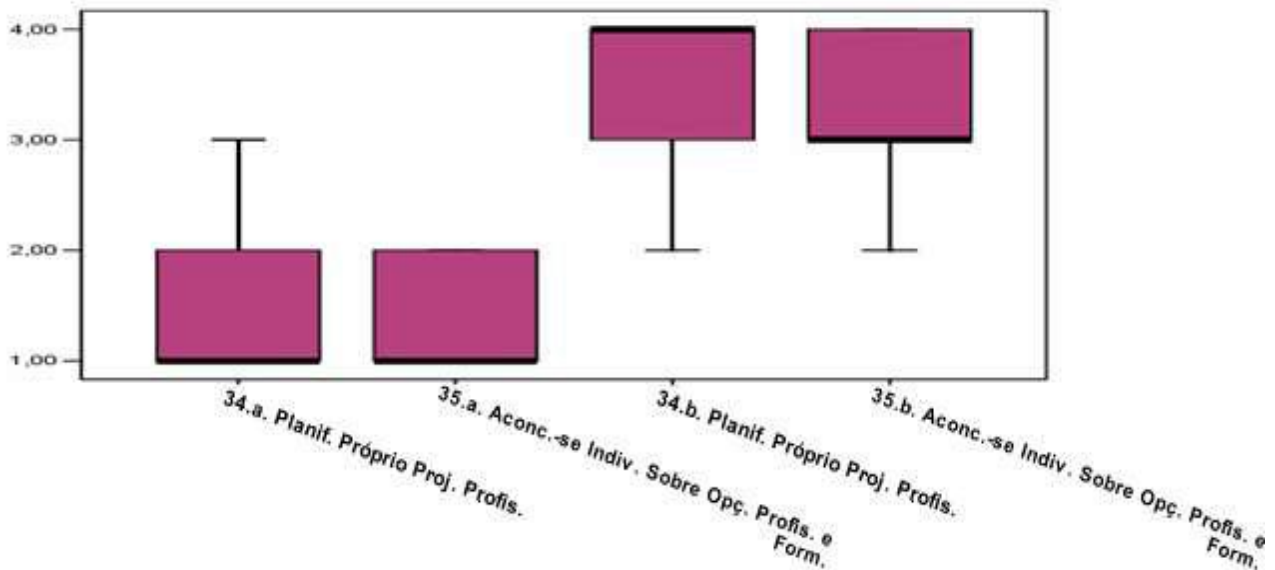
**Legends:** 32. Awareness-raising about social discrimination;  
 33. To train critical and conscientious citizens of the socio-labor situation

### 2.5 Professional project and individual counseling

At this point we analyze the professional project and the individual advice. The professional project is one of the key contents, in which the changes operated in the design and guiding procedures converge, in which the person assumes the fundamental protagonism of the guiding process. The elaboration of the professional project itself allows us to anticipate situations and provide them with intentionality in future actions. Its planning for the student is fundamental and should be developed gradually, in

phases or stages sequenced and with the help of motivating or encouraging strategies that serve as a lesson for this development. (RODRÍGUEZ MORENO, 2003). Individual counseling is the help provided by the specialist and which characterizes the counseling intervention model. In Graph 5 we also present these variables that addressed contents, necessary for university students, in the dimension Professional project and individual counseling.

Graph.5: Professional project and individual counseling. Orientation received and guidance you need



**Legends:** 34. Planning your own professional project  
 35. Individual counseling on professional options and training

### III. CHARACTERIZATION OF PROFESSIONAL ORIENTATION RECEIVED AT UNIVERSITY

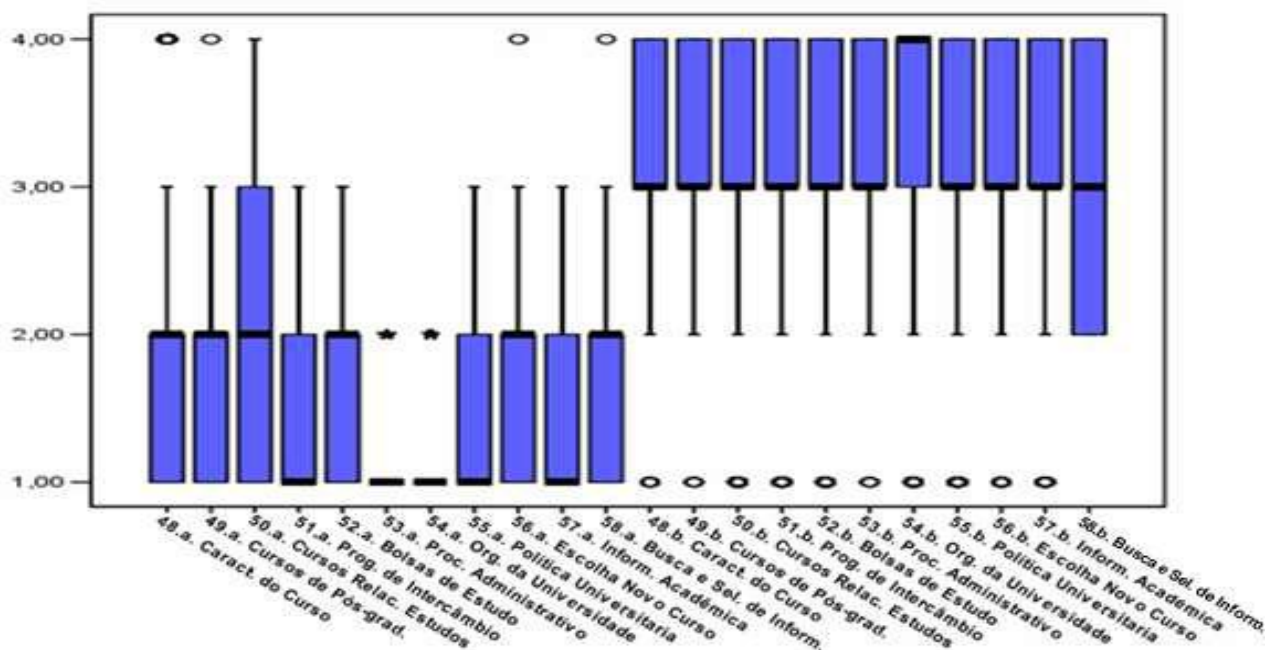
In this point the conclusions regarding one of the research objectives are indicated: characterize the orientation received during university teaching. As in high school, the orientation received is characterized by its scarce presence. In this trend, it should be remembered that in almost all subjects, the majority of the students stated that they received no guidance and that the received orientation was evaluated as the category indicating their lowest level of achievement. Another of the characteristics refers to the origin of the orientation received. The orientation comes mainly from outside the university institution. The family is the main guiding agent, followed by friendships and the media (internet, newspapers, TV). The professorship is the one that gave less guidance. The unequal presence of the areas and their contents is another characteristic that is identified in the orientation received. In this line, it is worth pointing out the following traits: The orientation received is fundamentally informative. The informative contents on academic issues (characteristic of the course that studies complementary training and postgraduate training) were the most attended. The passing of the university is a formative period with important consequences for social, personal and professional development. In the university course, the student faces changes of stage and new situations of integration of university life and of

academic, professional and work decisions. Vocational guidance will provide them with knowledge, skills and attitudes that will help them to respond appropriately to new situations. Thus, vocational guidance in Higher Education acquires a significant importance in the formation of students, enabling assistance for integration in university life, for academic decision making and for insertion in the job market. The analysis of the data presented below will allow us to know the characteristics of the professional orientation received and the needs of its most direct beneficiaries: the one of the six UFRO campuses in five dimensions: academic and professional information; self-knowledge; professional design and individual advice; techniques and strategies for job search and job information.

#### 3.1 Academic and professional information

Information is one of the essential components of career guidance. Its main contribution is to increase the knowledge of the academic options, the professions and the knowledge of the labor market. That is, diversify the knowledge of the educational, professional and labor world so that they can make more informed decisions. Higher education also requires information that allows the knowledge of the university institution and the existing resources, facilitating the integration of students in university life. Next, in Graph 6 will be presented the variables that approached different informative contents, necessary for the university student, in the dimension academic and professional information.

Graph.6: Academic and professional information. Received and needed



**Legends:**48. Course Characteristics; 49. Postgraduate Courses; 50. Curricula related to the studies  
 51. Exchange programs; 52. Scholarships; 53. Administrative procedure; 54. Organization of the University;  
 55. University policy; 56. Choose the new course; 57. Academic information; 58. Search and selection of information

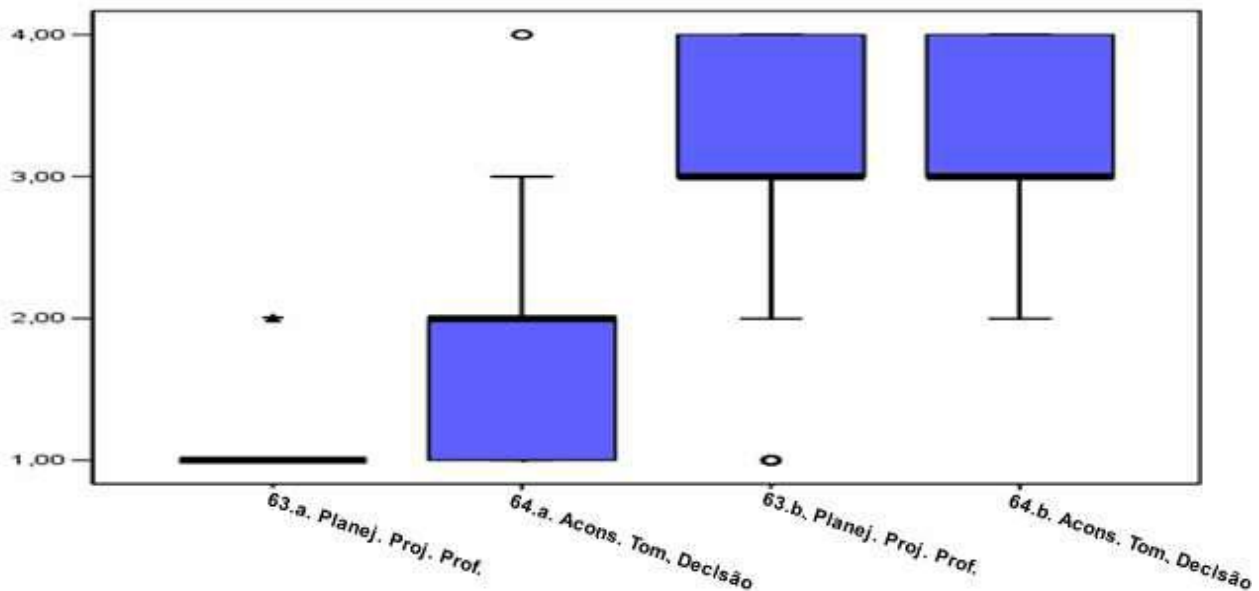
### 3.2 Self-knowledge. Received and needed

Self-knowledge refers to the possibility of the individual knowing himself, in those aspects related to professional choice and professional insertion. It is about knowing if it has information about its potentialities and limitations and how to overcome them. Besides, it provides the person to acquire the skills that favor this self-knowledge. The individual's options have to be very close to their personal preferences and professional life project. The characteristics of this knowledge within the university context must be dynamic and interrelated with the different sources of information, helping the individual to evaluate information not known in their process of self-knowledge, as well as those stereotypes that may interfere in some way training itinerary.

### 3.3 Professional project and individual counseling. Received and needed

This item analyzes the elaboration of the professional project and the advice in the decision making. The planning of the professional project can be considered the goal synthesis synthesis: to achieve that at the end of the guiding process the person defines his short and long term goals of the future and the plan of action for his achievement. Counseling is one of the functions of counseling, understood as an individualized help relationship. In Graph 7 will be presented the variables that approached different content, necessary for the university student, in the dimension Professional project and individual counseling.

Graph.7: Professional project and individual advice received and needed



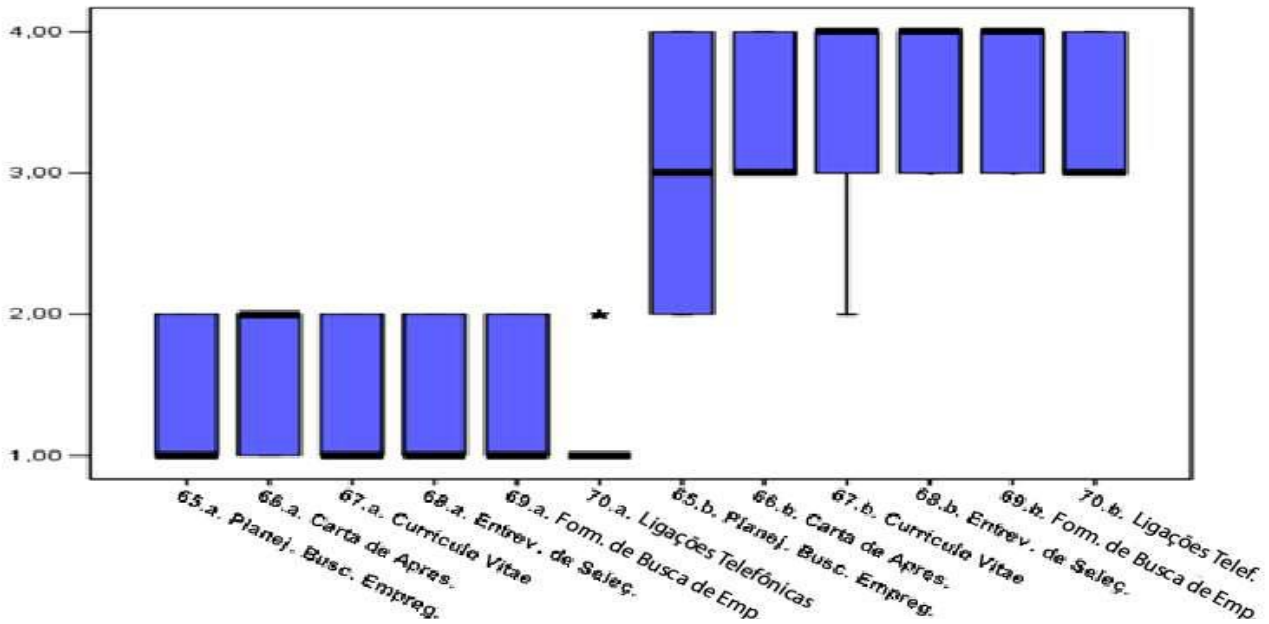
**Legends:** 63. Professional Project Planning; 64. Counseling for decision making

### 3.4 Techniques and strategies for finding employment. Orientation received and needs

The university studies constitute a stage of professional qualification, that in principle, allows the access to the labor market. In a complementary way, the professional orientation provides knowledge, attitudes and skills that

can facilitate the process of professional insertion. Traditionally called job search strategies and techniques are part of the vocational guidance oriented to the transition to the labor market. Figure 8 will present the variables that addressed contents, necessary for university students, in the Techniques and strategies of job search.

Graph.8: Techniques and strategies for seeking employment received and needed



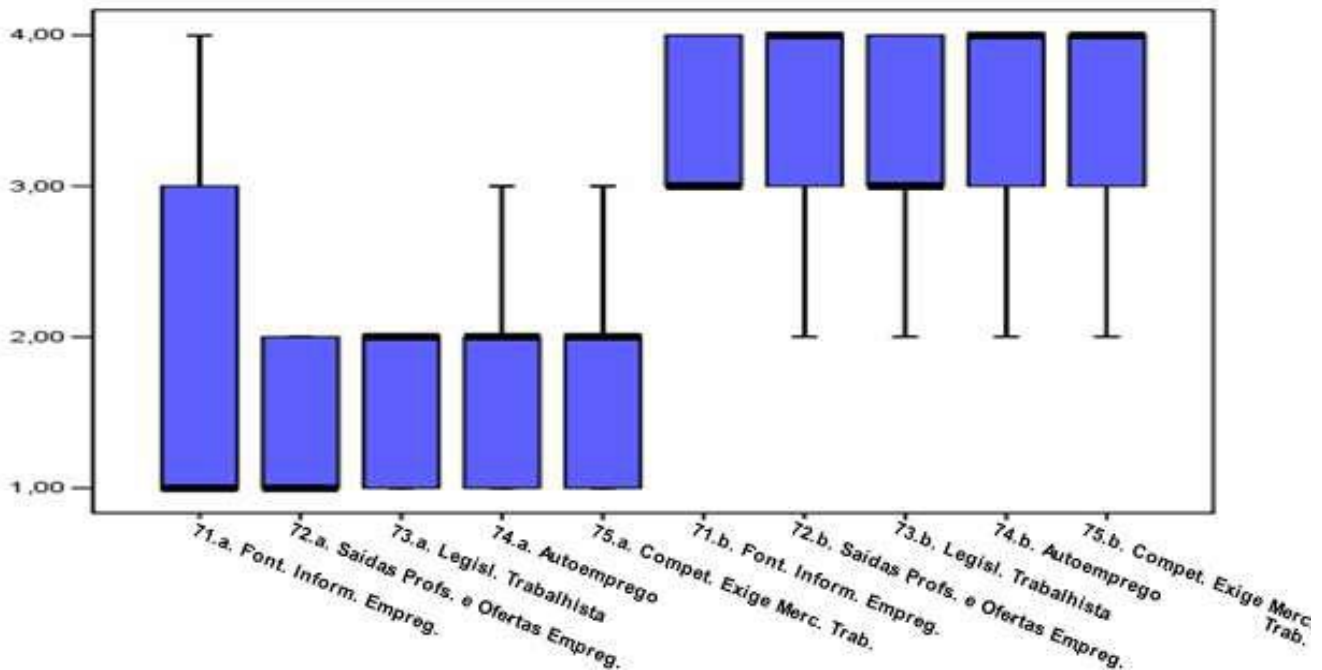
**Legends:** 65. Planning for job search; 66. Cover letter; 67. Curriculum vitae; 68. Selection interview; 69. Job search training; 70. Telephone calls

### 3.5 Labor information. Orientation received and needs

At this point, the results were analyzed the following contents of the specific information for the labor insertion: Sources of information on employment, Career opportunities and job offers related to the course you are doing; Labor legislation; Possibilities of self employment

in the professional scope and elaboration of an auto employment project; Professional skills required by the labor market. In Graph 9 will be presented the variables that approached contents, necessary for the university student, in the dimension Labor information.

Graph.9: Labor information received and needed



**Legends:** 71. Sources of information on employment; 72. Career opportunities and job offer; 73. Labor legislation; 74. Self-employment; 75. Skills required by the labor market

#### IV. DISCREPANCIES BETWEEN THE GUIDANCE RECEIVED AND GUIDANCE THAT YOU WOULD LIKE TO RECEIVE

In this section, we present the conclusions related to the objectives of the research, which aimed to identify the needs of vocational guidance, felt by students in high school and university education. The information is organized into two sub-items, one for high school and another for higher education. One of the evidences obtained with our study is the mismatch between the orientation received and the orientation they would like to have received. In this sense, starting from the concept of necessity, such as the discrepancy between a starting situation and that which is considered desirable or convenient, the distance between the orientation received and that which it would like to have received is taken as an indicator of the needs perceived by the group of students. Both in high school and university education, there were discrepancies between the orientation received and the orientation they would like to have received. Thus, a first general conclusion is the existence of orientation needs in all areas of vocational guidance studied. The orientation provided did not respond to the needs felt by the student, neither in high school nor in university education.

##### 4.1 Vocational guidance needs in high school

In High School did not meet the needs of professional guidance of the student. The student expressed a general dissatisfaction with the orientation received in this previous stage of joining the University. In the continuation, the main conclusions are summarized in relation to the needs felt by the pupil in high school.

- a) Needs affect all dimensions or areas studied (academic and professional information, self-knowledge, professional design and advice for decision-making, labor information and techniques and job search strategies).
- b) The most felt needs are not linked to a single area. The following contents are relevant: sources of employment information, information on scholarships and educational credit, development of social skills and knowledge of the influence of gender, academic and professional decision making, and knowledge of the professional spheres of work. course.
- c) The "less valued" needs cover some topics in the areas of academic information (characteristics of university education and skills to search for information), labor information (labor legislation) and self-knowledge.

##### 4.2. Vocational guidance needs in university education

As in high school, there is also general dissatisfaction with the orientation received and the demand for more guidance in all areas of vocational guidance. The need for

vocational guidance in university education affects all dimensions investigated (academic and professional information, self-knowledge, professional design and advice for decision-making, techniques and strategies for job search and job information). There is general dissatisfaction with the guidance received. The totality or almost the totality of the pupil manifested needs of orientation in all the areas. Particularly necessary are areas and content related to the transition to the labor market. Thus, among the most felt needs are the majority of the labor information topics (knowledge of job skills required by the labor market, professional exits and jobs related to the course), most of the techniques and strategies of job search (interview, curriculum vitae). In self-knowledge the most valued aspect is the one that most relates to the professional insertion, the identification of the own professional competences and the contrast with those that demand the labor market; Among the most important needs are also advice for decision-making and, within the area of academic information, knowledge of the organization and functioning of the university and knowledge of administrative procedures (registration, locking, transfer, etc.); The less felt needs correspond to different areas. The majority of the topics in the area of academic and professional information are the least valued: the abilities for the search and selection of information, information about further training, postgraduate training, university politics, scholarships and sources academic and professional information); The planning of job search and phone calls in the area of job search strategies and strategies and the integration of the gender perspective in self-knowledge are other topics that lie between the less felt period needs and the sex do not associate with larger needs. Significant differences in groupings with these variables affect the few orientation themes. In this line they manifest the following characteristics: The student from the beginning has more need in the area of self-knowledge and information, specifically in the information for choosing a new course, on administrative procedures and on exchange programs; At the end of the course, the information on complementary training and those related to the future professional insertion are prioritized, namely, the identification of professional skills and the knowledge of the professional skills required by the labor market; Advice on academic and professional decision-making, information on postgraduate training and on labor legislation are the most felt needs of the student in the middle period; the students prioritize the knowledge of the characteristics of the course, the planning of the professional project and the selection interview; The student adds value to information for self employment and scholarships.

## V. METHODOLOGY

This proposal of professional orientation arises from our research on the needs of professional orientation of the students of the Federal University of Rondônia that culminated in doctoral thesis. In view of the problem investigated, and in light of, particularly, the main objectives of our study, we adopted a line of descriptive inquiry type survey. This, besides being one of the most used in educational research, presents itself as the most adequate to the objectives that we propose in this investigation. Particularly to describe the nature of the existing conditions (Cohen and Manion, 1980). The methodological option of our study is justified by several reasons: It makes possible a wide population range; It allows a broad descriptive study, based on information collected and treated, of a significant number of the population universe. It is the first study of this nature in the State of Rondônia. So far, there are no basic information that could support this research. This requires an extensive collection of quantitative information that, while guiding and sustaining the ultimate goal of research, can serve as a starting point for future educational research in this geographical area. The instrument used to obtain the data related to the vocational guidance needs of UFRO students was a questionnaire, applied in those courses where there were university students in the beginning, middle and end periods, as previously mentioned. Data analysis once the questionnaires were in place, they were coded and prepared for further analysis. These were performed using the statistical software SPSS (Software Statistical Package for the Social Sciences) version 12.0 for Windows. Given the descriptive purpose of this investigation, the analyzes carried out were of four types: frequencies and percentages, graphic analysis through Box-Plot, Anova de Friedman; and proof of Wilcoxon's significance. The graphical analysis through Box-Plot was carried out for each one of the variables that should be answered based on the double appreciation of the orientation received and the orientation that it would like to receive. Its use enabled us to compare the two perspectives. Considering that the valuations performed on each of the items are of an ordinal type, the type of chart called the box or Box-plot seems to us the most adequate to inform about the distribution of such variables. It is a graph based on measures of position, which gives a summary of the most relevant information of the distribution: the median, the 25th percentile (1st quartile) and 75 (3rd quartile). Since this type of representation is little used, its characteristics were briefly described. The data revealing the professional orientation needs felt by the students served as a basis for designing a set of actions designed to meet the needs diagnosed and directed to the high school student and the UFRO.

## VI. OBJECTIVES

Develop a tutorial action plan; To bring together a first-rate information tool such as the web; Create A program of action with High School; Provide elaboration of manual edited in paper format and in its electronic version.

## VII. PROPOSALS

The results of the research concerning the characteristics of the professional orientation received and the lack of orientation perceived by the student require the UFRO to assume the progressive implementation of professional orientation. Thus, it is necessary to articulate realistic actions, adapted to the institution and that meet the demands of orientation of the student. In the continuation, using as reference the data of the investigation, four measures are suggested to integrate the professional orientation in the offer that the UFRO offers to its pupil as well as the one that studies high school:

1. A program of action with High School, for which we describe the objectives and activities;
2. The incorporation of new contents in the web of UFRO in order to make accessible to the information that the student needs;
3. A tutorial action plan in which different activities and guiding agents are integrated and
4. A UFRO manual addressed to the new student;

### 7.1 Some initial considerations

Before the presentation of the four proposals, we describe the characteristics of the professional orientation that underlies our proposals and guide the guiding action. It also details some necessary conditions for its realization and operation.

### 7.2 Assumptions for guiding action

The proposed actions we present are guided by the following assumptions that we consider to be basic and guide the guiding actions:

- a) Professional orientation is understood as a preventive, educational, procedural activity and for all students. In this sense, he must accompany the student from his entrance until his leaving the university. Their task is to acquire the knowledge, attitudes and skills that allow them to fully integrate university, build their training itinerary, configure their professional project and face the future professional insertion.
- b) Structuring the orientation along a continuum, with moments differentiated mainly by the themes that prioritize. Within this continuum we identified four moments: before entering university, beginning of university studies, during and the end of the course. The information has a cumulative character, that is, that can provide at different times different levels of deepening. Prior to joining the university, information on the access and registration systems (procedure and characteristics of

the tests, registration procedures), scholarships and educational credit, housing and on the courses: entrance profile (interests, attitudes, disciplinary knowledge), curricular matrix (specializations, internships, menus) and professional field. This orientation is necessary since high school, but UFRO should make this information available. At the beginning of university studies, integration and adaptation to university life, it is a priority to deepen the knowledge of the course and the knowledge of the university and the resources that it can have. During and at the end of the studies, priority is given to: the configuration of the training itinerary during the course (choice of optional subjects and specializations, complementary training) and completion of the course (postgraduate studies), mobility possibilities to other Brazilian universities and labor information and the acquisition of job search strategies and strategies.

c) One of the objectives to be assumed by UFRO is the creation of a global integrated guiding system organized at different levels of competence and responsibility. Tutoring and specialized guidance services would configure the two basic intervention levels of the system. The implementation of guidance services on campuses should be established as a medium-term goal. This service would extend its activities to other areas of orientation, that is, it would not focus exclusively on professional guidance, even if it is its priority field of action. Among its functions, the following should be highlighted: Recompiling, selecting, creating and disseminating academic, professional and computerized information, favoring a quick and effective consultation, and at the same time facilitating the processes of self-affirmation, self-exploration and realistic vocational decision-making; Provide individual or group counseling in decision making and professional project planning; Outline and develop the actions to train the student in the skills for the preparation of the professional project and for the job search; Inform and advise for self employment; Evaluate the orientation needs of the student and analyze their evolution; To strengthen the university's links with the world of work (companies and public bodies related to labor insertion); Collaborate and support the guiding function performed by the tutor teaching staff and the activities that take place in the nuclei and departments.

d) The diversity of agents involved: teachers, guidance professionals and students. Some of the themes of professional orientation take place in the disciplines and specialized functions of the teaching profession, such as tutoring. In the way that the disciplines are developed, the professional stage must be valued and used as a significant means to increase the professional information of the student, incorporating objectives in this direction.

e) The actions must cover all areas of professional guidance, you can not limit the information area.

### 7.3 Institutional support

The implementation of some of the proposed actions shares the characteristics of an innovation process and requires changes at different levels that require the commitment and implication of the agents in charge of the guiding function and of the institution itself, which, above all, has to take the direction of the proposals and the provision of resources and support to ensure the minimum conditions necessary for its implementation. The conditions it refers to are the following: Awareness of the need and importance of professional guidance in the promotion of quality education and in the improvement of the educational offer of UFRO; Providing the necessary human and economic resources; Recognition of orientation in the General Regiment of the University; Provide them with means to facilitate their achievement by promoting the broader participation of a range of functions and fields of intervention in close collaboration and cooperation with other teachers and especially with tutors; Ensure the agents involved in the perception of the direction of change through training, facilitation of resources, facilitate the exercise of the functions that are called to assume and through the sequence and evaluation of experience. The proposal of actions must be applicable and realistic based on the needs of the student and the resources and possibilities. He is also a finalist in that he marks the way forward. It does not imply that all actions take place at the same time and from the beginning. It is a proposal in which one must work, in the face of a long road to be traveled. It should also be an element of reflection on the possible ways to meet the demands of guidance of the student, in order to assist in the decision-making of those responsible for university policy.

#### - University orientation program for high school (PROEM)

The program that is proposed for the high school student is composed of several actions. Its main purpose is to provide academic and professional information. It also aims to strengthen the collaboration between the university and the secondary schools. It is a program that by its characteristics and, in principle, would be under the responsibility of the Departments of Education and Psychology and the guardianship of some of its professors. The actions included in the program are as follows:

a) UFRO manual for high school students.

Its purpose is to provide information on the following topics:

- About UFRO (a little of its history, the campuses and its offer of courses) - Structure and organization of university education. The objective is for the student to know the levels that are organized (graduation, post-graduation *stricto sensu*, post-graduation *lato sensu*,



improvement and/or update) and its characteristics (duration, degree obtained), Glossary that collects the specific terminology of the university studies and the organization of the university.

- University access system: administrative procedures, characteristics of the tests and advice to tackle them successfully; Courses offered with information on admission profile (interests, attitudes, disciplinary knowledge) the curricular matrix, type of subjects, internships, monograph, egress profile (skills and competences that need to be acquired) and fields or fields of professional activity. University housing. Scholarships and educational credit. With information about the type of scholarships, the recipients, the prerequisites, selection criteria, duration, the period of application, the benefit and the commitment of the scholarship holder. Enrollment: place, period and documents that have to accompany and Frequently asked questions.

The guide can not be a simple informational manual. A proposal for activating actions, which promote the search, selection and use of information for decision making, would complete the guide. It will also support the work of teachers, educational counselors and psychologists in secondary schools. The information has to be presented in a clear and synthetic way. The guide has an add-on on the web.

#### b) Days of Open Doors.

This activity offers the possibility of visiting the different faculties of the university and receive first-hand information about the characteristics of the studies and their professional exits. The responsibility of its organization would be of the Departments, with the support of the nuclei.

#### c) Information sessions in the secondary schools.

This activity consists of teachers and UFRO students participating in visits and informative meetings in the centers about access and the courses offered at UFRO.

#### - New content on the web of UFRO

The web is an informative tool of first magnitude. It is different from other traditional information media, it has the advantage of speed and ease in updating the information. The main problem stems from the limitations of Internet access and its quality. Since the survey data was collected, the UFRO website (<http://www.unir.br>) improved its structure and content and introduced themes related to some of the student's needs. The analysis of UFRO's website (October 2012), from the perspective of the needs of the student's professional orientation, reveals important shortcomings and a waste of their informative potential. The information of interest for the student of high school and university are in three items of the academic portal: Graduation, Post-graduation and Orientation. In the item of Graduation, it is informed of the offer of courses by *campus*. Only, for five courses,

more complete information is provided, through the connection to their Departments, specifically those of Physics, Electrical Engineering, Biological Sciences and Environmental Engineering. The information is not homogeneous, neither in the presentation, nor in the accessibility, nor in the issues that it treats. Only two courses have more complete information: course objectives, professional profile, curriculum matrix (distribution of subjects by periods, credits, contents and bibliography for each subject), academic calendar and schedule, simplified extract of the Political Pedagogical Project. This document collects information on multiple topics: course profile (justification, objectives), faculty, curricular structure (distribution of subjects by periods, credits, contents and bibliography), course activities, training profile (percentage of different subjects and activities in the training - practical activity, internships, completion work, basic nuclei and vocational and specific nuclei), egress profile (skills and competences), form of course access, course and process design evaluation system teaching and learning. In no case is there any information about the field of professional activity. At the University, in the item teaching, information is also added from the courses offered at UFRO's seven campuses. It offers information on fifteen courses, eleven more than on the graduation item. The information provided is different depending on the course and, in general, is much lower and of less quality than in the case of the courses commented in advance. In most cases, it is limited to the timetable, the academic calendar, the academic year and the curricular matrix (distribution of the subjects by periods and contents and credits of the subjects). Only one course includes information about the professional profile and the fields of professional activity. In the Postgraduate item, present a list of masters and doctorates. In most cases, it refers to the master's and doctoral web. The type of information provided is not homogeneous for all masters. The information they can collect focuses on the program (objectives, disciplines, areas and lines of expertise and research), the selection and registration process, evaluation, calendar and research groups. Some master's degrees include information on teacher and student exchange agreements. In Guidance, a guide is presented to the Student. Its items summarize information on different issues: Presentation of the UFRO (what it does, headquarters and location), government bodies, academic bodies, functions of other bodies and services, student representations, glossary of terms, frequently asked questions and attention calls on administrative procedures (enrollment, consequences of absences, doubts about academic control standards, reasons for loss of ties with UFRO) library and restaurant service. The information on the access system to UFRO is contained in the portal of selective processes

(competitions and vestibular). It offers information on the administrative procedures of enrollment and registration, the necessary forms and the vacancies offered by courses. A clear description of the access system and the characteristics of the evidence is lacking. Part of this information is scattered in the edicts. The information focuses on administrative procedures, the facilitation of forms and the novelties in relation to the process. From the UFRO web analysis, it is concluded that, despite the improvements introduced in recent years, there are important shortcomings related to the lack of information and the quality of the information offered. The shortcomings make reference to different areas and contents of the professional orientation on which the demanded orientation. In the first place, the areas most demanded by the student are absent: the labor information and the techniques and strategies of the job search. In addition to the issues identified in the analysis of the web (characteristics of the university access system, structure and characteristics of university education), information on scholarships and educational credit and mobility is not also provided to other universities. Our proposal describes below and focuses on improving some information that already exists on the web and incorporating new content. It is a question of adapting the information to the needs of both university and high school students, as shown below:

1) Homogenize the information of the courses and incorporate questions about the professional fields and the entry and exit profiles. As previously mentioned, in addition to providing very restricted information, few courses offered information and only one course provided information on the field of professional practice.

2) Creation of a Portal for the high school student that responds to their information needs. The categories to include, would be the following: university studies, access, courses, scholarships and educational credit and university housing. Especially important is the Courses section. Its objective is to contribute with information about the curriculum, about the entrance profile (knowledge, competences, interests and related attitudes), about the professional field of the course and about the egress profile. According to the data of our research, the student arrives at university education with little knowledge about these issues and demanded more information about them. In the current web page does not appear this item and the information on these questions does not exist or are partial.

3) Create another new portal of the University on the Labor Market. Its objective is to respond to the needs most felt by the student, those related to the professional insertion. We propose the following items: Techniques and strategies of job search. It would contribute information and advice on the most traditional ones (curriculum vitae, interview, cover letter, job search

planning) and the new means associated with web 2.0; Sources of employment information: job portals, National Employment Service (SINE), institutional websites offering information on public employment, etc. ; Career opportunities and jobs for each course; Self-employment: business project, administrative procedures, aids and credits for the creation of the company.

4) Scholarships and educational credit. In this item information about the scholarships for which the requirements and the dates on which the call notice is published are collected. It would have an item of news in which they would publish the scholarships that are in term of candidacy and that would allow, through RSS, the sending or enlisted student.

5) Housing. This item associated with the creation of an advertising desk about accommodation, apartments and houses available in the city of Porto Velho.

6) Schedule of administrative procedures (enrollment, transfer of students, request for use of disciplines, request for inclusion of subjects, reintegration of special enrollment, request for locking, etc.). It is more than a simple calendar, details each of the procedures.

7) Seek exchange with other universities. It collects information on the possibilities of studying stays in other Brazilian and foreign universities and on the requirements, selection criteria and procedure to be followed.

#### **- Tutorial Action Plan - TAP**

In Brazil, the tutoring understood as the guiding activity of teachers' responsibility has had a scarce development. Some tutelage actions only happen very timidly in some institutions, usually through isolated initiatives of a few teachers, who spend a few moments of their meager time to meet certain students in their various types of needs. However, they are totally voluntary actions with little or no planning and without the proper support of the institution. The tutoring linked to teaching in the subjects taught by the teacher does not have the proper recognition. The teacher does not have a specific time to attend to the student. Unlike Brazil, in Spain tutoring has recently achieved a prominent role, expanding its typology and functions and implementing specific programs, tutorial action plans. The tutorial action plan is another of the proposals that we suggest to meet some of the professional orientation needs that we detect among the student. The characterization and outline of our proposal inspired the authors and the experiences that have developed in recent years in Spanish universities, especially in the experience carried out at the University of Coruña (Arza, 2007). In spite of the distances and contextual differences between the Brazilian and Spanish university systems, we consider that this experience is perfectly transferable to UFRO, as long as it favors some necessary conditions for its implantation and

consolidation. In the continuation, the characteristics that describe the tutorial action plan are presented, in which conception and modality of tutoring is supported, what aims it attends and how it is organized.

**- Characteristics, design and types of tutoring on which it is based.**

We characterize the TAP (Tutorial Action Plan) with the following traits: It is a program that has its scope of action in the course. Each course has to outline and develop its own tutorial action plan; It is an institutional plan, establishes objectives, organization and tutorial actions; And a formative offer, complementary to that realized in the teaching of the subjects and that integrates a different type of performances; Its purpose is to cover the needs of the student's orientation that corresponds to different moments of their stay in the university and that were detected in our research. The guiding agent is the teacher. The tutorial / guidance function becomes part of the teaching responsibility. The exercise of this function implies a more personalized interaction between the teacher and the students with the objective of reaching the highest level of academic and professional development; The tutorial action developed by the teaching staff should be complemented by the professional orientation services. The tutorial action plan would form part of an orientation system in which different levels of intervention are differentiated: the orientation service and the tutorial action plan. The faculty is not an expert in professional guidance. Its function in this area is determined by the knowledge it has of the university institution, the course in which it teaches and the professional market of the course; The TAP includes a set of activities of different types: the individual and group that the tutoring teacher is responsible for. the Jornadas, lectures and workshops. These modalities are the most pertinent to address some needs that may exceed the competencies of the tutoring teacher. We are referring to: the topics related to self employment, the techniques and strategies of job search, with job information. These themes can be approached in this format by different agents (among others, professionals in the field of courses, professional advisers); TAP should be governed by the following three principles: (a) Contextualization: the objectives are defined based on the student's needs analysis and priority. Realism and applicability. Objectives and actions must be achievable and achievable, planning what can be done,

taking into account the material and personal resources available. Flexibility in the construction process. That is, susceptible of amplifying the needs and problems that it attends and in turn submitted to a continuous revision and improvement; The implementation of tutorial action plans should begin as an experimental and voluntary project for the nuclei, for the departments and for the courses and should have the proper support and support of the institution. In this line, it is essential to recognize this function and to allocate the necessary resources for its development: assignment of specific time, materials (planning guide, activity guide, assessment tools) and advice. Conception and tutoring modalities in which the TAP is supported The modality of tutoring that is proposed is based on the figure of the teacher-tutor who has assigned a group of students and who can be supported in his work by the tutor. In this context, tutoring is defined as an aid relationship, generated in an individual or group meeting with the student, planned in advance or the demand, which is concretized in the advisory, information exchange and analysis of issues or issues relevant to development academic, professional and personal experience of the student. The idea of tutoring that defends itself is that of an integral tutoring and of course. It is an integral tutor, since it focuses on the development of university students in their intellectual, academic, professional and personal dimension. One of its fields of action is the professional orientation, although its action extends to other areas of educational guidance. It is course tutoring in that it is carried out during the duration of undergraduate studies. Their temporal coverage has to be decided according to the needs, the priorities of the course and the number of the teaching staff. In this way, and initially, it can be established that the TAP is limited to the first year of the course, later, that extends to the intermediate periods of the course and to all the periods. Our proposal includes three tutorial figures: The tutor who is in charge of a restricted group of students; The tutor specializing in the labor market or post-graduate training; The ally mentor who collaborates with the other two figures.

**- Student needs and objectives**

From the results of our study, we conclude that the needs of the student extended to all areas of professional orientation. The TAP is one of the means that we can serve to serve them. Table 1 summarizes these needs.

*Table.1: Vocational guidance needs of the UFRO student*

- Knowledge of training options at the end of the studies (post-graduation, professional specialization)
- Knowledge of academic information sources.
- Knowledge of the professional market (professional fields, jobs, self employment, etc.)
- Knowledge of sources of labor information.
- Acquisition of techniques and strategies for job search.
- Acquisition of techniques and strategies for job search.

- Individualized advice for decision-making.
- Professional project planning.
- Selfknowledge.
- Knowledge of the university as an institution (governing bodies and academic management, services and extension and research programs)
- Knowledge of university policy (rights and duties of the student, participation of the student in the choice of leaders and councils, etc.)
- Knowledge of administrative procedures.
- Knowledge of the course (curriculum, prerequisites, professional internships, optional subjects.)
- Knowledge of scholarships and educational credit.
- Knowledge of the possibilities of complementary training (courses of improvement, extension, internships, congresses, seminars, language learning).

There are two types of objectives: those related to the learning that the student must acquire and those related to the professional orientation needs detected and those not less important, which can be derived from the tutorial activities as in the continuation:

a) Objectives in relation to the student - To acquire information and resources that facilitate the transition and integration in the university and the course - To know the services, the programs, the complementary training activities and the resources that UFRO places available to the student. - Acquire the necessary information for the configuration of the academic itinerary and professional specialization. - Acquire the information and skills necessary to face labor insertion. - Acquire a better knowledge of itself - Plan the professional project - Receive personalized advice.

b) Objectives in relation to the process In addition to the objectives linked to the needs of the student, the TAP can also achieve the following objectives: Detect and support the student in situation of abandonment of studies or change of courses; To obtain information on the adaptation, integration and progress of the students and promote actions to improve academic performance; To detect other specific support needs and to collaborate in conflict prevention, school failure or dropping out of studies, and to promote coordination networks among the professors of a course that contribute to evaluate and improve the quality of the educational offer.

#### - Organizational and functional issues

Here we describe some organizational issues and the roles of tutors and coordinators.

- **Coordination and commissions:** In each course a coordination of the TAP will be named. It will be chosen from the teaching staff that will take on the tutorial function. At least three times a year, the coordinators will meet with the tutors to outline, continue and evaluate the TAP. The TAP coordinator is responsible for the course's tutorial action program. Its main functions are as follows: Inform course teachers about the characteristics of the tutorial action plan; Promote the participation of teachers in the TAP; Inform the committee; Encourage and

support the teams of tutors (motivating, training and providing resources); Name the tutor; Participate in the drafting, follow-up and evaluation of the TAP; Prepare the corresponding evaluation reports; To channel to those who correspond to the needs and problems detected and, if applicable, also the possible alternatives of action; Give an account before the community and before the institutional leaders of the operation of the TAP. The work of planning, continuity, evaluation of the TAP and coordination between the TAPs of the core courses will be carried out within the framework of two committees: the TAP course committee and the core TAP committee. The first is the task of outlining, continuing and evaluating the course TAP, they are part of it, the tutor teaching staff and the course tutor student. The Core TAP Commission is responsible for coordination and exchange of experiences between core courses. This committee includes the TAP coordinators of the courses and the core director.

- **The tutor teacher:** designation, advisable profile, functions and activities.

#### a) Procedures for choosing and appointing tutors

It is suggested that all teachers who teach in the course and who voluntarily assume this task may be tutored. Priority will be given to exercising the tutorial function of those teachers who share professional and/or compulsory subjects in front of the electives, among those that have more credits and / or more students. The number of tutors will be what is necessary to attend the totality of the students. The average student/teacher will be determined according to the number of tutors. It would be desirable for this average not to exceed 10 students per tutor.

#### b) Recommended profile to be tutor teacher:

For the performance of the role of tutor is desirable what is presented in the continuation: Have a favorable attitude to the performance of the tutorial function; Knowledge and mastery of its purposes; Availability and dedication to attend the student, for the training itself and for the coordination tasks; Knowledge and resources to carry out the tutorial action; Profile of human qualities (empathy, maturity, respect for others), social and communication

skills, democratic leader, etc .; Knowledge of university, core and course; Knowledge of the professional scope of the degree. The characteristics described describe the advisable profile that a tutor should have and that to a great extent can be developed through specific training. However, their application does not mean that they have to be used as selection or exclusion criteria. The underlined characteristics should guide all the tutor that should be progressively enhanced.

**c) Functions:** Participate in the preparation, development and evaluation of the tutorial plan; To make known the academic norms, the services of the university and the sources of information that may be useful for a greater and better use of the resources of the university; To inform about the characteristics of the course and to guide it in the configuration of the academic itinerary; Encourage participation in activities related to their training; Inform the possibilities that have in the completion of the studies as much of formation as of professional exits; Follow-up of the academic achievement of the student; Identify aspects that interfere with the student's academic performance; Contribute to the teaching quality of the course, insofar as it can detect dysfunctions and deficiencies and propose possible solutions; The informative functions of the tutor should be understood not as simple transmitters of information, but as introducers of this information and its importance. In this sense, the tutor more than informant is a channel of information and sources where it can be obtained, and also a promoter of the motivation of the student to be informed. In order to carry out many of these functions, it is essential that the information is available and that it meets the needs of the student. Specialized tutors can also be incorporated. There are two fields of specialization: the professional market of the course and the complementary and postgraduate training. These new tutorial figures would be the closest institutional referent to which the student can request help. Its functions would be: To organize lectures and seminars on postgraduate training and on the professional market; Participate in the elaboration of information on the themes of his tutorial specialization; Organize and participate in workshops on techniques and strategies for job search and self employment; Inform about the themes of your tutorial specialization; Attend the consultations and advise on the themes of their responsibility.

**d) Activities:** The activities carried out by the tutor teacher are of two types: Activities with the group of students who tutor; Individual tutoring activities, sued by the student or planned in advance in the TAP.

#### - Functions of the students mentors

In the outline of the TAP, the participation of the tutor student can be agreed. The student mentor will be a student of the past periods and will act under the

supervision of the teacher or teachers who have appointed him. Its functions are as follows: Collaborate with tutors; Provide support and information (course dynamics, characteristics of the subjects, syllabus, activities that offer the nucleus and the university, organization and functioning of the university); To detect problems that interfere in academic achievement and channel it to the tutor; Encourage student participation in training, cultural and extension activities; Collaborate in the activities of the program destined for the secondary school student.

#### - Measures of support and support

In the development of this project it is fundamental the support and institutional support. Due to its relationship with the purposes of the TAP, the Pro-rector of culture, extension and student affairs (PROCEA) would be responsible for its execution, with the collaboration of the Departments of Education and Psychology. Support measures should include teacher training and mentoring, recognition of the tutorial role within the teaching functions, technical support and supervision, and development of resources for the outline, development and evaluation of the TAP. In the following we materialize these measures:

- a) Theoretical-practical seminar for the teacher that will assume the tutorial functions. The topics to be addressed are the following: Tutoring at the university: conceptual characteristics, typology, functions and spheres of action; The professional orientation as scope of action of the tutoring; Analysis of TAP experiments; Presentation of the UFRO Tutorial Action Plan; Guidelines for the planning and evaluation of the tutorial action plan; Strategies for tutorial action; Presentation of the dossier of activities and instruments for the draft and evaluation of TAP and the dossier of activities; TAP outline for the courses.
- b) Elaboration and diffusion of materials (proposal of activities, instruments of assessment of the TAP, specific bibliography, compilation of experiences, etc.);
- c) Creation of a web item specific to the TAP;
- d) Advice, continuation and support in the development of the TAP, through periodic meetings in the nuclei that implant this experience;
- e) Recognition of the task accomplished through the certification of their participation and the accounting in the teaching time of the activities performed as tutor.
- f) Incorporation of the TAP in the Pedagogical Project of the course.
- g) Journals for the exchange of experiences and for the evaluation of the developed projects and web publication of the TAPs developed. For the student tutor will also be offered a seminar with the following contents: The university orientation and professional orientation; The tutoring of equals: scopes of action and functions of the tutor student; Communication techniques and group

dynamics for guiding action; Student tutor program planning; Strategies and resources for university tutoring. With the implementation and optimal functioning of the courses tutorial action plans, the student will have personalized help to adapt and integrate in the university, to configure their academic-professional path, to improve their academic performance and to the labor market. All these issues are relevant elements in the achievement of a quality university education and are related to the needs that the student has to face at different times of his university career. With everything, the tutorial action must be complemented from the professional orientation services. Mentoring can not, and does not have the capacity to take on the whole, the development of career guidance. The faculty is not an expert in professional guidance. Their role in this area is determined by their knowledge of the university institution, the course in which they teach and the professional market of the course.

#### 7.4. UFRO Guide for the student of the Federal University of Rondônia

The Manual of the UFRO for the student of the Federal University of Rondônia is the fourth action that we suggest. As already mentioned in the analysis and proposal of new contents for the web, UFRO does not provide the academic and professional information that meets the needs of the student. This information, when it is offered, is scattered and incomplete. In this scenario, we think that the elaboration of a Guide is another instrument to meet the informational needs of the student and a resource for the action of the tutoring teacher. This is mainly intended for the student of new entry. The manual is edited in paper format and in its electronic version on the UFRO website. The objectives of the manual are: Provide basic and synthetic information and a clear and direct language. The contents focus on some of the informative topics in which the student manifested lack of information (organization and functioning of the University, university policy, student participation, services and resources that UFRO puts at the disposal of the student, organization and structure of university education, supplementary training, scholarships and educational credit, student exchange programs, regulations and administrative procedures). This information would be organized around the following items: The Federal University of Rondônia, structure and organization of university education, academic regulations and administrative procedures, scholarships, exchange programs with other universities, and to know more. In this last item would indicate the questions about which he should be informed and the sources where he can obtain this information. Make known the sources of information where you can get more information on the topics presented. The web is in this sense is the basic

informational reference. Facilitate resources for the development of the Tutorial Action Plan. The tutor as an information plumber needs resources of this type.

### VIII. FINAL CONSIDERATIONS

One of the reasons for this study was the need to deepen what the experience of the researcher as a teacher of the vocational guidance discipline had detected, that is, the immense difficulties faced by the students in various moments of their formative itinerary, among others: abandonment, changes and course lockouts. The results of the research confirm the dissatisfaction with the orientation received, both in the previous stage of admission to the university and during the stay in UFRO, and the existence of deficiencies that affect all areas of professional orientation and group of students of all courses. The data revealing the professional orientation needs felt by the students served as a basis for designing a set of actions designed to meet the needs diagnosed and directed to the high school student and the UFRO. Moving these actions to practice implies taking the first steps towards the institutionalization of vocational guidance in UFRO and recognizing their contribution to the achievement of higher quality education. This is one of the great challenges to face. The study has also provided us with a greater theoretical and practical knowledge of vocational guidance and has given rise to innovative reflections on instigating issues, opening up new possibilities for research and interest so that further study can be carried out. The implantation and evaluation of the proposed actions, the training of the professionals responsible for the orientation in the secondary education and the analysis of the situation of the professional orientation in university education refer these new lines of study. It is believed that the development of research in these themes can contribute to the necessary process of institutionalizing vocational guidance at different levels of education, which still lacks a long way to go.

### REFERENCES

- [1] ÁLVAREZ GONZÁLEZ, M. and ISUS, S. (1998). Career guidance. In Bisquerra, R. (Coord.). Models of orientation and psychopedagogical intervention. (pp.233259). Barcelona: Praxis.
- [2] ARZA, ARZA, N. (2007). The UDC's Titulación Tutorial Action Plan: guidelines and resources for its development. Unpublished document.
- [3] AUBREY, C. (1993). An overview of consultation, in Aubrey, C. (Ed.). Consultancy in the United Kingdom. Its role and contribution to educational change. London: Falmer Press
- [4] AZPILLAGA LARREA, B., and BEREZIARTUA ZENDOIA, J. (2005). Work analysis. Identification of competency components for the performance of

- the orientation. In: Proceedings of the XII National Congress of Models of Educational Research: Research in Educational Innovation (pp.795-802). Tenerife, University of La Laguna.
- [5] BARROS, D. T. R. LIMA, M. T., & ESCALDA, R. (Orgs.) (2007). Professional choice and insertion: Challenges for individuals, families and institutions: professional orientation: theory and technique. São Paulo: Vector.
- [6] BENAVENT, J. et al. (2000). Self-help program for decision-making After completing compulsory secondary education. C.E.S.O. F / 06, Spanish Journal of Orientation and Psychopedagogy, 12 (22) 283-302.
- [7] BISQUERRA, R. and ÁLVAREZ, M. (1996). Models of intervention in orientation, in BISQUERRA, R. and ÁLVAREZ, M. (coords.). (1998). Orientation and mentoring manual (331-351). Barcelona: Praxis.
- [8] BISQUERRA, R. (1998). Guidance and psychopedagogical intervention models. Barcelona: Editorial Praxis.
- [9] BOCK, SILVIO. (2001). Professional orientation: The socio-historical approach. São Paulo: Cortez.
- [10] CABRERA, L.ÁLVAREZ PÉREZ, P. (1997). Diagnosis of needs in the guidance intervention at university levels, In proceedings of the VII National Congress of Models of educational research. (pp. 414-418). Seville: University of Seville.
- [11] CABRERA PÉREZ, L. et al (2005). The influence of the teaching staff and of the degree in the abandonment of university studies. In Proceedings of the XII National Congress of Models of Educational Research: research in Educational Innovation, (707-714) Tenerife, University of La Laguna.
- [12] CASTAÑO, C. (1983). Psychology and vocational guidance. An interactive approach. Cambridge: Cambridge University Press.
- [13] CASTELLANO MORENO, F. (1990). A needs analysis among students of the University of Granada for the elaboration of a program of educational guidance, In Educational research magazine, 16,8; 49-155.
- [14] COHEN, L. E. MANION, L. (1980). Research methods. Madrid La Muralla. S.A.
- [15] ECHEVERRÍA, B., ISUS, S., MARTÍNEZ, P. and SARASOLA, L. (2008). Professional orientation. Barcelona. Editorial UOC.
- [16] ECHEVERRÍA, B. (2009). ICT-TAC orientation. At <http://www.educaweb.com/noticia/2009/02/09/tic-tac-orientacion13451.html> consulted on 12-15-2011).
- [17] ESCUDERO MUÑOZ, J.M. (1990). "School-centered training". Communication presented at the Workshop on the Educational Center. Huelva.
- [18] FILELLA, G. et al. (2005). The tutorial action plan of the University of Lleida. In AIDIPE: Proceedings of the XII National Congress of Models of Educational Research: Research in Educational Innovation. La Laguna: Publications Service of the University of La Laguna. (Cd-rom).
- [19] ISÚS, S. (2008). Concept and functions of Professional Orientation. In Echeverría, B. (coord.) Professional Orientation. Barcelona: Editorial UOC (125-170)
- [20] JACQUEMIN, A., MELO SILVA, L. and PASIAN, S. (2002). The Burefsbilder Test (BBT): Photo Test of Professions in professional orientation processes. In R. S. LEVENFUS, D. H. P. SOARES (Orgs.), Occupational vocational guidance: new theoretical, technical and instrumental findings for the clinic, the school and the company (pp.227-262). Porto Alegre: Artmed
- [21] LISBOA, M.D. (2002). Professional orientation and the world of work: reflections on a new proposal against a new scenario. In LEVENFUS, RS and SOARES, DH Vocational orientation - Occupational: new theoretical, technical and instrumental findings for the clinic, school and company .Porto Alegre: ARTMED.
- [22] MELO, SILVA, L., LASSANCE, M., SANTOS, M., & RISK, E. (2008). Revista Brasileira de Orientação Profissional: Management report for the periods 1997-1999 and 2003-2007. Brazilian Journal of Professional Guidance, 9 (1), pp. 112.
- [23] PÉREZ BOULLOSA, A. (2009). Orientation for professional insertion: strategies and resources, In SOBRADO, L. and PASCUAL, A (coords.), (2009). Professional orientation: new scenarios and perspectives. Madrid: Bilioteca Nueva.
- [24] RODRÍGUEZ MORENO, M.L. (2003). How to orient towards the construction of the professional project. Individual autonomy, value system and labor identity of young people. Bilbao: Editorial Desclée de Brouwer.
- [25] RODRIGUEZ MORENO, M. L. (2009). Techniques and resources of professional orientation, in SOBRADO, L. E. and PASCUAL, A. (Coords.) (2009). Professional orientation: new scenarios and perspectives. Madrid: New Library.
- [26] RODRÍGUEZ MORENO, M. L. (2010). Competence development: theory and practice: balance, professional project and learning basad. Barcelona: Laertes.
- [27] RODRÍGUEZ MORENO, M.L. (2010). Career guidance techniques and resources. Two stories

- house, L. E Cortés, A. (Coords) Professional orientation. New Scenarios and Madrid: New Library
- [28] RODRÍGUEZ ROMERO, M. (1996). Counseling in education, Archidona: Aljibe.
- [29] ROMERO RODRÍGUEZ, S. (2009). The vital and professional project. In SOBRADO, L. E. and PASCUAL, A. (Coords.) (2009). Professional orientation: new scenarios and perspectives. Madrid: New Library
- [30] SANTANA VEGA, L. E. et al (2010). The Educational and Socio-Labor Orientation Program: an instrument to facilitate decision-making in Secondary Education. *Journal of Education*, 351, 73-105.
- [31] SOARES, D.H.P. (2003). The Professional choice. São Paulo: Summus.
- [32] SOARES, D.H.P. (2003). Professional information via the Internet. In L.L. MELO, SILVA (Org.). Architecture of an occupation (pp. 363-376) São Paulo: Vector.
- [33] SOBRADO, L. E. and PASCUAL, A. (Coords.) (2009). Professional orientation: new scenarios and perspectives. Madrid: Biblioteca Nueva.
- [34] VIEIRA, M.J. and VIDAL, J. (2006). Trends for European Higher Education and implications for university orientation. *Spanish Journal of Orientation and Psychopedagogy*, 17 (1), 75-97.
- [35] VIDAL, et al. (2001). The offer of the Spanish orientation services: Innovation and adjustments to the needs of the university community. Madrid: general direction of the universities, Ministry of Education, Culture and Sports.
- [36] VIDAL, J., et al (2002). Offer of guidance services in Spanish universities. *Journal of Educational Research*, 20 (2), pp. 431-448.
- [37] VIEIRA ALLER, M.J. (2008). Criteria for the evaluation of the support system and orientation for university students: revision and proposal. *Journal of Education*, 345, pp. 399-423.
- [38] ZAMORANO, P. and OLIVEROS, L. (1994). Analysis of needs in first year students in the Faculty of Education, In XV International Congress of Human Resources, Orientation and Labor Market. Madrid: AEOEP.



# An Integrated Well-Reservoir Steam Injection Modelling for Steam Injection Optimization

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**Abstract**— *The limitation of Steam Injection to depths has been a subject of concern in the application of Steam Injection for heavy and extra heavy oil recovery. This is usually as a result of the complex mechanism of heat losses occurring in the wellbore and consequently the heat loss distribution in the reservoir. A conventional approach to the optimization of steam injection has been based on isolated analysis of the well system aimed at maintaining adequate steam quality at the sandface at optimal injection rate, pressure, temperature and overall heat transfer coefficient. This often results to total neglect of the effect of the interaction between the well system and the reservoir system in the Model results. This research presents an integrated approach in the modelling of steam injection project that incorporates both the well system and the reservoir system. In this study, a three case-study wells were analyzed which are located at INJ1 (1, 1), PROD1 (5, 5) and PROD2 (9, 1) respectively. The results of the findings reveals that the conventional practice of maintaining sufficient SQ at the sandface is not the last optimization strategy in real field scenario. This is because the efficiency of the heavy oil displacement by the steam is a co-function of the effective SQ at the sandface, the FHLR/FHLT and the relative distance of the injector(s) from the producer(s) which are characterized by the thermal properties of the reservoirs. As part of the objectives of this study, a novel numerical approach using PROSPER wellbore simulator is presented for analysing the impact of reservoir back pressure on the estimated SQ. The results as presented in the work shows that wrong estimations of downhole SQ can result from the total neglect of Reservoir Pressure especially in relatively deeper wells.*

**Keywords**— *Integrated, Modeling, Optimization, Reservoir, Steam.*

## I. INTRODUCTION

The global rise in oil price and the increasing worldwide energy demand are clear indications that many proved undeveloped hydrocarbon reserves has to be developed using available technology. These reserves have been identified as either conventional or unconventional based on its source. The OPEC Annual Statistics (2017) reported the world's total proven reserves as of 2016 to be **1,492,164Mbbbl**. According to PetroWiki (2017) classification, the unconventional sources of hydrocarbons include heavy oil, extra-heavy oil and Bitumen amounting to a total of 9 trillion barrels of oil (from both conventional and unconventional sources), accounting for about 83.42% of the world's total proven reserves. The efficient operation of steam injection requires the injection of steam of sufficient quality at sufficient rates. However, the cost of generating steam is quite high making up about a half of the overall cost of running the whole operation. Hence, the optimized use of the injected steam has been the industrial practice (Hong, 1994). For optimal application of steam, the reservoir depth must be duly considered as this poses a constraint to the efficiency of the operation.

The limitation of steam injection thermal EOR to depths not more than 5,000ft is due to significant heat losses in the wellbore, the formation and consequently, steam quality reduction. The development of models/ simulators is an important optimization tool in a more modern industrial society today. Thus, this enables the utilization of computer assisted numerical methods for the optimization of the parameter of interest over any possible number of ranges for convergence. Hence, an integrated model that can compensate for injection/reservoir pressure effect, choice of completion design and the reservoir response to steam will certainly be highly invaluable in the design and optimization of steam injection. This research provides an integrated ECLIPSE-PROSPER Steam Injection Model for

steam measurements along the injection as well as the reservoir response to steam thermal energy.

Thermal processes are generally classified as those EOR methods that involve the introduction of external heat energy into the reservoir to heat up the high viscous crude in the reservoir and as such make it more mobile. The temperature dependence of viscosity is of empirical basis. This forms the basics of every thermal recovery procedures since the entire aim is to raise the reservoir temperature for viscosity reduction. The viscosity of liquids as a function of temperature can be estimated using any of the following correlations:

- *The Andrade's exponential correlation*

$$\mu = Ae^{(B/T)} \quad (1.1)$$

Where;

$\mu$ = dynamic viscosity, cp

T= absolute temperature, K

A and B = constants which varies from liquid to liquid.

- *The Braden's correlation for oil*

$$\log(v_2 + C) = \left(\frac{T_1}{T_2}\right)^D \log(v_1 + C) \quad (1.2)$$

Where;

$T_1$  and  $T_2$  = absolute temperature at the original condition and the final conditions (when temperature is raised) respectively

$v_1$  and  $v_2$ = kinematic viscosity, cSt

C= constant (equal to 0.6 for  $v > 1.5$  cSt)

D= constant of the order 3.5 to 4 (Latil, 1980)

Generally, hot fluid injection can be classified as hot water injection, cyclic steam injection (also known as 'huff and puff') and direct steam injection (also known as steamflooding), (Latil, 1980). For the scope of this study, the attention is going to be concentrated on steam. The cyclic steam injection also known as steam stimulation or the huff 'n' puff is a practice that uses a single well alternately as injector and producer for a more efficient utilization of the heat injected. It basically involves three phases of operation for a given cycle:

- The steam injection phase( which is similar in operation with normal direct steam injection i.e. steamflooding)
- The soak period and
- The production phase.(Latil 1980)

In the assessment of the efficiency of the steam injection design, the major optimization criteria are to maintain optimum steam quality at a sufficient injection rate using the 'rule of thumb' (Hong, 1994). However, such rate must economically be considerable to compensate for the high cost of steam generation. For most practical consideration, the 'the rule of thumb' is to maintain an injection rate of

1.5B/D cold water equivalent(CWE) per acre foot of the reservoir and a steam quality of 40% at the sandface (Bursell et al, 1975; Farouq Ali,1979 and Doscher et al,1979).

The first paper ever presented on steam injection was done by Ramey, (1962) in which he developed equations for the estimation temperature profile as a function of depth and time for a single phase flow. The modelled generated was improved by (Satter, 1965)by considering the changes in steam quality, Overall heat transfer coefficient and the fluid properties which were not accounted by Ramey (1962). He thus presented better equations that compared the per cent of heat loss for superheated steam, saturated steam and understated steam.

(Hoist & Flock, 1966) was able to account for the effect of frictional loss and kinetic energy changes by dividing the entire injection system into three- (a) flowing fluid, (b) wellbore, and (c) formation with each part being treated separately and assuming they were interconnected only by heat transfer. This study shows that steam quality can be greatly affected by friction losses.

As an important steam optimization parameter, (Willhite, 1969) presented an iterative method for predicting the overall heat transfer coefficient by considering the various heat transfer mechanisms and thus presenting a method for the calculation of heat transfer coefficient for radiation through the annulus (*hr*) and the heat transfer coefficient for natural convection and conduction in the annulus (*hc*). Earlougher (1969) applied a depth-step technique similar to Satter's for calculating heat losses and downhole conditions. He extended Satter's approach by including the effects of pressure changes in the injection tubing and the effect of casing cement on heat transfer and studied the effects of various well completion schemes. He was able to demonstrate the importance of including the static pressure term in the pressure change. He also showed that by using insulated tubing heat loss could be reduced significantly. Earlougher concluded that the bottomhole properties of steam are a function of injection conditions and well completion, and also emphasized that the pressure change cannot be neglected in heat transfer calculation of steam injection. Pacheco & Farouq (1972) presented an analysis of wellbore heat losses and pressure drop for steam injection assuming the steam to be a perfectly homogeneous two-phase flow. Their studies showed that an increase of injection rate reduced heat loss and illustrated that frictional losses are important in determining downhole steam pressure, quality and temperature. This study was followed by Farouq Ali (1981) developed a comprehensive mathematical model to simulate the vertical upward and

downward flow of wet steam in a well. This model is a combination of the Paceco&Farouq(1972) model and the pressure/flow regime correlations of Gould et al (1974), Chierici et al (1974), and Duns and Ros (1961).

Farouq Ali (1986) used the Duns and Ros flow pattern map to determine flow regime for wet steam flow. His study showed it is necessary to include slip and flow regime in calculating the pressure change. Furthermore, using the Duns and Ros flow regime map, the flow regime was found to be predominantly in the Slug-Froth flow. Still on flow regime map, Sylvester (1984) has shown that the Taitel *et al* (1980) flow regime map is superior to the Duns and Ros map since it predicted the annular-mist flow at much lower superficial gas velocities especially at higher pressures.

As an improvement to Pacheco & Farouq (1972), Fontanilla& Aziz (1982) developed a mathematical model for wellbore heat loss that incorporated empirical two-phase flow correlations using Beggs& Brill (1973), Aziz et al (1972) and Yamazaki & Yamaguchi (1979) correlations. Yao and Sylvester (1987) have shown that the Beggs and Brill correlation is unsatisfactory for vertical annular-mist flow.

Another innovative study on steam injection was done by Jiansheet *et al* (2010). Their approach was able to account for the effect of the reservoir back pressure on the injection rate and consequently the steam quality by using a Nomograph developed for the Mukhaizna Field as against the conventional classical models that neglect the impact of the reservoir back pressure.

Most of the various classical models above has been used to develop the algorithm used by many steam injection softwares but the most common approach has been the independent analysis of the injection well and the reservoir.

## II. MODEL FORMULATIONS

Considering a steam injection well model as shown in Figure (1) transferring a steam-hot water mixture through a control mass,  $\Delta M$ , the general energy equation for the system at any two unique conditions (points) can be written as:

$$h_{m1} + \frac{g}{g_c} \cdot \frac{Z_1}{J} + \frac{V_{m1}^2}{2g_c J} = h_{m2} + \frac{g}{g_c} \cdot \frac{Z_2}{J} + \frac{V_{m2}^2}{2g_c J} \quad (2.1)$$

In differential form, Equation (3.1) becomes

$$dh_m + \frac{g}{g_c} \cdot \frac{dZ}{J} + \frac{V_m dV_m}{2g_c J} = 0 \quad (2.2)$$

If we include the heat loss term and assuming no work done by or on the steam, we have;

$$dh_m + \frac{g}{g_c} \cdot \frac{dZ}{J} + \frac{V_m dV_m}{2g_c J} - dQ = 0 \quad (2.3)$$

Equation (2.3) describes a general energy equation for the energy balance of the steam-hot water mixture in the system. For a general concern, it is often desired to express the energy equation as a gradient of the depth for the injection well optimization. Hence we can have,

$$\frac{dh_m}{dz} + \frac{g}{g_c} \cdot \frac{1}{J} + \frac{V_m}{g_c J} \frac{dV_m}{dz} - \frac{dQ}{dz} = 0 \quad (2.4)$$

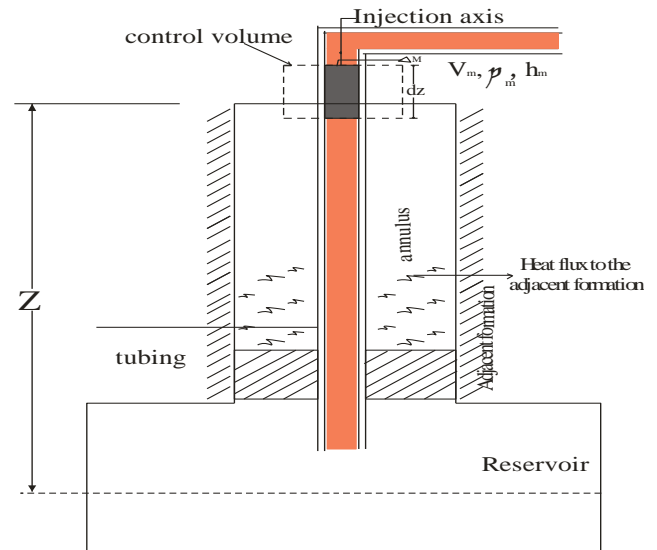


Fig.1: A Steam Injection Well Model

Sometimes, it is more convenient to express the steam mixture velocity,  $V_m$  in terms of the superficial velocity or the mass flux rate and specific volume of the individual components of the steam stream. By definition,

$$V_m = V_{sl} + V_{sg} = G_l v_l + G_g v_g \quad (2.5)$$

$$dV_m = G_l dv_l + G_g dv_g \quad (2.6)$$

Where;

$V_{sl}$  = Liquid (hot water) superficial velocity, ft/hr

$V_{sg}$  = gas (vapour) superficial velocity, ft/hr

$G_l$  = liquid mass flux rate, lb/hr-ft<sup>2</sup>

$G_g$  = gas mass flux rate, lb/hr-ft<sup>2</sup>

$v_l$  = liquid specific volume, ft<sup>3</sup>/lb

$v_g$  = gas specific volume, ft<sup>3</sup>/lb

Putting (2.4) and (2.5) into (2.6), we have the following result;

$$\frac{dh_m}{dz} + \frac{g}{g_c} \cdot \frac{1}{J} + \frac{1}{g_c J} \left[ v_l G_l^2 \frac{dv_l}{dz} + v_l G_l G_g \frac{dv_g}{dz} + v_g G_g G_l \frac{dv_l}{dz} + v_g G_g^2 \frac{dv_g}{dz} \right] - \frac{dQ}{dz} \quad (2.7)$$

Some of the essential properties of the steam that is of primary interest to this study are the mixture enthalpy, gas specific volume and liquid specific volume defined as;

$h_m = f(X, P)$ , hence,  $\frac{dh_m}{dz}$  can be evaluated as follows;

$$\frac{dh_m}{dz} = \frac{\partial h_m}{\partial X} \cdot \frac{dX}{dz} + \frac{\partial h_m}{\partial P} \cdot \frac{dP}{dz} \quad (2.8a)$$

More so,

$$\frac{dv_g}{dz} = \frac{\partial v_g}{\partial P} \cdot \frac{dP}{dz} \quad (2.8b)$$

$$\frac{dv_l}{dz} = \frac{\partial v_l}{\partial P} \cdot \frac{dP}{dz} \quad (2.8c)$$

Substituting Equations (3.8a-c), and solving for steam quality gradient, we can have the following result;

$$\frac{dX}{dz} = \frac{1}{\left[\frac{\partial h_m}{\partial X}\right]} \left[ -\frac{\partial h_m}{\partial P} \frac{dP}{dz} + \frac{g}{g_c} \cdot \frac{1}{J} - \frac{1}{g_c J} \cdot \frac{dP}{dz} \left( v_l G_l^2 \frac{\partial v_l}{\partial P} + v_l G_l G_g \frac{\partial v_g}{\partial P} + v_g G_g G_l \frac{\partial v_l}{\partial P} + v_g G_g^2 \frac{\partial v_g}{\partial P} \right) - \frac{dQ}{dz} \right] \quad (2.9)$$

The Equation (2.9) above is a first order differential equation that can be used to estimate the steam quality gradient analytically.

To estimate the pressure drop term,  $\frac{dP}{dz}$ , we establish the momentum balance equation in terms of the mechanical energy balance of the system. This is also sometimes conventionally expressed as the pressure drop equation for fluid flow through a pipe section. Hence we can write that;

$$\frac{dP}{\rho_m} - \frac{g}{g_c} dz + \frac{v_m dv_m}{g_c} + dW_s + dW_f = 0 \quad (2.10a)$$

Where:

$dP$  = total Pressure differential, lb/ft<sup>2</sup> (Psf)

$dW_s$  = Work done by or on the fluid, lb-ft/lb

$dW_f$  = Frictional work, lb-ft/lb

For  $dP$  in Psi, we can rewrite (3.10a) as;

$$\frac{144dP}{\rho_m} - \frac{g}{g_c} dz + \frac{v_m dv_m}{g_c} + dW_s + dW_f = 0 \quad (2.10b)$$

Since there is no Work done on or by the steam stream (expansion or compression of the fluid (steam)),  $\frac{dW_s}{dz} = 0$  such that Equation (3.10b) becomes,

$$\frac{144dP}{dz} - \frac{\rho_m g}{g_c} + \frac{v_m dv_m}{g_c dz} + \rho_m \frac{dW_f}{dz} = 0 \quad (2.11)$$

As usual by solving for the total pressure gradient, we can establish this equation below;

$$\frac{dP}{dz} = \frac{\rho_m \frac{g}{g_c} - \left(\frac{dP}{dz}\right)_{frictionlosses}}{144 + \frac{\rho_m}{g_c} \left[ v_l G_l^2 \frac{\partial v_l}{\partial P} + v_l G_l G_g \frac{\partial v_g}{\partial P} + v_g G_g G_l \frac{\partial v_l}{\partial P} + v_g G_g^2 \frac{\partial v_g}{\partial P} \right]} \quad (2.12)$$

In this study, the steam properties and the injection well conditions will be generated using PROSPER and a sensitivity test will be run using critical parameters as presented in the next chapter.

### 1. The Reservoir Back-Pressure Effect

It is a common experience that the reservoir pressure causes a significant constraint during steam injection. Therefore, a total neglect of this phenomenon will limit the accuracy of the predicted steam properties. The back-pressure phenomenon can be modeled using the figure below (Figure 2).

By capillary effect, the in-situ fluid tends to rise through the vertical column of the injector. For this set up, if we assume that the steam generator discharge pressure remains

unchanged at the wellhead, the total pressure of the injection well system at a constant injection rate can be established thus;

$$P_{inj} + (P_{res} - 0.052\rho_o dh) = P \quad (2.13)$$

Where;

$P$  = Actual Downhole Steam Pressure (which is equivalent to the total pressure of the system under injection conditions), Psi

$\rho_o$  = Oil density, ppg

$P_{inj}$  = Injection Pressure at depth  $dz$ , psi

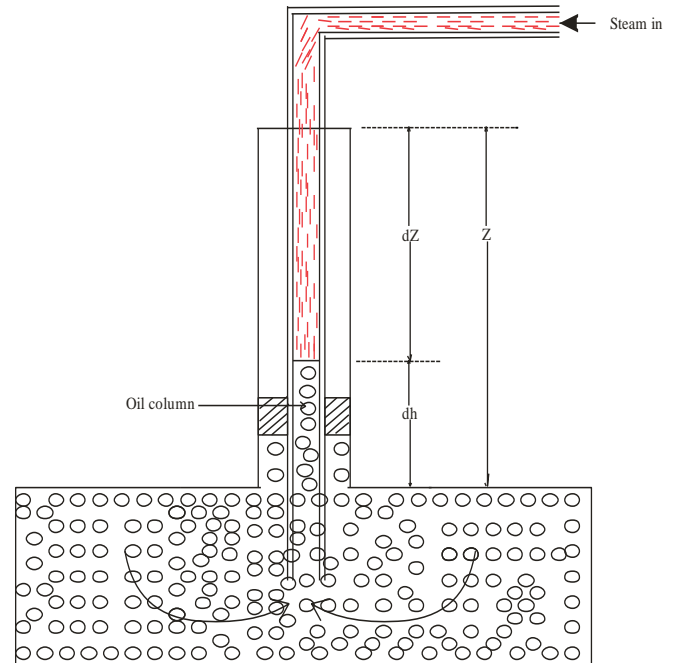


Fig.2: A well Model for Reservoir Back Pressure Effect

It is worth noting that this pressure ( $P_{inj}$ ) at the sandface ( $dz=Z$ ) can be greater or less than the injection constraint at the wellhead ( $dz=0$ ) depending on the dominating factor during the steam transfer to the downhole. If gravity dominates flow,  $[P_{inj}]_{dz=Z} > [P_{inj}]_{dz=0}$  but when frictional drag dominates the steam flow,  $[P_{inj}]_{dz=Z} < [P_{inj}]_{dz=0}$ . It only becomes unchanged when both the gravity losses and the friction losses have approximate equal impacts on the injection system.

As 'dh' approaches zero TVD, the influence of the reservoir pressure due to the capillary column of the rising becomes less significant.

In practice, the injection well is totally filled with the steam column such that  $dz$  approaches  $Z$ . This is certainly the case for heavy oil wells which do not readily flow by natural effect and also as a result of external constraint of the injection pressure. Therefore, we can rewrite Equation (2.13) as,

$$P_{inj} + P_{res} = P \tag{2.14}$$

In other words;

$$P_{inj} \left( 1 + \frac{P_{res}}{P_{inj}} \right) = P_{inj} (1 + \psi_p) = P \tag{2.15}$$

Where  $\psi_p$  is defined as the pressure ratio of the reservoir to the Steam injection pressure. The term  $(1 + \psi_p)$  is defined as the reservoir back pressure (RBP) correction factor denoted in this study as ' $\xi_p$ '. Therefore, the corrected pressure of the steam system can be expressed as,

$$P = P_{inj} \cdot \xi_p \tag{2.16}$$

The implication of the above Equation (2.16) is that a less accurate steam quality (overestimation) will be made by ignoring the reservoir back pressure especially for relatively high pressure reservoirs as this tends to constrain the injection pressure and consequently the injection rate of the steam. For convenience sake, this equation will be used to establish a table of values of  $\xi_p$  for different pressure ranges as presented in the appendix section. The effect of reservoir back pressure on the steam properties and the injection well system was analyzed numerically using PROSPER simulator and the result presented in the next chapter. To achieve this, the reservoir pressure was set at the corrected pressure based on Equation (3.16) using the following algorithm.

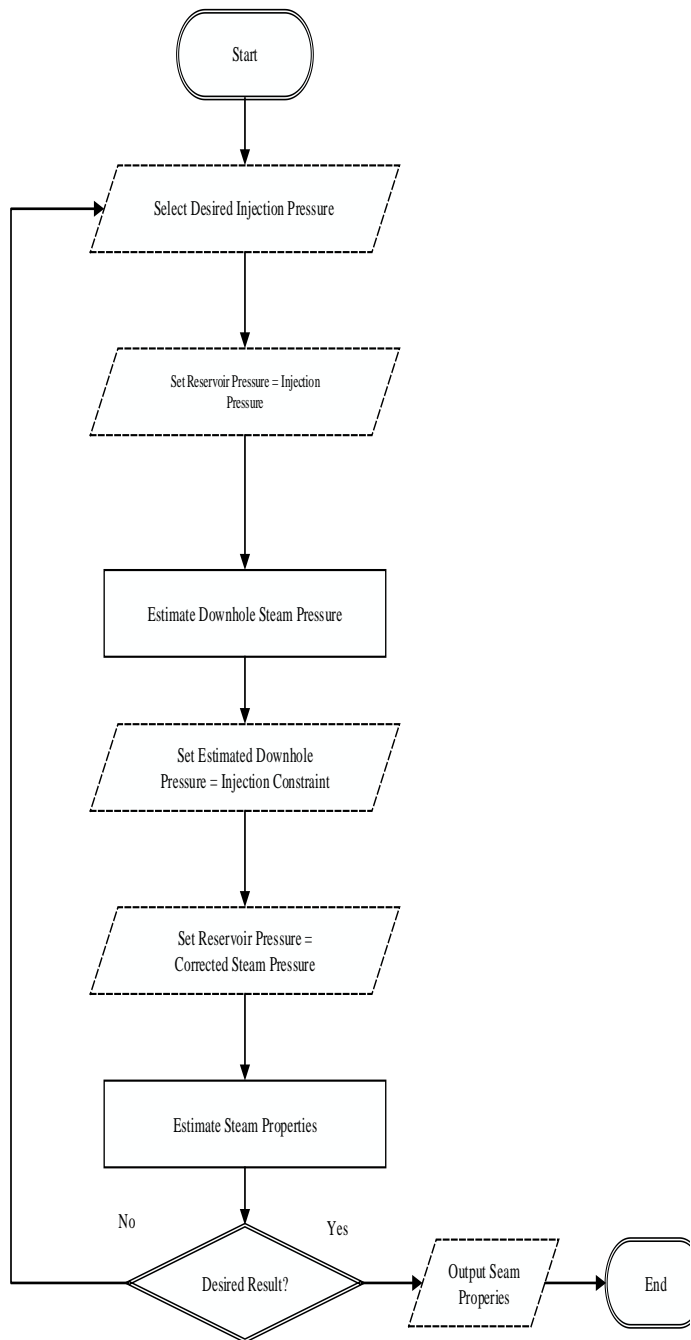


Fig.3: Algorithm for Reservoir Back Pressure Analysis

### 2. The Wellbore Heat Loss Calculations

In the literature review of this study as presented in the preceding chapter, it is clearly identified that the most influencing factor for the optimization of steam injection is the choice of completion. This is because the completion design directly affects the heat losses that occur in the injection well. A typical model for this is given in the figure below (Figure 4)

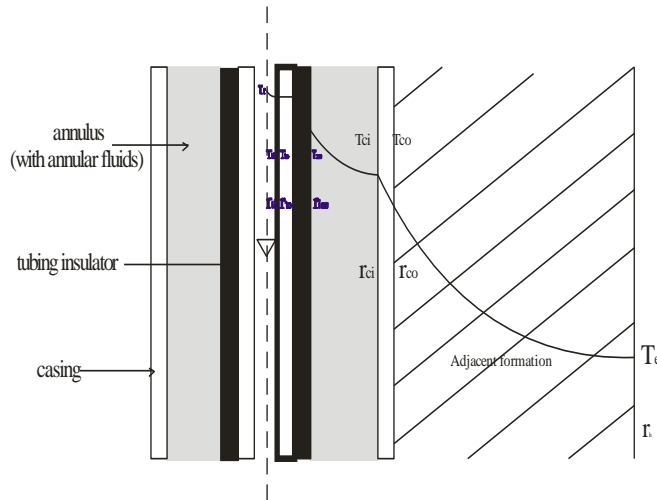


Fig.4: A Steam Injector Heat Loss Schematic Based on Tubing-Inserted-in-Tubing Model

Using the figure above, the heat transfer mechanism by conduction, convection and radiation can be modeled based on the following considerations/assumptions.

- Heat transfer in the injection well system is at pseudo-steady state
- The tubing and the casing are symmetrically vertically placed
- There is no annular refluxing
- The overall heat transfer coefficient is independent on depth

If we proceed with these assumptions, the following heat transfer summary can be written for the Model above in Figure (4).

- The heat transfer to the inner tubing wall due to steam motion is by convection
- The heat transfer between the inner tubing wall and the outer tubing wall is by conduction
- The heat transfer between the outer tubing wall and the solid insulation (for insulated tubing) is by conduction
- The heat transfer between the insulator and the annular space is by the annular fluid convection and conduction (if there is annular fluid) and the insulator radiation
- The heat transfer between the annulus and the inner casing wall is by conduction
- The heat transfer between the inner casing wall and the outer casing wall is by conduction
- The heat transfer between the outer casing wall and the cement bond is by conduction
- The heat transfer between the cement bond and the adjacent formation is by conduction

From Equations (2.4), (2.5) and (2.6), the 1-D heat transfer Model through a hollow cylinder can be written thus;

$$\frac{dq}{dz} = \frac{2\pi k}{\ln\left(\frac{r_o}{r_i}\right)}(T_i - T_o)\{for\ heat\ conduction\} \quad (2.17)$$

$$\frac{dq}{dz} = 2\pi r_i h(T_i - T_o)\{for\ heat\ convection\} \quad (2.18)$$

$$\frac{dq}{dz} = 2\pi r_i h_r(T_i - T_o)\{for\ heat\ radiation\} \quad (2.19)$$

From the heat transfer summary, we can solve for temperature differences as follows so as to define the overall heat transfer coefficient

$$T_f - T_{ti} = \left(\frac{dq}{dz}\right) / 2\pi r_{ti} h_s \quad (3.20a)$$

$$T_{ti} - T_{to} = \left(\frac{dq}{dz}\right) / 2\pi k_t \cdot \ln\left[\frac{r_{to}}{r_{ti}}\right] \quad (3.20b)$$

$$T_{to} - T_{ins} = \left(\frac{dq}{dz}\right) / 2\pi k_{ins} \cdot \ln\left[\frac{r_{ins}}{r_{to}}\right] \quad (\text{For insulated tubing}) \quad (3.20c)$$

$$T_{ins} - T_{ci} = \left(\frac{dq}{dz}\right) / 2\pi r_{ins} (h_c + h_r) \quad (3.20d)$$

$$T_{ci} - T_{co} = \left(\frac{dq}{dz}\right) / 2\pi k_c \cdot \ln\left[\frac{r_{co}}{r_{ci}}\right] \quad (3.20e)$$

$$T_{co} - T_e = \left(\frac{dq}{dz}\right) / 2\pi k_{cem} \cdot \ln\left[\frac{r_h}{r_{co}}\right] \quad (3.20f)$$

Using the Equations (3.20a-f), the overall temperature difference becomes

$$\text{Overall temperature difference} = T_f - T_e \quad (3.21)$$

Hence, the final equation for the overall heat transfer of the steam injection system becomes;

$$\frac{dq}{dz} = 2\pi r_{to} U_{to} (T_f - T_e) \quad (3.22)$$

This Equation can be equated to the Ramey's premier heat loss per unit length of injection path given as;

$$\frac{dq_L}{dz} = 2\pi r_{to} \cdot \frac{1}{R_{to}} (T_f - T_e) \quad (3.23)$$

Where;

$R_{to}$  = overall thermal resistance

During steam injection, the compensation for heat losses is basically by reducing  $U_{to}$  as low as possible by both tubing and annular insulation. If we therefore solve for  $U_{to}$ , using Equations (3.20a-f) through (3.23) it will give;

$$U_{to} = \frac{1}{\left[\frac{r_{to}}{r_{ti} h_f} + \frac{r_{to} \ln\left(\frac{r_{to}}{r_{ti}}\right)}{k_t} + \frac{r_{to} \ln\left(\frac{r_{ins}}{r_{to}}\right)}{k_{ins}} + \frac{1}{(hc+hr)} + \frac{r_{to} \ln\left(\frac{r_{co}}{r_{ci}}\right)}{k_c} + \frac{r_{to} \ln\left(\frac{r_h}{r_{co}}\right)}{k_{cem}}\right]} \quad (3.24)$$

For a steel casing and tubing (or any other high conductive metals),

$k_t = k_c \gg k_{ins}, k_{cem}, hc \text{ and } hr$ . Therefore, Equation (3.24) can be simplified to the following;

$$U_{to} = \frac{1}{\left[\frac{r_{to}}{r_{ti} h_f} + \frac{r_{to} \ln\left(\frac{r_{ins}}{r_{to}}\right)}{k_{ins}} + \frac{1}{(hc+hr)} + \frac{r_{to} \ln\left(\frac{r_h}{r_{co}}\right)}{k_{cem}}\right]} \quad (3.24.a)$$

If no insulation of the tubing,  $U_{to} =$

$$\frac{1}{\left[\frac{r_{to}}{r_{ti} h_f} + \frac{1}{(hc+hr)} + \frac{r_{to} \ln\left(\frac{r_h}{r_{co}}\right)}{k_{cem}}\right]} \quad (3.24.b)$$

For no annular insulation and tubing insulation,  $U_{to} =$

$$\frac{1}{\left[\frac{r_{to}}{r_{ti} h_f} + \frac{1}{hr} + \frac{r_{to} \ln\left(\frac{r_h}{r_{co}}\right)}{k_{cem}}\right]} \quad (3.24.c)$$

The terms,  $hc$  and  $hr$  can be evaluated independently based on empirical correlations/ charts for the different choice of insulation material as presented in Fidan (2011) studies. Also using PROSPER wellbore simulator by selecting *Enthalpy Balancing Model*, the overall heat transfer of the injection well can be calculated if there is adequate data for formation lithology and the completion status.

For the purpose of this study, in order to numerically analyze the impact of injection well completion, a sensitivity test was run for known values of overall heat transfer coefficient.

### 3. Study Simulation Methodology

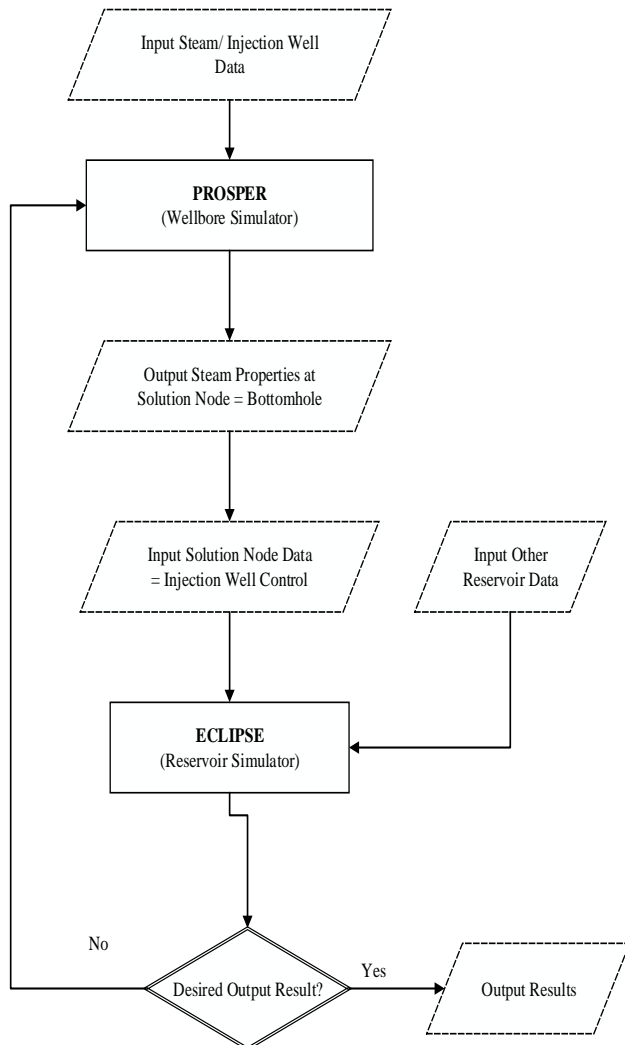
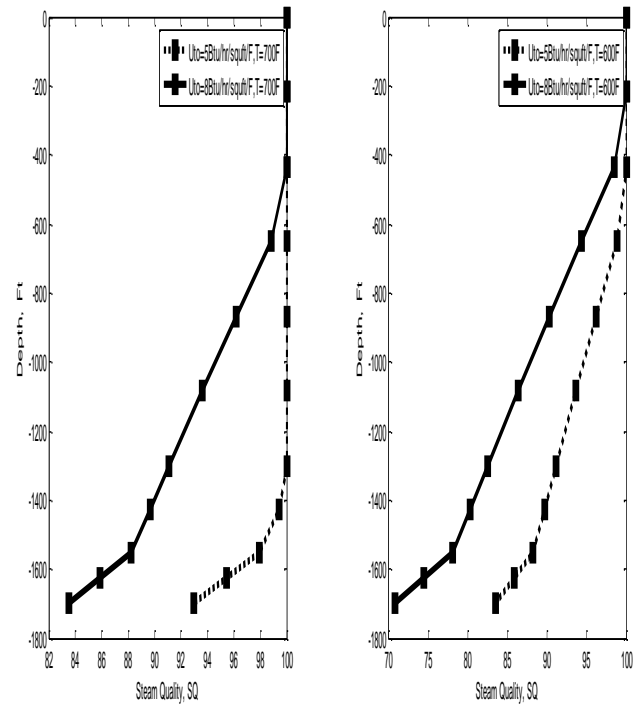


Fig. 5: Simulation Flow Chart

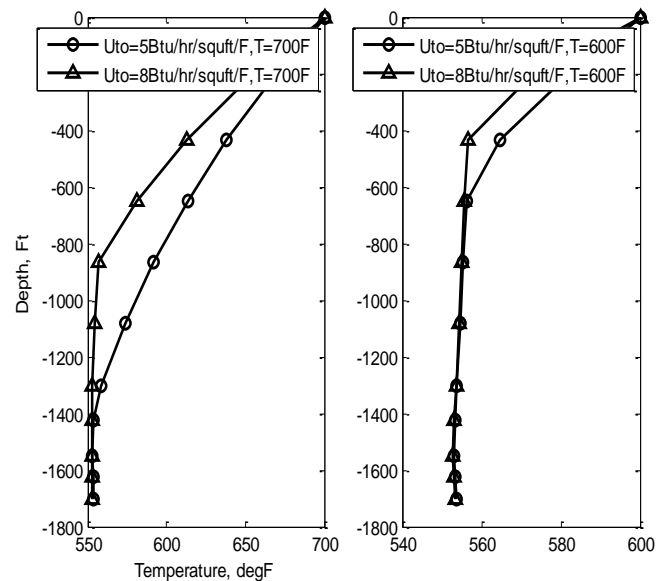
### III. MODEL RESULTS AND DISCUSSIONS

The analysis of steam injection starts with the specification of the input steam data and then the injection well configuration. A special consideration was made for injecting at the same temperature and different overall heat transfer coefficient and injecting at the same overall heat transfer coefficient and different temperatures.

Based on the specified data of the input steam and the injection well configuration used in this study, the steam data generated at a pressure of 1100psiw as presented in Fig 6 and Fig 7.



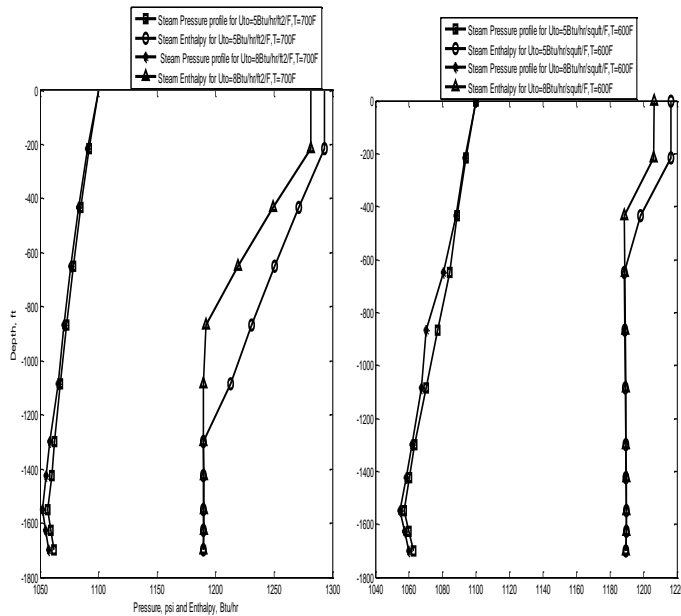
(a) Injection Temp=700<sup>o</sup>F (b) Injection Temp=600<sup>o</sup>F  
 Figure 6: Steam Quality Gradient at Different Injection Temperature and Uto



(a) Injection Temp=700<sup>o</sup>F (b) Injection Temp=600<sup>o</sup>F  
 Fig.7: Steam Temperature Gradient at Different Injection Temperature and Uto

From the figures above, it can be noted that though temperature of 700<sup>o</sup>F gave a good SQ but in as much as a sufficient steam quality can be generated, it will be more

economical to consider injecting at 600°F. The differences in the Overall heat transfer coefficient was used to analyse the possible necessity of insulating the wellbore or improving the insulation efficiency. Using this as a design guide shows that an overall heat transfer coefficient of 8Btu/hr/Ft<sup>2</sup>/°F can be adequate for this operation since it gave a sufficient SQ used to specify the Injection well control of the ECLIPSE programme.



(a) Injection Temp=700°F (b) Injection Temp=600°F

Fig.8: Steam Pressure and Enthalpy Gradients

### 1. Reservoir Back Pressure (RBP) Sensitivity Analysis

A major limitation to classical wellbore SQ analysis is total neglect of the effect of reservoir back pressure on the steam injection rate and consequently the SQ. The result in Table (1) is a sensitivity study performed with a 5000ft steam injector where the impact of reservoir back pressure is more pronounced. Hence, it was observed that the reservoir back pressure causes a significant constraint to the injection rate with a resultant significant SQ drop. Therefore, an optimal performance of steam injection design will require a negligible reservoir pressure. The phenomenon of RBP is also graphically illustrated in Figure (9) using a simple MATLAB multiple plot tool.

Table.1: SQ Vs Depth at Different Reservoir Pressure (RBP Sensitivity Analysis)

DEPTH (ft)	SQ @ $\xi_P = 1$	SQ @ $\xi_P = 1.1429$	SQ @ $\xi_P = 1.2857$	SQ @ $\xi_P = 1.4286$	SQ @ $\xi_P = 1.57$
0	100	100	100	100	100
250	100	100	100	100	100
500	100	100	100	100	100
750	100	100	100	100	100
1000	100	100	100	100	100
1250	100	100	100	98.22	94.96
1500	100	99.3	97.07	94.14	90.22
1750	98.22	96.14	93.51	90.07	85.51
2000	95.37	92.98	89.96	86.02	80.8
2233.3	92.75	90.08	86.69	82.3	76.42
2466.7	90.22	87.25	83.5	78.65	72.1
2700	87.75	84.5	80.4	75.05	67.82
2933.3	85.35	81.81	77.36	71.5	63.6
3166.6	83.02	79.22	74.37	67.99	59.41
3400	80.75	76.68	71.41	64.51	55.26
3633.3	78.57	74.18	68.5	61.09	51.14
3866.6	76.43	71.72	65.62	57.7	47.05
4100	74.33	69.3	62.78	54.34	42.99
4333.3	72.28	66.91	59.98	51.01	38.96
4566.6	70.26	64.56	57.21	47.71	34.94
4800	68.27	62.24	54.48	44.4	30.94
4900	65.91	59.5	51.28	40.66	26.38
5000	63.57	56.79	48.11	36.9	21.8

**NOTE**

Well head Constraints	Liquid Rate @RBP = 0Psi	Liquid Rate @RBP = 200Psi	Liquid Rate @RBP = 400Psi	Liquid Rate @RBP = 600Psi	Liquid Rate @RBP = 800Psi	Liquid Rate @RBP = 1217Psi
Uto=5Btu/hr/ft <sup>2</sup> /F	1996.4 STB/d	1801.7 STB/d	1607.1 STB/d	1412.4 STB/d	8 STB/d	1217 STB/d



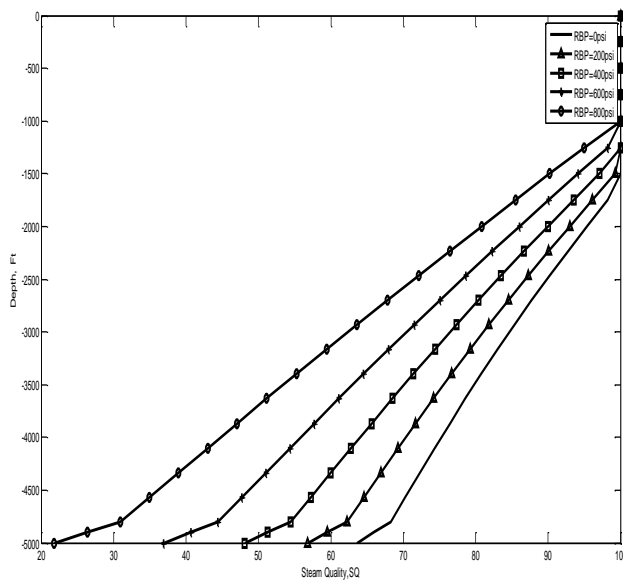


Fig.9: Reservoir Back Pressure Sensitivity

## 2. Reservoir Grid Definition

Reservoir X is a 9x5x4 reservoir with active cells specified in X-Y plane. There are Three wells- an injector at (1,1) and two producers at (5,5) and (9,1) respectively with different transmissibilities at each Z-layer. An injection design was specified for 10 years injection and a timestep of 365 days for selected for analysis.

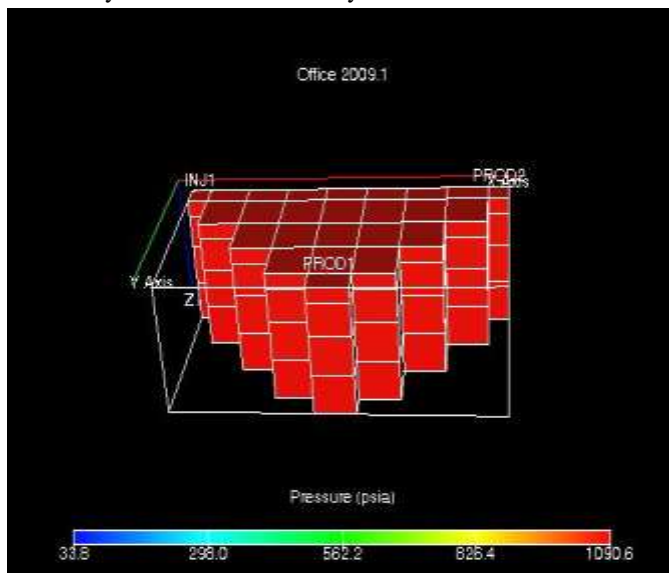


Fig.10: Reservoir Grid Layerout in 3-D

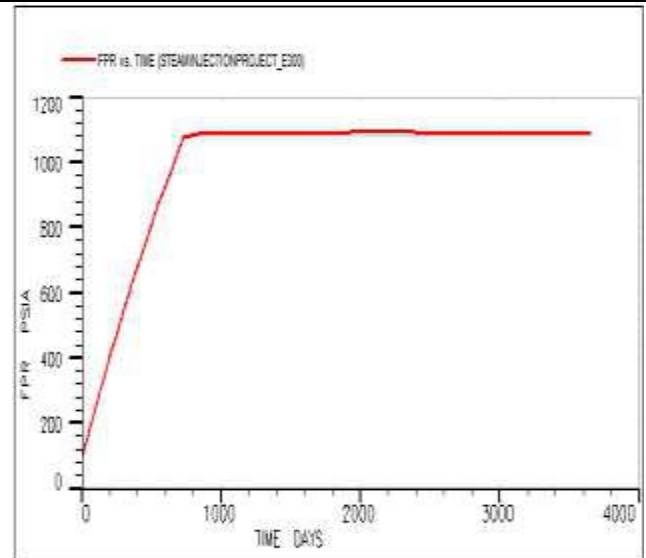


Fig.11: Field Pressure History for the 10yrs injection Period

## 3. Field Pressure Response

The Figure 11 above displays the pressure response of the steam injection from an initial datum depth pressure of 75psi to a stabilized pressure of about 1090psi which shows that steam does not just add thermal energy to the reservoir, hence, it also provides a water drive to the reservoir thereby aiding the area sweep efficiency.

## 4. Field Heat Loss Rate (FHLR) and Heat Loss Total (FHLT)

When steam is finally introduced into the reservoir at a particular SQ, the efficiency of the heavy oil displacement will be characterized by the rate of heat loss throughout the injection-period.

Figure 12-(a): Field Heat Loss Rate

Figure 12-(b): Field Heat Loss Total.

Figure 1(a) shows the simulated field rate of heat loss behaviour. It can be clearly seen that the FHLR increases at the initial period of injection of about 2years (700days) of injection before a decline in the FHLR. This is because at earlier stage of injection, the rate of heat conduction to the overlying formation is high and it is propagated similarly as a pressure transient. Hence, more heat is needed to warm up the reservoir than to keep it at a stabilized temperature. This is more clearly illustrated in Figure 12(b) which shows that at a later stage of the injection, FHLT becomes near constant. The resulting field temperature profile during the periods of injection is shown in Figures 13(a) to 13(c).

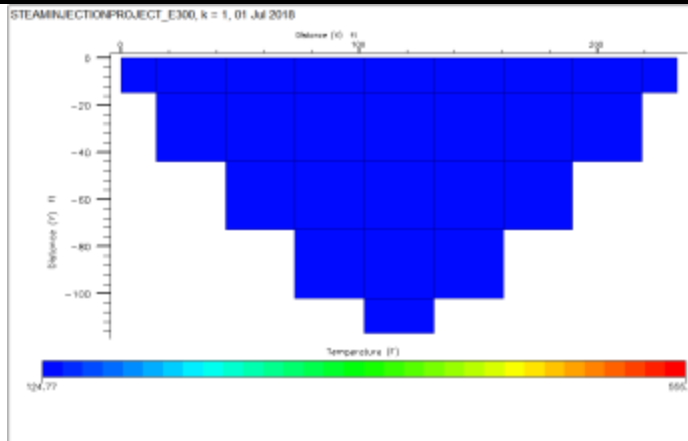


Fig.13(a): Field Temperature Profile Before Steam Injection (125°F)

Fig 13(b) shows that after 1yr of injection both PROD1 and PROD2 has not been adequately heated up while after 2yrs, PROD1 has been well affected by the steam injection while PROD2 remains slightly affected as shown in Fig 13(c). This is because PROD1 is closer to the INJ1 since heat distribution is both time and space dependent.

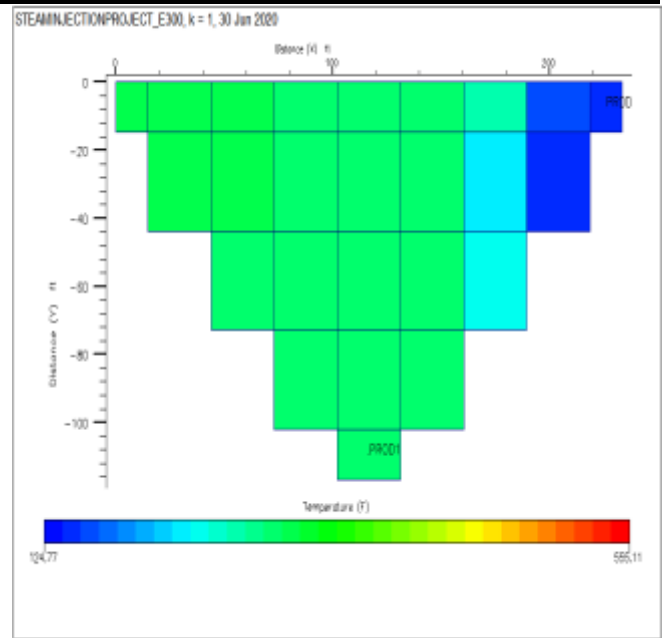


Fig.13: (b) Field Temp. Profile after 1 yr (c) Field Temp. Profile after 2 yrs

### 5. Field Water Production and Field Oil Production Analysis

A common experience with steam injection project is the increased water cut as the water-oil front changes with time and space and therefore tends to the producers. As a result of excessive turbulence in the reservoir caused by the injection, the condensed steam in the hot water zone are produced along with the heated oil bank. Hence, water production/water cut increases with time. A good advantage of this process is that it results to a secondary water drive mechanism that effects the sweeping of the heated oil bank. Figures 14(a) to 14(c) shows the field water production profile and the individual contributions of the two producers-PROD1 and PROD2.

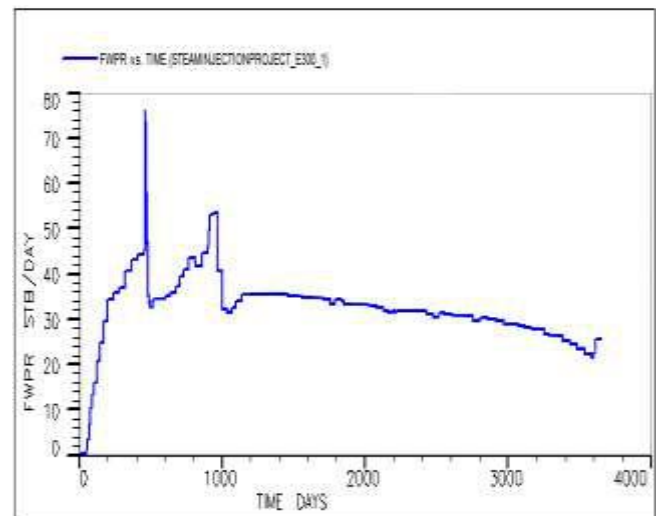
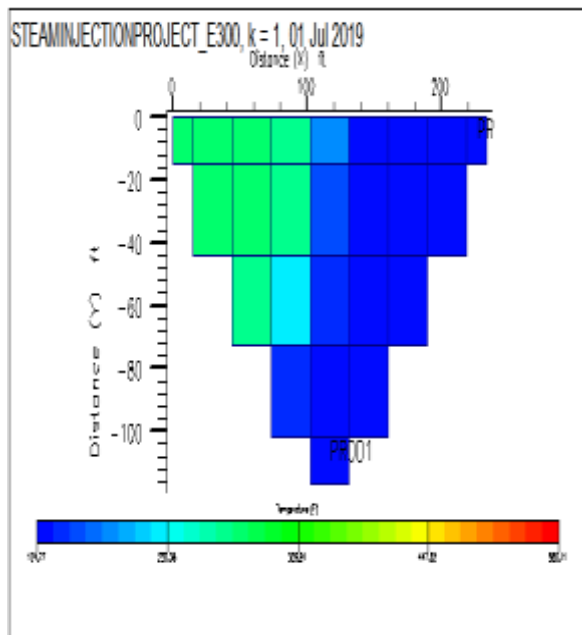


Fig.14(a): Field Water Production Rates

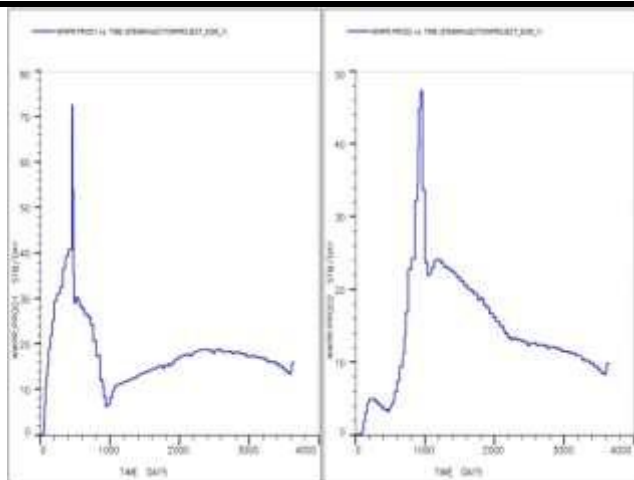
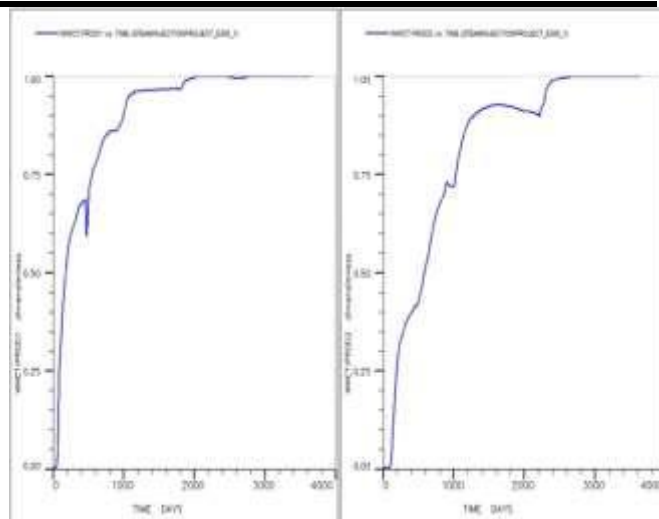


Fig.14(b): Field Water Production Rate (PROD1)  
 Fig.14(c): (PROD2)



(a) PROD1 (b) PROD2

Fig.15: Well Water Cut History

A similar analysis of Field Water cut is shown in Figures 15(a) to 15(c). It is observed that PROD1 responds faster to water cut than PROD2 which responds slower. This can be attributed to the differences in the location of the Producers with respect to the Injectors. The steam front during injection reaches PROD1 earlier than PROD2. The implication of this as illustrated in the simulation results is that subsequently at a much later period, the PROD1 will be dominated by hot water zone.

A comparative Analysis of Field Oil Production Rate-Field Water Production Rate and Field Oil Production Total-Field Water Production Total are given in Figures 16(a) and 16(b). The plots show that as water production rate increases, oil production Rate decreases. The Figure 16(b) precisely displays a saturation rate growth model and a near linear relationship for the oil production and water productions Total(s) of the injection period respectively.

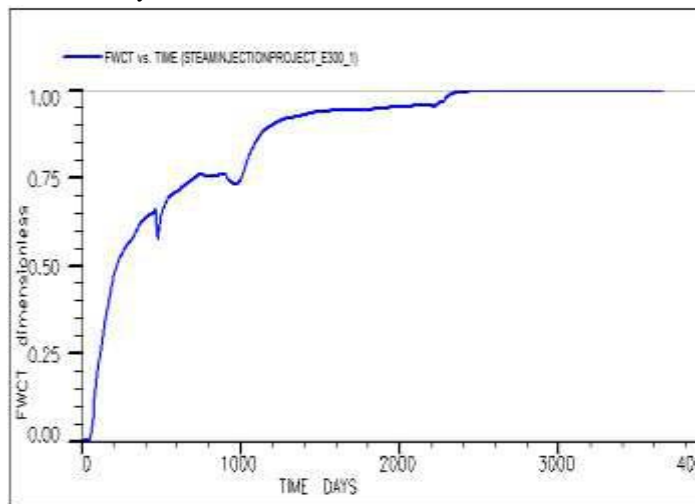


Fig.15(a): Field Water Cut History

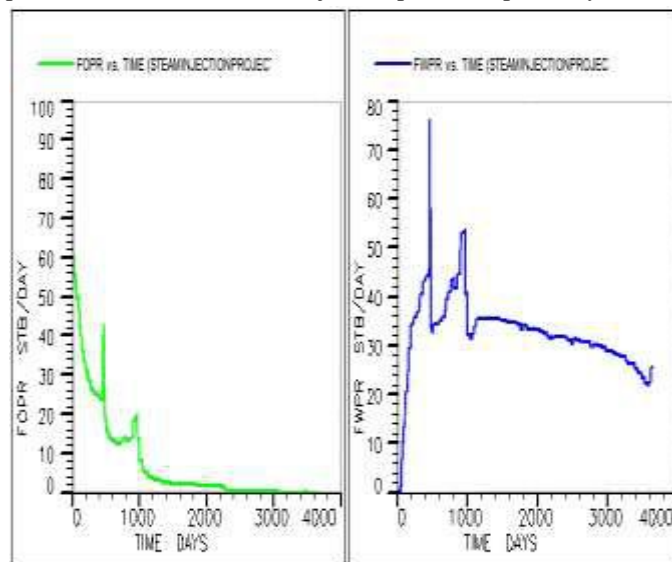


Fig.16(a): (i) Field Oil Production Rate  
 (ii) Field Water Production Rate

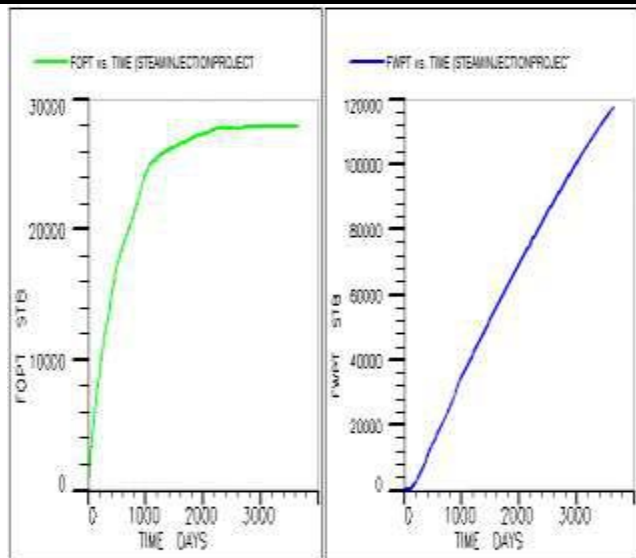


Fig.16(b): (i) Field Oil Production Total  
(ii) Field Water Production Total

### 6. Effect of Steam Injection on Oil and Gas Saturations

Steam injection like water injection causes the in-situ oil saturation to vary with both time and space as the steam front propagates along the reservoir grid cells towards the

producers. The counter result of this process is the increase in water saturation. Figure 17(a) shows the oil saturation history of the reservoir for 1 year (365 days), 5 years (1825 days) and 3 years (3650 days) of injection respectively. In the literature review, it was clearly stated that steam injection activates solution gas drive in the reservoir system and also improves the quality of the produced oil by thermal distillation. Hence, steam injection increases the gas saturation as the input thermal energy of the steam helps to liberate the light gas molecules in solution. The economic benefit of this is that recovery by thermal methods upgrades the API gravity of the in-situ oil. Figure (17) shows the oil saturation history while the corresponding gas saturation history of the reservoir is shown in Figure (18).

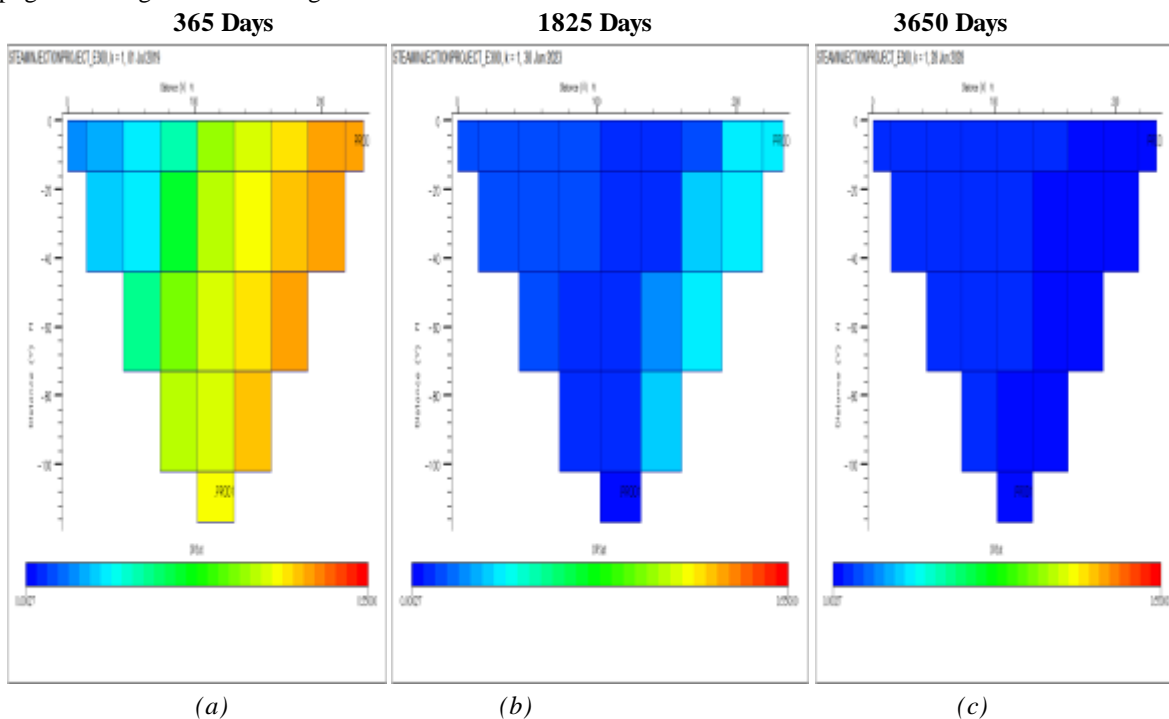


Fig.17: Field Oil Saturation History

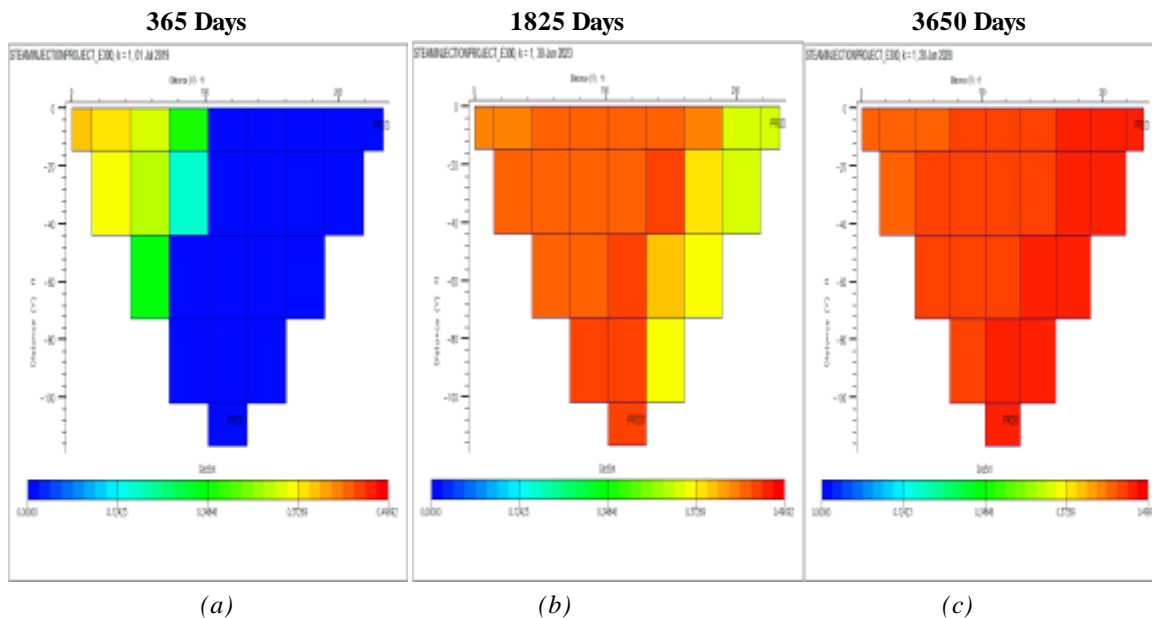


Fig.18: Field Gas Saturation History

#### IV. CONCLUSION

This study presents an integrated steam injection Model needed for the complete optimization of the steam injection project. The study frame work incorporates a well computer simulator known as PROSPER (An IPM Suit Product) and a reservoir simulator known as ECLIPSE (Eclipse300) for the analysis. Thus, the optimal use of the injected fluid was archived since a semi-iterative procedure can be used for data convergence as shown in simulation flow chart.

The steam properties predicted with this study shows that higher SQ will be generated at higher injection Pressure and Temperature and at lower overall heat transfer coefficient.

By adequately reviewing, formulating and analysing the basic analytics behind the steam injection mechanism, the impact of reservoir back pressure on the SQ and consequently the injection rate was numerically quantified using a 5000ft case study well at a constant injection well head constraint. The results showed that a most efficient steam injection will be achieved at the lowest reservoir initial pressure.

The various sensitivity results generated with ECLIPSE showed that production well spacing relative to the injector have a critical effect on the area sweep efficiency of the injected steam especially in the early stage of injection and hence optimal well spacing should also form the basic development criteria for a given field.

#### 1. Recommendations

The efficiency of steam injection is basically dependent on the effective SQ generated. To generate a high SQ especially in relatively deep wells, the only option has been to effectively thermally insulate the tubing and the annulus which will make the steam injection project a non-attractive venture because of the increased cost of insulation. To compensate for this, a consideration can be made for sourcing the insulation materials locally using the materials in the table below:

Table.2: The Thermal Conductivities of Some Locally Sourced Insulation Materials

Material	Thermal Conductivity (W/m k)	Thermal Conductivity (Btu/Ft °F)
Shredded Asbestos Sheets	0.17	0.1115
Dry Ash	0.12	0.078744
Cork, Felt	0.05-0.10	0.0328 - 0.06562
Freon	0.0083	0.0054465

Moreover, the difficulty involved in integrating two unique simulators made the study more tedious. Based on this, the study only forms a framework of a future integrated steam injection simulator which can be more efficient. Hence, this

research work welcomes any idea on the development of a fully integrated steam injection model/simulator.

As part of the above recommendation, such proposed simulator should be able to auto-calculate the overall heat transfer coefficient based on the defined completion status. This is necessary to avoid unnecessary switching between the rigorous analytics involved in the estimation of the overall heat transfer coefficient that often requires a third party simulator.

## 2. Contributions to Knowledge

This study provides a frame work for the complete optimization of steam injection design and as such constitutes a novel approach to steam injection modelling. Also very important to mention is the novel approach to the analysis of Reservoir Back Pressure impact on Steam Quality predicted during the steam injection processes.

## REFERENCES

- [1] Abdulbasit. (2013). *A Literature Review on Steam Injection*. Retrieved September 16, 2018, from Google: [https://www.google.com.ng/search?ei=ToOeW7\\_7HM2QkwWv-4eBQins=&q=literature](https://www.google.com.ng/search?ei=ToOeW7_7HM2QkwWv-4eBQins=&q=literature)
- [2] Appiah, E. A. (2014). Enhanced Oil Recovery in High Viscous Reservoir Using the Thermal Process. *Master's Thesis*. African University of Nigeria, Abuja.
- [3] Aziz, K., Govier, G. W., & Fogarasi, M. (1972). Pressure Drop in Wells Producing Oil and Gas. *Journal of Canadian Petroleum Technology*, 38-48.
- [4] Beggs, H. D., & Brill, J. P. (1973). A study of Two-Phase Flow in Inclined Pipes. *JPT*, 607-617.
- [5] Thermal Recovery of Oil and Bitumen. *SPE*(1st Edition).
- [6] Cheng, W. L., Huang, Y. H., Lu, D. T., & Yin, H. R. (2011). A Novel Analytical Transient Heat Transfer Conduction Time Function for Heat Transfer in Steam Injection Wells considering the wellbore Heat Capacity. *Energy*, 36: 4080-8.
- [7] *and Gas Journal*, 52.
- [8] Duns, H., & Ros, N. C. (1961). Vertical Flow of Gas and Liquid Mixtures in Wells. *Sixth World Petroleum Congress, Sec II*, (pp. 451-465). Frankfurt.
- [9] Earlougher, R. C., & Jr. (1969). Some Practical Considerations in the Design in the Design of Steam Injection Wells. *JPT*, 79-86.
- [10] Ezekwe, N. (2011). Enhanced Oil Recovery. *Lecture Notes*. African University of Science and Technology, Abuja.
- [11] Farouq, S. M. (1981). A Comprehensive Wellbore Steam/Water Flow Model for Steam Injection and Geothermal Applications. 527-534.
- [12] Fontanilla, J. P., & Aziz, K. (1982). Prediction of Bottomhole Condition for Wet Steam Injection Wells. *Journal of Canadian Technology*, 82-88.
- [13] Georgy, Z. (2015). Steam Injection for Enhanced Oil Recovery. *PH240 Coursework*. Stanford University, Fall.
- [14] Gould, T., Rasin, T. M., & Katz, D. L. (1974). Two-Phase Vertical Flow in Oil Wells-Prediction of Pressure Drop. *JPT*, 916-926.
- [15] Hoist, P. H., & Flock, D. L. (1966). Wellbore Behaviour during Saturated Steam Injection. *Journal of Canadian Petroleum Technology*, 184-193.
- [16] [ps://www.mathworks.com/matlabcentral/fileexchange/9817-x-steam-thermodynamic-properties-of-water-and-steam](https://www.mathworks.com/matlabcentral/fileexchange/9817-x-steam-thermodynamic-properties-of-water-and-steam)
- [17] Hong, K. C. (1994). Effects of Steam Quality and Injection Rate on Steamflood Performance. *SPE Reservoir Engineering*.
- [18] Jianshe, W., Macfadyne, R., & Zhang, E. (2010). Wellbore Heat Loss: Options and Challenges for Steam Injector of Thermal EOR Project in Oman. *Onepetro, Society of Petroleum Engineers*.
- [19] Latil, M., Bardon, C., Burger, J., & Sourieau, P. (1980). *Enhanced Oil Recovery*. Paris: Imprimerie Louis-Jean.
- [20] Company.
- [21] Nmehbu, C. G. J. (2017). Secondary and Enhanced Oil Recovery. *Lecture Note*. Rivers State University, Port Harcourt.
- [22] OPEC. (2017). *Annual Statistical Bulletin*. Viena, Australia: [prid@opec.com](mailto:prid@opec.com).
- [23] Pacheco, E. F., & Farouq, A. S. (1972). Wellbore Heat Losses and Pressure Drop in Steam Injection. *SPE*.
- [24] PetroWiki. (2017). *Unconventional Sources of Hydrocarbon Resources*. Retrieved June 18, 2018, from Petrowiki: [www.petrowiki.com/unconventional\\_sources\\_of\\_hydrocarbon\\_resources](http://www.petrowiki.com/unconventional_sources_of_hydrocarbon_resources)
- [25] Petrowiki. (n.d.). *Reserve Estimation of Heavy Oil*. Retrieved May 04, 2018, from Petrowiki: [http://petrowiki.org/Reserves\\_estimation\\_of\\_heavy\\_oil](http://petrowiki.org/Reserves_estimation_of_heavy_oil)
- [26] Popov, Y., Chekhonin, E. P., Law, D. H., Pissarenko, D., Miklashevskiv, D., Popove, E., . . . Tarashin, E. (2013). Experimental Investigation of Spatial and Temporal Variations in Thermal Properties as

- Necessary Stage in EOR. *Society of Petroleum Engineers*, 1-3.
- [27] Rajput, R. K. (2012). *Engineering Thermodynamics*. India: Laxmi Publications (P) Ltd.
- [28] Ramey, H. J. (1962). Wellbore Heat Loss Transmisssion. *JPT*.
- [29] Ramey, H. J. (1964). How to Calculate Heat Transmission in Hot Fluid Injection. *SPE*, 110-120.
- [30] Rubinstein, L. I. (1959). A Contact Thermal Conduction Problem. 135:805-808.
- [31] Satter, A. (1965). Heat Loss During Flow of Steam Down a Wellbore. *JPT*, 845-851.
- [32] Selcuk, F. (2011). Wellbore Heat Loss Calculations During SteamInjection in Onshore and Offshore Environments. *A Master's Thesis*, 10-17:110-122. Department of Energy Resources Engineering, Stanford University.
- [33] Shaibi,R, A., & Abri, A. A. (2018). Steam Optimization Topic, Injection Rate vs. Surface Steam Quality Reduction. *SPE EOR Conference*. Oil and Gas West Asia, Muscat,Oman.
- [34] Stewart, G. (2018). Eclipse Reservoir Simulation and Integrated Production Modelling. *A Private Training Note*.
- [35] Sylvester, N. D. (1984). Transition to Annular Flow in Vertical Upward Gas-Liqyuid Flow. *AIChE*, 26, 700.
- [36] ., & Moss, J. T. (1983). *Thermal Recovery Methods*. Tulsa: Pennwell Publishing Company.
- [37] Willhite, G. P. (1969). Overall Heat Transfer Coefficients in Steam and Hot Water Injection Wells. *JPT*, 607-615.
- [38] Y, T., & Bornea, D. (1980). Modelling Flow Pattern Transitions for Steady Upward Gas-Liquid Flow in Vertical Tubes. *AIChE*, 345-354.
- [39] Yamazaki, Y., & Yamaguchi, K. (1979). Characteristics of Concurrent Two-Phase Dowflow in Tubes. *Jpurnal of Nuclear Science and Technology*, 245-255.
- [40] Yang, C., Card, C., & Nghiem, L. (2009). Economic Optimization and Assessment of Commercial SAGD Operantis. *Journal of Canadian Petroleum Technology*, 33-40.
- [41] Yao, C., & Sylvester, N. D. (1987). A mechanistic Model for Two Phase Annular-Mist Flow in Vertical Pipes. *AIChE*, 1008-1012.
- [42] Zabel, F., Law, D. H., & Taylor, e. a. (2008). Impact of Uncertainty of Heavy Oil Fluid Property Measurements. *Journal of Canadian Petroleum*, 28-35.

# Comparative Study between Budget and Real Cost Obtained: Case Study at a construction company in Canaa dos Carajás-PA

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**Abstract**— *The budget is a tool of extreme importance in construction. It is from this that a cost forecast is obtained. In this way, this work had as objective to compare analytical budget with real cost obtained in the construction of a public nursery school held Construtora Monteiro & Pereira Ltda. For its development, it was used as methodology the analysis of budgetary worksheets and descriptive memorials that referred to the budgeting of the construction of a public nursery school. The results showed that the budget developed by the developer clearly showed the services and their respective costs, where they were detailed in a clear and precise way. At the end it was concluded that although the result was satisfactory, it was verified that there was an increase in the real cost of the work because the fixed costs incur changes in values, as the employees were admitted and / or fired.*

**Keywords**— *Analytical Budget, Real cost, Reliability.*

## I. INTRODUCTION

This study proposed to analyze the budget spreadsheet developed by a construction company located in the city of Canaa dos Carajás-PA in order to make a comparative analysis between budget and actual cost obtained.

The budget is a business planning tool that has information on estimated revenues and estimated expenses that aims to control the necessary activities for the services provided by the company, where its elaboration starts before the beginning of the work, and its preparation must follow certain criteria regarding the composition of costs so that there are no uncertain considerations that affect the efficient decision of the company (SANTOS, SILVA and OLIVEIRA, 2012).

The budget should encompass all activities of the company, establish relationships between revenues, costs,

expenses, investments, as well as compare the expected results with those actually carried out and mainly, should determine the operations that will be performed. It should also establish and coordinate objectives so that all areas of the work are covered, addressing all its dimensions (ROCHA, 2013).

Cardoso (2013) presents some basic and obligatory characteristics of the budget, where these characteristics are expressed in Law N° 8.661 / 93, these being: The indication of the global cost of the work - shown in an estimation spreadsheet must describe all values of the direct and indirect costs, and profit. Presentation of the composition of the unit costs that comprise the final price - the unit costs should be presented which must correspond to the prices available on the market. From the adequacy of the spreadsheet quantitative to the basic project - where all the work to be executed must be indicated, discriminating it, quantifying and valuing the budget spreadsheets.

The elaboration of the budget, according to Mattos (2014), comprises three stages, being these: study of the conditioners, composition of costs and determination of the price.

The study of the constraint helps in the identification of the conditions of the work through the study of the project that is carried by floor plans, cuts seen, clarifying notes, among others. In the study of the constraints, the budget should also analyze the qualitative description of the materials, finishing pattern, dimensional tolerances of the structural elements and pipes, among others (TISAKA, 2006).

In the composition of the costs it is important to have knowledge of the materials, labor, social charges and the BDI1. For the composition of the costs it is necessary first to identify all the services pertinent to the work,



quantifying each service. It is through the composition of the costs that the profitability is analyzed, as well as it is possible to establish the selling price and the BDI (BACKER; JACOBSEN, 2012).

In social and labor costs, the same is defined by the percentage applied in the labor force, involving taxes that affect the hour worked and the benefits that workers are entitled to that are paid by the employer (GOLDMAN, 2014).

The BDI is the percentage related to all indirect expenses, which will reach the direct costs, where, in the budget, it is determined that unit sales prices are linked to all the charges that bind the services that will be executed. Among the various projects that can be carried out, the indirect cost is altered by the fact that it varies according to its location, the requirements that the work requires, as well as the type of work to be performed (DIEFENTHÄLER, 2016).

Thus, the present study aimed to develop a research focused on the budget study and the real cost obtained, since from forecasts, the budget generates estimates used in the enterprise to meet the demands necessary for its execution, giving conditions for the evaluate the results that can be achieved.

In this way a problematic guided the present study, where it was based on knowing how the budget of the work of a kindergarten in the public network was realized and how this budget worked the cost to realize the work?

To target better the study, it was aimed to compare analytical budget with real cost obtained in the construction of a public school nursery conducted by Construction company X.

## II. MATERIAL AND METHODS

This study used as a methodology the analysis of budget spreadsheets and descriptive memorials that referred to the budgeting of the construction of a public kindergarten school.

The sample of the study was composed of the budget spreadsheets referring to a work that is a construction of

the pavement of a kindergarten school built of masonry, reinforced concrete, mortar coating, metallic cover, fiber cement tile.

In accordance with this analysis of the spreadsheets, a bibliographic review was also carried out in order to obtain a theoretical and substantial basis for the results obtained and consequently the discussion of these results.

## III. RESULTS AND DISCUSSIONS

The work, object of this study, is characterized in Table 01. Its conclusion and delivery took place on April 17, 2017.

*Table.1: Characterization of the work*

<b>Total construction area</b>		979,02 M <sup>2</sup>
<b>Nº Floors</b>		01
<b>Place of work</b>		Canaã dos Carajás-PA
<b>Structure</b>		Structure Reinforced concrete
<b>Walls</b>		Solid ceramic bricks 5,7x9x1 9cm
<b>Roofing</b>		Metallic structure and tile E=8mm
<b>Installations</b>		Hydrosanitary facilities; Electrical installations
<b>Purpose of construction</b>	<b>of</b>	Construction of a children's school
<b>Contractor</b>		City Hall
<b>Value of the Bid</b>		R\$: 2.044.712,15
<b>Start Date</b>		May de 2016
<b>End date</b>		17 de April de 2017

The analytical structure of the analyzed construction's budget was elaborated in the execution and control of the activities. The activities are open in the same manner both for planning and budget. Chart 1 shows how was divided the budget of the analyzed construction, as well as presenting an average percentage representatively of each budget group, where this budget is defined as basis in the average of budgeted costs.

Chart.1: Analytical structure of the budget

Description	Representatividade no orçamento (%)
Initial / General Service	3,14
Earth moving	3,08
Reinforced concrete structure (Building)	9,73
Reinforced concrete structure (Reservoir)	0,80
Hydrosanitary installations (cold water)	1,23
Hydrosanitary installations (rainwater drainage)	3,29
Electrical installations	15,23
Walls and panels	3,08
Scaffolding	4,75
Roofing	22,47
Lining	5,00
Coating	4,90
Paving	7,80
Plinth	0,29
Paintings	6,34
Decorative and other elements	1,48
Wall, gates and access facade	6,26
Finishing Services	1,13
<b>GRAND TOTAL</b>	<b>100</b>

In this demonstration is possible to visualize only the analytical structure of the “construction cost”. It is important to emphasize that the technical documents extracted on Monteiro & Pereira Construction Company were considered, among those: spreadsheet of quantitative and prices, physical-financial schedule, spreadsheets of cash flow, spreadsheet of payment receipts, spreadsheet of payments made for suppliers and service providers.

It was observed that the budget spreadsheet was divided between construction steps. Hermani; Daré (2014, p.2) predict: “Generally, the detailed budget is subdivided in services, or groups of services, facilitating the partial costs determination”. Chart 2 shows a part of the services specifications, with the execution steps and the respective costs.

It is important to emphasize that every service process with their respective costs were placed in the Excel

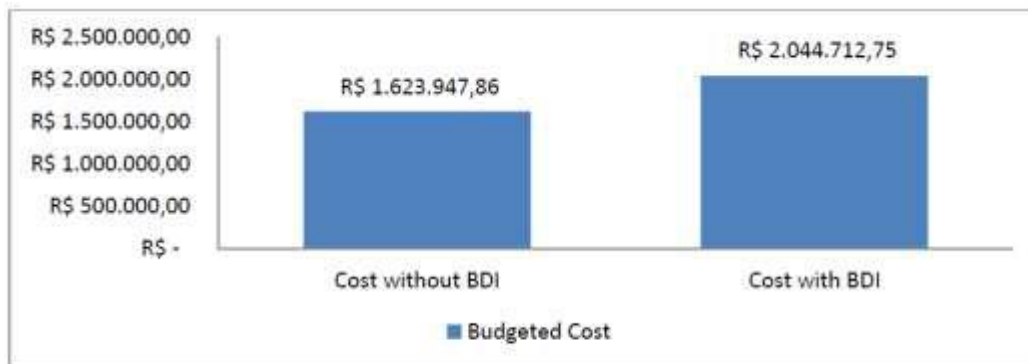
spreadsheet. The demonstration above shows the manner which these services and their respective costs were described in a detailed way. With this regard, Soares (2016) states that the budget for civil construction works and the survey of service quantities, their respective unit prices and the global price of the investment must be well detailed with the following specifications in the spreadsheet: description of the services with their respective units of measurements and quantities, composition of unit prices involving staff and material, unit price of each service and preferentially the total price by item, and, finally, the global price of the construction work.

It was specified the planned budget, percentage between the cost of the construction work without the BDI and the cost with the BDI, as illustrated in the chart below.

Table.2: Description of the services specifications in steps and its respective costs

QUANTITATIVES AND PRICES WORKSHEET							
MONTEIRO & PEREIRA CONSTRUTORA LTDA - EPP							
CNPJ : 10.614.595/0001-29							
ITEM	SOURCE	CODE	DESCRIPTION OF SERVICES	QUNT.	UNID.	UNIT PRICE (RS)	TOTAL PRICE (RS)
<b>1.0</b>			<b>INITIAL / GENERAL SERVICES</b>				
L.1.1	SEDOP	0002	MOBILL. OF STAFF AND EQUIPMENT	1,00	VB	24.999,00	24.999,00
<b>1.2</b>			<b>LICENSES AND FEES</b>				
L.2.1	SEDOP	10000	LICENSES, TAXES, CREATES, TAX IN ACCORDANCE WITH NORM. DOU DE 01/15/97.	1,00	VB	9.834,00	9.834,00
L.2.2	SINAPI	74209/001	PLATE OF WORK IN GALVANIZED STEEL SHEET	9,00	M2	273,47	2.461,23
<b>1.3</b>			<b>LAND CLEANING</b>				
L.3.1	SINAPI	73822/002	CLEANING MECAN. OF TER. WITH OAR. OF PLANT LAYING, USING MOTOR MOWER	3.786,37	M2	0,49	1.855,32
<b>1.4</b>			<b>PROVISIONAL INSTALLATIONS</b>				
L.4.1	SINAPI	73960/001	ELECTRICAL PROVISIONAL CONNECTION - INSTAL / LIG. PROV. ELECTRIC LOW VOLTAGE FOR CANT WORK, M3-KEY 100A LOAD 3KWH, 20CV EXCL FORN	1,00	UND	1.187,95	1.187,95
L.4.2	SINAPI	74217/001	PROVISIONAL CONNECTION OF COLD WATER - HYDROMETER 3.00M3 / H. D = 1/2" - SUPPLY AND INSTALLATION	1,00	UND	84,53	84,53
L.4.3	SINAP	73784/001	CONNECTION PROV. SEWER - ON. SEALED IN PVC PIPE SERIES-R DN 100MM, FROM BOX TO NETWORK, INCL. ESCAV. AND REAT. UP TO 1.00M, COMP. BY 10.50M OF PVC TUBE SERIES-R ESG. DN 100MM, SIMPLE PVC JUNCTION FOR ESG. PREDIAL DN 100X100MM AND CURVE PVC 90GRAUS FOR NET COL. DE ESG. DN 100MM - FORN./INST.	1,00	UND	821,00	821,00
L.4.4	SEDOP	10005	WOODEN / ALMOX BARRACÃO.	20,00	M2	156,04	3.120,80
<b>1.5</b>			<b>CONVENTIONAL WORK LEASE</b>				
L.5.1	SINAPI	73992/001	CONVENTIONAL LOCATION OF WORK, THROUGH GABARITO DE TÁBUAS RIDES PONTALETADAS AT EACH 1.50M, WITHOUT REAPROVEITAMENTO	979,02	M2	6,71	6.569,22
<b>TOTAL DO ITEM</b>							<b>50.933,06</b>

Graph.1: Difference between the construction work cost without the BDI and the Construction Cost with the BDI.



SOURCE: Monteiro & Pereira Construtora Ltda-EPP, modified by the author (2018)

When analyzing the chart below, it is possible to verify that that BDI is responsible for 17% of the total value of the construction work, which means that the value was R\$ 420.764,89. For Diefenthaler (2016, p.23) the BDI is the “percentage related to indirect expenses, which will lead to the direct costs, because in the budget it is determined

that the unit sale prices are interconnected to every cost related to the services about to be executed”.

It is verified that the researched construction company follows the parameters indicated for the elaboration of the budget spreadsheet of the construction work, where this spreadsheet makes possible the execution of the services,

minimizing the risks of executing a work that is not in agreement with what was budgeted.

As for the physical financial schedule of the construction work, it was elaborated with an execution planning for the

construction work to be finished in 210 days, as shown in the figure below.

Table.3: Physical Financial Schedule of the construction work of a public kindergarten school.

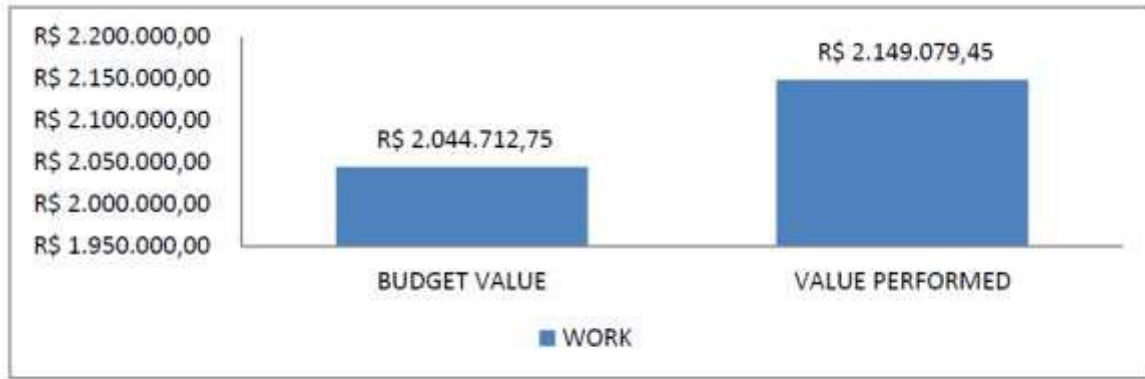
FINANCIAL PHYSICAL SCHEDULE										DATA	
WORK: CONSTRUCTION OF CHILDREN'S SCHOOL										mai/16	
LOCATION OF THE WORK: STREET H4, QD 40 - GARDEN AMERICA										VALUE OF THE WORK	2.044.712,75
PERIOD OF EXECUTION 210 DAYS										ITEM VALUE	
ITEM	DESCRIPTION	TIME OF IMPLEMENTATION (on working days)							210	ITEM VALUE (RS)	
		30	60	90	120	150	180	RS			
1	INITIAL / GENERAL SERVICES	100%								64.129,81	
2	EARTH MOVEMENT	100%								63.063,58	
3	ARMED CONCRETE STRUCTURE (BUILDING)	25%	50%	25%						199.008,72	
4	ARMED CONCRETE STRUCTURE (RESERVOIR)		50%	50%						16.427,89	
5	HYDROSURIAL INSTALLATIONS - COLD WATER		10%	25%	40%	25%				25.186,51	
6	HYDRO-SAFETY INSTALLATIONS - SEWAGE AND PLUVIAL			25%	75%					67.234,03	
7	ELECTRICAL INSTALLATIONS		10%	15%	25%	25%	15%	10%		311.338,67	
8	WALLS AND PAINTS		50%	50%						63.001,48	
9	SQUARES					50%	50%			97.044,07	
10	ROOFING				50%	50%				459.496,16	
11	LINING					100%				102.209,10	
12	COATING				50%	50%				100.122,49	
13	PAVING				30%	50%	20%			159.416,22	
14	FOOTWEAR				20%	70%	10%			5.855,48	
15	PAINTINGS					50%	25%	25%		129.723,62	
16	DECORATIVE AND OTHER ELEMENTS					25%	50%	25%		30.354,75	
17	WALL, GATES AND ACCESS FACADE	50%	50%							127.984,29	
18	FINAL SERVICES						50%	50%		23.115,87	
TOTAL	TOTAL PARTIAL	240.937,72	236.863,71	159.272,80	467.140,09	670.929,20	186.857,84	82.711,39		2.044.712,75	
	TOTAL ACCUMULATED	240.937,72	477.801,43	637.074,23	1.104.214,31	1.775.143,52	1.962.001,36	2.044.712,75			

It is observed that the construction company, in accomplishing the physical financial schedule of the work, performed the monitoring of the costs each month, based on the physical planning of the work. In preparing the physical financial schedule, the construction company ensures that the actions established are performed in order to meet the execution goals of each service. As can be seen, the schedule shows the stages of execution of the work and the estimate of the term from the beginning established through the order of service until completion and final delivery.

Regarding the physical financial schedule, Tisaka (2011: 53) states that: "Graphic representation of the development of the services to be executed over the duration of the work, demonstrating in each period the physical percentage to be executed and the respective financial value involved".

Although the construction company was able to comply with the pre-established deadlines, it was verified that the final budget was lower than the real cost of the construction work, as shown in the chart below.

Graph.2: Demonstration the budgeted value with the real cost obtained in the execution of the construction work.



SOURCE: Monteiro & Pereira Construtora Ltda-EPP, modified by the author (2018)

According to the precepts of the NPC - 17 of NPC - Accounting Standards and Procedures of IBRACON - Brazilian Institute of Accounting, costs of production are considered all the expenses included in the process of obtaining goods and services in contracts for construction works.

The Normative Instruction IN-003/05 from the INSS considers as cost all expenses incurred in a contract for construction works and services launched at the "Center of Costs" of the work in the general accounting of the company, according to previous registration in the "CEI - Specific register of the INSS".

Thus, in order to produce a scale of magnitude, according to figures obtained with the company, the analytical structure related only to the cost of construction represents approximately 40% of all costs involved in the business. It is an estimative, because as the total cost involves fixed costs of the central administration, these costs are constantly changing, as employees are admitted or fired.

As previously stated, the completion of the construction work was done on April 17, 2017. When analyzing the budget spreadsheets developed by the construction company, it was verified that the work is related to the physical schedule and the contractual deadline, where the company was able to fulfill all the steps as planned and deliver the work within the specified time, but with an increase in the real cost of 5% of the budgeted amount.

The fulfillment of the deadline determined by the city hall proves the warranty of the construction work, proving that the project followed the norms and security standards of the civil construction (SANTOS; SILVA; OLIVEIRA, 2012).

#### IV. CONCLUSION

This study aimed to compare the analytical budget with real cost obtained in the construction of a public kindergarten school made by Monteiro & PereiraLtd Construction Company. When analyzing the budget

elaborated by the construction company, it was concluded that the objective was to carry out the survey of the costs that were used for the execution of the work, where it was demonstrated, through a preliminary study, the estimation of the values that correlate with the quantities of materials and processes necessary for the execution of the work, which in this case was a kindergarten school of one pavement.

For the development of the budget, the construction company carried out a price survey of all the inputs, characterizing the composition of the costs, which provided an analytical and detailed budget, where the construction company managed to reduce the degree of uncertainty for the decision making and execution of the project.

During the analysis of all the material made available by the construction company to carry out the present study, it was possible to conclude that the analytical budget developed resulted in the reliability of the presented value, since the construction company considered all the resources and variables measured by direct cost and indirect costs plus BDI, thus forming the final price of the work, which demonstrated a satisfactory result. Although the result was satisfactory, it was verified that there was an increase in the real cost of the work because the fixed costs incur changes in values, as employees were admitted and/or fired.

#### REFERENCES

- [1] BACKER Morton; JACOBSEN Lyle E. Costs Accounting. São Paulo/Rio de Janeiro: Editora McGraw- Hill do Brazil Ltda 2012
- [2] CARDOSO, Roberto Sales. Budget of construction works in focus: a new look on Costs engineering. São Paulo, 3ª ed. Publisher: PINI, 2013
- [3] DIEFENTHÄLER, Gabriela Leidens. Comparative study between budgeting and real cost obtained in single-family residence. Monograph presented to the Regional University of the northwest of the state of

- Rio Grande do Sul – UNIJUI, 2016. Available in: <https://www.lume.ufrgs.br/bitstream/handle/10183/13464/000643250.pdf?sequence=1>. Access in: Sept 05. 2018
- [4] GOLDMAN, Pedrinho. Introduction to Planning and Cost Control in Brazilian Civil Construction. 5. ed. São Paulo: Pini, 2014
- [5] HERMANI, Camila Costa; DARÉ, Mônica Elizabeth. Analysis of the budget spreadsheet of a public construction work: case study in a basic health unit. UNESC- University of Catarinense South End– 2014/2. Available in: <http://repositorio.unesc.net/handle/1/3040>. Access in: Oct. 16 2018
- [6] MATTOS, Aldo Dórea. How to prepare construction work budgets. São Paulo, 2ª ed. Publisher Pini, 2014
- [7] ROCHA, Luiz Fernando de Farias. The importance of the budget in construction. Monograph presented to the Federal University of Minas Gerais, 2013. Available in [http://www.bibliotecadigital.ufmg.br/dspace/bitstream/handle/1843/BUOS-9A5JN/monografia\\_luiz\\_fernando\\_de\\_faria\\_rocha.pdf?sequence=1](http://www.bibliotecadigital.ufmg.br/dspace/bitstream/handle/1843/BUOS-9A5JN/monografia_luiz_fernando_de_faria_rocha.pdf?sequence=1). Access in: Sept. 05 2018
- [8] SANTOS, Ana Paula Santa dos.; SILVA Nilmara Delfina da.; OLIVEIRA, Vera Maria de. Budget in the civil construction as instrument for participation in bidding process. *Universitário @ - Scientific Journal of Unisaesiano - Lins - SP, year 3., n.7, jul / dez 2012*. Available at: <http://www.salesianolins.br/university/artigos/no7/artigo25.pdf>. Accessed on: 05 Sep. 2018
- [9] SOARES, Douglas Leonardi. Analysis of cost variations between budgeted and executed in civil construction works of a company of Porto Alegre. Monography (Undergraduate) presented to the Federal University of Rio Grande do Sul. 2016. Available at: <https://lume.ufrgs.br/handle/10183/148661>. Accessed on: Oct 16, 2018
- [10] TISAKA, Maçahiko. Budget in Civil Construction: Consulting, Project and Execution. 1. ed. São Paulo: Pini, 2006 \_\_\_\_\_ . Budget in civil construction: Consulting, project and execution, 2. ed. São Paulo: Pini, 2011

# Antimicrobial activity of per acetic acid for trans-operative disinfection of endodontic files

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**Abstract**— Reducing the accumulation of microorganisms on an endodontic file during endodontic treatment is important to limit recontamination of the root canal and increase likelihood of successful treatment outcome. **Objective:** To compare the antimicrobial activity of peracetic acid (PA), isopropyl alcohol and acetone against a range of bacteria and also for disinfection of contaminated endodontic K-files. **Material and Methods:** Antimicrobial activities of PA, isopropyl alcohol and acetone were compared against *Staphylococcus aureus*, *Enterococcus faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa*, vancomycin resistant *E. faecalis* (VRE) and methicillin resistant *S. aureus* (MRSA), using minimum bactericidal concentration (MBC) and time-kill assays. **Test solutions at different exposure times (15 s and 30 s) were assessed for treatment of endodontic files acting as carriers of *E. faecalis*-contaminated dental debris. Results:** All bacteria were susceptible to PA (MBC range 0.25-1%), acetone (MBC range 50-60%) and isopropyl alcohol (30-40%). Using a time-kill assay of the antimicrobials at the determined MBC, all test microorganisms, with the exception of *E. faecalis* (VRE) 7766 were killed after 15 s exposure. In the case of *E. faecalis* 7766, viable cells remained detectable after 120 s

exposure to acetone. Testing disinfection of endodontic K-files, previously coated with dental debris containing *E. faecalis*, it was found that PA (2%) completely killed *E. faecalis* after 15 s exposure. However, even after 30 s exposure, isopropyl alcohol (80%) and acetone (80%) had limited disinfecting activity. **Conclusion:** Extrapolation of these results to clinical practice would suggest that PA would be the most effective agent for trans-operative disinfection of endodontic K-files during treatment of a single patient.

**Keywords**— Antimicrobial activity, biofilms, dental therapy, disinfectants, peracetic acid.

## I. INTRODUCTION

It is well established that bacteria and their by-products are important factors in the development of pulp and periradicular pathogenesis [1]. Therefore, an essential component of endodontic treatment is the elimination of bacteria from the root canal system. This can be achieved by using chemical or mechanical procedures [2-4]. Appliances used in endodontic treatment are either 'single use' or can be reused following sterilization by autoclaving (actual approaches used differ between countries) [5, 6]. As such, cross infection between patients

is not possible from the appliances used. However, during the single treatment of an individual patient, inadvertent reinfection of the root canal over this treatment may occur from the instrument being used<sup>7</sup>. During endodontic therapy, 2% chlorhexidine and 5% sodium hypochlorite (NaOCl) are frequently used irrigants to kill the microbiota present in the root canal system<sup>3</sup>. However, the cleansing and disinfection of instruments during single endodontic sessions, remains a matter of concern,<sup>[5,6,8-10]</sup> as many of the approaches used are ineffective for removal of biological debris<sup>6</sup>. During single endodontic therapy, residual material can accumulate on the working surface of an endodontic instrument and maintenance of effective instrument disinfection during the treatment session is an important consideration<sup>[8,9]</sup>.

Peracetic acid (PA) is a recognized disinfectant that exhibits antibacterial, sporicidal, antifungal and antiviral properties. PA also lacks persistent toxic properties and does not generate mutagenic residuals or by-products <sup>[10]</sup>. Having a broad-spectrum activity, even in the presence of heterogeneous organic matter, PA has previously been suggested for use as a sanitizing agent for gutta-percha cone disinfection<sup>[11]</sup>, for endodontic irrigation<sup>[12]</sup>, and also for smear layer removal in the root canal <sup>[13]</sup>.

The primary aim of this study was to evaluate and compare the antimicrobial activity of PA, isopropyl alcohol (isopropanol) and acetone (propanone) against a range of bacteria and also for the disinfection of contaminated endodontic K-files.

## II. MATERIAL AND METHODS

Test solutions used were 2% peracetic acid (PA) (SekuseptTMAktiv - Henkel AG & Co. KGaA, Düsseldorf, DE), acetone (>97%) and isopropyl alcohol/isopropanol (>98%). Acetone and isopropyl alcohol were obtained from Merck (Darmstadt, DE).

The microorganisms tested included *Staphylococcus aureus* (ATCC 25923), *Enterococcus faecalis* (ATCC 29212), *Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853) and vancomycin resistant *E. faecalis* (VRE) 7766, *E. faecalis* (VRE) 7767, methicillin resistant *S. aureus* (MRSA) 5963 and MRSA 6784. Non-ATCC strains originated from clinical samples.

The Minimal bactericidal concentration (MBC) of isopropyl alcohol, acetone and PA was initially determined. Briefly, standardized bacterial suspensions (OD<sub>680nm</sub>=0.1; 10<sup>7</sup> to 10<sup>8</sup> cell/mL) were generated in Trypticase Soy Broth (TSB) and 5 µL of these preparations transferred to sterile tubes. Aliquots (100 µL) of isopropyl alcohol (concentration range 20% to 90% in water), acetone (concentration range 20% to 90% in water), or PA (concentration range 0.125% to 2% in

water) were then added to the bacterial suspensions for 120s. Sterile water was included in place of an antimicrobial as a negative control. A 100-µL volume of double strength tryptone sodium chloride (TSC; 1g/L Tryptone (Difco), sodium chloride (Merck) 8.5g/L) was then added as a neutralizing agent, bacterial viability was then determined by plating 10 µL portions of serially diluted preparations in TSC on to an appropriate agar media and incubating for 24-48 h at 37°C.

The bacteria were cultured on Trypticase Soy Agar (TSA; Difco Laboratories) at 37°C for 24 h according to a method of the British Standards Institution (BS EN 1276)<sup>[14]</sup>. Antimicrobial efficacy of isopropyl alcohol, acetone and PA (at the previously determined MBC) was measured after 15, 60 and 120 s exposure at room temperature (~25°C). Briefly, 1 mL of bacterial suspension (at an OD<sub>660nm</sub>=0.5) was centrifuged in microtubes and the pellet resuspended in 1 mL of test disinfectant or sterile water (control). After appropriate contact time (15 s, 60 s or 120 s), 20 µL aliquots of the suspension were transferred to 1.98 mL of TSC, which served as a neutralizing agent. After serial dilution in TSC, microbial suspensions were plated on to TSA and incubated at 37°C for 24 h. The number of CFU/mL was then determined for the test microorganisms.

The antimicrobial activity of isopropyl alcohol, acetone and peracetic acid on K-files contaminated with *E. faecalis* biofilms: Antimicrobial activities of test solutions (80% acetone, 80% isopropyl alcohol, and 2% PA) at different exposure times (15 and 30 s) were examined for endodontic files acting as carriers of *E. faecalis*-contaminated dental debris. Briefly, in vitro coronal access was performed to expose the root canal system of healthy teeth that had previously been extracted for orthodontic purpose (the study protocol was approved by the Institutional Ethics Committee from Rio de Janeiro State University – Brazil – Authorization 051-2009). The exposed tooth chamber was then placed inside a test tube containing 3 mL of TSB, and the preparation sterilized by autoclaving. *Enterococcus faecalis* ATCC 29212 (OD<sub>660nm</sub>=0.5, 100-µL) was inoculated into the test tubes to generate a biofilm on the dentinal surfaces<sup>[15]</sup>. The preparation was incubated for 14 days with changes of TSB medium every 24 h to maintain biofilm growth. The teeth were then removed from the broths and the pulp chamber sealed with ColtosoITM (Coltene/Whaledent<sup>TM</sup>, New Jersey, USA). Teeth were immersed in a 5.25% NaOCl solution for 2 min to eliminate external contamination. The NaOCl was then neutralized using 10% sterile sodium thiosulphate solution for 2 min. The temporary coronal filling material was removed and K-endodontic files (#30K-type files, 21 mm long) were introduced into the contaminated root



canals with a filing motion until the flutes were visibly filled with dental debris. One group of K-files (n=30), with freshly removed biofilm (wet group) were immediately exposed to test antimicrobials in petri dishes (n=10 for each chemical test solution). For each chemical, the K-files were further divided into two groups of 5, being exposed to the agent at either 15 s or 30s. A second group (dehydrated) of K-files (n=30) were tested in the same manner, but these files were initially dried within a laminar flow chamber for 10 min prior to exposure to chemical agents. All files were transferred to test tubes containing Enterococcosel broth (BBL, Becton & Dickinson, Oxford, UK) and incubated for 48 h at 37°C, after which, bacterial growth was evident as a black precipitate within the medium. Controls were contaminated files exposed to saline and sterile files immediately immersed into test tubes containing Enterococcosel broth.

### III. RESULTS

The MBCs for isopropyl alcohol, acetone and peracetic acid are presented in Table 1. Antimicrobial susceptibility to the chemical agents varied for the bacterial species. Enterococci were more resistant to acetone than other groups of microorganisms, with *P. aeruginosa* ATCC 27853 and MRSA 6784 found to be the most susceptible to isopropyl alcohol, and VRE 7767 and MRSA 5963 the most susceptible to PA. All strains were sensitive to PA concentrations  $\geq 1\%$ .

Table.1: Disinfectant activity evaluated by Minimal Bactericidal Concentration.

Microorganisms	TSC	Acetone	Isopropanol	Peracetic acid
	120 <sup>a</sup>			
Minimum Bactericidal Concentration				
<i>E. coli</i> ATCC 25922	2.5 X 10 <sup>8</sup>	50	40	1
<i>P. aeruginosa</i> ATCC 27853	2.6 X 10 <sup>8</sup>	50	30	1
<i>E. faecalis</i> ATCC 29212	1.6 X 10 <sup>8</sup>	60	40	1
<i>S. aureus</i> ATCC 25923	3.0 X 10 <sup>8</sup>	50	40	1
<i>S. aureus</i> MRSA 5963	1.6 X 10 <sup>8</sup>	50	40	0.25
<i>S. aureus</i> MRSA 6784	3.0 X 10 <sup>8</sup>	50	30	1
<i>E. faecalis</i> VRE 7766	3.5 X 10 <sup>8</sup>	60	40	1
<i>E. faecalis</i> VRE 7767	2.9 X 10 <sup>8</sup>	60	40	0.25

<sup>a</sup> Inoculum of viable bacteria in 5µL incubated in TSC medium as negative control.

<sup>b</sup> Minimum bactericidal concentration of dilutions of disinfectant agents capable to kill all viable microorganisms ( $\sim 10^8$ - $10^9$  CFU) after contact to bacterial preparations (time kill) for 120 seconds. Isopropanol (isopropyl alcohol) and acetone were used in concentrations varying from 90 to 20%, and Peracetic acid from 2 to 0.125%.

The antimicrobial activities of isopropyl alcohol, acetone and PA, were evaluated for several bacterial species at different contact times (Table 2). Contact with acetone, isopropyl alcohol, or 2% PA resulted in a total kill ( $<3.3 \times 10^2$  CFU/ml; minimum level of detection of viable cells in this assay) after 15 s exposure. However, VRE 7766 remained detectable ( $2.3 \times 10^4$  CFU/mL) even after 120 s exposure to acetone.

Table.2: Disinfectant activity (time kill assay) after exposure to acetone (97%), isopropyl alcohol (98%) and peracetic acid (2%).

Microorganisms	*TSC	Acetone	Isopropanol	Peracetic Acid
<i>E. coli</i> ATCC 25922]	9,0 X 10 <sup>9</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>
<i>P. aeruginosa</i> ATCC 27853	3,0 X 10 <sup>10</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>
<i>E. faecalis</i> ATCC 29212	3,6 X 10 <sup>10</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>
<i>S. aureus</i> ATCC 25923	4,5 X 10 <sup>10</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>
<i>S. aureus</i> MRSA 5953	1,2 X 10 <sup>12</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>
<i>S. aureus</i> MRSA 6784	1,2 X 10 <sup>12</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>
<i>E. faecalis</i> VRE 7766	1,1 X 10 <sup>11</sup>	**2,3 X 10 <sup>4</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>
<i>E. faecalis</i> VRE 7767	6,0 X 10 <sup>10</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>	< 3,3 X 10 <sup>2</sup>

\* Original inoculum of microorganisms exposed to 1mL acetone (97%), isopropyl alcohol/Isopropanol (98%) or Peracetic acid (2%), until 2 minutes.

Experiments using sessile *E. faecalis* grown on dental surfaces and transferred to the flutes of K-endodontic files were undertaken to establish the antimicrobial activity of the test chemicals under conditions closer to those encountered in the clinical environment. These studies showed that 15 s or 30 s exposure to both isopropyl alcohol and acetone (at 80%) did not eliminate bacterial contamination, especially when the files had previously been dried prior to exposure to the solutions (Table 3). In the case of contaminated and non-dried K-files exposed 15 s to 80% isopropyl alcohol, viable bacteria were not detected in 1 of 5 (20%) tested K-files. With longer exposure (30 s), 3 of 5 K-files (60%) were found to be free of contamination. Antimicrobial effects were also evident for freshly contaminated files following exposure to acetone for both test periods (Table 2). In these experiments, exposure to isopropyl alcohol for 30 s was more effective than for acetone ( $p < 0.05$ , chi-square test). Experiments performed with concentrated isopropyl alcohol or acetone failed to completely eliminate bacterial biofilms after 30 s exposure times. PA demonstrated the greatest antimicrobial activity being able to eliminate viability of both freshly and dried sessile *E. faecalis* cells on all K-endodontic files after exposure for 15 s (100%).

Table.3. Antimicrobial activity of Isopropyl Alcohol (80%), Acetone (80%) and Peracetic acid (2%) on K-files (carrier test) contaminated with *E. faecalis* grown in biofilms on dentin matrix (percentage of elimination).

Chemical	Period of exposure	Wet <sup>1</sup>	Dehydrated <sup>1</sup>
Isopropyl alcohol	15 <sup>''</sup>	20%	0%
	30 <sup>''</sup>	60%	20%
Acetone	15 <sup>''</sup>	20%	0%
	30 <sup>''</sup>	20%	0%
Peracetic acid	15 <sup>''</sup>	100%	100%
	30 <sup>''</sup>	100%	100%

<sup>1</sup> K-files used as carriers were maintained inside a sterile humidified chamber (wet) or dried inside laminar flow chamber previously to the exposure to chemicals for 15 or 30 seconds.

#### IV. DISCUSSION

Microorganisms can remain viable on the surfaces of endodontic instruments for varying lengths of time and as such they may act as reservoirs of re-contaminating organisms during a single treatment period[16].

Concern over reducing microbial load on the surfaces of dental instruments during the same treatment period has arisen in recent years. This is largely due to previous cross-contamination of individuals through non-autoclavable instruments such as bronchoscopes, endoscopes [17] and other apparatus like dental chairs waterlines[18,19].

Of additional concern has been the potential acquisition of microbial resistance[20] to frequently used disinfectants and antiseptic agents[21]. Therefore, continuous monitoring of resistance profiles to disinfectant agents is highly important to ensure safety within clinical practice.

Although stated as disinfectants[22], to our knowledge, relatively few reports have tested the sensitivity of bacteria to both isopropyl alcohol and acetone, motivating inclusion of these agents in comparable tests with PA.

The approaches used to clean endodontic instruments are generally ineffective for the removal of biological debris, and therefore, single use instruments are advocated to avoid cross-infection occurring between patients. However, for a single patient, the same endodontic file may be used throughout the treatment process and it is possible that this instrument may, in effect, 're-infect' the root canal during the treatment. Since one of the key objectives of endodontic therapy is eradication of bacteria, effective disinfection of instruments during such a single treatment procedure would be beneficial[16,22,23].

In the present study, differences in antimicrobial susceptibility of microorganisms were detected in relation

to microbial growth pattern (sessile or planktonic). Bacteria growing as biofilms have distinctive features compared with the same bacteria growing planktonically (free floating). For example, biofilm cells are frequently more tolerant to antimicrobial agents, conditions of stress and host defenses, compared with their planktonic equivalents. This recalcitrance of biofilms makes them extremely difficult to treat[23].

In our results, microorganisms grown planktonically were highly susceptible to all disinfectant agents after evaluation by a time-kill assay. A reduction in bacterial viability higher than 10<sup>5</sup> CFU/ml was observed for all test solutions, indicating that the chemicals had adequate disinfecting activity for planktonically grown Gram-negative and Gram-positive bacteria after exposure for 15 s. The only exception was VRE 7766 which, by time kill assay, demonstrated a residual number of viable cells (2.3 × 10<sup>4</sup> CFU/mL) after exposure of ~10<sup>11</sup> CFU/ml to concentrated acetone[16,17,22,23].

Determination of the MBC for all microbial strains also reinforced the susceptibility of planktonic microorganisms. The MBC, determined by exposure for 2 min to different concentrations of the tested chemical agents, demonstrated that all strains were sensitive to PA concentrations ≥1%, and isopropyl alcohol was more active than acetone in reducing viability of bacteria (~10<sup>5</sup>-10<sup>6</sup> CFU), including the VRE 7766. Therefore, as isopropyl alcohol had a lower MBC concentration (40%) than acetone (60%), it should theoretically be more effective in clinical use[23,24].

Whilst isopropyl alcohol and acetone are ineffective at killing bacterial spores, maintenance of decontamination of instruments by vegetative organisms should be achievable by these agents[24]. Importantly, microorganisms exhibiting resistance to antibiotics or antimicrobial agents often also have higher tolerance to disinfectants[25]. This study therefore also evaluated activity of acetone, isopropyl alcohol and PA to both MRSA and VRE strains, and the test agents were shown to inhibit the viability of planktonic forms of these microorganisms. In contrast, the effectiveness of disinfectants against microorganisms grown in biofilms was relatively limited. In this study, sessile *E. faecalis* removed from dentine walls by K-files used in the carrier test, exhibited resistance to acetone and isopropyl alcohol after 30 s exposure. This was particularly evident when contaminated K-files were dried prior to exposure to the disinfectant, even at higher concentrations. The volatility of both isopropyl alcohol and acetone might lead to variations in their concentrations within clinical situations[26,27]. As a result, our experiments using K-files in carrier tests were conducted with acetone and isopropyl alcohol diluted to 80%. This finding suggests that biofilm growth in dentine matrices is an important

factor for microbial resistance to acetone or isopropyl alcohol. Furthermore, in skin surface experiments, microorganisms are usually sensitive to alcohol-based antiseptics, with studies showing that the most effective antimicrobial activity occurs with 2% chlorhexidine digluconate in 70% isopropyl alcohol[26]. Moreover, isopropyl alcohol-based hand antiseptics have demonstrated higher activity against *E. coli*, *Micrococcus luteus*, and *S. aureus* than ethanol-based disinfectants in experiments on skin surfaces[27].

Overall, 2% PA was deemed to be the best disinfectant, as it was able to eliminate all microbial isolates, regardless of their growth form, or test method used. Significantly, total elimination of microbial viability occurred with sessile cells derived from dentinal matrices for all K-file carriers (100%) after 15 s exposure[25-27]. PA is an oxidizing agent used in the decontamination of a wide range of medical equipment as well as in food and water treatment processes. PA disinfection is rapid and effective against bacteria, fungi, viruses and spores[10-12, 28-30].

In this study, a modified K-file carrier test was developed that enabled the assessment of disinfectant efficacy against biofilm microorganisms in the presence of dentine debris. The method was relatively easy to perform, and simulated conditions observed in clinical practice, in which the files may present a dense biofilm contamination.

## V. CONCLUSION

Based on the study findings, it was concluded that PA was the most effective of the test disinfectants and as such is advocated as an appropriate disinfectant for single use endodontic instruments during use in a single treatment session. We suggest the use of 2% PA inside the 'endo stand', to allow all instruments being used in the canal treatment be kept at hand in the order of their use and disinfection.

## REFERENCES

- [1] Kakehashi S, Stanley HR, Fitzgerald RJ. The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. *Oral Surg Oral Med Oral Pathol.* 1965; 20:340-9.
- [2] Williams JA, Pearson GJ, Colles MJ. Antibacterial action of photoactivated disinfection {PAD} used on endodontic bacteria in planktonic suspension and in artificial and human root canals. *J Dent* 2006; 34: 363 - 71.
- [3] Tirali RE, Bodur H, Sipahi B, Sungurtekin E. Evaluation of the antimicrobial activities of chlorhexidine gluconate, sodium hypochlorite and octenidine hydrochloride in vitro. *Aust Endod J*, 2013; 39:15-8.
- [4] Yap B, Zilm PS, Briggs N, Rogers AH, Cathro PC. The effect of sodium hypochlorite on *Enterococcus faecalis* when grown on dentine as a single- and multi-species biofilm. *Aust Endod J*, 2014; 40:101-10.
- [5] Van Eldik DA, Zilm PS, Rogers AH, Marin PD. Microbiological evaluation of endodontic files after cleaning and steam sterilization procedures. *Aust Dent J.* 2004; 49: 122-27.
- [6] Aasim SA, Mellor AC, Qualtrough AJE. The effect of pre-soaking and time in the ultrasonic cleaner on the cleanliness of sterilized endodontic files. *Int Endod J.* 2006; 39: 143- 49.
- [7] Podgórska M, Jakimiak B, Röhm-Rodowald E, Chojecka A. Assessment of disinfection and sterilization processes in dental practice as an important factors in prevention of infections. *Przegl Epidemiol.* 2009; 63: 545-50.
- [8] Popovic J, Gasic J, Zivkovic S, Petrovic A, Radicevic G. Evaluation of biological debris on endodontic instruments after cleaning and sterilization procedures. *Int Endod J.* 2010; 43: 336-41.
- [9] Bulem UK, Kececi AD, Guldaz HE. Experimental evaluation of cyclic fatigue resistance of four different nickel-titanium instruments after immersion in sodium hypochlorite and/or sterilization. *J. Appl. Oral Sci.* [online]. 2013; 21: 505-10.
- [10] Mehmet K. Disinfection of wastewater with peracetic acid: a review. *Environ Int* 2004; 30: 47–55
- [11] Salvia ACRD, Teodoro GR, Balducci I, Koga-Ito CY, Oliveira SHG. Effectiveness of 2% peracetic acid for disinfection of gutta-percha cones. *Braz Oral R.* 2011; 25: 23-7.
- [12] Kühfluck I, Klammt J. Suitability of peracetic acid for root canal disinfection. *Stomatol DDR* 1980; 30: 558-63.
- [13] De-Deus G, Souza EM, Marins JR, Reis C, Paciornik S, Zehnder M. Smear layer dissolution by peracetic acid of low concentration. *Int Endod J.* 2010; 44: 485-90.
- [14] BS EN 1276 (European Standard). Chemical disinfection and antiseptics – Quantitative suspension test for the evaluation of bacterial activity of chemical disinfectants and antiseptics used in food, industrial, domestic and institutional areas – Test method and requirements (phase 2, step 1) Brussels: European Committee for Standardization 1997.
- [15] Bhuvra B, Patel S, Wilson R, Niazi S, Beighton D, Mannocci F. The effectiveness of passive ultrasonic irrigation on intraradicular *Enterococcus faecalis*

- biofilms in extracted single-rooted human teeth. *Int Endod J.* 2010; 43: 241-50.
- [16] Gendron R, Grenier D, Maheu-Robert L. The oral cavity as a reservoir of bacterial pathogens for focal infections. *Microbes Infect.* 2000; 8: 897-906.
- [17] Rutala WA, Weber DJ. Reprocessing endoscopes: United States perspective. *JHosp Infect.* 2004; 56: S27-39.
- [18] Coleman DC, O'Donnell MJ, Shore AC, Swan J, Russell RJ. The role of manufacturers in reducing biofilm in dental chair waterlines. *J Dent.* 2007; 35: 701-11.
- [19] Walker JT, Marsh PD. Microbial biofilm formation in DUWS and their control using disinfectants. *J Dent.* 2007; 35: 721-30.
- [20] Lins RX, de Oliveira Andrade A, Hirata Junior R, Wilson MJ, Lewis MA, Williams DW, Fidel RA. Antimicrobial resistance and virulence traits of *Enterococcus faecalis* from primary endodontic infections. *J Dent* 2013; 41: 779-86.
- [21] Sheldon AT Jr. Antiseptic "resistance": real or perceived threat? *Clin Infect Dis* 2005; 40: 1650-56.
- [22] Duarte M, Giordani RB, De Carli GA, Zuanazzi JA, Macedo AJ, Tasca T. A quantitative resazurin assay to determinate the viability of *Trichomonas vaginalis* and the cytotoxicity of organic solvents and surfactant agents. *Exp Parasitol.* 2009; 123:195-8.
- [23] Marsh PD. Controlling the oral biofilm with antimicrobials. *J Dent* 2010; 38: S11-15.
- [24] Rutala WA. APIC Guideline for Selection and Use of Disinfectants. *American J Infect Control* 1990; 18: 99-117.
- [25] Martin DJ, Denyer SP, McDonnell G, Maillard JY. Resistance and cross-resistance to oxidizing agents of bacterial isolates from endoscope washer disinfectors. *JHosp Infect.* 2008; 69: 377-83
- [26] Reichel M, Heisig P, Kohlmann T, Kampf G. Alcohol for skin antisepsis at clinically relevant skin sites. *Antimicrobial Agents and Chemother.* 2009; 53: 4778-82.
- [27] Goroncy-Bermes P. Hand disinfection according to the European Standard EN 1500 (hygienic handrub): a study with Gram-negative and Gram-positive test organisms. *Int J Hyg Environ Health* 2001; 204: 123-6.
- [28] Loukili NH, Granbastien B, Faure K, Guery B, Beaucaire G. Effect of different stabilized preparations of peracetic acid on biofilm. *JHosp Infect.* 2006; 63: 70-2.
- [29] Baldry MG. The bactericidal, fungicidal and sporicidal properties of hydrogen peroxide and peracetic acid. *J Appl Bacteriol.* 1983; 54: 417-23.
- [30] Wutzler P, Sauerbrei A. Virucial efficacy of a combination of 0.2% peracetic acid and 80% (v/v) ethanol (PAA-ethanol) as a potential hand disinfectant. *JHosp Infect.* 2000; 46: 304-8.

# Interfaces between wind energy aspects analysis and Weibull distribution: Evidences from a bibliometric study

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**Abstract**—This paper aims to address and understand the knowledge application of Weibull distribution to analyze wind energy aspects, which is related to technical, sustainable and economic assessment, along with wind characteristics. It is structured under bibliometric analysis and reveals a panorama of 177 papers from 2007 to 2017 that presents where and how these relationships between wind energy aspects and Weibull distribution occur. This study presents six different analyses to understand these possibilities: papers by year, wordcloud, papers by author, papers by topic, papers by affiliation, papers by journal and its subjects. Main findings of this research show that the leading areas where these interfaces occur in academic research are energy, engineering and environment science. Another relevant result is that the intersection of wind energy and the Weibull distribution has been figured as a core research topic to individual or a group of researchers around the world. The main contribution of this paper to the academic community is the pioneering on presenting a view on the size and on the main characteristics of this interface through bibliometric analysis.

**Keywords**— Renewable energy, Wind energy, Weibull distribution, Bibliometrics.

## I. INTRODUCTION

The demand for energy is expected to expand continuously, more than tripled by the end of the century [1]. According to Pereira et al. [2], the world is mainly consuming fossil fuel energy and, in the case of final energy consumption, this corresponds to 79% of the world energy matrix. In this context, the conventional processes of electric power generation are among the main responsible for emissions of greenhouse gases [3].

In response to an enhanced awareness of the negative impacts of large-scale, fossil-fuel intensive energy generations, as well as the realization that the earth's resources are finite, governments, organizations and individuals are showing increasing interest in small-scale, decentralized and low-carbon energy sources [4]. As a result, policy makers, business leaders, consumers and researchers have increasingly turned their attention to the alternative energy sources such as solar, wind, and biomass [5].

Among the available renewable energy sources, wind energy is currently regarded as one of the most significant, fastest growing, and commercially attractive sources to generate electricity because of the mature and cost-effective wind energy technologies [6]–[7].

The success of the determination of the wind energy potential depends on accurate wind speed modeling and the statistical properties of wind speed are important to predict the output energy of a wind conversion system [8]. Wind characteristics and power potential of various locations have been studied in many countries worldwide, in order to fully describe the mathematical procedures useful to perform analysis in sites with the potential for wind farm installation [9].

The Weibull function is one of the most used distribution functions for different purposes such as modeling, reliability analysis, life time data analysis, and many applied science areas such as mechanic, bio system, nuclear, and energy system engineering [10]. In studies, it is seen that two-parameter Weibull distribution is used for the determination of wind energy potential in the different regions in the world [11]–[12]. Therefore, much consideration has been given to the Weibull two-parameter –  $k$ , shape parameter and  $c$ , scale parameter –

function because it has been found to fit a wide collection of wind data [13].

According to Archambault et al. [14], the increased availability of data such as bibliographic impact returns to more importance as a publication activity and citations can be included as part of a more holistic review of the literature. Zupic and Cater [15] pointed out that bibliometric methods employ a quantitative approach to a description and evaluation of published research. Indeed, bibliometric techniques have become an indispensable instrument to measure the scientific progress in various fields [16].

This paper aims to quantitatively and qualitatively map the scientific research about the studies on wind energy that used the Weibull Distribution as an analysis method. Using bibliometric method, various publication characteristics will be obtained such as publication year, authors, institution affiliation, knowledge topics, main journals and its subjects as well as a database content analysis by wordcloud, to measure the its consistency.

These results not only provide a better understanding of global hotspots in the research related to the wind energy analysis, but may also influence researchers' future research directions.

## II. METHODOLOGY

This paper is structured under bibliographic analysis. It intends to analyze quantitative data about papers and allocating them in categories in order to make a good comprehension about the interface between wind energy and the Weibull statistical distribution.

This type of analysis facilitates a cross-referencing, resulting in a previous study composed by the works that will integrate the so-called starting nucleus, where the researcher will have sufficient background for the bibliographic study. For this, bibliometric techniques are used, which employ quantitative methods in the search for an objective evaluation of scientific production.

The researches carried out in the Scopus database were carried out in order to find papers related to the Weibull function and wind energy source. In addition, no exclusion filters were used in order to avoid the reduction of results, choosing a return with the widest possible

In order to better track the scientific papers that relate the Weibull function to wind as an energy source, the search terms should be defined. Due to some different approaches, the same subject has evaluated with various expressions in researches. So, in some papers this energy source is known as wind power and, in other, it is known as wind energy. It is possible to say that wind power is more directly applied to problems related with the power plants issues. Wind energy is a more diversified term and is related to power generation processes, which can occur

in industrial plants, but also in public investments, domestic use, discussions on renewable energy and sustainability.

About the Weibull distribution function, the first strategy was to use the word 'Weibull' to better assimilate the results about the matter. However, it had felt it should make some more filters to the results. Hence, the terms "Weibull distribution function", "Weibull function" and "Weibull parameters" were used.

The next step was the definition of the temporal cut of research and it was decided to work with works published from 2007 to 2017, to clarify the evolution of the publications in the period of a decade. The structure of our search terms as well as the preliminary results for setting our papers database are 609 registers, and it's listed on the Table 1.

Table.1: Search keys used

Search	Results
TITLE-ABS-KEY ("wind power" AND "Weibull distribution function") AND (PUBYEAR > 2006)	104
TITLE-ABS-KEY ("wind power" AND "Weibull function") AND (PUBYEAR > 2006)	58
TITLE-ABS-KEY ("wind power" AND "Weibull parameters") AND (PUBYEAR > 2006)	181
TITLE-ABS-KEY ("wind energy" AND "Weibull distribution function") AND (PUBYEAR > 2006)	71
TITLE-ABS-KEY ("wind energy" AND "Weibull function") AND (PUBYEAR > 2006)	43
TITLE-ABS-KEY ("wind energy" AND "Weibull parameters") AND (PUBYEAR > 2006)	152
Total of registers	609

Due to the many results found, a restriction was applied in the types of works. These were restricted to only articles published in journals, excluding conference papers, theses and reports, reducing that set to 177 records.

## III. RESULTS AND DISCUSSION

Initially, it was analyzed the papers distribution by year, represented in Fig. 1. This graph can be separated in two distinct moments: the first moment is from 2007 to 2013, when there is a tendency of publish oscillation. The

other moment is from 2014 to 2017, which represent just over half of the papers analyzed, there is also a certain constancy, or low variation, in the number of publications about the matter.

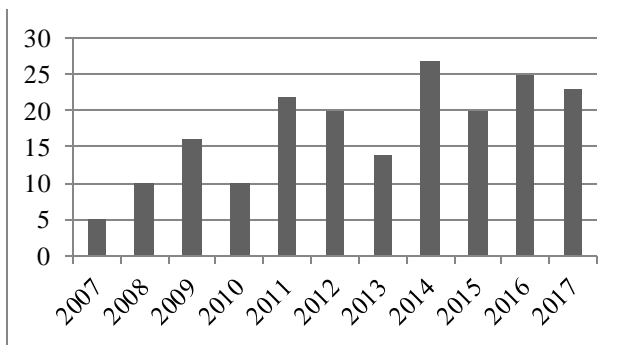


Fig. 1: Papers identified by year

The next step, as we have set the database, is to realize an analysis through the tool of word clouding that also works as a uniformity analysis. In order to carry out this wordcloud, it have been used the website Wordle, using the abstracts of the 177 papers, and the results of this analysis are shown in Fig. 2.



Fig. 2: Wordcloud of database abstracts

Firstly we can see that this wordcloud shows us we have a very consistent database covering the terms we intend to find, like “wind”, “power”, “energy” and “weibull”. We can also see in the cloud words like “data”, “speed”, “distribution” and “parameters” that consists in our core of the results we will discuss more in the following analysis. More than the analysis of each of the words, by its grouping to the often words appear in the texts, this cloud is important for us to ensure the data consistency.

A good approach to improve comprehension about database is to evaluate the average amount of journal papers published. In this sense, the value for the average of 17.45 published papers by year indicates the matter has a good acceptance and relevance for the research worldwide, granting more than one article by month on indexed journals since 2007.

Despite this first impression, the figure also let us know that, if we consider the whole amount of articles from 2007 to 2017, it’s what was not possible to trace a trend

line. So, considering the data universe, we can assume the amount of published papers for the next period may continue increasing, according to the trend from 2014 to 2017.

Next, the authors and affiliation with the highest number of publications on the matter were highlighted in Fig. 3 and Fig. 4, respectively. Only those authors and affiliations with four or more records were considered, due to the considerable amount of these with only three or less related publications.

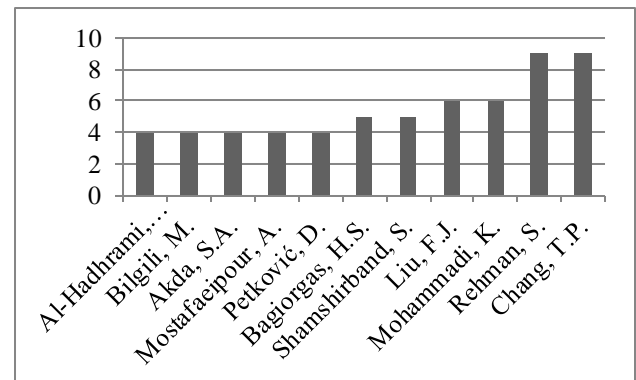


Fig. 3: Authors with the highest number of records

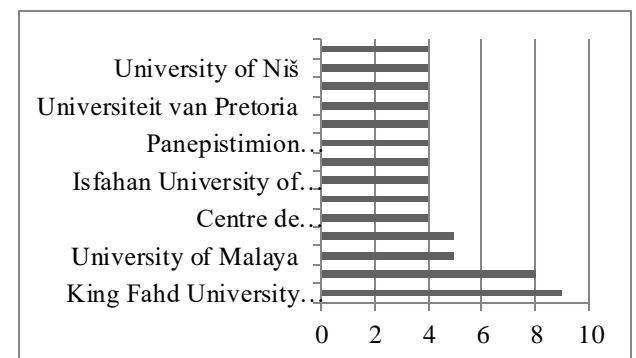


Fig. 4: Affiliations with the highest number of records

As we can see in Fig.3, it can be said that Rehman, S., from Saudi Arabia, and Chang, T.P., from Taiwan, are the authors in the leadership of scientific production about the matter.

In Fig. 4, we can notice two institutions with great relevance in number of publications, King Fahd University of Petroleum and Minerals, from Saudi Arabia, and Nan Kai University of Technology, from Taiwan.

When the two analysis indicators get related, it can be observed that the most prominent authors on the subject belong to the affiliations that have the largest number of publications. Hence, there is two rising groups of scientific paper production that are called the references on the topic.

About the cover topics for the matter, all the 178 papers were related and allocated into the topics

according to the scientific database, with special emphasis on Energy, representing 50% of the registers, Engineering and Environmental Science (Fig. 5).

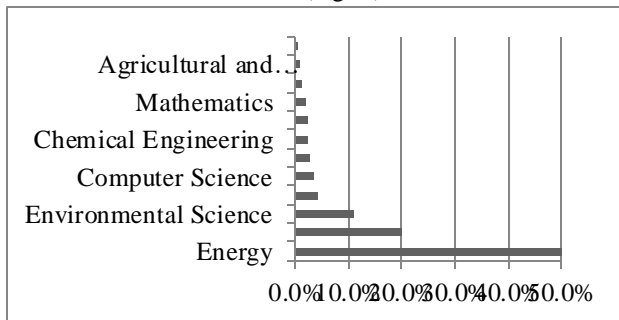


Fig. 5: Papers by topics in the database

For the most part, the papers are listed in the topic Energy, so there is an agreement with the terms used in the search keys and indicate the prominence of investigation lines related to the topic under discussion.

Nonetheless, it has been observed that the amount of articles that refers to more than one topic is relevant. We can cite as examples Costa Rocha et al. [17], allocated in Energy and Engineering, Hulio et al. [18] refers to Energy and Social Science, Fazelpour et al. [19] appointed as Environmental Science and Energy, and Gani et al. [20], allocated in three cover topics: Chemical Engineering, Energy and Environmental Science. This fact corroborates the comprehensiveness and relevance of this research.

Another aspect noted is that the article with the highest number of citations is allocated only in the Energy topic. Akdağ and Dinler [21], cited by 202 papers, developed a method to estimate Weibull distribution parameters for wind energy applications, called power density (PD) method. To demonstrate the accuracy of this method, they had made comparisons based on power density and mean wind estimation results of previous studies. Results of this study indicate that PD method is adequate method estimate Weibull parameters and it might have better suitability than other methods. The analysis showed some superiority of the PD method, because it has simple formulation, it does not require binning and solving linear least square problem or iterative procedure. According to them, it is very simple to estimate Weibull parameters, if power density and mean wind speed are available.

Some of papers following this line are Azad et al. [22], which analyzed seven different methods, including the Power Density method, to determine the best one to estimate the Weibull parameters, however, the results found did not indicate the said method as the most efficient one, Zhou and Smith [23], that estimated global variation in wind parameters, by using the PD method, as fitted to a Weibull density function using NCEP/climate forecast system reanalysis (CFSR) data over land areas,

and Akdağ and Güler [12], which presented a novel method, considered by them better than standard methods, to estimate Weibull parameters, being compared with another eight methods, including the Power Density method, presented by one of this paper's authors in 2009.

We can have some other analysis by looking to the journals that lead the ranking of papers related to our search terms. Fig. 6 shows the papers arranged by journals. For a better viewing, we have put on this graph only journals that count on four papers or more.

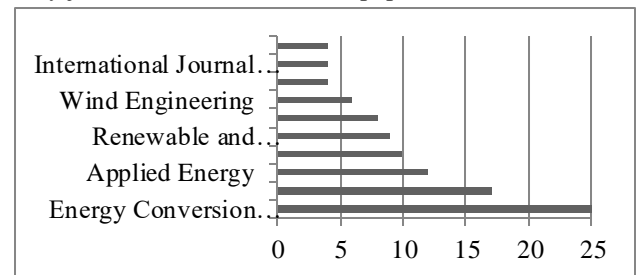


Fig. 6: Papers by journal

First of all, we can note that the leader journal is "Energy Conversion and Management". The focus of this journal is the research on all important energy aspects, including energy generation, utilization, conversion, storage, transmission, conservation, management and sustainability. The far leadership of this journal is in line with the previous results we have got analyzing the graphic of papers by topic. Most of the papers published by this journal are associated with Energy. So, this journal is an important scientific vehicle to spread knowledge on energy in which concern the intersection between renewable resources, such as wind energy and the processes, operation and performance prospects, like the Weibull function.

The second one, "Renewable Energy", is a journal that has the purpose of discussing various topics and technologies of renewable energy systems and components. It includes discussion about the wind energy and to apply alternative energy solutions to current practices. On the set of journals plotted in this graphic, we can identify two groups of journals. The first one, which encompasses "Energy Conversion and Management", "Applied Energy", "Energy" and "Energies", is associated with all of energy types, including wind energy.

Another group consists of journals with a more concise range of subjects like "Renewable Energy", "Renewable and Sustainable Energy Reviews", "International Journal of Green Energy", "International Journal of Renewable Energy" and "Energy Sources, Part A: Recovery, Utilization and Environmental Effects". At this group, kinds of papers we will find vary and can have many different approaches and points of view about renewable



energy and sustainability.

Besides that, we can highlight the journal “Wind Engineering”, as the one more focused on a lot of wind aspects, such as the aerodynamics of rotors and blades, machine subsystems and components, power generation and transmission, measuring and recording techniques, installations and applications, and economic, environmental and legal aspects involved with wind as a source of energy.

#### IV. CONCLUSION

Combining the six different analyses we have done – papers by year, wordcloud, papers by author, papers by topic, papers by affiliation, papers by journal and its subjects, the main conclusion of this work is that the intersection of wind energy and the Weibull distribution has been figured as a core research topic to individual or a group of researchers around the world.

As a formal research topic, papers continue to be written on issues involving wind as energy source or power generation, and Weibull distribution, along with its function and parameters. From 2007 to 2017, 177 articles were produced by using two-parameter Weibull distribution for the determination of wind energy potential.

Inside the topics covered by our database of 177 papers, we can note that technical, sustainable and economic assessment or Wind power characteristics of a determined place are the major subtopics in which the Weibull distribution method can be useful. These results are supported by the journal analysis that demonstrates “Energy Conversion and Management”, which is strictly associated with environmental issues on energy systems, is the journal that has the biggest amount of papers on our database.

Energy, Engineering and Environment Science are the research topics in which collaborations of this kind of assessment can be more easily tracked and perceived, which remains as a subject for future studies.

In general, the study demonstrates that bibliometric study is a methodology that is capable of providing a knowledge base that is useful in the development of research, and is supported in scientific papers of great relevance and credibility.

We believe that this work can be useful to the scientific community on pointing out there are many ways an estimation method, like Weibull distribution, can contribute on analyzing wind aspects as energy source. Therefore, this paper may also be useful to the public entities and meteorological analysis bodies, and the community of engineering around the world.

#### ACKNOWLEDGEMENTS

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#### REFERENCES

- [1] J. Knox-Hayes, M. Brown, B. Sovacool, Y. Wang (2013). Understanding attitudes toward energy security: Results of a cross-national survey. *Global Environmental Change*, 23(3), 609-622. <http://dx.doi.org/10.1016/j.gloenvcha.2013.02.003>.
- [2] M.G. Pereira, C.F. Camacho, M.A.V. Freitas, N.F. Silva (2012). The renewable energy market in Brazil: Current status and potential. *Renewable & Sustainable Energy Reviews*, 16(6), 3786-3802. <https://doi.org/10.1016/j.rser.2012.03.024>.
- [3] F.R. Pazheri, M.F. Othman, N.H. Malik (2014). A review on global renewable electricity scenario. *Renewable and Sustainable Energy Reviews*, 31, 835-845. <https://doi.org/10.1016/j.rser.2013.12.020>.
- [4] S. Weekes, A. Tomlin (2013). Evaluation of a semi-empirical model for predicting the wind energy resource relevant to small-scale wind turbines. *Renewable Energy*, 50, 280-288. <http://dx.doi.org/10.1016/j.renene.2012.06.053>.
- [5] Z. Zhao, J. Hu, J. Zuo (2009). Performance of wind power industry development in China: A Diamond Model study. *Renewable Energy*, 34(12), 2883-2891. <http://dx.doi.org/10.1016/j.renene.2009.06.008>.
- [6] P. Harborne, C. Hendry (2009). Pathways to commercial wind power in the US, Europe and Japan: The role of demonstration projects and field trials in the innovation process. *Energy Policy*, 37(9), 3580-3595. <http://dx.doi.org/10.1016/j.enpol.2009.04.027>.
- [7] Q. Wang, C. Zhang, Y. Ding, G. Xydis, J. Wang, J. Østergaard (2015). Review of real-time electricity markets for integrating Distributed Energy Resources and Demand Response. *Applied Energy*, 138, 695-706. <http://dx.doi.org/10.1016/j.apenergy.2014.10.048>.
- [8] S. Pishgar-Komleh, A. Keyhani, P. Sefeedpari (2015). Wind speed and power density analysis based on Weibull and Rayleigh distributions (a case study: Firouzkooch county of Iran). *Renewable and Sustainable Energy Reviews*, 42, 313-322. <http://dx.doi.org/10.1016/j.rser.2014.10.028>.
- [9] P. Simons, W. Cheung (2016). Development of a quantitative analysis system for greener and economically sustainable wind farms. *Journal of Cleaner Production*, 133, 886-898. <http://dx.doi.org/10.1016/j.jclepro.2016.06.030>.

- [10] G. Quercia, D. Chan, K. Luke (2016). Weibull statistics applied to tensile testing for oil well cement compositions. *Journal of Petroleum Science and Engineering*, 146, 536-544. <http://dx.doi.org/10.1016/j.petrol.2016.07.012>.
- [11] C. Andrade, H. Maia Neto, P. Costa Rocha, M. Vieira da Silva (2014). An efficiency comparison of numerical methods for determining Weibull parameters for wind energy applications: A new approach applied to the northeast region of Brazil. *Energy Conversion And Management*, 86, 801-808. <http://dx.doi.org/10.1016/j.enconman.2014.06.046>.
- [12] S. Akdağ, Ö. Güler (2015). A novel energy pattern factor method for wind speed distribution parameter estimation. *Energy Conversion and Management*, 106, 1124-1133. <http://dx.doi.org/10.1016/j.enconman.2015.10.042>.
- [13] I. Lun, J. Lam (2000). A study of Weibull parameters using long-term wind observations. *Renewable Energy*, 20(2), 145-153. [http://dx.doi.org/10.1016/S0960-1481\(99\)00103-2](http://dx.doi.org/10.1016/S0960-1481(99)00103-2).
- [14] E. Archambault, D. Campbell, Y. Gingras, V. Larivière (2009). Comparing bibliometric statistics obtained from the Web of science and scopus. *Journal of the Association for Information Science and Technology*, 60(7), 1320-1326. <https://doi.org/10.1002/asi.21062>.
- [15] I. Zupic, T. Cater (2015). Bibliometric methods in management and organization. *Organizational Research Methods*, 18(3), 429-472. <https://doi.org/10.1177/1094428114562629>.
- [16] H. Du, N. Li, M. Brown, Y. Peng, Y. Shuai (2014). A bibliographic analysis of recent solar energy literatures: The expansion and evolution of a research field. *Renewable Energy*, 66, 696-706. <http://dx.doi.org/10.1016/j.renene.2014.01.018>.
- [17] P. Costa Rocha, R. Sousa, C. Andrade, M. Silva (2012). Comparison of seven numerical methods for determining Weibull parameters for wind energy generation in the northeast region of Brazil. *Applied Energy*, 89(1), 395-400. <http://dx.doi.org/10.1016/j.apenergy.2011.08.003>.
- [18] Z. Hulio, W. Jiang, S. Rehman (2017). Technical and economic assessment of wind power potential of Nooriabad, Pakistan. *Energy, Sustainability And Society*, 7(1). <http://dx.doi.org/10.1186/s13705-017-0137-9>.
- [19] F. Fazelpour, N. Soltani, M. Rosen (2014). Wind resource assessment and wind power potential for the city of Ardabil, Iran. *International Journal of Energy And Environmental Engineering*, 6(4), 431-438. <http://dx.doi.org/10.1007/s40095-014-0139-8>
- [20] A. Gani, K. Mohammadi, S. Shamshirband, T. Altameem, D. Petković, S. Ch (2016). A combined method to estimate wind speed distribution based on integrating the support vector machine with firefly algorithm. *Environmental Progress & Sustainable Energy*, 35(3), 867-875. <http://dx.doi.org/10.1002/ep.12262>.
- [21] S. Akdağ, A. Dinler (2009). A new method to estimate Weibull parameters for wind energy applications. *Energy Conversion and Management*, 50(7), 1761-1766. <http://dx.doi.org/10.1016/j.enconman.2009.03.020>.
- [22] A. Azad, M. Rasul, T. Yusaf (2014). Statistical Diagnosis of the Best Weibull Methods for Wind Power Assessment for Agricultural Applications. *Energies*, 7(5), 3056-3085. <http://dx.doi.org/10.3390/en7053056>.
- Y. Zhou, S. Smith (2013). Spatial and temporal patterns of global onshore wind speed distribution. *Environmental Research Letters*, 8(3), 034029. <http://dx.doi.org/10.1088/1748-9326/8/3/034029>.

# The security of information and the risks associated with its use, a model for its implementation

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**Abstract**— *To assess whether the management of information security and the risks associated with its use, through computer networks, at the Peninsula State University of Santa Elena, is effective, it is proposed to implement a model that establishes the goals to achieve to advance through the different levels that make up the rating scale.*

*To evaluate the management of information security and the risks associated with its use, it is necessary to have a maturity model that not only allows evaluating the processes involved in the management of information security, but also those associated with the management of the risks linked to the processing of information in all its phases, since an adequate information security plan depends on it.*

*Based on the aforementioned, the objective of this paper is to propose a model for the management of information security and the risks associated with its use, in computer networks.*

**Keywords**— *Information security management, information processing, risks associated with the use of information, computer networks*

## I. INTRODUCTION

The information systems that in educational institutions are manipulated, sometimes, are directed towards the mission of the organization which usually have a hostile environment, that is why the security of information is a discipline that integrates a set of policies, processes, procedures, organizational structures and software and hardware functions to help protect the confidentiality, integrity, availability and traceability of resources managed by IS in organizations (Achiary, 2005).

- Confidentiality: it is guaranteed that the information is accessible only by authorized persons.
- Integrity: safeguard the accuracy and completeness of the information and processing methods.
- Availability: it is guaranteed that authorized users have access to the information and resources related to it, whenever they require it.
- Traceability: make the IS auditable through a history that allows knowing the location and trajectory of a resource.

From these fundamental objectives of safety derive others such as:

- Authenticity: seeks to ensure the validity of information in time, form and distribution. Likewise, the origin of the information is guaranteed, validating the issuer to avoid identity theft.
- Non-repudiation: avoid that an entity that has sent or received information alleges to third parties that it did not do so.

In order to regulate aspects related to security in information systems (IS), standards have been developed that propose a set of policies and good practices, which help to strengthen the security of information. Computer security is commonly associated with a small group of technical measures such as antivirus and firewalls, the controls to be established are many and varied (Montesino, 2009).

Computer security as a concept has been evolving over time. Initially it was a discipline dominated by the elite of professionals specialized in the subject, but since the beginning of this century a more encompassing vision of information security has been proposed, which formally

links elements such as technology, the individual and the organization, emphasizing in the study of these and their relationships, to rethink computer security beyond the traditional technological experience (Cano, 2005).

According to Solms (2006), computer security has gone through history through four stages. The first stage was characterized by the technical aspect, the second was related to the management approach, where aspects such as policies and processes began to be considered. The third stage became standardized and documents of good practices and certifications began to appear.

Topics such as computer security culture, evaluation and monitoring began to be important. The fourth stage has been driven by regulations, where computer security has become a key aspect for the managers of the organizations and therefore is addressed from the first level of management.

The process of information security management is described in the ISO / IEC 27001 standard, which is an internationally certifiable standard. This standard offers a model for the establishment, implementation, operation, monitoring, review, maintenance and improvement of an information security management system (ISMS) (ISO / IEC, 2005).

The standard proposes a process approach where information security is not a state that is reached in a certain moment of time and remains unchanged, but is a continuous process that needs to be managed. Several actions are proposed that form a closed cycle for the continuous improvement of the system.

The ISM3 consortium, made up of several companies and organizations, has developed the Maturity Model of Information Security Management (ISM3). This model aims to extend the quality principles established in ISO 9001 to an ISMS. Instead of being oriented to controls, it focuses on computer security processes that may be common to all organizations (Aceituno, 2007).

Five basic configurations for an ISMS are described, equivalent to levels of maturity, which allows organizations to scale up levels depending on their needs. There are three categories of management: strategic, tactical and operational, for which 45 processes are defined that must be considered.

In ISM3 the processes related to computer security are described in detail, establishing objectives and metrics that allow establishing a quality system. The practical and measurement approach, as well as the orientation towards the business objectives of the organization, is what differentiates this model from the rest of the related standards.

## II. MATERIALS AND METHODS

In this research, an integrative analysis is carried out, considering all computer security controls proposed by

the main international guidelines and standards (ISO / IEC 27002 and NIST SP 800-53), implemented in the Peninsular State University of Santa Elena in Ecuador. For the management of information security and the risks associated with its use in computer networks, the model shown in Figure 1 is proposed.

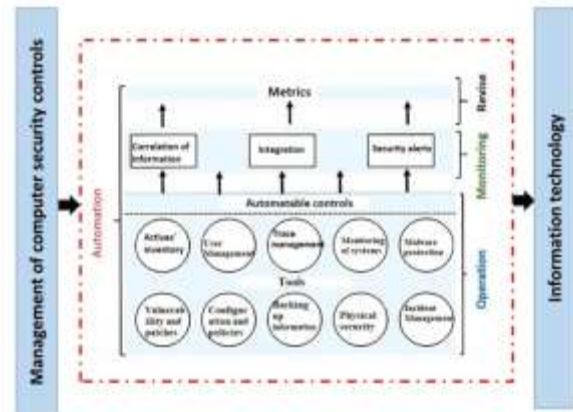


Fig. 1: Model for the management of information security and the risks associated with its use in computer networks. Source: self-made.

The model is based on the following principles:

1. Maximum automation: all automatable computer security controls must be considered.
2. Integration: the management of computer security controls must be done from a centralized system that allows the monitoring and review of them.
3. Synthesis: an adequate process of grouping and synthesis of the automatable controls must be carried out to manage a relatively small number of controls.
4. Objective measurement: the effectiveness of the controls must be evaluated and measured by means of objective indicators obtained automatically from the data provided by the different IT security tools.
5. Continuous improvement: the management of controls must be seen as a dynamic process consisting of several actions, which form a closed cycle for the continuous improvement of computer security controls.
6. Generality: the model must be applicable to a wide variety of organizations.

Based on the description of the principles of the model, which is proposed for the management of information security and the risks associated with its use in the computer networks of the Peninsula State University of Santa Elena, Ecuador, the automation for the automatable controls identified, defining the main computer security controls that must be automated for the protection of information security and the risks associated with their use through the computer networks of the Península de Santa Elena State University, Ecuador. Automated computer security controls represent a grouping and synthesis of the automatable controls identified in the ISO / IEC 27002 and NIST SP 800-53

standards. Automation is applied to the actions of operation, monitoring and review of computer security automation controls for the protection of information security and the risks associated with their use through the computer networks of Santa Peninsula State University Elena, Ecuador.

The central component of the model allows the integration of different IT security tools, the correlation of information and the generation of security reports in an automated way. Computer security controls are implemented and operated by different tools, but their monitoring is done centrally in the central component of the model.

The central component of the model receives the information through the traces generated by the different systems, for which it is necessary to define connectors that allow interpreting the different formats of existing traces. The review of the controls is done through a group of computer security metrics, also defined as part of the model, which are calculated and reported in an automated way.

The model developed for the management of information security and the risks associated with its use in computer networks of the Peninsula de Santa Elena State University, offers a comprehensive vision of the automation of computer security controls, considering all the automatable controls and defining the actions to be carried out automatically in each of the cases. The model also proposes an automation of the actions of operation, monitoring and review of computer security automation controls for the protection of information security and the risks associated with its use through computer networks, which is intended for Trace management and security event detection. This presupposes that a deep process of personalization and adaptation of the operation, monitoring and revision actions must be carried out to apply the proposed model, through the definition of connectors, policies, correlation rules and computer security reports.

It is important to note that through the application of the model the operation, monitoring and review of a group of computer security controls is automated, which represents an important part of the process of managing computer security in its entirety. However, it should not be interpreted that the model solves all problems in an automated way. For an adequate management of information security, it is necessary to implement the rest of the controls proposed by the existing standards and regulations, which are not contemplated in this model. In addition, the model addresses the automation of the do and verify phases, so it is necessary to complete the management cycle even for automated controls. The automatically calculated indicators should be adequately reviewed by computer security specialists to take

corrective actions on the security controls implemented.

### III. RESULTS

Through a survey applied to managers and specialists of the Santa Elena Peninsula State University, which aimed to evaluate the factors that contribute to increase the effectiveness of the controls and to reduce the complexity of the computer security management, the positive effect of automation and integrated management of controls, while recognizing the importance of other factors that are also key in the management of information security in computer networks. With respect to the use of some system of indicators to evaluate the effectiveness of computer security controls, 75% of the respondents answered affirmatively their use.

It is also noted that the application of the model achieves maximum automation in the operation of the controls, and also automates the processes of monitoring and review thereof, which translates into greater effectiveness of computer security controls on the management of information security and the risks associated with its use in computer networks.

### IV. CONCLUSION

After having assessed the controls proposed by the main international standards, it can be concluded that around 40% of computer security controls are automatable. For the automated and integrated management of computer security controls, we propose the model for the management of information security and the risks associated with its use in computer networks at the Peninsula de Santa Elena State University, a model that has the following general characteristics:

- Computer security controls are defined which represent a grouping and synthesis of the automatable controls identified.
- Automation is applied to the actions of operation, monitoring and review of controls.
- The correlation of information and the generation of security reports in an automated way is the central component of the model, allowing the integrated management of computer security controls.
- The controls are reviewed through a group of computer security metrics, also defined as part of the model, which are calculated and reported automatically.

The model developed offers a comprehensive vision of the automation of computer security controls, considering all the automatable controls and defining the actions to be carried out automatically in each case.

The implementation of the model is carried out through the installation, configuration and personalization of existing IT security applications, as well as the complementation of them through small developments

that enable their adaptation to the proposed model.

#### REFERENCES

- [1] Aceituno, V. (2007). ISM3: Information security management maturity model v2.0. ISM3 Consortium.
- [2] Achiary, C. (2005). Modelo de Política de Seguridad de la Información para Organismos de la Administración Pública Nacional. E. Oficina Nacional de Tecnologías de Información (ONTI). SGP N° 45/2005, pp: 7-16. Disponible en: [http://www.arcert.gov.ar/politica/PSI\\_Modelo-v1\\_200507.pDF](http://www.arcert.gov.ar/politica/PSI_Modelo-v1_200507.pDF), [Consultado 15/05/2011]. 2005.
- [3] Agoulmine, N. (2010). Autonomic network management principles: from concepts to applications. London: Academic, 2010.
- [4] Alberts, C., Dorofee, A., Stevens, J. y Woody, C. (2003). Introduction to the OCTAVE® Approach. Carnegie Mellon University.
- [5] BSI (2005). IT Baseline Protection Catalog. German Federal Office for Security in Information Technology (BSI).
- [6] Cano, J. (2005). Un concepto extendido de la mente segura: pensamiento sistémico en seguridad informática, Criptored.
- [7] Chew, E., Swanson, M., Stine, K., Bartol, N., Brown, A. y Robinson, W. (2008). NIST SP 800-55: Performance measurement guide for information security.” National Institute of Standards and Technology, 2008.
- [8] DSD (2012). Australian Government Information Security Manual (ISM). Department of Defense. Australian Government, Sep-2012.
- [9] Eloff, M. M. (2000). A Multi- Dimensional Model for Information Security Management, PhD Thesis.
- [10] ISO/IEC (2008). ISO/IEC 27005: Information technology - Security techniques - Information security risk management. International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC).
- [11] ISO/IEC. (2005). ISO/IEC 27001: Information technology - Security techniques - Information security management systems - Requirements. International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC).
- [12] Martin, R. A. (2009). Making security measurable and manageable. In Military Communications Conference, 2008. MILCOM 2008. IEEE, 2009, pp. 1-9.
- [13] Masera, M. y Fovino, I.N. (2010). Security metrics for cyber security assessment and testing. Joint Research Centre of the European Commission, Aug-2010.
- [14] MINHAP (2012). MAGERIT – versión 3.0. Metodología de Análisis y Gestión de Riesgos de los Sistemas de Información. Ministerio de Hacienda y Administraciones Públicas, Gobierno de España, Oct-2012.
- [15] Montesino, R. (2009). Gestión de la seguridad informática: de la teoría a la práctica. IX Seminario Iberoamericano de Seguridad en las Tecnologías de la Información, La Habana, Cuba.
- [16] NIST (2012). NIST SP 800-30 rev1: Guide for Conducting Risk Assessments. National Institute of Standards and Technology, Sep-2012.
- [17] Nof, S. Y. (2009). Springer Handbook of Automation. Springer
- [18] OGC (2007). Information Technology Infrastructure Library (ITIL v3). Office of Government Commerce UK (OGC).
- [19] Schmidt, D. (2010). Security automation: a new approach to managing and protecting critical information. IA newsletter, vol. 13, no. 1, 2010.
- [20] Solms, von B. (2006). Information Security – The Fourth Wave,” Computers & Security, vol. 25, no. 3, pp. 165-168, May. 2006.
- [21] Tashi, I. y Ghernouti-Hélie, S. (2009). A Security Management Assurance Model to holistically assess the Information Security posture. Presented at the International Conference on Availability, Reliability and Security (ARES).

# Comparison of the signal characteristics measured by a MEMS and a Piezoelectric accelerometers

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**Abstract**—This study is dedicated to verifying the performance of a MEMS accelerometer when used for machine condition monitoring based on vibration analysis. The performance of the MEMS accelerometer was compared to that of a piezoelectric sensor, traditionally used in this type of analysis. This goal was reached by measuring the RMS, Kurtosis and Crest levels of the signal obtained by the MEMS sensor against those obtained by the piezoelectric sensor under the same excitation parameters. Both the piezoelectric sensor and the MEMS circuit board were mounted on a special device attached to a shaker. The sensors were submitted to vibrations of 0.5g, 1g and 2g RMS on a frequency ranging from 1Hz up to 2500Hz on steps of 20Hz. The results show that the readings of the MEMS sensor present a maximum deviation of 6.6% when compared to the piezoelectric sensor. It was possible to conclude that a great portion of the deviation encountered was due to the dynamic characteristics of the mounting device and the fixation conditions of the MEMS sensor on this device

**Keywords**—Accelerometer, MEMS, Vibration,

## I. INTRODUCTION

In today's economy, being competitive is the key to success. Industries that have an advantage are the ones that manage to produce more with fewer resources. As factories, face the challenge of getting smarter and more efficient, the need for process monitoring tools increase. One of the obstacles to efficiency is machine downtime. A great way to reduce this issue is the use of machine vibration monitoring systems. Up until very recently, the only suitable sensor to acquire condition monitoring grade vibration was the piezoelectric accelerometers. These sensors are great for the task, as they have a great frequency response and low noise. The drawback is that, these sensors are costly and require a reasonable amount of power to operate, which limit is the use of such sensors on battery-operated systems.

Starting of the past decade, the advancement of nanotechnologies enabled a new type of sensor that would tackle both problems at the same time, the cost and energy consumption. The MEMS accelerometer appeared as a promise of a low-cost, low power consumption, high manufacturing volume sensor, which could potentially be used for large-scale machine vibration monitoring. The question that needs to be answered is if these sensors deliver the required performance in terms of dynamic range and frequency response, two factors that are key to vibration anomalies detection, especially when dealing with bearings. Other researchers on this matter, have already done some work. Back in 2008, the first papers on this subject were published [1]. Albabar&Mekid compared the performance of three different MEMS sensors with piezoelectric and got good results, though some of the chosen models presented a higher level of noise than expected. In [2], the author concluded that the tested low-cost MEMS accelerometer presented compatible diagnose performance that of a high-end model.

This paper proposes a deeper look into the performance of the ADXL203 MEMS accelerometer and evaluate whether its amplitude and frequency responses are adequate for machine condition monitoring. To achieve this goal, three ADXL203 subjects are compared against a piezoelectric accelerometer. A software written in LabView controlled a shaker that swept the frequency span of this accelerometer while recording the results for further analysis.

## II. MATERIALS AND METHODS

### 2.1 Sensor encapsulation

The tested MEMS sensor comes in a LCC encapsulation, thus, requires to be mounted on a PCB. As exposed PCBs are rather fragile to be mounted on a machine, a special stainless steel encapsulation was used to contain

the circuitry and the connectors. Fig. 1 shows the internal structure of the steel body.

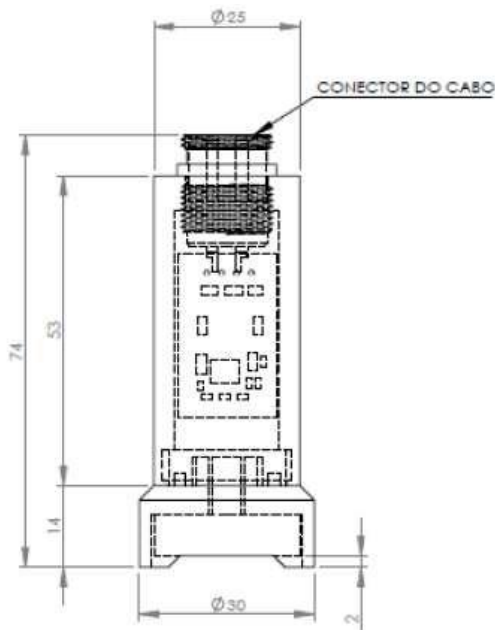


Fig. 1: Sensor encapsulation



Fig. 2: Sensor mounted on shaker

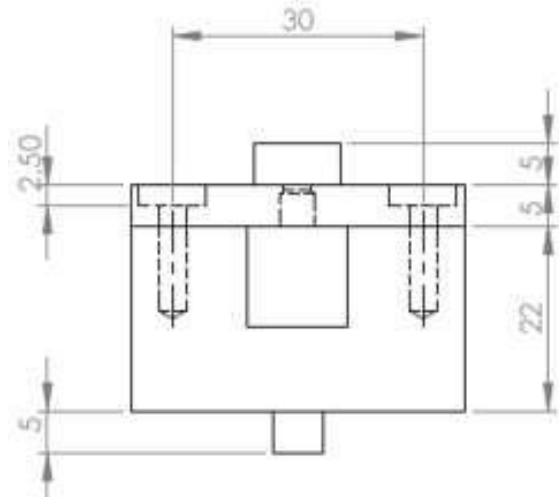


Fig. 3: Mounting device

To compare the response of the piezoelectric and the MEMS sensors, it is vital to excite them with the same source of vibration, in a controlled environment. It is desirable to capture its signals simultaneously, as it provides means for comparing the phase of the signals. In order to achieve these two requirements, a special mount was built (Fig. 3) and both sensors were connected to a data acquisition card that ensures simultaneous sampling between all the channels. The purpose of the mount is to provide a rigid base to hold the piezoelectric and the MEMS sensor and connect them to the shaker. Fig. 2 shows the piezoelectric sensor and the MEMS sensor attached to the mount on the shaker. The piezoelectric reference sensor is mounted under the base while the subject MEMS accelerometer was mounted on top.

### 2.2 Control Software

A LabView software was written to provide control and data acquisition capabilities to the test stand. A NI9264 signal-generating card was used to control a BKSV 4808 shaker with a BKSV 2719 amplifier. A NI9234 24-bit ADC card was used to read the piezoelectric and the MEMS accelerometer using the same time base, which enables phase comparing.

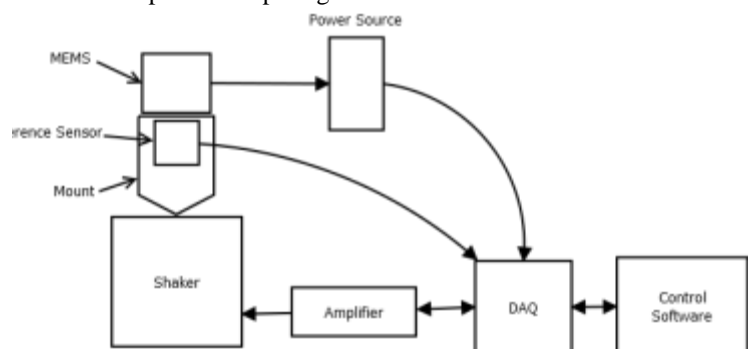


Fig. 4: Test stand schematics



The software implements a PID control and uses the signal provided by the piezoelectric accelerometer as the feedback signal. The signal-generating card is controlled by the software to provide the input signal for the shaker's amplifier, according to the response of the PID algorithm. The goal is to control the amplitude and frequency of the shaker so it can meet all the set points defined for the test. The test stand schematics is shown in Fig. 4

The controlled variable in the PID loop was the RMS level of the vibration. The piezoelectric sensor provided the reference signal. There was no need to control the frequency in a closed loop, once there was no relevant variance between the frequency being commanded to the shaker by the software and the measured frequency in the observed conditions. For the test, the used values for each one of the coefficients were  $P = 0.2$ ,  $I = 0.01$  and  $D = 0,005$ . This method is rather similar to that used in [1], though the authors did not mention explicitly whether they used a PID loop to control the excitation. Fig. 5 shows the control loop used.

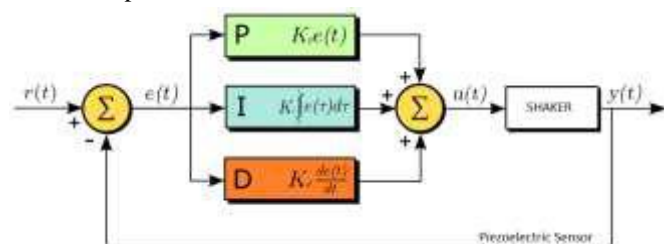


Fig. 5: Control loop

### 2.3. Test conditions

Three parameters were chosen to analyze the obtained data; the RMS value, Crest and Kurtosis form indexes. The RMS or Root Mean Square, indicates the vibration energy in the signal. It is defined according to (1).

$$y_{rms} = \sqrt{\frac{1}{N} \sum_{n=0}^{N-1} x_n^2} \quad (1)$$

The Crest index is used to measure the amplitude of the highest peak in the signal in relation to the RMS value of the signal. If the Crest value is high, it means that the signal presents pronounced peaks, which indicates that the signal is not smooth. It is defined by (2).

$$C = \frac{P_t}{RMS} \quad (2)$$

The Kurtosis index translates in a numeric value, the "spikiness" of a signal. It represents a measure of the flattening of the density probability function near the average value [3] [4]. In other words, if the value of this

index is higher than three, the signal is "spiky" and if it is lower than three, it means that the signal is flatter.

$$R_{ku} = \frac{1}{NR^4} \sum_{i=1}^N Y_i^4 \quad (1)$$

The form factors were chosen in order to identify any form distortions in the signal produced by the MEMS sensor in relation to the piezoelectric sensor, throughout the given frequency range. In the same way, the RMS value comparison was chosen in order to check both signals for

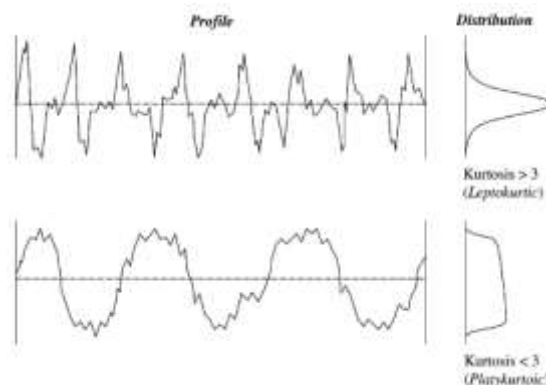


Fig. 6: Kurtosis characteristics

any difference in energy level through the frequency range. The intention was to verify if the MEMS sensor behaves in a similar way to the piezoelectric in different operation conditions.

## III. RESULTS AND DISCUSSION

### 3.1. Obtained data

To investigate the behavior of the sensors in different conditions of excitation, three prototypes were prepared. The frequency was increased in steps of 5Hz. Table 1 shows the test conditions

Table.1: Test conditions

Test Number	Prototype	Excitation amplitude (g RMS))	Excitation frequency (Hz)
1	660075	0,5gRMS	1 a 2500
2	660075	1,0g RMS	1 a 2500
3	660075	2,0gRMS	1 a 2500
4	660078	0,5gRMS	1 a 2500
5	660078	1,0g RMS	1 a 2500
6	660078	2,0gRMS	1 a 2500
7	660080	0,5gRMS	1 a 2500
8	660080	1,0g RMS	1 a 2500
9	660080	2,0gRMS	1 a 2500

In the graphs below, the RMS level is maintained steady in the setpoints described in Table 1, by the PID algorithm. Fig. 7 presents the RMS levels measured by the reference transducer. It shows the three levels of excitation imposed on the MEMS sensors on each of the three passes.

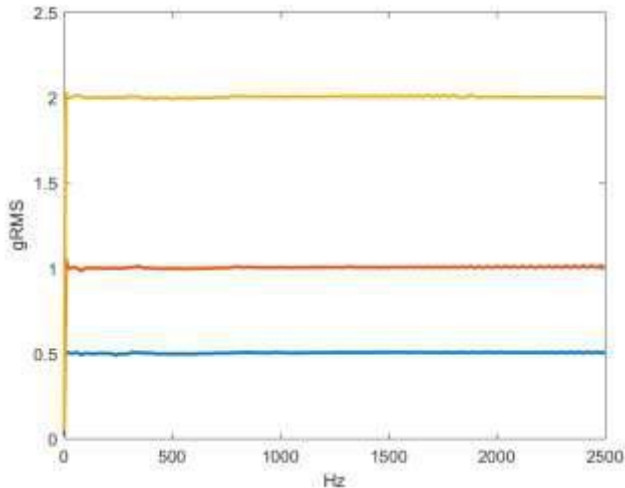


Fig. 7: Piezoelectric RMS level

Fig. 8 shows the obtained results for the RMS value of the three tested sensors. Fig. 9 and Fig. 10 shows the obtained results for Crest and Kurtosis values measured along the frequency range. Each graph contains the three tested prototypes on the three different amplitude setpoints.

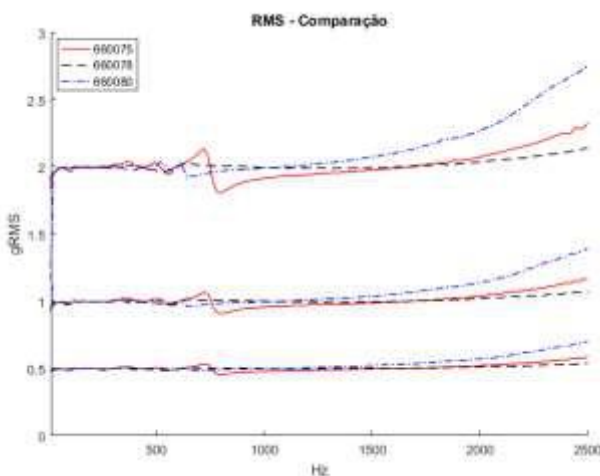


Fig. 8: MEMS RMS level

### 3.2. Data analysis

As seen on Fig. 7, the excitation levels were steady through the test. It means that the PID loop was effective on maintaining the reference signal constant, laying firm ground for the conclusions to be taken from the test. Fig. 8 shows that the three prototypes presented a constant measured level in almost the entire frequency span for all three excitation levels tested, except for the regions around 700 Hz and above 2000 Hz.

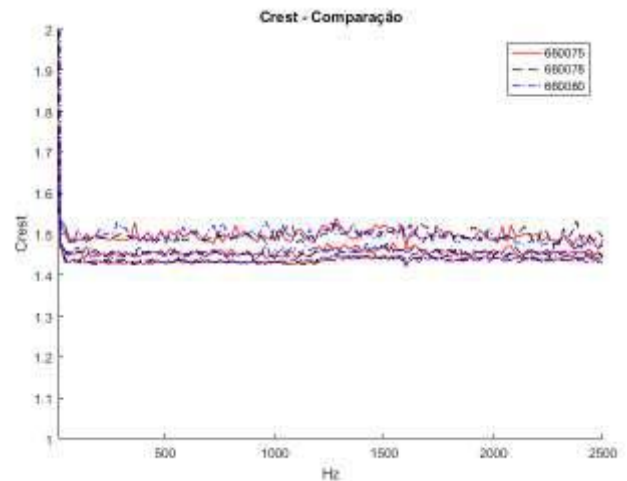


Fig. 9: Crest levels

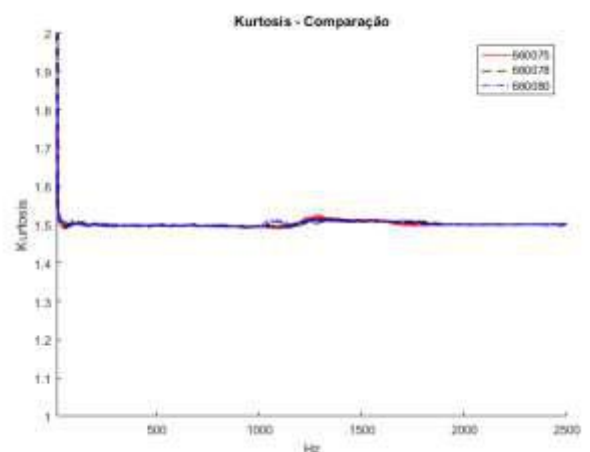


Fig. 10: Kurtosis levels

After finding these discontinuities in the measured signals during the post-processing procedure, the focus was on the mounting device used to secure both sensors on the shaker. Further observations suggested that the first ditch could be caused by the natural frequency of the device. The differences in the level of the signal could be explained by a not so firm mounting of the MEMS sensor on the mounting devices. As it can be seen on Fig. 2, a latter analysis proved that the MEMS sensor was not scrolled all the way, which could have caused the deviation observed, especially on frequencies above 2000 Hz. Each of the three sensors showed a different deviation level, what suggests that they were fixed using different torque levels on the mounting scroll. An analysis on the mounting device revealed that the thread that held the MEMS sensor had an imperfection, which kept the sensor from being scrolled all the way down.

The Crest graph on Fig. 9, shows that the three tested subjects have a very similar response in all the three test conditions along the entire frequency range. There is a

total nine curves in this graph, with each different color representing a different test subject. The Crest value measured for the 0,5gRMS excitation is around 1.42. For the 1gRMS and 2gRMS this value is around 1.46 and 1.5 respectively. As the acceleration level increases, the peak level measured in relation to the RMS value if the signal also increases. However, it is not possible to conclude, by this data alone, that this rise in the peak level is due to a deviation in the measurement by the MEMS sensor or caused by the shaker itself.

Fig. 10 shows the Kurtosis response for all the three test subjects in the three levels of excitation are very similar. The shape of the measured waveform is uniform along the tested amplitude and frequency range. There is a little distortion in the kurtosis level in the frequency around 1200Hz in all the tested subjects and all the conditions. This means that, in this frequency, the measured signal got a little more "spiky". Again, it is not possible to determine, by this data alone, what might have caused this change. This is a matter for further investigation.

#### IV. CONCLUSION

This work showed that the MEMS sensor has traceable and consistent signal characteristics. The RMS levels, Crest and Kurtosis values of the sensors are consistent with what can be obtained by a piezoelectric sensor. The differences found in the measured signal among the three tested sensors, especially in the highest frequencies, showed the importance of ensuring the correct fixing conditions of the sensor on the device in which the vibration is measured. The shape and level of the acceleration signal obtained by the MEMS sensor is uniform along its frequency and amplitude span. Further studies, such as a modal analysis in the mounting device, have to be conducted in order to investigate the cause of the discontinuity in the RMS level graph in the frequency around 700Hz. The same affirmative is valid for the slight increase in the kurtosis index measured around the 1200Hz frequency.

#### REFERENCES

- [1] Albarbar, A., Mekid, S., Starr, A., & Pietruszkiewicz, R. (2008). Suitability of MEMS Accelerometers for Condition Monitoring: An experimental study.
- [2] Almeida, R. G., Vicente, S. A., & Padovese, L. R. (2002). New technique for evaluation of global vibration levels in rolling bearings. *Shock and Vibration*.
- [3] Lotfi, S., Jaouher, B. A., Mohamed, B., & Bechhoefer, E. (2016). The use of SESK as a trend parameter for localized bearing fault. *ISA Transactions*,
- [4] Miranda, V. R. (2018). O uso de acelerômetros MEMS no monitoramento de vibrações em máquinas

rotativas. Pontifícia Universidade Católica de Minas Gerais.

- [5] Miljkovic, D. (2015). Brief Review of Vibration Based Machine. *Hrvatskaelektroprivreda, Zagrebe*.
- [6] Siliang Lu, P. Z. (2018). Condition monitoring and fault diagnosis of motor bearings using undersampled vibration signals from a wireless sensor network. *Journal of Sound and Vibration*.
- [7] Khadersab, D. S. (2018). *Vibration Analysis Techniques for Rotating Machinery and its effect on Bearing Faults*. Elsevier.

# The Progress of Indonesia's Administrative Boundaries Mapping after 72 years of Independence

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**Abstract**—Administrative boundaries are belong to the fundamental dataset of national base map. These information have an affect to the management of home affairs such as natural resources, tax, land administration, natural disasters. Indonesia proclaimed its independence in 1945. It means, Indonesia is 72 years old in 2017. Now, One Map Policy becomes one of hot issues in Indonesia especially for geospatial society. Every region needs definitive administrative boundaries for their activity but not available yet for all region. This paper aim is to explain the development or trend of Indonesia's administrative boundaries mapping after 1945 in order to get the information of Indonesian government performance in the "national boundary making". The method of this research is comparing the spatial and numerical data of Indonesia's administrative boundaries which are limited to the province and regency/city boundaries. The result of this research shows that there are 3 significant periods which are affect Indonesia's administrative boundary mapping i.e. 1998-2005, 2006-2012, and 2013 to this day. The conclusion of this study is the definitive boundaries of The Republic of Indonesia in 72 years after independence reached 472 segments or 48.31% of total 977 segments.

**Keywords**—administrative boundaries, segment, trend.

## I. INTRODUCTION

Administrative boundaries are belong to the fundamental geospatial datasets to support development agenda for each countries in the world e.g. Ukraine, US, Colombia, Mexico, Nigeria, Western Australia, South Africa, Bostwana, etc [1]. United Nation (UN) through UN-GGIM (Global Geospatial Information Management) leads the standardization process of fundamental geospatial datasets among countries in order to can support Sustainable Development Goals (SDGs)[2]. Administrative boundaries are important and have an affect to the management of home affairs such as natural resources, tax, land administration, natural disasters[3].Indonesia's independence has been proclaimed by Soekarno with Hatta standing by his side on 17 August 1945 [5]. Proclamation is the historical milestone of Indonesia's independence. A day after proclamation, the committee of Indonesia's independence declared the 1945 Constitution of the Republic of Indonesia [6].

The Republic of Indonesia is one of archipelagic country in the world[4].The territory of Indonesia was divided into provinces, regencies and city. Both regencies and city were technically the same level of government. In 2017, the Republic of Indonesia is 72 years after independence and it has 34province which are widely distributed from 6°N – 11°S to 95°E – 141°E. The province number rose significantly from 8 in 1945[7] to 34 in 2018[8] (see Table 1 for the details).

Table.1: The province number in 1945 – 2017 [9]

Year	Number of Province	Remark
1945	8	Sumatera, Jawa Barat, Jawa Tengah, Jawa Timur, Nusa Tenggara (Sunda Kecil), Maluku, Sulawesi, and Kalimantan
1950	11	- Sumatera was divided into: Sumatera Utara, Sumatera Tengah, and Sumatera Selatan - Jawa Tengah was divided into: Jawa Tengah and Daerah Istimewa Yogyakarta

Year	Number of Province	Remark
1956	15	- Sumatera Utara was divided into: Sumatera Utara and Daerah Isimewa Aceh - Jawa Barat was divided into: Jawa Barat and Daerah Khusus Ibukota Jakarta - Kalimantan was divided into: Kalimantan Barat, Kalimantan Timur, and Kalimantan Selatan
1957	17	- Sumatera Tengah was divided into: Sumatera Barat, Riau, and Jambi - Kalimantan Selatan was divided into: Kalimantan Selatan and Kalimantan Tengah
1958	20	- Nusa Tenggara was divided into: Bali, Nusa Tenggara Barat, and Nusa Tenggara Timur - Riau was divided into: Riau and Jambi
1959	21	- Sumatera Selatan was divided into: Sumatera Selatan and Lampung
1960	22	- Sulawesi was divided into: Sulawesi Utara& Tengah and Sulawesi Selatan& Tenggara
1964	24	- Sulawesi Utara & Tengah was divided into: Sulawesi Utara and Sulawesi Tengah - Sulawesi Selatan & Tenggara was divided into: Sulawesi Selatan and Sulawesi Tenggara
1967	25	- Sumatera Selatan was divided into: Sumatera Selatan and Bengkulu
1969	26	- Irian Jaya was formally incorporated into Indonesia
1976	27	- Nusa Tenggara Timur was divided into: Nusa Tenggara Timur and Timor-timor
1999	26	- Referendum made Timor-timor as a new country called Timor Leste - Maluku was divided into: Maluku and Maluku Utara
2000	32	- Irian Jaya was divided into: Irian Jaya Timur, Irian Jaya Tengah, and Irian Jaya Barat - Sumatera Selatan was divided into: Sumatera Selatan and Bangka Belitung - Jawa Barat was divided into: Jawa Barat and Banten - Sulawesi Utara was divided into: Sulawesi Utara and Gorontalo
2001	31	- Irian Jaya Timur and Irian Jaya Tengah have been merged into Papua
2002	32	- Riau was divided into: Riau and Kepulauan Riau
2004	33	- Sulawesi Selatan was divided into: Sulawesi Selatan and Sulawesi Barat
2012	34	- Kalimantan Timur was divided into: Kalimantan Timur and Kalimantan Utara
2018	34	There is no change in number of province

The province number rose in 1945 – 1998 period was caused by the geographic reason such as too large area of each existed province. Different reason caused the growth of the number of province in 1999 – 2018. The regional autonomy/decentralization age was one of the reason why much more province were established in recent years. Each region (province and city/regency) has authorities to manage their own region i.e. government affairs, public interest, natural resources, etc. Some of new region establishment were bottom-up process through community aspirations [10].

Different maps covering the same thing i.e. Indonesia's forest cover became one of the reason why "One Map" has been mandated as a national target on mapping sector by president of the Republic of Indonesia in 2010[11]. Then, it was followed by Presidential Instruction No 10 year 2011 and Geospatial Information Agency establishment by the Law of Geospatial Information No 11 year 2011[12]. Then, 5 years after the ratification of the Law of Geospatial Information, the Presidential Regulation No 9 year 2016 has been legalized as the implementation of One Map Policy although only cover 1:50,000 of scale. The target of "One Map Policy" based on Presidential Regulation No 9 year

2016 must be finished at 2019. It shows the positive action in reducing the spatial conflict problems [11]. The target of that policy was to reintegrate all map themes in Indonesia into one map (single reference, single standard, single database, and single geoportal). Boundary dataset was the one of these themes. The One Map Policy is a catalyst for speeding up administrative boundaries. Regional boundary disputes are generally caused by the quality of the map which is an attachment to the new regional expansion law (such as the attachment of the New Region Establishment Law)[13].

Definition of boundaries as imaginary lines that represent natural and man-made features based on aspects of culture such as language, religion or etymology, known as anthropomorphic[14]. Boundary making in the implementation of regional boundary mapping has been implemented in the international boundary mapping. There were three significant contributors on the development of international boundary making theory i.e. Lapradelle (1928), Jones (1945), and Nichols (1983)[15]. Based on the analysis result of Donaldson, the boundary making theory of Stephen B. Jones (1945) is the most comprehensive and still relevant for 21 century [16][13]. The Jones's boundary making has four main

stages namely: 1) allocation; 2) delimitation; 3) the demarcation of boundaries in the field; and 4) boundary administration. Sumaryo used that theory as the base theory for his dissertation. His dissertation focused on regional context (province and regency/city in Indonesia) of boundary making and boundary dispute [15].

Sumaryo argued that the regulation of regional boundary making must refer to the present theory i.e. Jones's theory. That regulation is related to "the Law of Local Government". Before independence, Indonesia has three dominant regulation about home affairs i.e. *Decentralisatiewet* 1930, *Wet op de Bestuurshervorming* (Stb 1922/216) and *Osamuseirei* No. 27 year 1942. Then, after independence, Indonesia has eight regulation about "Local Government" namely: 1) Law No 1 year 1945; 2) Law No 22 year 1948; 3) Law No 1 year 1957; 4) Law No 18 year 1965; 5) Law No 5 year 1974; 6) Law No 22 year 1999; 7) Law No 32 year 2004; and 8) Law No 23 year 2014 [17]. The regulation for regional boundary making in Indonesia has been three times changed/revised i.e. Ministerial Regulation of Home Affairs No 1 year 2006, Ministerial Regulation of Home Affairs No 76 year 2012, and recent valid regulation called Ministerial Regulation of Home Affairs No 141 year 2017 on

Guidelines for Affirmation of Regional Boundaries. There were 4 general steps of Indonesia's regional boundary making namely: 1) document preparation; 2) boundary tracking; 3) the demarcation of boundaries in the field; and 4) boundary map creation.

Each province and regency/city has different characteristic of boundary making process. Some case need more than 20 years but the other case just need 2-5 years of boundary making process. It depends on the factors that caused the boundary dispute such as interest (natural resource, finance), structural (unequal power/authority), data (different interpretation), values (belief systems), and relationships (negative experience in the past) [13].

This paper aim is to explain the development or trend of Indonesia's administrative boundaries mapping after 1945 in order to get the information of Indonesian government performance in the "national boundary making".

## II. MATERIAL AND METHODS

The study was conducted in The Republic of Indonesia, located in between from 6°N – 11°S to 95°E – 141°E. Location of the study is shown in Figure 1.

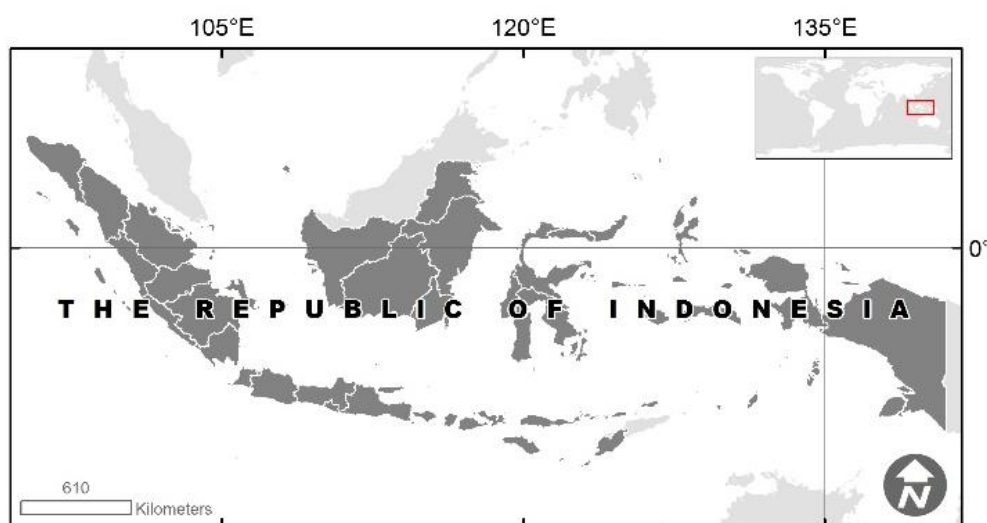


Fig.1: Research location map

This research used various data such as updated Indonesia's regional boundary datasets, Indonesia's regional segments database, and legal documents. This research used the latest spatial boundary datasets which were updated on December 2017 due to the limitation of updated data. Using vary data sources such as Geospatial Information Agency, Ministry of Home Affairs, and Ministry of Law and Human Right. These data were analyzed by using statistic methods i.e. time-series analysis. Literally, time-series term is "a series of a

quantity obtained at successive times, often with equal intervals between them" based on oxford dict. Time-series is time-ordered sequence of observations. The examples of such data which is categorized as time-series data are quarterly crime rates, annual birth rates, monthly unemployment figures, etc. Time-series may be quantified discretely or continuously [18]. Statistical method for analyzing time series is called time-series analysis [19]. That method is usually used to investigate the phenomena which dealing with time-ordered data.

Matalas argued that time-series analysis may also be used to investigate the phenomena that vary in space especially in hydrologic study [20].

This research used three general steps. Figure 2 shows the research stages. Firstly, spatial and non-spatial boundary datasets were extracted as numerical data. Secondly, these

data were clustered by use the periods based on the regulation of boundary affirmation i.e. 1945 – 2005, 2006 – 2012, and 2013 – 2017. Thirdly, all data were analyzed using time-series analysis method (ARIMA model) through SPSS software (trial version).

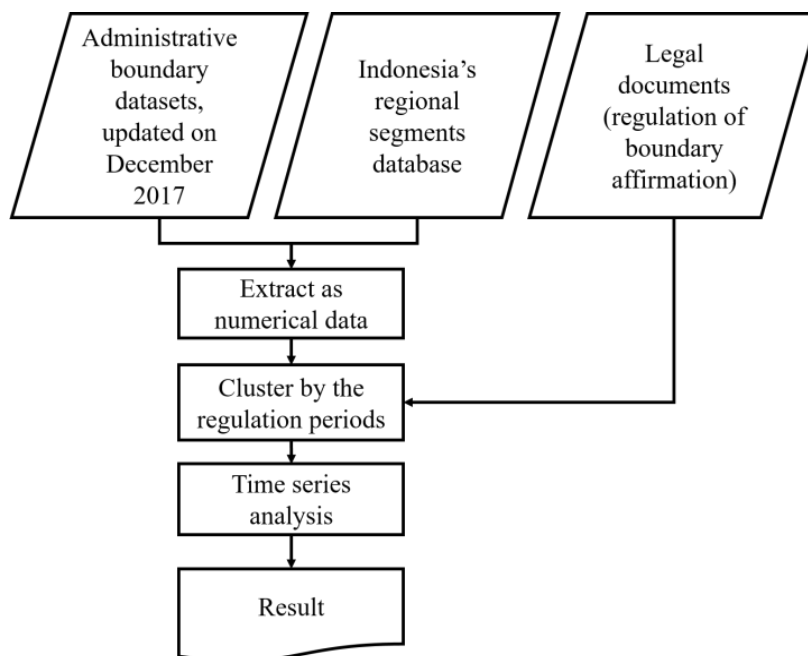


Fig.2: Research stages

### III. RESULT AND DISCUSSION

#### Administrative Boundaries Affirmation in 1945 – 2005

In the period 1945 - 2005, there were several regulations relating to regional government. At that time, there were no specific guidelines regarding the confirmation of regional boundaries. In 1945-2003 there was absolutely no affirmation of regional boundaries for both regency / city and provincial segments. Basically, regional boundaries are an important component of the development law for the regions and several laws state that definite boundaries are made by the Minister in this case the Minister of Home Affairs. Then, the numbers differed in 2004 and 2005. There were affirmations of 5 regional boundary segments in 2004 and 12 regional boundary segments in 2005. In 2004, two Ministerial Decrees were made by the Minister of Home Affairs on regency boundaries: namely: 1) Minister of Home Affairs Decree No 163 of 2004 on Determination of the Boundary of the Mimika and Paniai Regency and Puncak Jaya Regency on Mount Grasberg and its surroundings (consist of 2 segments); and Minister of Home Affairs Decree No. 246 of 2004 on the Boundary of the Cirebon Regency Region of West Java Province (consist of 3 segments). Therefore a total of 5 segments were obtained in 2004. The number of segments

can be seen in Table 2 and spatially are presented in Figure 3.

In 2003, precisely on December 22, Minister of Home Affairs Decree No 130 of 2003 on the Organization and Work Procedure of the Ministry of Home Affairs was officially issued with one of the objectives to support the implementation of orderly government administration. The Ministry of Home Affairs is a government implementing element in the field of domestic governance including one of them is related to the formulation and implementation of technical policies in the field of general government. The author identifies that with the existence of the Minister of Home Affairs Regulation, implications for confirming boundaries in several regions. This is evidenced by several considerations of the issuance of the Minister of Home Affairs Decree concerning the boundaries of an area that is related to orderly administration and the resolution of problems of natural resources. Both Minister of Home Affairs Decree No 163 of 2004 and Minister of Home Affairs Decree No 246 of 2004 used several legal bases, such as Minister of Home Affairs Decree No 130 of 2003 concerning the Organization and Work Procedure of the Ministry of Home Affairs.

Table.2: Definitive boundaries in 1945-2005

Year	Definitive boundaries per year (segments)	Aggregate of the definitive boundaries (segments)
1945 - 2003	0	0
2004	5	5
2005	12	17

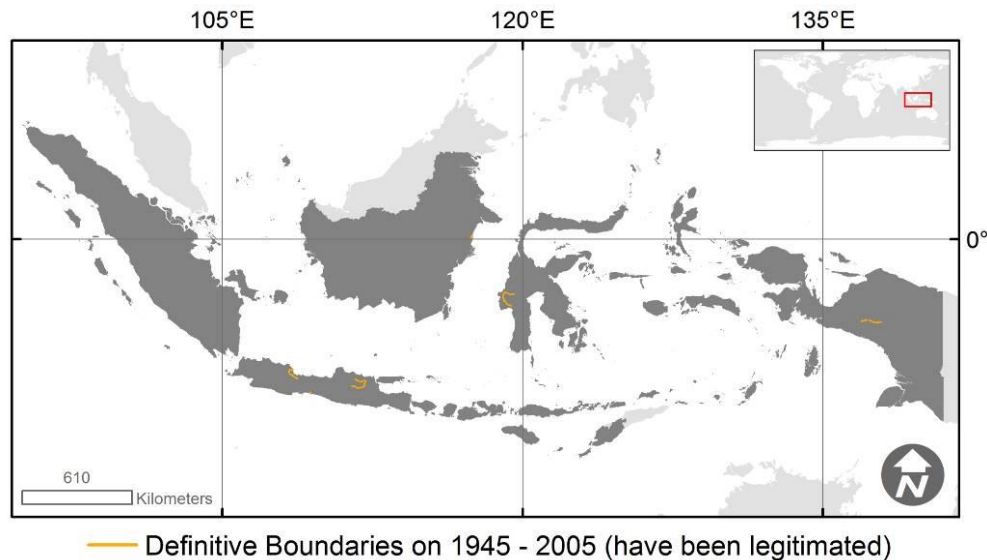


Fig.3: Definitive boundaries in 1945 – 2005

#### Administrative Boundaries Affirmation in 2006 – 2012

In contrast to the previous period, in the period of 2006-2012 there was only one regulation concerning regional governance, namely Law No. 32 of 2004. Article 152 of Law No. 32 of 2004 explained that in regional development planning it was based on accurate and reliable data and information. One of the data and information is basic territorial information including regional boundaries. Then, in 2006, on January 12, the Minister of Home Affairs Regulation No. 1 of 2006 was issued on Guidelines for Affirmation of Regional Boundaries. The Minister of Home Affairs emphasizes efforts to realize clear and definite regional boundaries both from juridical and physical aspects in the field. The affirmation of regional boundaries refers to regional boundaries that have been stipulated in the law on regional establishment. Stages of affirmation of land regional boundaries, namely: 1) document review; 2) border tracking; 3) installation of boundary pillars; 4) measurement and positioning of boundary pillars; and 5) making boundary maps. The affirmation of regional boundaries in accordance with Minister of Home Affairs Regulation No. 1 of 2006 is carried out by Regional Boundary Affirmation Teams consisting of successive central, provincial and regency / city which were

determined respectively by the Minister of Home Affairs, Governors and Regents / Mayors. Decisions on regional boundaries affirmation are determined by the Minister of Home Affairs based on the results of verification of the central Regional Boundary Affirmation Team and includes maps of regional boundaries. In addition, in 2007 a Government Regulation No. 78 of 2007 was issued on the Procedures for Establishment, Elimination and Merger of Regions. The Government Regulation also stipulates that the regency / city and province boundaries must be resolved / affirmed no later than 5 (five) years after the establishment of the relevant provinces and regencies / cities. That affirmation of boundaries was carried out in the field and should determined / legalized by the Minister of Home Affairs. If it is not fulfilled according to the 5 (five) year deadline, then the affirmation of regional boundaries is carried out by the Minister of Home Affairs.

With the existence of written rules as a guideline, it turns out that it can increase the quantity of affirmation of regional boundaries from the previous 17 segments in the period 1945 - 2005 to 144 segments in 2012. There was an addition of around 747% in 2012 from the achievement in 2005 despite volatile realization. The overall trend from 2006 to 2012 can be seen in Table 3.



Table.3: Definitive boundaries in 2006-2012

Year	Definitive boundaries per year (segments)	Aggregate of the definitive boundaries (segments)
2006	11	28
2007	25	53
2008	15	68
2009	24	92
2010	13	105
2011	7	112
2012	32	144

One of the factors that influenced this was related to financing because in accordance with Minister of Home Affairs Regulation No. 1 of 2006, the implementation of regional boundary enforcement activities was financed through the National Income and Expenditure Budget and supported through the Regional Revenue and Expenditure Budget. The affirmation of regional boundaries in the period 2006 - 2012 is still concentrated in Java, although there are several segments in Sumatra, Kalimantan and Sulawesi (distribution can be seen in Figure 4).

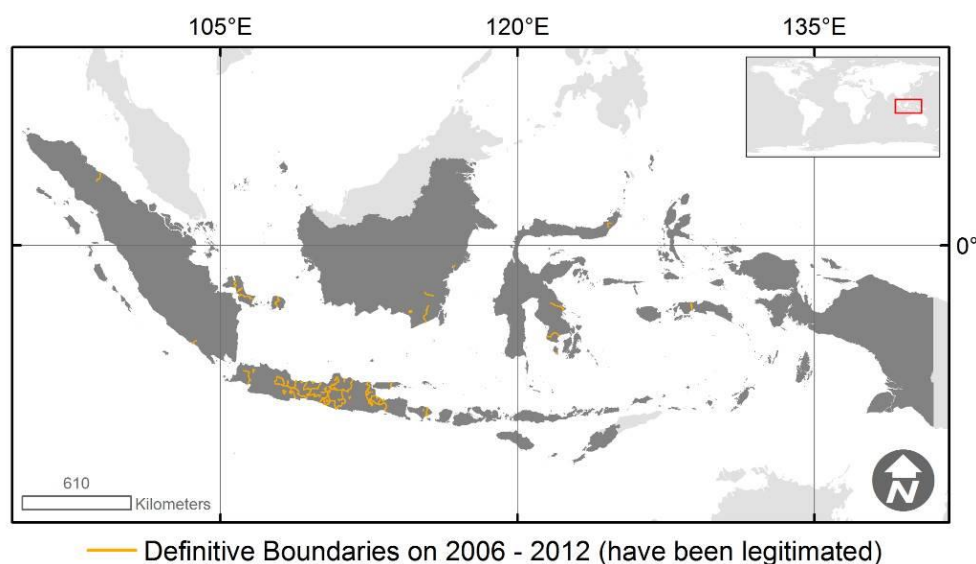


Fig.4: Definitive boundaries in 2006 – 2012

#### Administrative Boundaries Affirmation in 2013 – 2017

During this period, there were 2 (two) laws concerning regional government which were made as a basis. The first is Law No. 32 of 2004 up to September 29/2014 because of September 30/2015, Law No. 23 of 2014 began to take effect on Regional Government. The fundamental difference regarding the regional boundaries of the two laws is that Law No. 23 of 2014 clearly states that regional boundaries become one of the basic requirements of the territoriality that must be proven by coordinate points on a base map before an area can be divided. One of the reasons for using the basic map is that the boundary mapping uses one version of data that can be accounted for. If in the future there are boundary

problems, for example due to natural disasters, it can be reconstructed with the basic map. The Geospatial Information Agency of Indonesia as an institution authorized to organize base maps has provided a base map of a scale of 1: 50,000 for the entire territory of Indonesia and a scale of  $\geq 1: 25,000$  in some region of Indonesia.

On December 12/2012, Minister of Home Affairs Regulation No. 1 of 2006 was replaced by Minister of Home Affairs Regulation No 76 of 2012 on Guidelines for Affirmation of Regional Boundaries. Stages of confirming regional boundaries on land, namely: 1) document preparation; 2) border tracking; 3) measurement and positioning of boundaries; and 4)

making boundary maps. The basic issue is that Minister of Home Affairs Regulation No. 76 of 2012 allows the implementation of the cartometric method for border tracking and measurement and determination of boundaries. The cartometric method according to Minister of Home Affairs Regulation No. 76 of 2012 is the search / withdrawal of boundaries on work maps and measurement / calculation of point position, distance and area coverage by using basic maps and other maps as a complement. According to Maling, the cartometric method is a method of measuring and calculating the numerical value of a map [21]. The stipulation of the

cartometric method as one method in tracking regional boundaries was followed by the addition of realization of affirmation of regional boundaries. It was recorded that until 2017, the definitive regional boundary was 472 segments or around 227% from 144 in 2012. As in the previous period, the realization of the regional boundary affirmation in the period 2013-2017 experienced fluctuations. The overall trend for 2013 - 2017 can be seen in Table 4. In this period, the distribution of the definitive boundary has been fairly evenly distributed on the islands of Sumatra, Kalimantan and Sulawesi (can be seen in Figure 5).

Table.4: Definitive boundaries in 2013-2017

Year	Definitive boundaries per year (segments)	Aggregate of the definitive boundaries (segments)
2013	74	218
2014	70	288
2015	49	337
2016	55	392
2017	80	472

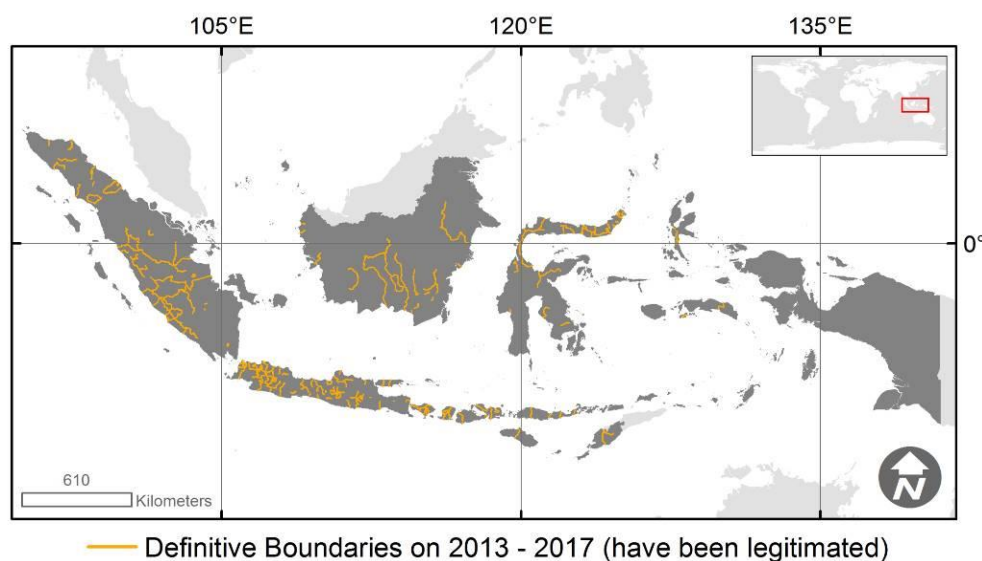


Fig.5: Definitive boundaries in 2013 – 2017

The cartometric method can be said to accelerate the realization of boundary affirmation. In addition, indirectly the One Map Policy is also indicated to be one that contributes in accelerating the realization of boundary affirmation. The Presidential Regulation concerning the Acceleration of the One Map Policy was promulgated in 2016. According to the data in 2016 - 2017, the number of definitive segments significantly increased by 45.45%.

**Administrative Boundaries Affirmation in 1945 – 2017**

The period of 1945 – 2017 showed some extreme points of realization of boundary affirmation. The highest

number of affirmations is in 2017, namely 80 segments, while the lowest number is in 1945-2003, namely 0 segments. During this period, regional boundaries were not a priority because there had not been a regional boundary dispute. Disputes began to occur because of the factors of decentralization where there were conflicts of interest between regions. Significant increase in realization of boundary reinforcement was in 2012 towards 2013, from 32 segments to 74 segments. The trend of realization of boundary assertions in the period 1945 - 2017 has fluctuated according to Figure 6. The definitive regional boundary distribution based on

aggregate per 2017 can be seen in Figure 7. Based on the distribution map in Figure 7, the most definitive regional boundary segments are still concentrated on Java. In aggregate, every year the definitive limit in Indonesia always experiences an increase or an increase (see Figure

8). For 72 years after independence, the definitive segments of Indonesia are still low i.e. 48.31% of all administrative boundary segments.

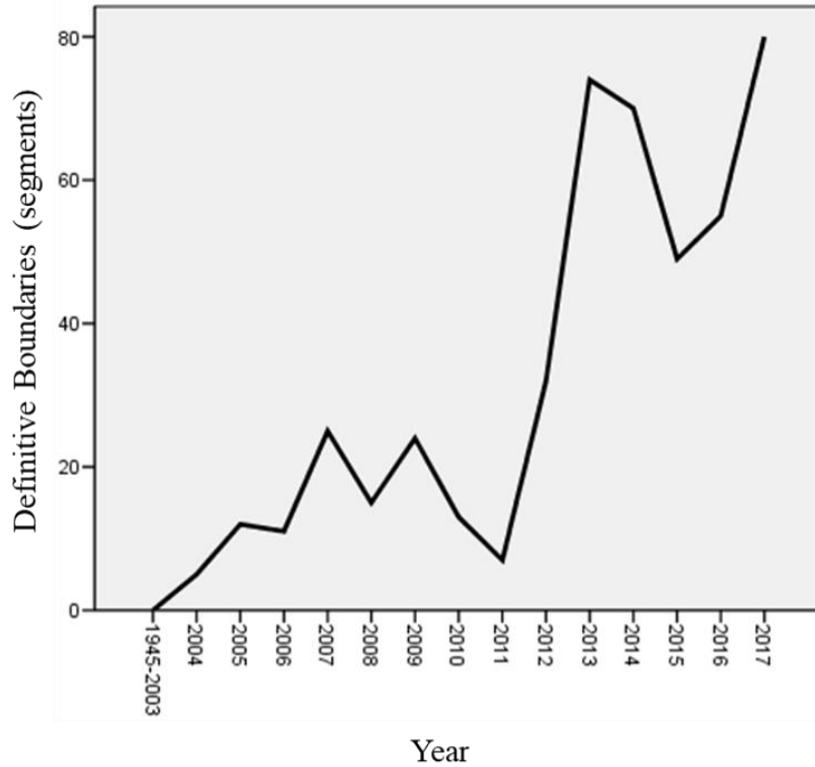


Fig.6: The realization of administrative boundaries affirmation per year in 1945 – 2017

Then time-series analysis was carried out on the definitive aggregate value from 1945 to 2017. Model statistics and Model parameters which were resulted by time-series analysis can be seen respectively in Figure 9 and Figure 10. Based on Ljung-Box result, ARIMA model (1,0,1) is

suitable to be used as a short-time forecast in the future because all coefficients are significant (<0.05) except intercept (constant) and Error White Noise by using (1):  

$$Y_t = 249.236 + 1.978Y_{t-1} - 0.978Y_{t-2} + 0.832e_{t-1} \cdot (1)$$

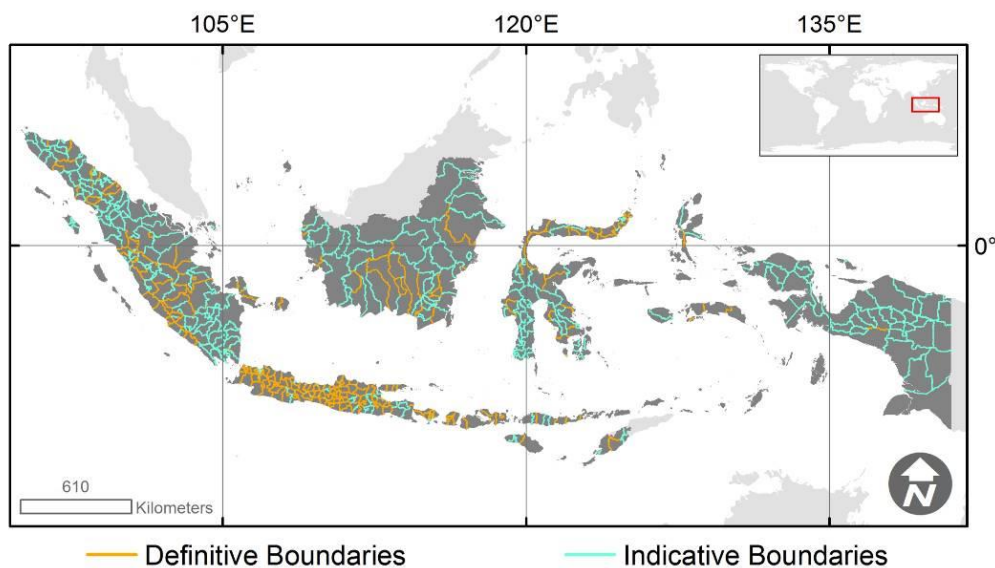


Fig.7: All boundaries status based on December 2017 datasets

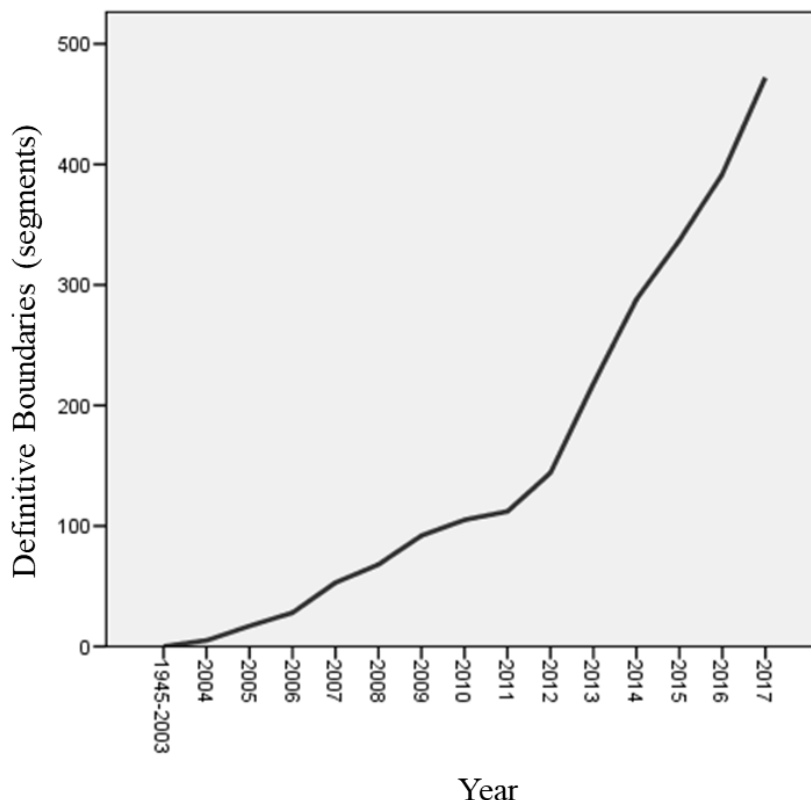


Fig.8: The aggregate of the definitive boundaries in 1945 – 2017

Model	Number of Predictors	Model Fit statistics	Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	Statistics	DF	Sig.	
Accum_ Definitif-Model_1	0	.774	.	0	.	0

Fig.9: Model statistics

				Estimate	SE	t	Sig.
Accum_ Definitif-Model_1	Accum_ Definitif	No Transfor mation	Constant	249.236	796.833	.313	.760
			AR Lag 1	.978	.139	7.056	.000
			MA Lag 1	-.832	.359	-2.316	.039

Fig.10: ARIMA Model parameters

#### IV. CONCLUSION

In the period of 1945-2003 the affirmation of territorial boundaries had not yet received priority. Changes in a centralized government system to decentralization of boundary determination and confirmation activities began to get priority. Regional boundary disputes due to economic potential and inter-regional interests. In 2004

there were 5 (five) boundary setting and confirmation segments and in 2005 12 regional boundary segments were completed. Issued a boundary regulation in 2006 increasing the quantity of affirmation of regional boundaries, the period of 2006-2012 has been resolved 127 segments of regional boundaries. In 2017, the definitive boundaries of The Republic of Indonesia in 72

years after independence reached 472 segments or 48.31% of total 977 segments.

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### REFERENCES

- [1] United Nations Economic Commission for Africa, "Determination Fundamental Datasets for Africa," 2007.
- [2] C. Hadley, "The Global Fundamental Geospatial Data Themes Journey." United Nations Committee of Experts on Global Geospatial Information Management, 2018.
- [3] U.S. Geological Survey, "USGS National Boundary Dataset (NBD) Downloadable Data Collection," *catalog.data.gov*, 2018. [Online]. Available: <https://catalog.data.gov/dataset/usgs-national-boundary-dataset-nbd-downloadable-data-collectionbc141>.
- [4] Republik Indonesia, *Undang-Undang Nomor 17 Tahun 1985 tentang: Pengesahan United Nations Convention On The Law Of The Sea (Konvensi Perserikatan Bangsa Bangsa Tentang Hukum Laut)*. Indonesia, 1985.
- [5] G. M. Kahin, "Sukarno's Proclamation of Indonesian Independence," *Indonesia*, vol. 69, no. April, pp. 1–3, 2000.
- [6] D. Utomo, "Arsip Sebagai Simpul Pemersatu Bangsa," *J. Kearsipan*, vol. 7, 2012.
- [7] "Penetapan Panitia Persiapan Kemerdekaan mengenai Daerah Republik Indonesia," *Berita RI 1945, II No 7*, 1945. [Online]. Available: <https://ngada.org/ppki3-1945.htm>.
- [8] Kementerian Dalam Negeri, *Peraturan Menteri Dalam Negeri No. 137 Tahun 2017 tentang Kode dan Data Wilayah Administrasi Pemerintahan*. Indonesia: Menteri Hukum dan Hak Asasi Manusia Republik Indonesia, 2017.
- [9] G. Law, "Pemekaran provinsi di Indonesia sejak merdeka," *www.statoids.com*, 2015. [Online]. Available: <http://www.statoids.com/uid.html>. [Accessed: 31-Oct-2018].
- [10] T. Ratnawati, "Satu dasa warsa pemekaran daerah era Reformasi: kegagalan otonomi daerah," *J. Ilmu Polit. Ed.*, vol. 21, pp. 122–235, 2010.
- [11] Humas Sekretariat Kabinet Republik Indonesia, "Menuju Satu Peta (One Map): Penetapan Peraturan Presiden Nomor 9 Tahun 2016 tentang Percepatan Pelaksanaan Kebijakan Satu Peta," *setkab.go.id*, 2016. [Online]. Available: <http://setkab.go.id/menuju-satu-peta-one-map-penetapan-peraturan-presiden-nomor-9-tahun-2016-tentang-percepatan-pelaksanaan-kebijakan-satu-peta/>.
- [12] Nurwajedi, Suprajaka, and T. W. Dheny, "Implementation of One Map Policy for Building National Land Cover Map in Indonesia," in *From the Wisdom of the Ages to the Challenges of the Modern World*, 2015.
- [13] S. Joyosumarto, Subaryono, S. Sutisna, and D. Wardaya, "Geospatial Information and Regional Boundary Dispute in the Regional Boundary Demarcation during the Regional Autonomy Era in Indonesia," in *FIG Congress 2014 Engaging the Challenges - Enhancing the Relevance*, 2014.
- [14] T. Virág and M. M. Váradi, "Spatial Exclusion and Boundary-Making in Different Roma Neighbourhoods in Hungarian Rural Small Towns," *J. Econ. Soc. Geogr.*, 2018.
- [15] Sumaryo, "Asesmen Peran Informasi Geospasial dalam Proses Boundary Making dan Sengketa Batas Daerah Pada Era Otonomi Daerah di Indonesia," Universitas Gadjah Mada, 2015.
- [16] J. W. Donaldson and A. J. Williams, "Delimitation and Demarcation : Analysing the Legacy of Stephen B. Jones's Boundary-Making," *Geopolitics*, vol. 13, no. 4, pp. 676–700, 2008.
- [17] W. R. Jati, "Inkonsistensi Paradigma Otonomi Daerah di Indonesia: Dilema Sentralisasi atau Desentralisasi," *J. Konstitusi*, vol. 9, no. 4, 2012.
- [18] R. A. Yaffee and M. McGee, *An introduction to time series analysis and forecasting: with applications of SAS and SPSS*. Elsevier, 2000.
- [19] W. W. S. Wei, "Time Series Analysis," in *The Oxford Handbook of Quantitative Methods in Psychology, Vol 2, Statistical Analysis*, T. D. Little, Ed. Oxford University Press, 2013.
- [20] N. C. Matalas, "Time series analysis," *Water Resour. Res.*, vol. 3, no. 3, pp. 817–829, 1967.
- [21] D. H. Maling, *Measurements from Maps: Principles and Methods of Cartometry*. Oxford: Pergamon Press, 1989.

# Adjusting the Capital Index (ICS), to the Population of Santarém-Pa, It's Capacity for Mobilization and Political Action the Environmental Exposure to Mercury

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**Abstract**— Until the mid-1980s, the scientific literature focused on the environmental issue, particularly in the Brazilian Amazon, attributed the mercurial contamination, the anthropic action, especially the mining activities. The region of Santarém, in the state of Pará, was chosen to conduct this research because it is at the center of the discursions of mercury contamination in the Amazon. The objective of this study is to analyze the perception of risk to mercury contamination in the population of Santarém, with the application of Integrated Questionnaires to Measure the Social Capital Index - QI-MCS proposed by the World Bank. The methodological procedures were based on the application of structured questionnaires in open and closed questions, through individual interviews, which addressed several aspects related to groups and networks; trust and solidarity; collective action and cooperation; information and communication; cohesion and social inclusion; authority or capacity building and political action; mercury contamination. In order to determine the ICS, variables that express interpersonal relationships among community members were considered as well as their participation in participatory and cooperative associations. It is concluded that the risk is underestimated by the local population, since it does not have enough information regarding the mercurial

contamination and actions taken by the State to prevent this type of accident.

**Keywords**— Contamination, Amazon, Participation, Economy.

## I. INTRODUCTION

The Social Capital Index (ICS), defined first by Pierre Bourdieu as "the aggregate of actual or potential resources linked to the possession of a durable network of more or less institutionalized relations of knowledge or mutual recognition" (Bourdieu, 1958), apud PORTES (1998)), will be analyzed in this work, where its assessment to the population of Santarém, state of Pará, Amazonia Brazil, was evaluated to measure the mobilization capacity and political action, when exposed to an environmental risk, in the case the mercurial contamination.

For Bourdieu, this idea arises in an attempt to overcome the focus of traditional economic theory that fixes its eyes and attention only on economic and human capital, disregarding other forms of social exchanges, citing (HIGGINS, 2005). FIALHO (2004), affirms that every individual action makes possible the mobilization of the social structure, making possible an individual and collective gain. This would be a resource available only to the privileged classes, while the lower classes would be

deprived of this power within the corporate structure. However this fact can be inferred because of its position in the social pyramid, says Bourdieu.

Capital emphasizes the fact that non-monetary forms and relations can be important sources of power and influence, even when current literature shows that, because the concept is understood and evaluated in different ways, many criticisms have been made about its use (PATTUSSI, 2006). It is difficult to gauge, because it is lodged in the relations between individuals and individual groups. From the ideological point of view, social capital can be the empowerment of citizenship, pluralism and democratization.

Within this perspective, we will adopt the point of view of COLEMAN (1990), where social capital manifests itself through cooperation networks and norms of collective reciprocity, in order to propose public policies aimed at meeting demands of the local population regarding access to information, prevention and control of possible mercury contamination in the research area. This situation is only possible because the individual is immersed in a network of dense social relations, according to this author.

However, most of the time, the concept of social capital is used as an analytical category that seeks to explain how individuals and collectivities have access to differentiated resources in society. More specifically, it seeks to understand how different networks of relationships are articulated, which can bring individual or collective benefits, even though it originates in a network of

relationships, and is an individual attribute that allows access to resources differentiated not only from nature but also those referring to social status - symbolic capital - and cultural goods - cultural capital. (VENEROUS, 2014).

The objective of this research is to test the proposal to measure the social capital index from the Integrated Questionnaire to Measure the Social Capital Index - QI-MCS, proposed by the Working Group on Social Capital of the World Bank in 2008. Applying this methodology may be the tip of the lance and an alternative to measure the social capital of a population, with this, to detect the organizational capacity and mobilization in the face of extreme events that could compromise their corporate organizations, collective welfare, measure their mobilization and action power environmental exposure to mercury.

## II. MATERIAL AND METHOD

The municipality of Santarém, is located in the region of the mouth of the Tapajós river, confluences with the Amazon river, mesoregion of the Lower Amazon and the microregion Santarém in the western portion of the state, coordinates 02o 25 '30 "S and 54o 42' 50" W Gr, (IDESP / SEPOF-Pa, 2011) (Fig. 1), in Fl. SA.21, RADAM Project, 1976. According to IBGE, for the year 2010, Santarém has a population of 294,580 inhabitants, an area of 22,887 km<sup>2</sup> and a population density of 12.8 inhabitants per km<sup>2</sup>.

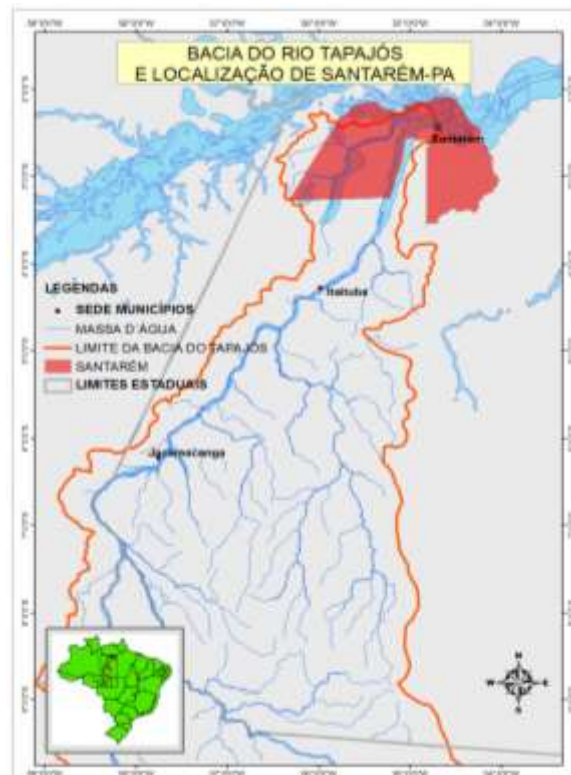


Fig 1. Map of the location of the Tapajós river basin and the area of the municipality of Santarém.

**Methodological approaches**

The following steps describe the methodological procedures that aim to establish a sequence of activities aimed at deepening and analyzing the presence of social capital in the municipality of Santarém-Pa., Which included a bibliographic review; fieldwork and application of Integrated Questionnaires to Measure Social Capital - IQ-MCS, of the World Bank; statistical approaches and data analysis.

**Calculation of the Capital Stock Index (ICS)**

In the calculation of this index, the responses of 139 individuals interviewed in the communities of Cucurunã, São Brás, Alter do Chão, Arapixunas and Santarém urban area from July 18 to 28, 2014 were considered. In order to measure social capital, questionnaires with 34 questions with the following variables: Groups and Networks; Confidence and Solidarity; Collective Action and Cooperation; Information and Communication; Cohesion and Social Inclusion; Empowerment and Policy Action and Hg Research Register.

The Mercury Register was not originally included in the World Bank's IQ-MCS, however, it was added by the authors to try to visualize how the respondents' perception in this regard is. Seven questions were proposed: 1) In your opinion, which environmental problem is most relevant in your city? 2) How did you become aware of mercury contamination? 3) What activity do you consider responsible for the mercury contamination in the area? 4) Do you have confidence in the governing bodies responsible for the management of contaminated areas? 5) Have you ever had a miscarriage during your fertile life? (Applicable to women of childbearing age); 6) What is your main source of protein? 7) How many days of the week do you consume this type of food? All proposed questions were idealized and based on a theoretical framework on the subject of mercury. From that point on, quantitative data were generated on the various faces of the social capital evaluated.

The six dimensions of IQ-MCS (Integrated Questionnaire to Measure Social Capital - WB)

Based on the World Bank's Thematic Group on Social Capital, GROOTAERT (2009), the six dimensions of the World Bank's IQ-MCS were measured and analyzed to measure social capital, which can be summarized as follows:

1) Groups and networks - considers social participation in social organizations, formal and informal networks and

feedback of these relationships. The Network would be the various daily friendship relationships of the individual or organizations, usually known as the network.

2) Trust and solidarity - this item seeks to elicit data on trust in individual relationships between extrafamilial elements, service providers and their variations over time.

3) Collective action and cooperation - this category investigates the working relationships of household members and the community in joint projects and / or joint responses to a crisis and consequences of non-compliance with the expectations generated by such participation. In this case, we will consider environmental contamination by Hg, a central theme in our research.

4) Information and communication - access to information as a central theme to help impoverished communities to have an active voice in matters related to their well-being (World Bank, 2002, apud Grootaert, 2009). Especially information on markets and public services.

5) Cohesion and social inclusion - seeks to identify social relations between co-opted individuals and their everyday relationships within and outside their social niche. Which groups are excluded from essential public services, taking into account their social interactions.

6) Authority or empowerment and political action - here the empowerment, or empowerment of the cooperative and capacity to act together is observed and quantified.

These variables served as indicators to form the ICS in the Tapajós bay environment, all applied in the five communities at random and based on previous surveys of social capital, and contributions of the authors to observations of issues related to this problem.

**Location of IQ-MCS application points**

The choice of places to be applied the IQ-MCS was not by chance, the urban area of Santarém, was chosen because it is the municipality directly associated with contamination by this metal; the Alter do Chão Village, functions as an important tourist pole, in the scenario, state and national, therefore, an area directly impacted with possible dissemination of environmental contamination by Hg; the community of Arapixunas, located in the same hole, has its protein base in fish consumption, besides receiving seasonal influences from the waters of the Amazonas and Tapajós rivers, as well as communities along the Everaldo Martins Highway (Santarém-Alter do Chão), an area known as the *Eixo Forte*.



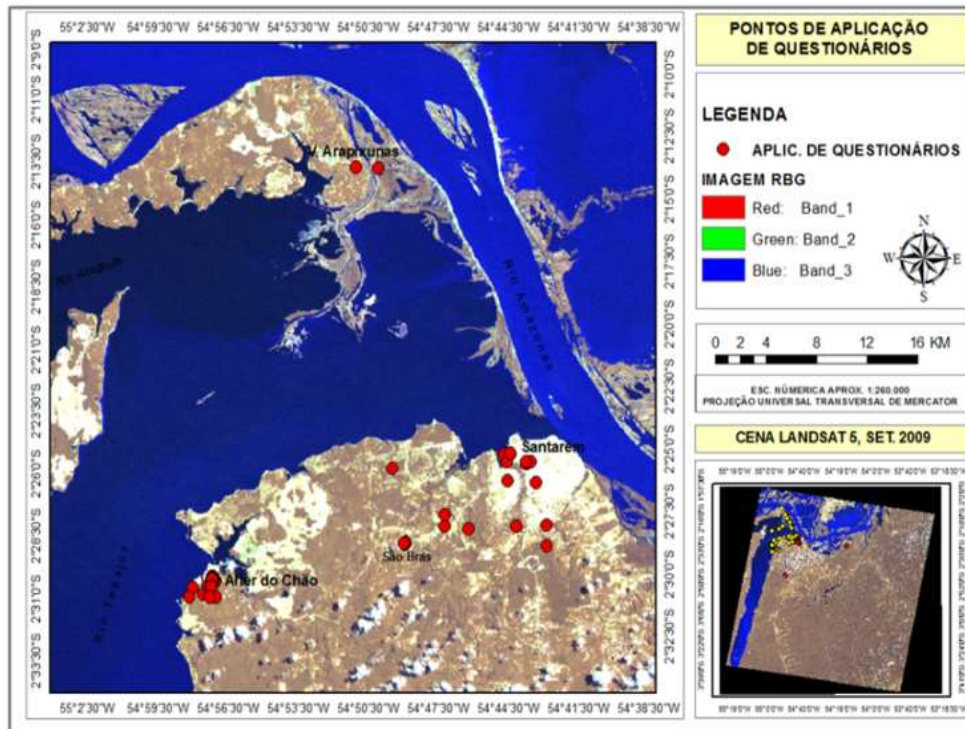


Fig. 2: Location of the points of application of the questionnaires in Santarém.

The Social Capital Index (ICS) considers variables that express interpersonal relationships among members of the locality, as well as their participation in participatory and cooperative associations. The Social Capital Index is mathematically defined as (Pinheiro and Mendonça, 2008) and Moreira, (2009):

$$ICS = \frac{1}{n} \sum_{j=1}^n \left[ \frac{\sum_{i=1}^m E_{ij}}{\sum_{i=1}^m E_{max_i}} \right] \quad (1)$$

The contribution of each variable (or indicator) in ICS is given by,

$$C_i = \frac{\sum_{j=1}^n E_{ij}}{\sum_{i=1}^m \sum_{j=1}^n E_{max_i}} \quad (2)$$

ICS: Capital Stock Index

E<sub>ij</sub>: score of the i-th indicator obtained by the j-th interviewee

E<sub>max, i</sub>: maximum score of the i-th indicator

C<sub>i</sub>: contribution of the "i" indicator in the Social Capital Index

i = 1, ..., m: number of indicators

j = 1, ..., n: number of individuals interviewed

The value of the Capital Stock Index ranges from zero to one, with 1 being the highest level of social capital accumulation, while zero represents the lowest level:

- 0 < ICS ≤ 0,5 means low level of capital accumulation;

- 0.5 < ICS ≤ 0.8 means average level of capital accumulation; and

- 0.8 < ICS ≤ 1.0 means high level of social capital accumulation.

### III. RESULTS OBTAINED

The calculated Capital Stock Index was 0.810 which corresponds to a high level of social capital according to the scale that classifies the level of accumulation and described above. Table 1 shows the participation of the indicators in the constitution of the ICS.

Table.1: Absolute and relative participation of ICS social capital indicators.

QUESTION / INDICATOR	C <sub>i</sub>	C <sub>i</sub> (%)
1. 7. Provision of other people to offer money on loan	0,025543	1,683
2. 9_A. People willing to help	0.032943	1,683
3. 9_B. Chance of someone taking advantage	0,038195	2,783
4. 10_A. Trust in local government members	0,064693	4,644
5. 10_B. Trust in Central Government Members	0,066842	6,568
6. 10_C. Trust in members of the state government	0,068274	8,533
7. 14. Cooperation in water supply problems	0,027333	9,320
8. 17. Differences between the characteristics of people	0,047267	10,68

9.	23.	Feeling about crime and violence	0,035450	11,70
10.	24.	Feeling of happiness	0,029124	12,54
11.	25.	Ability to change life	0,066126	14,44
12.	26.	Number of times people asked for the community	0,341370	15,42
<b>ICS</b>			<b>0.810</b>	<b>100.00</b>

Those responsible for the lowest level of social capital accumulation of the items presented were the willingness of others to lend money, people willing to help, chance of someone taking advantage of third party, and trust in local government members. On the other hand, the indicators that contributed the most to increasing social capital accumulation were the number of times people asked for community, the ability to change lives, feelings of happiness and feelings about crime and violence. This indicates people willing to strive for collective well-being (altruism to be taken into account), great capacity to face changes in their lives, high satisfaction and happiness, and people with a personal capacity and a high degree of sociability of people living in the community in localities.

**Descriptive analyzes of IQ-MCS dimensions**

The values not stated in the percentage of each category, then, refer to individuals who did not know or did not answer the questions in each item analyzed. In these results are presented only the most significant categories for conclusion of the research, as we will see next.

In the Groups and Networks category, most respondents reported that they belonged to the same social group, 61, 87% of the community, against 25.17%, who state otherwise. However, in the item religion, only 39.56%, say they belong to the same religious denomination, against 49.64%. Attention was drawn to the responses related to identification by ethnic-racial groups, none, declared of the Black race, according to the IBGE denomination, (2008), while 43% declared themselves Pardos and 35.25%, Indigenous and other 17, 9%, are presented without declaration (Table 2).

Table.2: Table of the category Groups and Networks, representing the thinking of the members of the groups related to Identification by Race / Ethnicity.

Thinking about the members of this group, most of them are from the same group		
Identification of responses (ETHNIC GROUP)	N. ABSOLUTE	%
01 White	03	2,15
02 Black	00	0,0
03 Yellow	02	1,43
04 Brown	60	43
05 Indigenous	49	35,25
06 No declaration	26	17,9

Regarding the occupation, the interviewees belong to the same occupational branch, 64.74%, against 24.17%, and the same social class. The schooling presents a significant difference, 40.60%, stating that they do not have the same level of schooling as the other members of the family group. This statement may be related to the increase in social achievements reached by the lower class population, including access to formal education. Among those surveyed they occasionally work outside their communities, being this their main space where they develop their economic activities, 55.39%. This situation corroborates, for the degree of confidence among members, who occasionally declare (33.81%), talk to each other about particular matters or when they need help; another 41.44%, say they often use this habit. They even declare that they have one to five people of confidence in their range of action 51.79% of the ears.

Another 62.58% said that if they needed a small amount of money, these members would be willing to provide them.

In Confidence and Solidarity, when asked about the level of trust among group members, they say they trust themselves, but 79.85% say they can never be too careful. This item questions the degree of relationship and trust between individual members, directly related community and

In this category, participation and trust in local, state and central (federal) government members were also evaluated and in both cases the evaluation was not very receptive. Regarding the local government the trust index, I totally trust or trust very much, they were below 10%, while I trust very little, with 47.48%, almost half of those interviewed

In relation to the members of the state government, the indexes are worse, 0,0% and 5,03% of the respondents declare to totally trust or to trust in the government. On the other hand, 53.95% are very close to the actions of the state government. Representing a high rate of population rejection and approval

The central government evaluations are also not the best, being very close to the rejection rates of the state government, with 0.0% and 7.19%, for I totally trust and trust a lot, respectively 49.64%, I very much trust little

In Collective Action and Cooperation, the response of the communities, their participation in collective activities, aimed at the common good, were evaluated, as if they would be willing to work on solutions to a possible problem of water supply, even if it did not reach it. The responses were very satisfactory, with a rate of 61.14%, two respondents stating that very likely, would help solve the problem.

In Information and Communication, the number of telephone calls received by individuals and the main and most important sources of information about what governments are doing for the common good of the population were considered. Television and radio are still the main means of communication, which socialize the actions of governments to society, with 22.06% and 20.62%, respectively, even when it is opportune to choose more than one vehicle in the total of three sources of information.

Cohesion and Social Inclusion, in this modality the interviewee is given the opportunity to evaluate the differences in characteristics between people living in the same neighborhood or locality. For example, differences in income, social position, ethnic origin, race, caste, or tribe. They were also able to take into account differences in religious beliefs, politics, age and sex. In this respect, significant differences that could generate some disturbance in the collective were not identified by the groups. Among the questions proposed in the questionnaires are: difference in education, land tenure, wealth / material possession, social position, between men and women, generations, new and old residents, political affiliation and religious belief. There is a balance from the point of view of the interviewee.

When asked how they feel about crime and violence when they are alone at home? The results go beyond the standards of large urban centers, as 38.13% of respondents said they felt very safe and 35.25%, Moderately safe, only 7.91% were very insecure. Showing the relationship of trust between members of social groups and their families.

In the category Authority or Capitulation (Empowerment) and Political Action, pointed to a population with high levels of personal satisfaction. When asked: How do you

consider yourself? Part of the population considers themselves Very happy, 40.28% and Moderately happy, 46.76%, while only 0.71, declare Very unhappy. This group also has the power to make decisions that can change the course of their lives, 42.44%, are generally able to change their lives. In the past 12 months they have come together to jointly file a petition to a member of government or political leaders asking for something for the benefit of the community, showing a capacity to mobilize the group when called upon or pressured by events that may affect their relationships.

In the last part of the IQ-MCS, the Hg Research Register was introduced, in order to quantify and evaluate the population's response capacity, to a possible environmental contamination by heavy metals (Hg), assisted by IQ-MCS. Initially the interviewee is asked what their opinion about the most relevant environmental problem in the city under their point of view. The following were suggested: Burned; Extinction of species of flora and fauna; Deforestation; Contamination of soils and water by mercury; and Waste and waste generated. Garbage and human waste generated, deforestation and mercury contamination are the environmental problems that most concern the population, with 30.93%, 28.77% and 25.89%, respectively.

When questioned about how he became aware of the mercury contamination, 46.04% reported, Newspapers, Magazines and / or Television; 36.69%, from different sources. While 0.0% say that they did not have any kind of information coming from the Secretaries of Environment or Health of the governments. The campaigns of education and environmental awareness, total 3.59%, while 13.66%, from informal conversations with friends or acquaintances.

Also in the Hg Search Registry item, when asked: What activity do you consider responsible for the mercury contamination in the area? The majority attributed the activity of Garimpos (41%), Deforestation (15.82%), Mining (9.35%), Agriculture (5.75%), and 28.05%, other sources.

The level of trust in government agencies responsible for the management of contaminated areas was another item disapproved in the survey, with 85.61% of those interviewed who do not trust these bodies, against 11.51% saying they trust.

The questionnaire on spontaneous abortion, applied to women of childbearing age (15 to 65 years old - suggested), was introduced to close the questionnaire, even though it was not intended to investigate the clinical aspects of the interviewees. history, and try to observe possible metabolic changes related to Hg contamination, SANTOS (1999). A question was elaborated with this

theme, they answered if they had some spontaneous abortion during their fertile life, 12.23% said yes, and 58.99%, no, other 28.77% did not know or did not respond. The main source of protein consumed daily in this group are: 52.51% consume beef as protein, 25.89% fish, 19.42%, chicken and 2.15% of other proteins.

#### IV. CONCLUSION

The analysis of the Social Capital Index, referring to the IQ-MCS methodology proposed by the World Bank, applied in the surroundings of the Tapajós river bay, Santarém-Pa., Allowed to recommend it as a valid and reliable instrument for measuring the concept of quality of life and elaboration of public policies in the region surveyed. It is important to emphasize the importance of introducing the quality of life evaluation among the performance indicators in health programs and interventions, thus incorporating the perspective of the subjects targeted by these actions. Therefore, the application of IQ-MCS in Santarém is that the related communities have a high level of social capital, where we can estimate a capacity for mobilization and political action the environmental exposure to mercury in the region of the bay of the Tapajós river, by local communities. Especially when observed a proactivity of the populations involved, related to events that compromise their collective well-being. Although it has demonstrated the presence of social capital, there does not seem to be an effective use of these resources, in many cases, probably due to the lack of leadership or more persuasive means of convincing.

#### REFERENCES

- [1] ALMEIDA, M.G.; Vargas, M.A.M.; Mendes, G.F., Territórios, paisagens e representações: um diálogo em construção. Revista Mercator, Universidade Federal do Ceará - UFC, Fortaleza-Ce, v. 10, n. 22, p.23-35, mai./ago. 2011.
- [2] BANCO MUNDIAL, Questionário Integrado para Medir Capital Social (QI-MCS). Grupo Temático sobre Capital Social, julho 2009.
- [3] BOURDIEU, Pierre. O Poder simbólico. Editora Bertrand Brasil S.A. Rio de Janeiro, 1989.
- [4] BRASIL, Notas técnicas: Histórico da investigação sobre cor ou raça nas pesquisas domiciliares do IBGE, Características Étnico-raciais da População: um estudo das categorias de classificação de cor ou raça 2008. Web: <http://www.ibge.gov.br>, acesso 10/02/2015.
- [5] COLEMAN, J. Foundations of social theory. Cambridge: Harvard University Press, 1990.
- [6] FREITAS, M. G. A., *A teoria do poder simbólico na compreensão das relações sociais contemporâneas. Congresso Internacional Interdisciplinar em Sociais e Humanidades, Niterói, RJ: ANINTER-SH/PPGSD-UFF, 2012.*
- [7] LIMA, j. c., *A teoria do capital social na análise de política públicas. Revista em Ciências Sociais – Programa de pós-graduação em Sociologia da UFPB, Edição on line <http://www.biblionline.ufpb.br/> (Acesso em 29/01/2015).*
- [8] MENEZES, D. B., Oliveira, E. A. A. Q., Carniello, M. F., O Capital Social: uma ferramenta para implantação de planejamento de desenvolvimento regional. The 4th International Congress on University-Industry Cooperation – Taubate, SP – Brazil, 2012.
- [9] MOREIRA, J. C. P., et al. Capital Social como um dos fatores de sucesso das Cooperativas Agroindustriais. Documentos Técnico-científicos, Revista Econômica do Nordeste, Vol. 40, No. 3, 2009.
- [10] MOURA, E. A. F., Práticas socioambientais na Reserva de Desenvolvimento Sustentável Mamirauá Estado do Amazonas, Brasil. 2007. 315p. Tese (Doutorado em Ciências Sociais) – Universidade Federal do Pará – UFPA, Belém-Pa, 2007.
- [11] FIALHO, F. M. “Capital Social: usos e definições do conceito nas Ciências Sociais”. Revista Três Pontos, 1.0, p. 31-35. Bel Horizonte, 2004.
- [12] HIGGINS, S. S. Fundamentos teóricos do capital social. Argos, Chapecó, 2005.
- [13] KIMURA, M; SILVA, J. V. da. Índice de qualidade de vida de Ferrans e Powers. Ver. Esc. Enferm USP, 2009; 43 (Esp.): 1098-104.
- [14] PATTUSSI, M. P.; MOYSÉS, S. J.; Junges, J. R.; Sheiham, A. Capital social e a agenda de pesquisa em epidemiologia. Cad. Saúde Pública, Rio de Janeiro, 22 (8): 1525-1546, Ago., 2006.
- [15] PEREIRA, S. B., Processos Tangíveis e Intangíveis do Desenvolvimento Local. Revista Econômica do Nordeste, Fortaleza, v. 38, nº 2, abr-jun. 2007.
- [16] PRATES, I; VENEROSO, C. Capital Social e Pobreza: implicações teórico empíricas para estudos de Programas de Renda Mínima. <http://www.sinteseeventos.com.br/bien/pt/papers/ianpratesCapitalsocialepobreza.pdf>. (acesso em 01/07/2014).
- [17] PORTES, A. Capital Social: Origens e aplicações na sociologia contemporânea. Sociologia, Problemas e Práticas, número 33, p. 133-158. Tradução de Frederico Ágoas. Lisboa, 2000.
- QUEIROZ, J. C. B., Utilização da geoestatística na quantificação do risco de contaminação por metais pesados, na área portuária de Santana – Amapá,

Tese de Doutorado Curso de Pós-Graduação em Geociências UNESP, Rio Claro - Sp, 2003.

[18] SANTOS, E. C. O. et al, Estudo de Saúde e Exposição ao Mercúrio da Comunidade Ribeirinha de Brasília Legal, Estado do Pará, Brasil. Cad. Saúde Colet. 7(2), Fundação José Bonifácio, Rio de Janeiro, 1999.

[19] SILVA JR., J. D. S., O Capital Social: discussão em torno da construção de um conceito. Revista Espaço Acadêmico – No. 72 – Maio de 2007 – Mensal Ano VI - <http://www.espacoacademico.com.br>. (acesso em 01/03/2015).

# Diethyl ether additive effect in the performance of single cylinder D I diesel engine with B20 Biodiesel blend fuel

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**Abstract**—The present work involves in production of methyl ester (Biodiesel) from inedible oils like *Jatropha* oil and application of its B20 blend fuel with diethyl ether (DEE) as an alternative fuel in D I diesel engine to investigate the performance and properties of test fuel. The methyl ester was obtained by base catalyzed transesterification process and 20% of biodiesel blended with 80% of diesel to form B20. The use of oxygenative additive in blend fuel reduces the ignition delay and combustion period of a diesel engine. This lowers the sulfur and nitrogen oxide emissions with less combustion period by the additive. The results show that the brake thermal efficiency increases with increase in load. The maximum brake thermal efficiency is obtained for diesel, B20 and B20DEE3 respectively at full load. The brake specific fuel consumption decreases and minimum fuel consumption occurred for B20DEE6 fuel at full load. The exhaust gas temperature increases linearly with load and is minimum for B20DEE3. The test fuel property results show that significant improvement in flash point, fire point, viscosity and density, whereas increase in energy content is observed with addition of DEE in B20 blend fuel.

**Keywords**—Performance, Emissions, Blend fuels, Viscosity, Biodiesel, Additive, Diethyl ether, Properties.

## I. INTRODUCTION

Mostly for transportation sector future energy requirements can be replaced by alternative fuels like biodiesels derived from edible and inedible oils. Biodiesel is becoming a significant, renewable, future alternative fuel, lubricant and also as an additive to the existing petroleum fuels. Biodiesel is a biodegradable, non-toxic and mostly renewable and alternative fuel. It can be produced from various edible and inedible oils, waste cooking oil or animal fats [1]. The properties of biodiesel

may change when different feed stocks are used. In comparison of biodiesel properties with diesel fuel, it has higher viscosity, density and cetane number. But the energy content in biodiesel is about 10-12 % less than that of conventional diesel fuel on the basis of mass [2].

Biodiesel properties are similar to diesel fuel; hence there is no need to modify the diesel engine when it is fueled with biodiesel or biodiesel blends with diesel fuel. Additive is a chemical material added in base fuel to improve desirable chemical properties and also functions as a detergent or dispersed. Oxygenated additives like triacetin, diethyl ether etc. solve problems occur prior to burning and promote complete combustion of fuel in the combustion chamber which reduces engine deposits, smoke and other emissions [3], [4].

Additives can be considered to improve combustion, fuel economy, to decrease the emissions and to make biodiesel quality equivalent to diesel. The metal based additives, cetane number additives, antioxidant additives and oxygenated additives help in improving the quality of the biodiesel [5]. Alcohols lower the flash point slightly and reduce the viscosity and density of blend fuel marginally. With this fuel, ignition can start at lower temperature and able to burn completely to extract total energy content. The combustion rate of fuel is increased due to more oxygen availability in alcohol, that results in reducing the levels of pollutants in exhaust gases [6]. Additives significantly improve the quality of biodiesel and its blends; enhance biodiesel properties, reduction from fuel system cleanliness with optimized performance and economy of fuel [7].

DEE has the required properties to use in diesel engines, such as miscibility in diesel and biodiesel with high oxygen content, low ignition temperature and high cetane number. The effect of DEE addition in mahua oil methyl ester (MOME) is revealed that carbon monoxide and

smoke were reduced more than 50% [8]. Diethyl ether has been identified as a potential renewable bio-based fuel and oxygenated additive. Tests on diesel engine with neat Karanja oil methyl ester as a base fuel and blends of 5, 10, 15 and 20% of DEE by volume basis improves, the fuel properties like combustion characteristics, viscosity and cold starting problems [9]. With the experiments conducted on a single cylinder D I diesel engine fuelled biodiesel with various percentage of DEE addition (5%, 10%, 15%), concluded that 5% DEE addition lowered the CO and smoke emissions with increased HC and NOx formation [10].

The experimental studies were carried out to evaluate the effect of Triacetin (T) as an additive with biodiesel on DI diesel engine performance and combustion characteristics. By adding triacetin additive to biodiesel, the results showed that the engine knocking problem can be alleviated to some extent and the tail pipe emissions were reduced. Experiments were conducted to compare the results with Petro-diesel, biodiesel and triacetin additive blends of biodiesel on the engine. Coconut oil methyl ester (COME) was used with an additive at various percentages by volume for all load ranges of the engine from zero up to full load. The results showed that performance is better compared with neat diesel in respect of engine efficiency and exhaust emissions. Among the all blend fuels tried, 10% Triacetin combination with biodiesel shows encouraging results [11], [12].

The results with oxygenated additives indicate that smoke and particulate emissions are reduced without sacrificing other emission characteristics and thermal efficiency due to the high oxygen content in the fuels [13]. Addition of 10% DEE improved the BTE, lowered the smoke and CO emissions without affecting NOx emissions [14]. The report with 5% addition of DEE resulted in higher BTE with lower CO and smoke emissions compared to diesel. At higher percentages of DEE (20% and 25%), decreases BTE, with increase in CO and smoke emissions as compared to diesel. This is due to phase separation of DEE, injector nozzle cavitations and improper fuel droplet injection in cylinder chamber [15]. The performance with diesel-biodiesel-ethanol blends in CI engine show that, BSFC increased at lower loads with reducing BTE (21.7%). CO emissions decreased with increasing CO<sub>2</sub> and NOx emissions. HC emissions reduced in all engine load conditions [16]. Triacetin being antiknock fuel, with 10% blend emanated as a best blend fuel with coconut oil methyl ester to reduce HC, NO, CO<sub>2</sub>, CO and smoke emissions with high performance and no cylinder vibration in vertical direction of the engine [17], [18].

The results with ethanol in biodiesel decreases oxides of nitrogen, smoke, carbon monoxide and hydrocarbon

emissions at higher loads and increase at lower loads. Increase of maximum heat release rate and maximum pressure for the blends at higher loads and decreases at lower load. Brake thermal efficiency of the blends is similar to that of diesel fuel [19]. In this work diethyl ether additive was used to conduct the experiments with Jatropa oil methyl ester (JOME), the main advantage of this additive is easily soluble in biodiesel, suppress the knocking of engine, improve efficiency and reduce emissions. DEE additive at 3, 6, 9 and 12% with B20 test fuels were used to study the properties and performance of engine to replace it as an alternative to diesel fuel.

## II. MATERIAL AND METHODS

**2.1 Preparation of Biodiesel:** Jatropa oil methyl ester (Biodiesel) blends B20 with oxygenated additive DEE is considered to study the properties. Raw jatropa oil is filtered and heated up to 105°C temperature in order to remove solid particles and water content. In acid treatment methanol of 120ml and 2ml of concentrated highly pure H<sub>2</sub>SO<sub>4</sub> per liter of oil is added and heated with magnetic stirrer at 62°C for about half an hour in a closed conical flask. The mixture is allowed to settle down in a decanter. The settled glycerin is separated at bottom of decanter from methyl ester. *Sodium Methoxide* was prepared by mixing thoroughly 200ml of methanol (20% by vol.) with 6.5 grams of NaOH per liter of oil. This solution is added to the oil obtained from acid treatment, then stirred continuously at 62°C for one hour in the base treatment and allowed to settle down in decanter. The collected Jatropa oil methyl ester (JOME) is bubble washed with pure water in order to remove soap contents, acid and methanol. The sequence of biodiesel making, reaction takes place and prepared biodiesel are shown in figures 1 to 3 respectively. The washed JOME is heated further above 100°C for some time to remove water content. This biodiesel is used to prepare B20 (20% JOME + 80% diesel by volume) blend fuels and then test fuels from B20 with DEE additive.

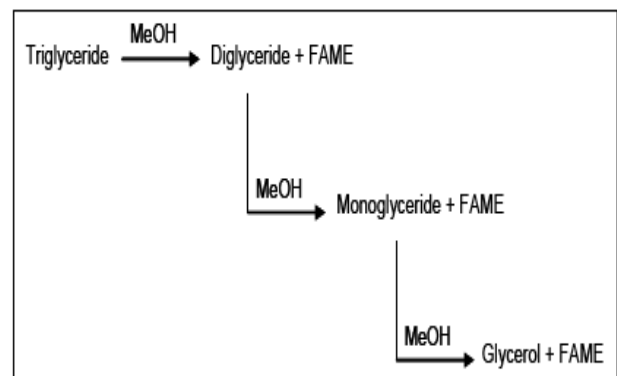


Fig.1: Stages of Biodiesel (JOME) preparations

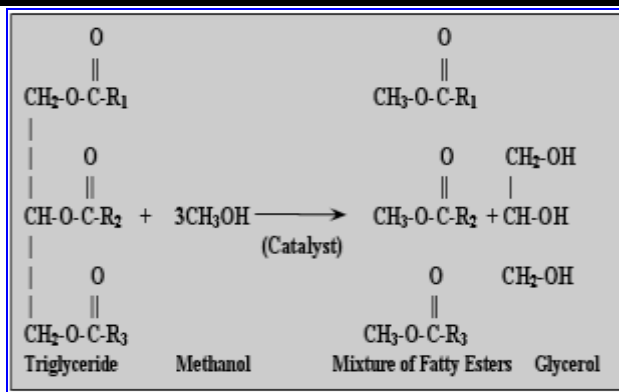


Fig.2: Reaction in formation of Biodiesel (JOME)



Fig.3: Biodiesel (JOME)

## 2.2 Methodology Used

The required test fuels were prepared with B20 and at different percentages of diethyl ether (DEE) as shown in table 1 with their percentages to study the properties and performance of the engine. Diethyl ether and B20 blend fuel are easily miscible homogeneously.

The properties like flash point, fire point, viscosity, density and heat value were measured as per the ASTM standard procedures recommended by manufacturers. These tests were conducted in a controlled room temperature, pressure and relative humidity to ensure that the result will not be influenced with change in environment and compared the same with B20 blend fuel. Performance experiments were carried out on single cylinder diesel engine with the test fuels at different load conditions 0, 25, 50, 75 and 100 in percentage. Engine performance parameters such as mechanical efficiency, brake thermal efficiency, brake specific fuel consumption and exhaust gas temperatures results were compared with B20 blend fuel.

Table.1: Blend fuels for Test

S. No	Type of Fuel	Percentages in Blend Fuel
1	Diesel	100% Diesel
2	B20	20% Biodiesel (BD) + 80% Diesel
3	B20DEE3	97% B20+ 3% DEE
4	B20DEE6	94% B20+ 6% DEE
5	B20DEE9	91% B20+ 9% DEE
6	B20DEE12	88% B20+ 12% DEE

## III. RESULTS AND DISCUSSIONS

The properties of biodiesel blend fuels B20 with diethyl ether additive at different percentages provide important data to further investigate and analyze the operation of DI diesel engine in terms of performance and compare the results with diesel fuel.

**3.1 Fuel properties:** The following general properties of B20 blend fuel with diethyl ether results are summarized:

*i) Viscosity:* High viscosity of biodiesel causes poor atomization in fuel spray system and inaccurate fuel injectors operation causes improper combustion in the engine cylinder, results increased exhaust smoke and emissions as compared to diesel fuel. Biodiesel can be used as a substitute to diesel fuel at lower viscosity with minimum environmental pollution. Under low temperatures viscosity has a greater impact on fuel to flow smoothly from the storage tank into the engine cylinder. From the figure 4 it is observed that the viscosity of B20 is 28.57% more than diesel fuel due to concentration of free fatty acid (FFA) in biodiesel. Due to the low viscosity of DEE additive in blend fuels (B20) viscosity decreases as the increase in percentage of additive. On the other hand, viscosity of B20 blend fuel decreases by 11.12%, 13.89%, 22.24% and 27.49% with the addition of 3%, 6%, 9%, and 12% of DEE as compared to B20 blend fuel.

*ii) Flash and Fire point:* Flash and fire points of B20 biodiesel blends with diethyl ether at various percentages were tested are shown in figure 5. Biodiesels are non volatile due to higher molecular weight and produce sufficient vapours at higher temperatures to form a combustible mixture with air, hence flash and fire points of biodiesel and B20 blend with diethyl ether are much higher than diesel fuel. The flash and fire points of test fuels gradually decreases with increase in percentage of diethyl ether in B20 blend fuel. For the test fuels B20 with 3, 6, 9 and 12% of DEE the flash point decreases by 3.07, 7.46, 9.7, 13.43% and fire point decreases by 5.97, 8.45, 7.74, and 10.56% when compared with B20 blend fuel. The decrease flash and fire points of test fuels makes it as a convenient fuel to use it in diesel engines.



iii) **Heating value:** The amount of heat energy released by combustion of one unit fuel is known as heat value. The heat value of fuel varies with the amount of moisture content in fuel. In the biodiesel standards (ASTM D6751) heat value is not specified but is prescribed in EN 14213 (for heating purpose of biodiesel) with a minimum of 35 MJ/kg. Figure 6 shows that the heat values of neat diesel, B20 and B20 with DEE additive blends at 3, 6, 9, and 12% by volume are gradually increasing. Heat value increases as the percentage of DEE increases in the blend fuel because the heat value of DEE additive is much higher than biodiesel. The maximum heat value obtained for 12% of DEE additive with biodiesel blend (B20DEE12) was 41.7MJ/kg, which is 7.48% higher than the heat value of B20 used for testing. The heat values of all blend fuels are within the requirement of standards as compared to diesel fuel.

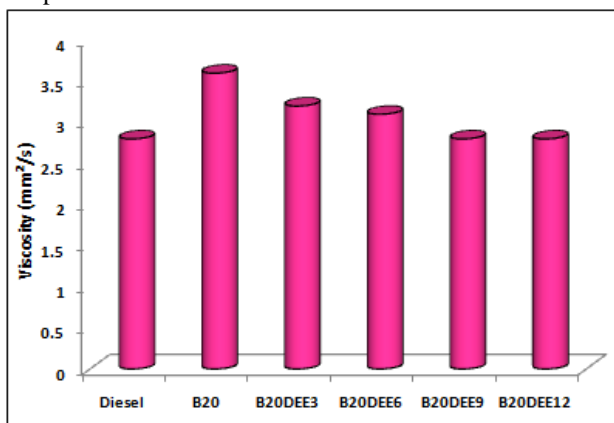


Fig.4: Viscosity values of B20 with DEE

iv) **Density:** Biodiesel density is higher than the diesel fuel and this can be improved with the addition of additives for better combustion and high output of the diesel engine. Density is measured by using Portable Density/Gravity Meter. High viscosity of fuel leads to problem in pumping and spray characteristics such as atomization, penetration and combustion etc. The improper mixing of fuel with air contributes to incomplete combustion that leads to low power output and with high exhaust pollutants. Figure 7 shows the density of diesel; B20 and B20 with DEE blend fuels. It is observed that the density of B20 is higher at 0.889 kg/m<sup>3</sup> and the density of diesel is lower at 0.842 kg/m<sup>3</sup>. The addition of diethyl ether additive in B20 decreases the density by 1, 1.7, 2.24 and 3.15% for 3, 6, 9 and 12% of DEE as compared to B20 blend fuel.

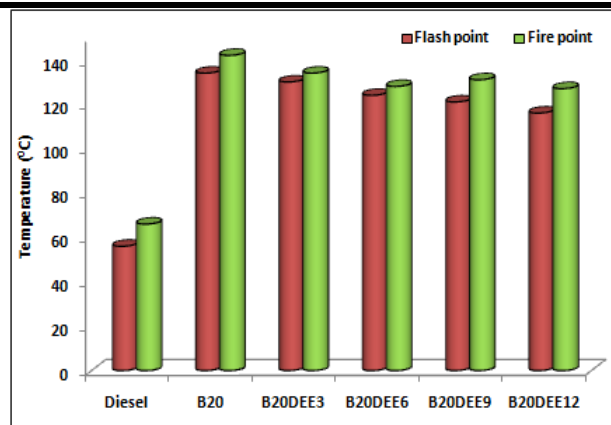


Fig.5: Flash & Fire point values of B20 with DEE

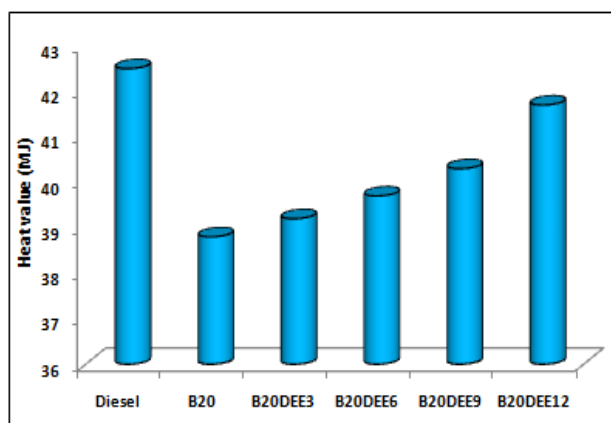


Fig.6: Heat values of B20 with DEE

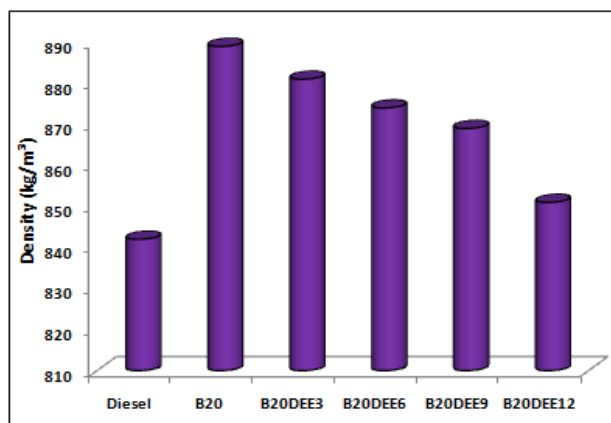


Fig.7: Density values of B20 with DEE

### 3.2 Performance:

i) **Brake Thermal Efficiency (BTE):** Brake thermal efficiency variation with respect to load is shown in fig. 7 for B20 blend fuel at different percentages of DEE additive. The BTE of DEE blends with B20 and B20 are higher as compared to JOME biodiesel. This is because of DEE addition decreases the viscosity of mixture and improves the atomization of fuel; hence combustion is better to release more heat that improves the efficiency.

ii) **Brake specific fuel consumption:** The consumption of blend fuel variation with the addition of DEE is shown in the fig 8. The fuel consumption is less in case of B20 and 3, 6% of DEE, whereas for 9 and 12% are higher with B20 when compared to diesel fuel. Addition of DEE with B20 leads to decrease in BSFC, but further increase in the concentration of additive, it is clearly observed that the value of BSFC tends to increase. The BSFC is higher due to its lower heating value, greater density and high bulk modulus at higher percentages of additive. The minimum BSFC is less than diesel fuel for 6% DEE additive with B20 and is at 3.32%, whereas it is 9.27, 18.3% more than diesel fuel for 9 and 12% addition of DEE additive with B20 blend fuel.

iii) **Exhaust Gas Temperature (EGT):** Fig. 9 shows temperature of exhaust gas with respect to the load on engine. Blend fuels EGT increases with increase in load on engine because more fuel is drawn at higher loads. EGT of diesel fuel is observed higher than all blend fuels tested. In case of biodiesel, EGT is lesser due to lower calorific value than diesel fuel. EGT increased as the percentage of DEE increases, this may be due to higher cetane number which reduces the ignition delay period that changes the burning rate of blend fuel. The exhaust gas temperature of 9 and 12% of DEE additive blend fuels with B20 are 6 and 2.1% below the temperature of diesel fuel at full load on engine because of improvement in the process of combustion.

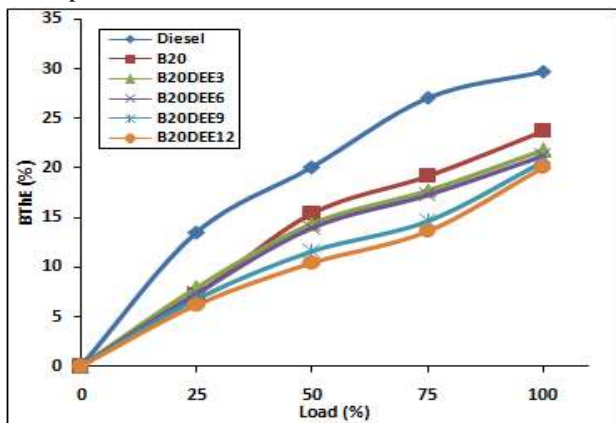


Fig.8: Thermal Efficiency variation with Load

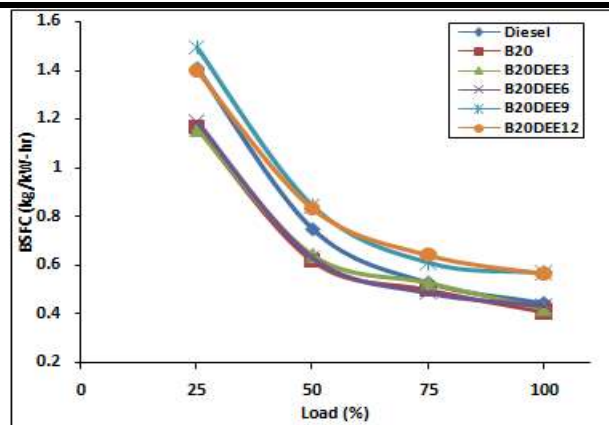


Fig.9: BSFC variation with Load

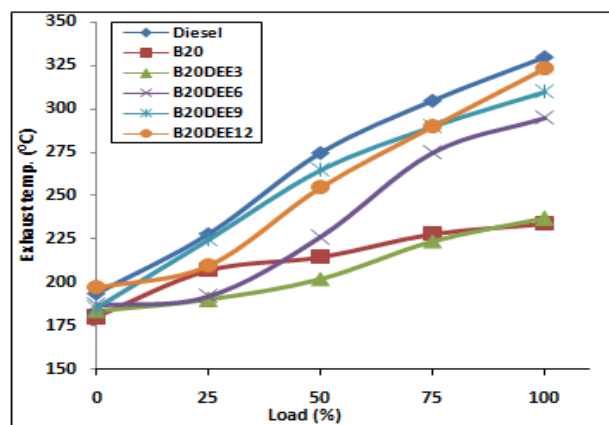


Fig.10: Temperature variation with Load

#### IV. CONCLUSIONS

From the experiments conducted the following conclusions are drawn:

- The minimum BSFC is for 6% DEE with B20 blend and 3.32% less than diesel fuel. Brake thermal efficiency of engine increases by addition of DEE additive which provides complete combustion to release heat and reduce carbon emissions.
- Exhaust gas temperature of 9 and 12% of DEE additive with B20 blend fuels are 6 and 2.1% below the temperature of diesel fuel at full load on engine because of improved rate of combustion.
- The addition of DEE additive in B20 decreases the viscosity and density of blend fuel, which leads to better performance.
- A maximum heat value is obtained for 12% of DEE additive with B20 blend fuel was 41.7MJ/kg, which is 7.48% higher heat value than B20 blend fuel used for testing.
- Higher cetane rating of DEE and oxygen content are also advantageous for obtaining lower smoke emission.

## REFERENCES

- [1] Sunil Kumar, A. Chaube, S. Kumar, "Experimental evaluation of C I engine performance using diesel blended with Jatropha biodiesel", *International Journal of Energy and Environment.*, 3(3), pp. 471-484, 2012.
- [2] Cengiz Oner and Sehmus Altun, "Biodiesel production from inedible animal tallow and an experimental investigation of its use as alternative fuel in a direct injection diesel engine", *Journal of Applied Energy*, 86, pp. 2114-2120, 2009.
- [3] Venkateswara Rao P., S. Ramesh, "Optimization of Biodiesel production parameters (Pongamia pinnata oil) by transesterification process", *Journal of Advanced & Applied Sciences*, 3(3), pp. 84-88, 2015.
- [4] Bhale P V, Deshpande N V and Thombre S B, "Improving the Low Temperature Properties of Biodiesel Fuel", *Renewable Energy*, 34, pp. 794–800, 2009.
- [5] M. Vijay Kumar, A. Veeresh Babu, P. Ravi Kumar, "The impacts on combustion, performance and emissions of biodiesel by using additives in direct injection diesel engine", *Alexandria engineering Journal*, 57(1), pp. 509-516, 2018.
- [6] P. Venkateswara Rao, D. Prabhakara Chary, "Characteristics comparison of Biodiesel-Diesel Blend (B20) Fuel with Alcohol Additives" *International Journal of Advanced Engineering Research and Science*, 5(8), pp. 128.132, 2018.
- [7] H. K. Rashedul, H. H. Masjuki, M. A. Kalam, A. M. Ashraful, S. M. Ashrafur Rahman, S .A. Shahir, "The effect of additives on properties, performance and emission of biodiesel fuelled compression ignition engine", *Energy Conversion and Management*, 88, pp. 348-364, 2014.
- [8] Ramesh Babu P., Prasada Rao K., Appa Rao B V., "The role of oxygenated fuel additive (DEE) along with Mahuva methyl ester to estimate performance and emission analysis of DI-diesel engine, *International Journal of Thermal Technologies*, 2(1), pp. 119-123, 2012.
- [9] M Iranmanesh, J P Subrahmanyam and M K J Babu, "Potential of Diethyl Ether as a Blended Supplementary Oxygenated Fuel with Biodiesel to Improve Combustion and Emission Characteristics of Diesel Engines", *SAE Paper No. 2008-01-1805*, 2008.
- [10] Sivalakshmi S, Balusamy T., "Effect of biodiesel and its blends with diethyl ether on the combustion, performance and emissions from a diesel engine", *Fuel*, 106, pp. 106–110, 2013.
- [11] Venkateswara Rao P. and B. V. Appa Rao, "Performance, Emission and Cylinder Vibration studies of DI diesel Engine with COME-Triacetin Additive Blends", *International Journal of Engineering, Science and Metallurgy*, 1(2), pp. 300-309, 2011.
- [12] P. Venkateswara Rao, and B. V. Appa Rao, "Heat release rate, performance and vibration analysis of diesel engine operating with biodiesel - Triacetin additive blend fuels", *International Journal of Automobile Engineering Research and Development*, 8(2), pp. 1-12, 2018.
- [13] N. Miyamoto, H. Ogawa and T. Arima, "Improvement of Diesel Combustion and Emissions with Addition of Various Oxygenated Agents to Diesel Fuels," *SAE Paper No. 962115*, 1996.
- [14] Subramanian K A, Ramesh A., "Operation of a compression ignition engine on diesel-diethyl ether blends", *ASME Proceedings-2002, Internal combustion engine division fall technical conference*, Paper No. ICEF2002-517, pp. 353-360, 2002.
- [15] Barabas I., Todorut A., Baldean D., "Performance and emission characteristics of a CI engine fueled with diesel–biodiesel–bioethanol blends", *Fuel*, 89 (12), pp. 3827-3832, 2010.
- [16] Mohanan P, Kapilan N, Reddy R P., "Effect of diethyl ether on the performance and emission of a 4-S DI diesel engine", *SAE paper No. 2003-01-0760*, 2003.
- [17] P. Venkateswara Rao, "Role of Triacetin additive in the performance of single cylinder D I diesel engine with COME biodiesel", *International Journal of Advanced Engineering Research and Science*, 5(8), pp. 128-132, 2018.
- [18] P. Venkateswara Rao and B. V. Appa Rao, "An Application to Detect Knock and Combustion Severity of Diesel Engine Working with Biodiesel (COME)-Additive Blends Using Cylinder Vibration Signature" *The IUP journal of mechanical engineering*, 8(2), pp. 17-28, 2015.
- [19] Prabhakaran B., Dinoop Viswanathan, "Experimental investigation of addition of ethanol to biodiesel on performance, combustion and emission characteristics in C I engine", *Alexandria engineering Journal*, 57(1), pp. 383-389, 2018.

# Extraction and Evaluation of Tamarind Kernel Mucilage powder for Hydrocolloidal Properties

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**Abstract**— Hydrocolloids are commonly used as dietary fibers, thickeners, gelling agents, emulsifiers, stabilizer, fat replacers, clarifying agents, flocculating agents, clouding agents and whipping agents. The development of applicable hydrocolloids from crops and food disposals allow the recovery, recycling and sustainability of high value-added ingredients in the food chain.

Tamarind seeds are subjected to various methods (soaking, drying, parching) for removal of seed coat. Finally parching at 80c for 20min resulted in 72% seed coat removal. The kernels were then milled through 355µm mesh using hammer mill. TKM is isolated from powder by hydrating TKP and dried with spray dryer which yielded 40% of TKMP. Physical and bio chemical parameters are studied for the kernel powder and mucilage powder. Functional properties such as solubility, water holding capacity, oil holding capacity, swelling index, emulsifying ability and foaming capacity were analyzed.

Solubility, WHC, OHC increased with increase in temperature, foaming and emulsifying capacity increased with increased weight to volume ratio of mucilage powder. The efficiency of using TKMP as coating agent was studied by dipping potato wedges in different aqueous 0.5% solutions of CMC, xanthan gum and TKMP. The percent coat pick up of TKMP was recorded as 6% which is higher than CMC. The percent frying yield of potato wedges dipped in TKMP solutions recorded 68.4% which is higher than the potato wedge dipped in CMC solution (60.97%). These results show that TKMP can be effectively used as coating material for increasing frying yield of the samples.

**Keywords**— Tamarind seeds, hydrocolloids, TKP, TKM, TKMP, emulsifying ability, foaming capacity.

## I. INTRODUCTION

Mucilage is mainly water soluble polysaccharide. Plant mucilage are most widely used as thickening agent, binding agent, suspending agent,

emulsifying agent, stabilizing agent, gelling agent. They also possess characteristics of sustainable release in to the product when added. (Gandhi *et al*, 2012)

Mucilages extracted from seeds are sources of natural hydrocolloids with low-cost offering a low-calorie intake turning it in an ideal product for the development/improvement of health products with beneficial properties to human consumption, making them a potential option for application in the food.

Tamarind seed polysaccharide is a natural polysaccharide. Tamarind seed polysaccharide contains monomers of galactose, xylose and glucose sugars with each other by covalent bonds. Polymers are used present in a molar ratio of 3:1:2, which constitutes 65% of the seed components. Xylose is very crucial sugar of tamarind seed, which can be used for xylitol production, Tamarind seed polysaccharide is mainly water soluble polysaccharide. (Malviya *et al*, 2012)

The tamarind seed mucilage dispersed in water has the ability of forming viscous solutions, with high thermal and chemical stability, edible, biodegradable, non-carcinogenic, biocompatible and nontoxic properties (Sharma *et al.*, 2014). Tamarind mucilage contains high amount of many essential amino acids, like isoleucine, leucine, lysine, methionine, phenylalanine and valine (Panigrahi *et al.*, 1989), making the mucilage affordable as food additive.

Due to high water activity of mucilage ( $a_w > 0.90$ ) and carbohydrate composition, the shelf life is limited to hours at room temperature, so it is necessary to use a conservation process to preserve most of the active ingredients and increasing its life span. One of the most common technologies for this purpose is drying; particularly spray drying which allows the properties of the product such as color, flavor and nutrients to be retained in high percentages (León-Martínez *et al.*, 2010).

As tamarind seed is a byproduct from pulp industry and the hydrocolloids which are in food uses are expensive. So, an attempt was made to extract the

mucilage from tamarind kernel. As the mucilage doesn't possess any shelf life properties it is spray dried to evaluate for hydrocolloid properties.

Therefore, the aim of the present study was to extract and evaluate the functional properties and physicochemical characteristics of tamarind seed mucilage powder with the following objectives:

- a. Extraction of tamarind seed mucilage and spray drying
- b. Evaluation of spray dried mucilage for its functional and physico chemical properties.

## II. MATERIALS AND METHODS

Tamarind seeds were procured from the local markets of Bapatla. Physical properties like length, thickness are measured using vernier calipers. Density, Sphericity and number of seeds/100g were performed for both tamarind seeds and kernels. Tamarind seeds are subjected to various treatments for efficient seed coat removal (Fig 1)

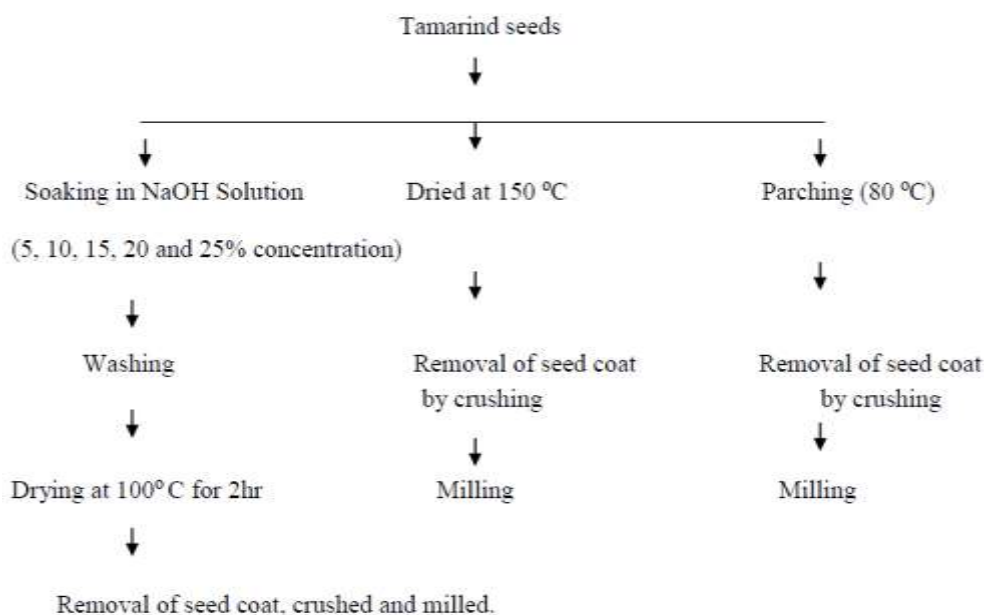


Fig 1: Flowchart of treatments for seed coat removal

Percent seed coat removal was calculated using the following formula

$$\% \text{ removal of seed coat} = \frac{\text{Wt of the seeds taken} - \text{Wt of the seeds without seed coat}}{\text{Total weight of the seeds taken}} * 100$$

After every treatment tamarind seeds without seed coat were milled through 355 µm mesh by using hammer mill. The percentage of extraction yield of kernel powder was calculated by following equation,

$$\% \text{ Extraction yield} = \frac{\text{Wt of the kernel powder}}{\text{Total weight of the seeds taken}} * 100$$

The moisture content of tamarind kernel seed powder was determined by air oven drying method by placing about 2 g of sample for 24 h in an air oven maintained at 103 ± 1 °C (AOAC, 2000). The moisture content (m.c.) on wet

basis (w.b.) was calculated by using the following equation,

$$\text{Moisture content (\%w. b.)} = \frac{(w_2 - w_3)}{(w_2 - w_1)} * 100$$

where, w<sub>1</sub> = weight of empty box, g,  
 w<sub>2</sub> = weight of box + weight of sample, and  
 w<sub>3</sub> = weight of box + weight of bone dry material, g.  
 The protein content is measured by using Micro kjeldahl method, The Total Carbohydrate content can be measured by Phenol Sulphuric Acid method, The fat content of the samples is estimated by Soxhlet method. Swelling index of tamarind seed polysaccharide was determined by using the formula

$$\text{Swelling Index} = \frac{\text{Increase in the height of graduated cylinder}}{\text{Height at initial addition}}$$

Tamarind kernel Mucilage (TKM) extraction was done using the following procedure

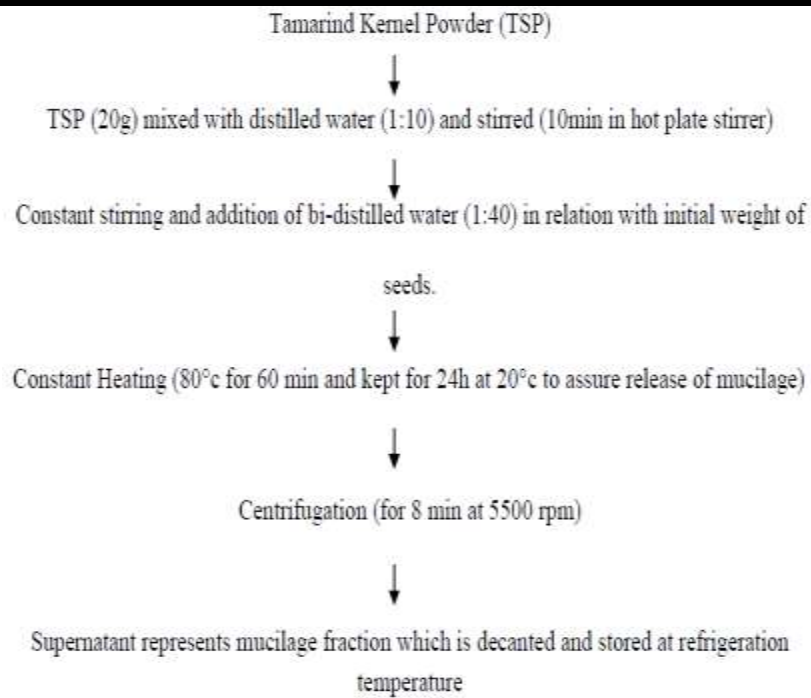


Fig 2: Flowchart for extraction of TKM

### Spray Drying: Spray drying of mucilage:

In general, fruits and vegetable juices are being spray dried after adjusting the total soluble solids (TSS) of the juices to 5% by incorporating maltodextrin. It increases the spray drying ability. It acts as an additive.

It was tried in the present study to decrease the addition of maltodextrin to increase the TSS level through trial and error experimentation and achieved spraying capability for tamarind kernel mucilage. The mucilage (100 mL) was spray dried with a laboratory scale spray dryer (LabPlant SD-05, England) with a concurrent air flow at different inlet drying air temperature  $135 \pm 5^\circ\text{C}$  and the outlet temperature of  $80 \pm 5^\circ\text{C}$ . The realistic values for spray dryer operational parameters were obtained from Lab Plant SD-05 manual.



Fig 3: Spray Dryer

The percentage of extraction yield of powder from mucilage after spray drying was calculated by following equation,

% Extraction yield

$$= \frac{\text{Wt of the mucilage powder}}{\text{Total weight of the mucilage taken}} * 100$$

### Solubility:

Dispersions were prepared with 1.0 g of dry tamarind seed mucilage in 10 mL of bi distilled water at different conditions of temperature ( $15^\circ$ ,  $25^\circ$ ,  $45^\circ$ ,  $55^\circ$ ,  $65^\circ$ ,  $75^\circ$  and  $85^\circ\text{C}$ ) for 30 min with continuous stirring at 400 rpm. The dispersions were then centrifuged with a cooling centrifuge for 15 min at 5500rpm. Supernatant were dried in a hot air oven at  $100^\circ\text{C}$  for 12 h. Percent solubility was calculated by following equation,

$$\% \text{ solubility} = \frac{\text{Dried weight of supernatant}}{\text{Total weight of the sample taken}} * 100$$

### Water holding capacity (WHC):

The WHC and OHC were evaluated at different conditions of temperature ( $15^\circ$ ,  $25^\circ$ ,  $45^\circ$ ,  $55^\circ$ ,  $65^\circ$ ,  $75^\circ$  and  $85^\circ\text{C}$ ). For WHC, dispersions of 1% (w/v) of mucilage powder were prepared and placed in centrifuge tubes previously weighted containing a magnetic stirrer. Put in an agitation water bath for 30 min at the prescribed temperature. Then, the dispersions were centrifuged for 15 min at 5500 rpm. The supernatant was decanted, and the sample was reweighed.

$$\text{WHC g/g} = \frac{\text{Dried weight of supernatant}}{\text{Total weight of the sample taken}}$$

### 3.7.3. Oil holding capacity (OHC)

For the OHC at 15°, 25°, 45°, 55°, 65°, 75° and 85° C at 1% dilution of powder mucilage with corn oil (w/v) was prepared in a previously weighted centrifuge tube containing a magnetic stirrer. And put in an agitation water bath for 30 min at the prescribed temperature. The dilution was centrifuged the supernatant was decanted and the swollen granules were weighted.

$$\text{OHC g/g} = \frac{\text{Weight of oil absorbed sample}}{\text{Total weight of the sample taken}}$$

**Emulsifying ability**

Homogenized mixtures prepared (0.2, 0.4, 0.6, 0.8 and 1.0 %) from mucilage powder and 10 mL corn oil were homogenized at 6400 rpm. The homogenized mixture was centrifuged at 5500 rpm for 10 minutes.

$$\text{Emulsifying ability} = \frac{\text{Emulsion volume}}{\text{Total volume}} * 100$$

**Foaming capacity**

Mucilage powder dispersions (0.2, 0.4, 0.6, 0.8 and 1.0 %) were prepared and whipped. Foaming capacity of the powder was calculated by the following equation

$$\text{Emulsifying ability} = \frac{\text{Foam volume}}{\text{Total suspension volume}} * 100$$

**Percent coat pick up and frying yield**

The percent coat pick up was calculated after dipping the sample (Potato wedges) in various prepared hydro colloidal solutions for 1 minute. Percent coat pick by the sample was calculated by the following equation

$$\text{Percent coat pick up} = \frac{\text{Wt of sample after dipping} - \text{Wt before dipping}}{\text{Initial weight of the sample before dipping}} * 100$$

**Frying yield**

Frying yield of the sample treated with different hydrocolloids after tray drying at 80° C for 25min was calculated by deep fat frying the sample in edible oil at 180° C for 1 minute.

Frying yield

$$= \frac{\text{Weight of the sample after frying}}{\text{Initial weight of the sample taken for frying}} * 100$$

**III. RESULTS AND DISCUSSION**

Table.1: Physical properties of seeds and Kernel

Properties	Tamarind seeds	Tamarind kernel
Length	15.04mm	14.25mm
Thickness	6.41mm	5.26mm
Density	1.43g/cc <sup>3</sup>	1.12g/cc <sup>3</sup>
Sphericity	0.74	0.72
No of seeds/100g	32	25

As the seed coat is removed all the physical property values are less for kernel. The percentage of seed coat is 20% and the kernel which is also called as endosperm is about 80% weight of the total seed weight.

Among all the combinations of the treatments parching for 22 min resulted in higher percentage of seed coat removal (72%) when compared with other treatments. 25% concentration of soaking in NaoH resulted higher percentage in seed coat removal (25%). 30% concentration of NaoH resulted in leaching of mucilage and also more absorption of moisture which resulted in higher drying time. Among drying samples, drying for 75 min resulted in 52% of removal of seed coat. More prolonged time of drying resulted in increase of volume of tamarind seeds and explosion of the seeds have been observed.

Parching for 25 min still resulted for higher percentage (76%), but the color of the kernel inside has been changed to dark brown due to the effect of temperature charring and dextrinisation. So, comparing between combinations of all the treatments parching for 22 min i.e., 72% removal of seed coat was considered as best option. After parching, tamarind seeds are crushed to remove the seed coat and were milled through 355 µm mesh by using hammer mill. 78.84% kernel powder was obtained after milling.



Fig.4: Tamarind Kernels and Powder

Table.2: Parameters of Tamarind Kernel Powder (TKP)

Properties/parameters	Readings
Bulk density	0.508g/cc
Tap density	0.526g/cc
Carr's index	3.422
Moisture content	2%
Protein	20.02g/100g
Total Carbohydrates	74.50g/100g
Fat	20g/100g

Protein content in kernel powder is about 20.02g/100g which is higher than the protein content of wheat flour. The protein content of the tamarind kernel powder has nutritional significance, and as such intake of the powder by substitution or replacement in different product formulations will greatly increase the total dietary intake of consumers. Total carbohydrates present in kernel powder (74.50g) are almost close to the carbohydrate values of other starchy grains/seeds. Due to its higher carbohydrate content and higher fat content

(20g/100g) it can be used as mucoadhesive and also as thickening agent in different food products.

The swelling index of the TKP is 2.75. Water retention capacity was found to be 5mL/g of the sample.

This was attributed due to the presence of good protein content along with the polysaccharides.

#### Extraction of Tamarind Kernel Mucilage (TKM):

Table.3: Combination of kernel powder to water ratio for mucilage extraction

Seed powder water ratio used for stirring	Amount of water addition for heating	Total seed powder : water ratio	Mucilage remained after condensing, mL
20g:50mL (1:2.5)	800mL (1:40)	1:42.5	170 mL
20g:100mL (1:5)	800mL (1:40)	1:45	200 mL
20g:150mL (1:7.5)	800mL (1:40)	1:47.5	220 mL
20g:200mL (1:10)	800mL (1:40)	1:50	250. mL

Among all the combinations used for extraction of mucilage from TKP 1:50 (Total seed: Water) ration found to be effective and the mucilage leached into water is about 250mL after condensation. About 250 ml of TSM is subjected to spray drying by adding 1% of malto dextrin with an Inlet temperature:  $135 \pm 5^\circ\text{C}$ , Outlet temperature:  $80 \pm 5^\circ\text{C}$  and Pressure of compressed air: 4 bar. The extraction yield after spray drying is 40% (8g of TSMP).

Table.4: Physical and bio chemical Parameters of TKMP

Parameters	Readings
Bulk density	0.367g/cc
Tap density	0.372g/cc
Carr's index	2.4
Moisture content	2%
Protein	14.78 $\pm$ 0.45%
Total CHO	69.76 $\pm$ 0.72%
Fat	4.76 $\pm$ 0.36%
Ash	0.702 $\pm$ 0.12%

Results presented in table 4 of various parameters of Tamarind Seed Mucilage Powder. As the difference between bulk and tapped density values are close which indicates that the powder has lesser inter particle interactions. Carr index value of the TSMP is 2.4 indicates that the powder has good flow ability. The Carr's index of TSMP is lesser than TKP.

#### Functional properties of mucilage powder

Solubility of tamarind seed mucilage particles showed that the solubility increased with increase in temperature. There was a drastic increase in the solubility percent till a temperature of  $45^\circ\text{C}$  ( $76.4 \pm 0.31\%$ ), from this point for every  $10^\circ\text{C}$  raise in the temperature the increase in the solubility percent was minimum. Heating above  $75^\circ\text{C}$  ( $88.14 \pm 0.50\%$ ) showed solidifying effect

due to high temperature and this type of insolubility might be due to the removal of water of imbibitions from the protein particles, since such an explanation would account for the effect of hot water in restoring the solubility of the protein.

Water holding capacity (WHC) is an important property in food technology from a viewpoint of stability, yield, texture and sensory evaluation. WHC represents the amount of water held and absorbed by the hydrated sample afterward an external force is applied. WHC for tamarind seed mucilage particles is showed in Table 4.7, this value increased as temperature was increased. This may be explained because an increment on temperature results in an increment on molecular mobility of molecules promoting the water absorption till  $65^\circ\text{C}$  ( $0.6 \pm 0.024\text{g/g}$ ). Decreasing trend was observed after increasing of temperature above  $65^\circ\text{C}$ . At the temperature of  $75^\circ\text{C}$  the WHC recorded was  $0.54 \pm 0.056\text{g/g}$ .

As the temperature increased OHC of the TSMP has increased till  $65^\circ\text{C}$  ( $4.0 \pm 0.04\text{g/g}$ ) and OHC showed a decline trend when further heated to  $75^\circ\text{C}$  ( $3.33 \pm 0.07\text{g/g}$ ). Similar values of OHC were observed in durian seed gum (Amid and Mirhosseini, 2012) in guar and xanthan gum (Segura-Campos et al., 2014). These values of OHC shows that tamarind seed mucilage powder could play an important role in food processing, since fat acts on flavor retainers and increases the mouth feel of foods.

Emulsifying ability increased when the weight of spray dried tamarind seed mucilage/volume of oil ratio was increased. This fact can be explained from the increase in the fraction of mucilage and a subsequent increase of the chains of the branched structure among the surface active to absorb oil molecules that lower the surface tension. TSMP's emulsifying ability was done using 0.2, 0.4, 0.6, 0.8 and 1% concentrations of powder.



Highest emulsifying ability was recorded at 1% concentration ( $92.4 \pm 0.005\%$ ).

Good foaming properties are linked with flexible mucilage structure that can reduce surface tension. This effect is attributed to the increased amount of mucilage, which is transported to the interface to form visco elastic films that improve the foam formation. As the concentration increased foaming capacity also increased. Highest foaming capacity was recorded at 1% concentration ( $3.70 \pm 0.04\%$ ).

Among all the treatments sample treated with xanthan gum has the highest coat pick up (34%), this is due to the viscosity of the xanthan gum is more among the three treatments at particular concentration. The percent coat pick up of TKMP was recorder as 6% which is higher than CMC. The percent frying yield of potato wedges dipped in TKMP solutions recorded 68.4% which is higher than the potato wedge dipped in CMC solution (60.97%). Highest yield was observed in potato wedges dipped in xanthan gum solution (75.6%). These results show that TKMP can be effectively used as coating material for increasing frying yield of the samples.

#### IV. SUMMARY AND CONCLUSIONS

Carr index value of the TSMP is 2.4 indicates that the powder has good flowability. The Carr's index of TSMP is lesser than TKP.

There was a drastic increase in the solubility percent till a temperature of  $45^{\circ}\text{C}$  ( $76.4 \pm 0.31\%$ ), from this point for every  $10^{\circ}\text{C}$  raise in the temperature the increase in the solubility percent was minimum. Decreasing trend was observed after increasing of temperature above  $65^{\circ}\text{C}$ . At the temperature of  $75^{\circ}\text{C}$  the WHC recorded was  $0.54 \pm 0.056\text{g/g}$ . As the temperature increased OHC of the TSMP has increased till  $65^{\circ}\text{C}$  ( $4.0 \pm 0.04\text{g/g}$ ) TSMP's emulsifying ability was done using 0.2, 0.4, 0.6, 0.8 and 1% concentrations of powder. Highest emulsifying ability was recorded at 1% concentration ( $92.4 \pm 0.005\%$ ). Highest foaming capacity was recorded at 1% concentration ( $3.70 \pm 0.04\%$ ). The percent coat pick up of TKMP was recorder as 6% which is higher than CMC. The percent frying yield of potato wedges dipped in TKMP solutions recorded 68.4% which is higher than the potato wedge dipped in CMC solution (60.97%). These results show that TKMP can be effectively used as coating material for increasing frying yield of the samples.

Apart from coating agent TKMP can also be considered as effective stabilizing, emulsifying and foaming agents in food formulations instead of artificial (synthetic) extracted sources.

#### REFERENCES

- [1] Gandhi, K.K.J., Deshmane, S.V. and Biyani, K.R. 2012. Release Matrix Tablets Prepared by Wet Granulation Polymers in Pharmaceutical Drug Delivery System: a review. *International Journal of Pharmaceutical Sciences Reviews and Research*. **14**(2): 57-63.
- [2] Malviya, R., shukla, P., Srivatava, R. and kulkarni, GT. 2012. Preparation and characterisation of mango peel pectin as disintegrated polysaccharides. *MEdyCyne*. **42**(3), 185-190.
- [3] Sharma, M., Mondal, D., Mukesh, C. and Prasad, K. 2014. Preparation of tamarind gum based soft ion gels having thixotropic properties. *Carbohydrate Polymer*. **102** (1): 467-471.
- [4] Panigrahi, S., Bland, B. and Carlaw, P.M. 1989. The nutritive value of tamarind seeds for broiler chicks. *Animal Feed Sci. Technol.* **22** (4): 285-293.

# An Experiment with 3 Layers Development for IoT with NodeMCU12e + Nextion

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**Abstract**—This paper presents the results of an experimental research with the development of a 3 layer solution for the Internet of Things using the NodeMCU12e controller and the Nextion touchscreen display to provide monitoring projects for individuals who require remote monitoring and special care, involving the health area, monitoring of patients, children or people who are in medical treatment who need a remote monitoring. The results demonstrated the possibilities for creating solutions that could serve as a basis for new projects with greater amplitude, contributing to more robust solutions that can meet different types of products that can collaborate with the health of the population in general.

**Keywords**—IoT; NodeMCU12e; Nextion; development; layer.

## I. INTRODUCTION

Due to the increase in the development of new solutions for the creation of products for the Internet of Things, this work has as main objective to present the results obtained with the development of experiments with the use of programming in 3 layers, using devices for monitoring of individuals requiring special care, which can be monitored remotely using devices developed for the Internet of Things or IoT.

As specific objectives, a solution should be presented using the C++ programming language, usually used with development of solutions for the Arduino controller, the PHP development language, for building the business layer, the AppInventor tool for building the interface on a Smartphone device, a database developed with MySQL

The motivation for the development of this project came from the observation during the participation on health projects, in which the absence of solutions and academic materials was identified, which could collaborate to create solutions in which there is a need for distance monitoring of patients, who need special needs,

such as the elderly, people who are injured, children, or even people who are bedridden, for some temporary period.

There are many technical materials, but few have characteristics and content aimed at developing a solution for the Internet of Things, especially with the object of scientific research, for this fact this work intends to contribute to the development and improvement of solutions that can serve as a basis for academic and scientific studies.

The concept of Internet of Things is mainly used when thinking about creating solutions for residential and industrial automation, a few materials deal with the application of the Internet of Things to the health area, because it is a study that involves different areas such as electronics, computing, software development, database and internet, the creation of projects to address this type of solution, is characterized as very complex.

This project presents the technical results obtained with the creation of a solution for the application of software development technologies in the period of 2018, in which the knowledge about the studies carried out was applied, proposing a model that could be used in different types of projects, allowing a coupling or extension of its resources in new models that use 3 layers of development.

## II. BIBLIOGRAPHY REVIEW

The materials available in the IEEE Xplore library, IEEE Latinamerica, were used as a study base, which did not present significant contents which could contribute to the development of this project, presenting a gap for the contribution of academic material that can collaborate with the development of solutions more robust, with similar characteristics, or even to complete other studies to be developed.

Based on studies of the Internet of Things, as explained by CERN and ITU-IT, it is considered the use of devices that can be connected between different

objects, such as those used in residences, companies, among other places. The connection between these objects, or things, allows the individual to control the different objects remotely, or even controlled according to their profile.

When using three-tier development, it is possible to create a database infrastructure, a layer to control the business rules, this being the programming code itself, on the other hand, there is the creation of graphical interfaces, so that the platform can be accessed in different places, with different devices.

The studies about IoT (Internet of Things) were developed about authors as: Kargin et al. [3]; Rajalakshmi & Shahnasser [4]; CERP [7]; Minchev & Dimitrov [8]; Hejazi et al. [10]; Miladinovic et al. [11]; ITU-T [15]; Raj & Sankar [16]; Özgür et al. [17]; Poongothai et al. [18]; Srinivas et al. [20]; Singh et al. [12]; Hlaing et al. [25].

For the devices operations were used technical materials, as documents, manuals, technical references from manufacturers, and others as: Arduino [6]; Škraba et al. [5]; Bento [1]; Bento [2]; Oliveira et al. [9]; Singh et al. [12]; Itead [13]; IteadlibNextion [14]; Srivastava et al. [21]; Saha & Majumdar [24]; Pakalapati et al. [23]; Barai et al. [22].

During the research, the IEEE Xplore databases, IEEE LatinAmerica, the Scopus database, were used as the information base. During the research, the key words that involved this study were used during the research, but few references were found on the subject addressed, references on the devices for the Internet of Things, were found in few quantities in these bases, the few that were located, were used during this study, thus this lack of research papers, provided an opportunity for the development of this study.

### III. METHODS AND MATERIALS

As a methodology, the experimental research was used, in which experiments were developed with the selected devices and tools, considering the hypothesis for the creation of a solution that can be used in different environments, serving as the basis for the development of more complex projects, the which can be adapted with different types of resources. Usually used for solutions that meet the needs of individuals who need to control or monitor objects in different locations, or even people.

After the studies on the devices and tools, the experiments were applied considering the connection and data transmission during the testing phase, prototypes were created considering the technical documentation and operations manuals provided by the manufacturers. In addition to other scientific materials that were used as a

research base, providing an understanding of the processes required to create the solution.

As tools were used the Windows 10 operating system; the IDE to build the screen for the Nextion display; the Arduino IDE for the construction of the algorithm for the controller; the 000WebHost webpage server includes the construction of pages in the PHP language, also for the creation of the MySQL database; the AppInventor MIT tool for creating the interface used with a smartphone.

The devices used are: a Compaq Presario notebook with Windows 10 64 bits; a NodeMCU12e device as controller and WiFi network access; a Nextion touchscreen display device; a Samsung Galaxy SmartPhone with Android; a WiFi network for remote data transmission and replay.

### IV. RESULTS AND ANALYSIS

With the three-layer design, there is the structure of a three-way communication, such as a layer for interface, in this layer solutions are developed for access to the business layer, this being the second layer, used for treatment of the business rules created with the necessary algorithms for the validation of the data, being this the third layer, for storage and access to the data.



Fig. 1. Three layer development model.

The NodeMCU12e controller was selected for its low cost, compared to other devices available in the national and international market, due to its specific characteristics, in which it already has an integrated WiFi devices, considering its high capacity of storage, processing and size, these being its main advantages compared to other devices like the Arduino Uno. Considering the studies developed by Bento [1].

The Nextion touchscreen display was used in this project because it has advantages in comparisons with other devices, such as a proprietary IDE, has a reduced number of connection cables, with reduced size, storage and processing capacity, superior to other models, considering the model ILI9341, comparative results of a study developed by Bento [2].

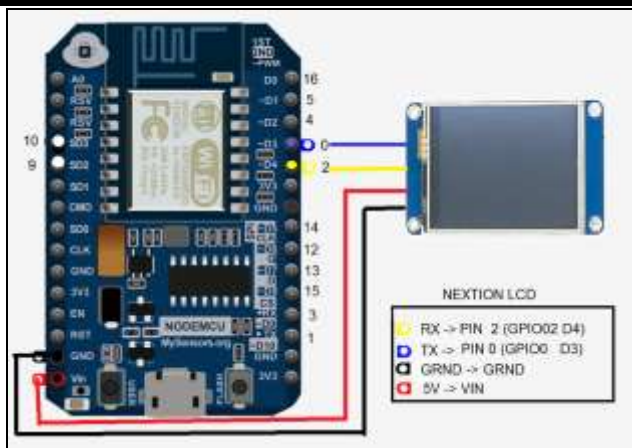


Fig. 2. Connection scheme with the devices NodeMCU12e and the Nextion touchscreen display.

The following is part of the code used for accessing the WiFi network by the NodeMCU12e device, firstly the configuration of the email and password for accessing the WiFi network is performed, soon after the attempt is made to access the network, as demonstrated in the algorithm. After access the data is transferred to the data layer.

```
int loop_wifi_get(String v_dev, String v_sensor, String v_radio, String v_dtrec)
{ if (WiFi.status() != WL_CONNECTED) {
  Serial.println(F("Error during connection...\r\n"));
  Serial.println(esid.c_str());
  Serial.println(epass.c_str());
  Else {
    WiFiClient client;
    // Attempt to make a connection to the remote server
    if ( !client.connect(HOST_NAME, HOST_PORT) ) {
      Serial.println(F("Not success..."));
      Serial.println(F("Tentando enviar GET..."));
      // Make an HTTP GET request
      //cod_sensor val_sensor val_reg event_date
      event_message cod_patient
      v_dtrec=Formata_relogio("");
      Serial.println("GET
      /_action.php?txt_v_dev="+String(v_dev)+"&txt_v_senso
      r="+String(v_sensor)+"&txt_v_radio="+String(v_radio)+
      "&txt_v_dtrec="+v_dtrec+" HTTP/1.1");
      client.println("GET
      /_action.php?txt_v_dev="+String(v_dev)+"&txt_v_senso
      r="+String(v_sensor)+"&txt_v_radio="+String(v_radio)+
      "&txt_v_dtrec="+v_dtrec+" HTTP/1.1");
      client.print("Host: "
      client.println(HOST_NAME);
      client.println("Connection: close");
```

```
client.println();}}
```

A. First layer (the interface)

With the algorithm in the NodeMCU12e devices, it was possible to send data, such as for pulse control, humidity, heart rate, then send the device code so that it can be used to create reports in future consultations, allowing the presentation by graphics, images, or even in reports with filters, all this information is stored in the layer of data, which receives the data sent through the internet, using the algorithms of the business layer.

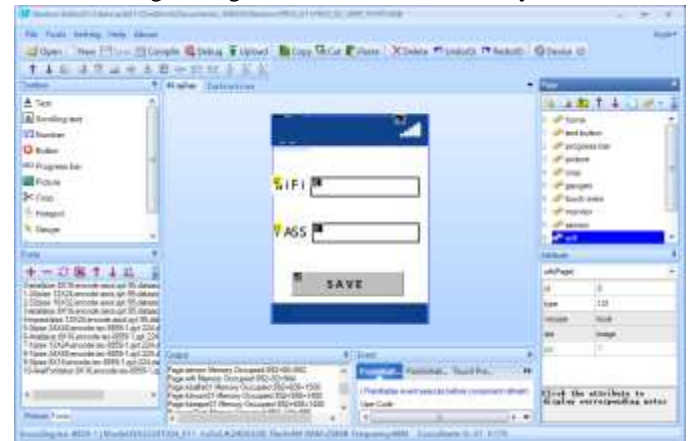


Fig. 3. ITEAD editor for Nextion display screen project created for the solution, to validate the WiFi access.

The following screens were created to allow access to the settings for the WiFi network, allowing the entry of Login ID and access Password for the WiFi devices, in this way it is possible to start the data for tests. This data was used for reading at the business and data layer with the Smartphone.



Fig. 4. The main screen for entry login acces and password, created with ITEAD editor for Nextion display.

This interface layer was created to facilitate the configuration of the NodeMCU12e device, enabling the validation of access and transmission of collected data during a patient monitoring process, served as a communication medium for the internet transmission to the business layer, the which should receive the

transmitted data, at this point the data is validated by the router of the residence, the data on the WiFi network and password should be recorded in the device NodeMCU12e for future access.

Another layer of interface was created to allow the user access that should monitor the data remotely, using a smartphone device with the Android operating system, so it is possible that even the distance monitoring is possible, for the development of the solution was used the platform of IT AppInventor, developed for programming in blocks, facilitating the understanding of the process.



Fig. 5. Appinventor screen for user and password authentication.

In the screen of the appinventor that is used in the mobile phone, only the user and password information that is registered in the main system are validated, after the validation of the user the other screens should be possible, allowing the visualization of the reports.

The appinventor works with the development of algorithms in the form of blocks, allowing to drag the components to compose a rule of validation of the steps to be used during the process. Some of the main rules that were used during the project are presented.



Fig. 6. Part of the algorithm created with the AppInventor for user and password validation.

During the creation of the screens with the appinventor, it is necessary to carry out the construction of the solution using the tools menu, after the creation of the project package, which should have the .APK file extension, the created file can be sent by email, or directly to the cell phone via USB cable, or even through the internet with

the access by QRCode, another way, is to send the package by email, soon after this should be installed on the smartphone.



Fig. 7. The smartphone interface screen for user and password validation.

After confirmation of access to the user and password registered in the system, the user should be directed to a monitoring screen, in which should be alerted if there is any occurrence of the type increase in temperature or of the patient's heart rate, in this way who is monitoring can monitor the events immediately and take some action to check if the patient needs any special care.

At this point the smartphone performs the internet access, sending the user data and password, from the other page the page server which has the codes in PHP, perform the validation of the username and password, giving the interface a message, informing if the access was successful or not, if it has been successfully completed the system in smatphone should release access to pass next pages.

#### B. Second layer (the algorithm)

The second layer was developed with the PHP development language, for the application was created an algorithm to verify the user's email and password, registered in a database with the MySQL Database Management System, this being the storage used in the third layer, which should be presented next. The algorithm in the second layer allows access using an internet network, in which data is sent by the Post or Get methods, depending on the model adopted.

```
<?php
$db = "dbname";
$dbuser = "dbuser";
$dbpass = "dbpassword";
$connection =
mysqli_connect("dbservernameorlocalhost", $dbuser,
$dbpass) or print (mysqli_error());
```

```

mysqli_select_db($connection,$db) or
print(mysqli_error($connection));
$email=$_POST['femail'];
$password=$_POST['fpass'];
$sql = "SELECT * FROM user_regs WHERE
user_email='$email' and
aes_decrypt(user_pass,'passencrypt')='$password'";
$result=mysqli_query($connection, $sql) or die
(mysqli_error());
$rows=mysqli_num_rows($result);
if ($rows>0) {
while($cons = mysqli_fetch_array($result)) { }
echo "<center>Success</center>"; }
else { echo "<center>Error</center>"; }
mysqli_close($connection);
?>

```

The algorithm was made available in a web environment, in the case 000WebHost, a web hosting service, also had a MySQL database system integrated to the environment, which facilitated the construction of the solution. The algorithm makes the call on the database server, the access settings must be entered correctly during access.

After access is sent a message on the page informing if the connection and the access data are correct, returning the message Success, in case of success and Error in case of failure during the validation of the email and password.

The second layer must be available in a web environment, to facilitate access in different devices, providing portability and accessibility in different locations and devices, in the case of this project an application developed with AppInventor is who should perform the interface between the algorithm and the database that is in the third layer.

### C. Third layer (the database)

The creation of the third layer was done using the web access environment, by the db4free site, which allows the creation of database structures in MySQL for testing and validation of programs, another alternative is the use of the environment 000WebHost, which also allows the creation of environments for testing, the steps for the creation are the same, changing only the access address for the servers, username, password and database name.

The following algorithms demonstrate how to create the database, insert records and construct the inserted data, allowing access remotely, using internet resources, this same environment can be used for larger and complex projects, serving as a basis for the creation of more robust solutions.



Fig. 8. The database phpMyAdmin login screen, for second layer creation..

Access to create the database structure was developed using the phpMyAdmin graphical interface, after selecting the database and the creation screen for queries, the development environment for the project was created.

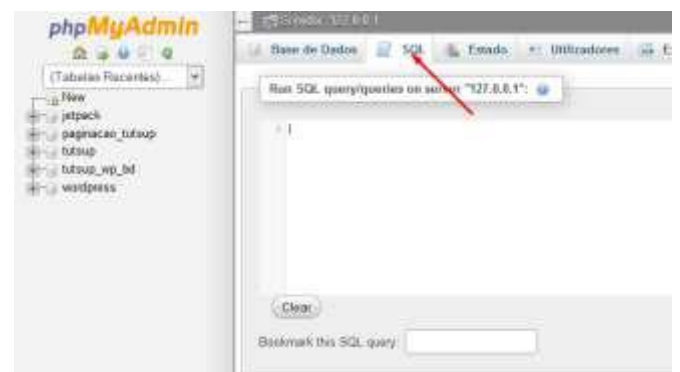


Fig. 9. Query construction with the phpMyAdmin.

```

//Creating the database with user, email and password
encrypted
CREATE TABLE user_regs ( cod_reg int(11) NOT
NULL PRIMARY KEY AUTO_INCREMENT,
user_name varchar(60),
user_email varchar(40) UNIQUE KEY,
user_pass varbinary(256) NOT NULL ) ;
//Inserting records with user, email and encrypted
password
INSERT INTO user_regs (user_name, user_email,
user_pass) values ('Antonio','teste@teste.com.br',
aes_encrypt('123', 'uni9'));
//Verifying all records in the database
SELECT * FROM user_regs;
// Testing the password decryption
SELECT user_name, user_email,
aes_decrypt(user_pass,'uni9') FROM user_regs;

```

As shown in figure 7, the project developed in the AppInventor, makes the access by sending the data typed on the smartphone screen, as shown in figure 6, the algorithm should first access the web page that has the algorithm developed in the php language, sending the email address and password provided by the user during access.

The algorithm developed in php should access the database, with the appropriate settings provided during the access, soon after, the algorithm verifies if the email and password, exist in the database, soon after these are validated and informed the success or not during the access.

## V. CONCLUSIONS

The results obtained with the development of this study, allowed to conclude that the construction of solutions in three layers allows the transfer and reception of data in a remote way, enabling a fast communication, allowing the device which should perform the interface, as in this case the smartphone with the Android operating system, has a very small processing load, because the communication with the second layer is who should make the effort to process the data.

With the tests carried out, it was also possible to validate the infrastructure, analyzing its different aspects and resources, allowing a deeper understanding of its main characteristics, considering the weak and strong points, validating the proposal and the research hypothesis, in the presented model a practical test is used, without the intention of being complex, this for the understanding and validation of the results obtained with the tests.

As a future project is intend to build more robust solutions, which can meet more sophisticated projects, since it is understood that more complex solutions need more resources and tools, depending on the type of need, the project can be adapted, because flexibility is very large in relation to the materials used. Hopefully this all can contribute to the development of new projects of scientific research, in which studies are used on the Internet of Things, for the aid of patients, or people with special needs.

## ACKNOWLEDGMENT

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## REFERENCES

- [1] A. C. Bento. IoT: NodeMCU 12e X Arduino Uno, Results of an experimental and comparative survey. International Journal of Advance Research in Computer Science and Management Studies, v. 6, p. 46-56, 2018.
- [2] A. C. Bento. IoT: Results of an Experimental Survey with Nodemcu, Nextion, DS1307 and NRF24L01+. International Journal of Current Innovation Research, v. 4, p. 969-974-974, 2018.
- [3] A. Kargin ; O. Ivaniuk ; G. Galych ; A. Panchenko. Polygon for smart machine application. 2018 IEEE 9th International Conference on Dependable Systems, Services and Technologies (DESSERT). p. 464-468. IEEE Conference.
- [4] A. Rajalakshmi ; H. Shahnasser. Internet of Things using Node-Red and alexa. 2017 17th International Symposium on Communications and Information Technologies (ISCIT). p. 1-4. IEEE Conference.
- [5] A. Škraba ; A. Koložvari ; D. Kofjač ; R. Stojanović ; Vladimir Stanovov; Eugene Semenkina. Prototype of group heart rate monitoring with NODEMCU ESP8266. 2017 6th Mediterranean Conference on Embedded Computing (MECO). p. 1-4. IEEE Conference.
- [6] Arduino. 2018. Official Available at: <https://www.arduino.cc>
- [7] CERP. (2009). IoT – Internet of Things of European Research Cluster. Internet of things: Strategic Research Roadmap, Available at: [http://www.internet-of-thingsresearch.eu/pdf/IoT\\_Cluster\\_Strategic\\_Research\\_Agenda\\_2009.pdf](http://www.internet-of-thingsresearch.eu/pdf/IoT_Cluster_Strategic_Research_Agenda_2009.pdf)
- [8] D. Minchev ; Atanas Dimitrov. Home automation system based on ESP8266. 2018 20th International Symposium on Electrical Apparatus and Technologies (SIELA). p. 1-4. IEEE Conference.
- [9] G. M. B. Oliveira ; D. C. M. Costa ; R. J. B. V. M. Cavalcanti ; J. P. P. Oliveira ; D. R. C. Silva ; M. B. Nogueira ; M. C. Rodrigues. Comparison Between MQTT and WebSocket Protocols for IoT Applications Using ESP8266. 2018 Workshop on Metrology for Industry 4.0 and IoT. p. 236-241. IEEE Conference.
- [10] H. Hejazi ; H. Rajab ; T. Cinkler ; L. Lengyel. Survey of platforms for massive IoT. 2018 IEEE International Conference on Future IoT Technologies (Future IoT). p. 1-8. IEEE Conference.
- [11] I. Miladinovic ; S. Schefer-Wenzl. NFV enabled IoT architecture for an operating room environment. 2018 IEEE 4th World Forum on Internet of Things (WF-IoT). p. 98-102. IEEE Conference.
- [12] I. Singh ; V. Pallagani ; V. Khandelwal ; U. Venkanna. IoT based smart home automation system using sensor node. 2018 4th International Conference on Recent Advances in Information Technology (RAIT). p. 1-5. IEEE Conference.

- [13] Itead. Studio. Nextion Development Software and Informations. <https://nextion.itead.cc/>
- [14] IteadLibNextion. Libraries and examples for Nextion devices. [https://github.com/itead/ITEADLIB\\_Arduino\\_Nextion](https://github.com/itead/ITEADLIB_Arduino_Nextion)
- [15] ITU-T. (2012). Internet of Things Global Standards Initiative. Available at: <http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=y.2060>.
- [16] J. Thyparampil Raj ; J. Sankar. IoT based smart school bus monitoring and notification system. 2017 IEEE Region 10 Humanitarian Technology Conference (R10-HTC). p. 89-92. IEEE Conference.
- [17] L. Özgür ; V. K. Akram ; Moharram Challenger ; Orhan Dağdeviren. An IoT based smart thermostat. 2018 5th International Conference on Electrical and Electronic Engineering (ICEEE). p. 252-256. IEEE Conference.
- [18] M. Poongothai ; P. Muthu Subramanian ; A. Rajeswari. Design and implementation of IoT based smart laboratory. 2018 5th International Conference on Industrial Engineering and Applications (ICIEA). p. 169-173. IEEE Conference.
- [19] M. Singh ; S. L. Shimi. Implementation of room automation with cloud based monitoring system. 2018 2nd International Conference on Inventive Systems and Control (ICISC). p. 813-817. IEEE Conference.
- [20] M. Srinivas ; P. Durgaprasadarao ; V. Naga Prudhvi Raj. Intelligent medicine box for medication management using IoT. 2018 2nd International Conference on Inventive Systems and Control (ICISC). p. 32-34. IEEE Conference.
- [21] P. Srivastava ; M. Bajaj ; A. S. Rana. IOT based controlling of hybrid energy system using ESP8266. 2018 IEEMA Engineer Infinite Conference (eTechNXT). p. 1-5. IEEE Conference.
- [22] S. Barai ; D. Biswas ; B. Sau. Estimate distance measurement using NodeMCU ESP8266 based on RSSI technique. 2017 IEEE Conference on Antenna Measurements & Applications (CAMA). p. 170 - 173. IEEE Conference.
- [23] S. S. Pakalapati ; G. G. Chary ; A. K. Yadaw ; S. Kumar ; H. K. Phulawariya ; R. Kumar. A prosthetic hand control interface using ESP8266 Wi-Fi module and Android application. 2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIECS). p. 1-3. IEEE Conference.
- [24] S. Saha ; A. Majumdar. Data centre temperature monitoring with ESP8266 based Wireless Sensor Network and cloud based dashboard with real time alert system. 2017 Devices for Integrated Circuit (DevIC). p. 307-310. IEEE Conference.
- [25] W. Hlaing ; S. Thepphaeng ; V. Nontaboot ; N. Tangsunantham ; T. Sangsuwan ; C. Pira. Implementation of WiFi-based single phase smart meter for Internet of Things (IoT). 2017 International Electrical Engineering Congress (iEECON). p. 1-4. IEEE Conference.



# KCS34 evaluation for WHR in cement industry

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**Abstract**—The simple Kalina cycle system 34 (KCS34)-has been studied to perform energy cogeneration from the waste heat recovery (WHR) in preheater cement industries. The preheater available energy was considered from a 5000 tc/day cement production capacity. Thermodynamic and simplified exergoeconomic models were developed in the Engineering Equation Solver (EES) software. Several cycle thermodynamic parameters as ammonia-water mixture concentration and turbine operating pressure were wide-ranging in order to maximize the cycle thermal efficiency aiming to minimize the electricity generation cost. The temperature-entropy KCS34 schematics were shown for different best results aiming to understand which set of parameters targets the maximum KCS34 performance. The produced power, the thermal cycle efficiency, the exergetic efficiency and the exergoeconomic electricity specific cost were plotted for the different ranges of the independent parameters. The optimum results for a range specific investment price were presented. The main conclusions indicate that in the range of the studied parameters the turbine operating pressure caused a generated power variation greater than the ammonia-water mixture concentration in the KCS34 performance. It was also possible to conclude that the KCS34 is competitive with the existing electricity prices. In this case the KC proved to be applicable for WHR in the cement industry.

**Keywords**—Kalina Cycle, Waste heat recovery, cement industry, CHP, cost.

## I. INTRODUCTION

Currently, the industrial sector is a pioneer in energy consumption. In Brazil there is a total of 88 cement plants according to the Cement Industry Union [1], which fueled an apparent cement consumption of 353 kg/person/year in 2013, showing an increase of 1.4% over the previous year. Brazil is one of the world's largest cement producers placing fifth in the rank [1]. This way, the cement industry is in a large scale, a great investment option for energy recovery. Consequently, new technologies applied to this sector is a point to be thought out, discussed and worked mainly aim for improvements in industrial

processes, the possibility of using thermodynamic cycles, especially the Kalina cycle in the utilization of waste heat during the cement production process for the cogeneration of electric energy [2]. The KCS34 has been studied to perform energy cogeneration from the waste heat recovery in cyclonic preheater of the cement industries with dry production process. The preheater available energy was considered from a daily capacity of 5000 ton of clink.

## II. LITERATURE REVIEW

Since the 1980s, when it was patented, the Kalina cycle has been an efficiency promising. The expected conversion efficiency is as high as 45% [3]. An optimization procedure for heat recovery boilers in combined power noticed higher exergetic efficiency with fluid ammonia-water compared with the use of pure fluids [4]. A Kalina cycle for electricity generation from the exhaust gases of a gas turbine combined cycle have attested that the Kalina cycle was found to be 10-20 % more efficient than the Rankine [5]. Other paper indicates that Kalina cycle has 3% higher performance than Rankine cycle in Husavick plant [6]. In order to compute and locate the irreversibilities in a Kalina cycle, the exergetic efficiency values reached 55% for an input of the turbine steam temperature of 525°C and an ammonia fraction of 75% in the working fluid [7]. The exergy analysis of a cogeneration plant formed by a Kalina cycle and a four-stage desalination plant was performed with the purpose of the cogeneration plant was to generate electricity with the simultaneous production of fresh water from geothermal energy [8]. A detailed description of the Kalina cycle terminology for waste heat recovery in the cement industry has been presented by several authors. The advantages of using ammonia-water mixture as working fluid and points out the major design challenges for the application of waste heat recovery in the cement industry, which focus on the design of heat exchangers that recovers energy from gases and the design of the components of distillation and condensation system [9, 10]. Different Rankine cycle configurations were compared for waste heat recovery in the cement

industry [11]. The authors also mention that if you want to improve or increase the generation rate per ton of clink should choice to use the Kalina cycle because with it has a higher waste heat recovery in the cement industry. A Kalina cycle was optimized for waste heat recovery application [12]. A computer code was developed in Matlab to simulate the cycle. In the ammonia concentration range, between 0.8 and 1.0, at the turbine inlet, it was observed that a higher temperature in the separator and turbine inlet, which leads to increased efficiency, and that the maximum efficiency was obtained with a concentration of 0.9. An overview about the state of the art power generation technology from thermal sources temperature range with non-aqueous fluids shows the advantage of the Kalina cycle due to the evaporation process in the boiler at a variable temperature [13].

### III. METHODOLOGY

The study of waste heat recovery in the cement industry has been developed in the steps mentioned below:

- Thermal schematic definition for waste heat recovery. The focus of this work is the cement plants that have satellite clinker coolers. In these plants the only available source of heat is the exhaust gas from the cyclonic preheaters;
- Thermal cycle modeling. The modeling included the mass, energy, entropy and exergy balances. The estimated calculation of the cost of electricity generated was included into the model;
- Heat recovery optimization. Different process variables taking place in the thermal cycle were found to maximize the generation of electricity and/or minimize the cost of the generated power.

#### 3.1 Thermal schematic definition

Considering the thermal source in focus, was selected a KCS34 for the waste heat recovery. The schematic of the cycle is shown in Fig 1. Table 1 shows the data of the preheater available energy that was considered from a daily capacity of 5000 ton of clink. These data are at state '17' in Fig. 1.

The Kalina cycle can be considered simply to have a small number of components. In the state '1' it is specified the steam at the turbine inlet conditions '1', specifically ammonia concentration, the pressure and temperature of the working fluid. The fluid has a rich concentration of ammonia at the turbine inlet in state '1'. After expansion, in the state '2', the fluid is mixed with a poor solution coming from the ammonia separator - EPS (8). For mixing was employed a valve (9) to equalize the pressure of the mixture at the turbine exhaust. The leaner mixture to ammonia in state '3' can be condensed at a lower temperature and pressure, thus allowing greater power generation in the cycle. Before entering the

condenser (11), the heat exchanges operating fluid in the low temperature regenerator - LTR (6). In the pump (7) the fluid is pressurized to the operating pressure at the turbine inlet. In LTR and high temperature regenerator - HTR (5) the working fluid is preheated before it enters the waste heat recovery boiler. The boiler is made up of the economizer - ECON (4), the evaporator - EVAP (3) and the super heater - SA (5). After passing the working fluid through the EVAP and ECON, the fluid enters SEP where it reaches the desired concentration of ammonia in the saturated vapor state '11'. The operating temperature at the turbine inlet is achieved by passing the fluid through SA.

Table 1: Available energy for WHR [14]

Composition	% Mol
CO <sub>2</sub>	28.0
N <sub>2</sub>	69.0
O <sub>2</sub>	3.0
Parameter	Value
Temperature (K)	623.15
Pressure (kPa)	101.32
Volumetric flow (m <sup>3</sup> /h)	269,526

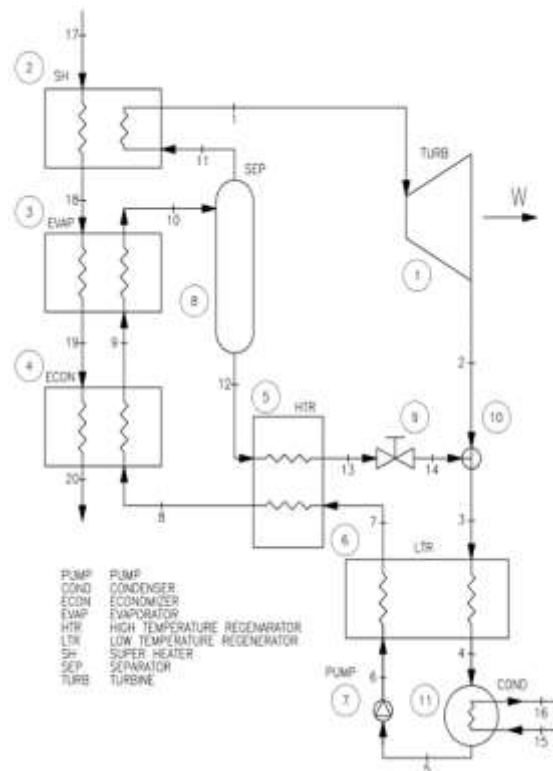


Fig. 1: The KCS34

#### 3.2 Thermal cycle modelling

The modeling of the thermal cycle was performed in the Engineering Equation Solver (EES) software. The modeling included the mass, exergy, entropy and exergy balances as well as the calculation of exergetic Fuels and exergetic Products and exergetic efficiencies for each

component and thermal cycle as a whole. In equations 1 to 6 we present the model for the Kalina cycle as a whole. In these equations, the different states correspond to those shown in the thermal cycle of Fig. 1. The different quantities and terms in these equations are:  $\dot{Q}_{in}$ , heat added to the Kalina cycle, in kW,  $\dot{Q}_{out}$  heat rejected from the Kalina cycle, in kW,  $\dot{W}$ , Net generated power in the Kalina cycle, in kW,  $\dot{m}$ , mass flow, in kg/s;  $h$ , specific enthalpy, in kJ/kg;  $ex$ , specific exergy (considering physical plus chemical, as explained later), in kJ/kg  $\dot{F}$ , exergetic fuel, in kW;  $\dot{P}$ , exergetic product, in kW;  $\eta_{ex}$ , exergetic efficiency and  $\eta$ , thermal efficiency.

$$\dot{Q}_{in} = \dot{m}_8 \cdot (h_{10} - h_8) + \dot{m}_{11} \cdot (h_1 - h_{11})$$

$$\dot{Q}_{out} = \dot{m}_4 \cdot (h_4 - h_3)$$

$$\dot{W} = \dot{m}_1 \cdot (h_1 - h_2) - \dot{m}_5 \cdot (h_6 - h_5)$$

$$\eta = \frac{\dot{W}}{\dot{Q}_{ent}}$$

$$\eta_{ex} = \frac{\dot{P}}{\dot{F}} = \frac{\dot{W}}{\dot{m}_{17} \cdot (ex_{17} - ex_{20})}$$

$$k^* = \frac{1}{\eta_{ex}}$$

For the purposes of the calculation, we used the calculation subroutines gas mixtures properties presented by [15]. With these subroutines the properties in the states '17' to '20' are calculated. Specific exergy for the working fluid (states '1' to '14') considers both the physical and the chemical portions according to equations 7 to 9.

$$ex = ex_f + ex_q$$

$$ex_f = h - h_0 - T_0 \cdot (s - s_0)$$

$$ex_q = x \cdot ex_{q-NH_3} + (1 - x) \cdot ex_{q-H_2O}$$

In the last equations we considered  $T_0 = 295K$  e  $P_0 = 101.32 \text{ kPa}$  to compute the values of  $h_0$  e  $s_0$ ,  $x$  is the ammonia fraction in the working fluid. We considered 341,250 kJ/kmol, 3,120 kJ/kmol and 11,710 kJ/kmol for the specific chemical exergy of the ammonia, the liquid water and the vapor water, respectively [16]. For the states '15' to '20' only the physical exergy was considered. Additionally, for modeling the data presented in Table 2 were assumed. In this table the temperature differentials presented refer to the state of higher temperature in the thermal cycle with respect to the state of lowest temperature, so the values are positive. In the case of  $\Delta T_{sat\_9}$  it is referred to the subcooling degrees under the saturation temperature at the turbine operating pressure. This guarantees that the working fluid will always be subcooled at the economizer outlet. The value of  $\Delta T_s$  represents the temperature difference between stages '17' and '1'. The other fixed values are the cooling water inlet pressure ( $P_{15}$ ), the ammonia concentration at the turbine inlet ( $x_1$ ), and the pump ( $\eta_B$ ) and turbine ( $\eta_T$ )

isentropic efficiencies. The values that were presented in a range were used for optimization.

Table 2. Input data for modeling

Parameter	Unit	Value
$x_1$	-	0.96
$P_{15}$	kPa	250
$\Delta T_{sat\_9}$	K	5
$\Delta T_{5\_15}$	K	5
$\Delta T_{3\_7}$	K	5
$\Delta T_{4\_16}$	K	10
$\Delta T_s$	K	20
$\Delta T_{15\_16}$	K	8 (1)
$\Delta T_{12\_13}$	K	44.78(2)
$\eta_B$	-	0.85(3)
$\eta_T$	-	0.85(4)
Parameter	Unit	Range
$P_1$	kPa	5,700 – 8,000
$q_{10}$	-	0.66 – 0.82
$x_{10}$	-	0.869 – 0.925
$\Delta T_{19\_9}$	K	11 - 25

The estimation of the power generated cost is done with equation (10) and data from Table 3:

$$C_{ger} = CR \cdot \left( C_{inv} \cdot \frac{FA}{HO} + C_{O\&M} \right)$$

where

$$C_{inv} = \frac{IC_{1985}}{IC_{2013}} \cdot C_{invref} \cdot \left( \frac{C}{C_{ref}} \right)^{0.6} \quad (7)$$

$$FA = \frac{i \cdot (1+i)^n}{(1+i)^n - 1} \quad (8)$$

$$FA = \frac{i \cdot (1+i)^n}{(1+i)^n - 1} \quad (9)$$

Table 3. Input data for cost calculation

Parameter	Unit	Value	Reference
$CR$	-	2.34	[17]
$HO$	h/year	6000	
$i$	% year	5	
$n$	year	20	
$IC_{1985}$	-	175	[18]
$IC_{2013}$	-	100	[18]
$c_{ref}$	kW	6000	[19]
$C_{invref}$	US\$/MW	973,000	[19]
$C_{O\&M}$	US\$/MWh	0.096	[19]

The financial values were actualized and referenced for December 2013. In equations 10 to 12  $C_{ger}$  is the cost of the generated power, R\$/MWh,  $CR$  is the change rate, in R\$/US\$,  $C_{inv}$  is the investment cost in US\$/MW,  $FA$  is the amortization factor,  $HO$  is the operation time per year,  $C_{O\&M}$  is the operation and maintenance cost, in US\$/kWh,

$i$  is the interest rate,  $n$  is the life time,  $IC$  is the cost index for a given year,  $C_{inv_{ref}}$  is the investment cost at the reference capacity in US\$/MW,  $c$  is the calculated generation capacity of the Kalina cycle, in kW,  $e_{c_{ref}}$  is the reference generation capacity, in kW.

### 3.3 Heat recovery optimization

The optimal region was located using the optimization procedure by genetic algorithms available in the EES. This optimization method was chosen because it is mathematically robust and running error-free with large number of variables and constraints. In order not to incur large calculation time was set to 3 the number of individuals, in 4 the number of generations, and in 2 the mutation rate. Mathematically the optimization problem was formulated by the Eq. (13). The values of the restrictions are higher than the values in Tab. 2 in some cases. The latter constraints are practical or conceptual, in the case of  $T_{20}$ , it is the minimum temperature of the gases in the exhaust to atmosphere and in the case of the generation entropy,  $\dot{\sigma}_{ger_i}$ , which requires that in each of the system components meet the second law of thermodynamics.

$$\left\{ \begin{array}{l} \text{Maximize } \dot{W} \\ \text{subject to:} \\ 5,700 \text{ kPa} \leq P_1 \leq 8,000 \text{ kPa} \\ 0.40 \leq q_{10} \leq 0.90 \\ 0.20 \leq x_{10} \leq 0.85 \\ 0.90 \leq x_1 \leq 0.96 \\ s_{2s} \geq 0.0 \text{ kJ/kgK} \\ T_{20} \geq 340 \text{ K} \\ \dot{\sigma}_{ger_i} \geq 0.0 \text{ kW/K } i = 1, 2, \dots, 11 \end{array} \right.$$

## IV. RESULTS AND DISCUSSION

Note that in Tab. 3 for most parameters the values found are close to one of their extreme limits. In the cases of  $P_1$ ,  $x_{10}$ ,  $x_1$ , and  $\Delta T_{12,13}$  the values were close to the maximum. In the case of  $\Delta T_{19,9}$  and  $\Delta T_s$  the values were close to the minimum. In the case of  $q_{10}$  the value was close to the middle of the range. Further simulations showed that the variation of  $\Delta T_{12,13}$  and  $q_{10}$  do cause variation in the generated power and the efficiencies of the Kalina cycle. In the case of  $q_{10}$  a very little increase in the generate power was noted at 0.74. On the other hand, the value of the  $\Delta T_s$  must be in the minimum to obtain the maximum power. At the optimal condition the net generated power was 2,725 kW, the thermal efficiency was 0.218, the exergetic efficiency was 0.552, a very high value which is explained by the input source of exergy to the system has a low exergy potential to be a residual gas stream of low temperature. At this condition the cost of the generated power was 278,03 R\$/MWh, corroborating

the breakthrough that results using KCS34 for generating electricity from waste heat in the cement industry.

Table 4. Values for the optimal condition

Parameter	Unit	Value
$P_1$	kPa	7,941
$q_{10}$	-	0.6667
$x_{10}$	-	0.849
$x_1$	-	0.960
$\Delta T_{12,13}$	K	47.48
$\Delta T_{19,9}$	K	11.73
$\Delta T_s$	K	23.5

The pressure of the working fluid in the turbine inlet has a strong influence on the net generated power. As we can see in Fig. 2 (A), as increases the pressure at the inlet to the turbine rise the net generated power. The net power also increases with increasing concentration of ammonia in the working fluid in the evaporator. Note that for the maximum concentration of ammonia that was studied in this simulation below the pressure of 6211 kPa at the turbine inlet the system cannot operate because violates the thermodynamics' laws. The increase in the net generated power by the pressure is explained by the increase of the steam enthalpy at the turbine inlet. With increasing ammonia concentration at the evaporator outlet the generated steam flow increases. This happens because with more ammonia in the mixture the working fluid becomes zeotropic causing a uniform temperature profile in the evaporator, which reduces the destruction of exergy and allows you to generate more steam. Note that with the combination of these two parameters the net power varied hundreds of kW values in the ranges studied.

In Fig. 2 (B) it is noted that with increased pressure at the turbine inlet, the thermal efficiency and exergy efficiency also increase. This increase is due to the increased enthalpy of the working fluid at the turbine inlet with increasing pressure. Note further that the influence of pressure on the efficiency is enhanced causing variation in several percentage points.

Reducing the temperature difference between the evaporator outlet gas (state '19') and the working fluid at the evaporator inlet (state '9'), i.e. the  $\Delta T_{19,9}$ , increases the generation of net power in simple cycle Kalina to increase the generation of steam to the turbine. Note in Fig. 3 (A) that the largest power values were achieved with the highest concentration of ammonia in the working fluid, reinforcing what was already explained before. It is also observed that although varied in the same proportion, the effect of increased ammonia concentration exceeds the reduction of the title at the evaporator outlet (which should reduce the generated steam flow). The ammonia concentration is therefore one of the most influential variables in the generation of net power in cycle. The temperature difference between the evaporator gas output

and the working fluid in the evaporator inlet  $\Delta T_{19,9}$  has a strong effect in the calculation cycle of the investment cost. This variable is directly bonded to the surface of the evaporator heat exchange, and thus to the cost. Thus, operating in the minimum level of  $\Delta T_{19,9}$ , will not necessarily lead to lower cost of generation.

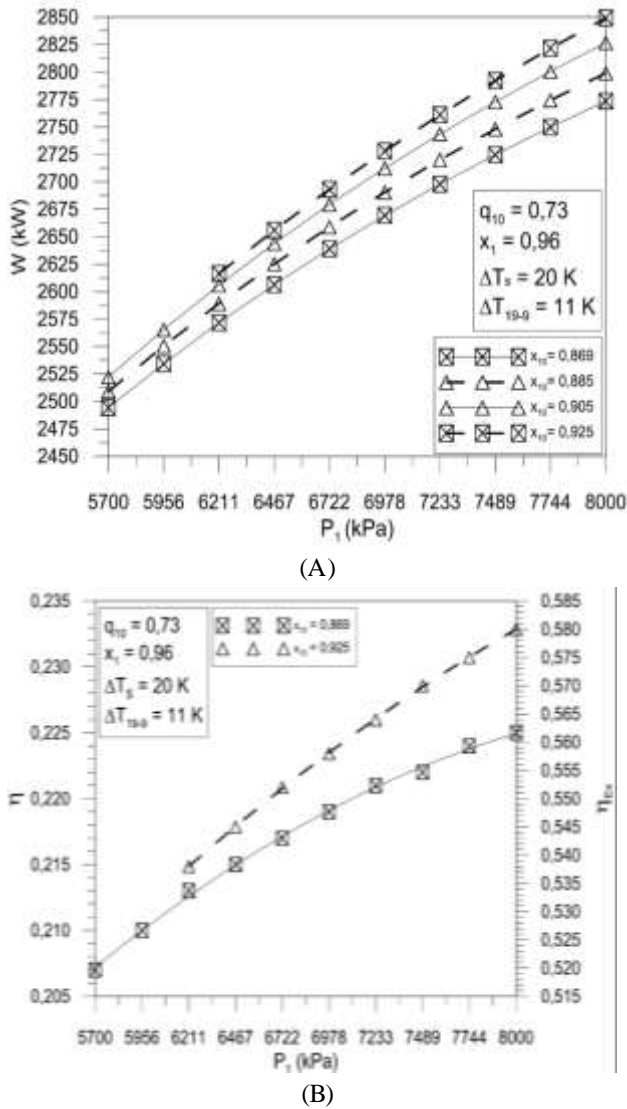


Fig.2 The influence of the turbine inlet pressure on the KCS34 performance

The influence of the temperature difference between the evaporator outlet and the gas working fluid at the evaporator inlet ( $\Delta T_{19,9}$ ) on the thermal efficiency and the exergetic efficiency can be observed in Fig. 3 (B). The thermal efficiency remains unchanged with the variation of this parameter because it depends mainly on the enthalpy at the inlet and outlet of the boiler and turbine, which is not altered by the  $\Delta T_{19,9}$ . On the other hand, the exergetic efficiency becomes sensitive to this parameter ( $\Delta T_{19,9}$ ), which once changed, impacts on exergy destruction in the evaporator, which is the largest in the cycle.

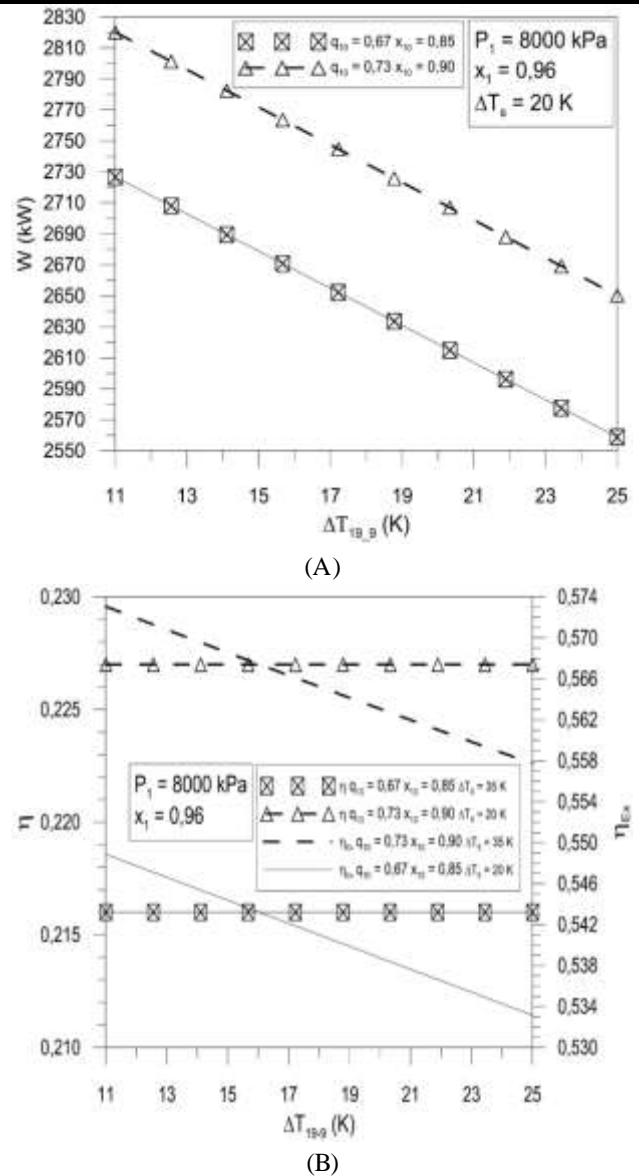
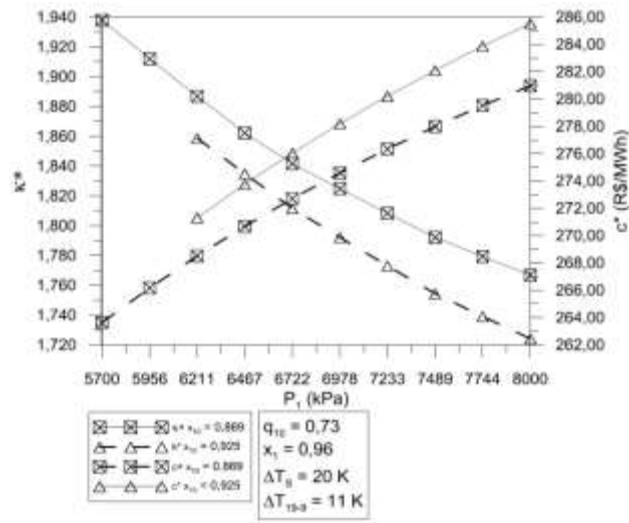


Fig.3. The influence of the  $\Delta T_{19,9}$  on the KCS34 performance

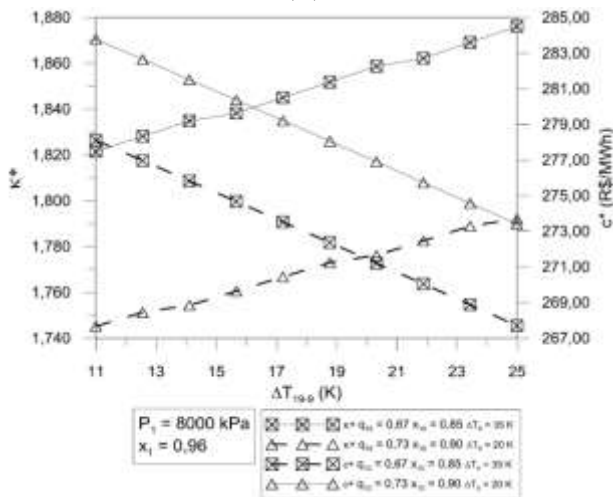
The effect of varying the pressure at the inlet to the turbine on the generating cost can be seen in Fig. 4 (A). According to this figure the cost of electricity generated increases with pressure, which has a practical sense, because to adopt higher working pressures requires greater material thickness and higher cost. But the right explanation for this behavior is the cost model that was adopted. As it was said before, the value of the cost of the electricity generated is associated to the generation amount and the same has been observed which increases with the pressure at the turbine inlet.

Figure 4 (B) shows the effect of temperature variation in the evaporator difference ( $\Delta T_{19,9}$ ) on the generation cost. The cost of electricity generated decreases with increasing temperature difference in evaporator following the same trend behavior power according to the adopted cost calculation model. The trend shows that the cost model is

assertive in order to reflect that a greater temperature difference in the evaporator will reduce the purchased cost with this equipment and thus causing a lower total cost of the cycle and in the generated electricity.



(A)



(B)

Fig.4. The influence of the turbine inlet pressure and  $\Delta T_{19,9}$  on the KCS34 generation cost

From the information shown in Fig. 4 the generated power range between 2,500 and 2,850 kW with generation costs values ranging from 262.00 and 286.00 R \$/MWh. The optimization performed with genetic algorithms finds a middle ground in the region with power values and costs of 2,725 kW and 278.03 R\$/MWh, respectively. These results allow us to state that depending on the context of this great region it is possible to opt for a solution that leads to a minimum generation cost, with less generation of power, or a solution leading to a generation of maximum electricity but with a greater generation cost. In any case, the cost of generated power is competitive in the Brazilian market. According to the Ministry of Mines and Energy [20] the average tariff value supply practiced by Companhia Energética de Minas

Gerais- CEMIG for the industrial sector in May 2014 was 296.38 R\$/MWh.

## V. CONCLUSION

The study about the waste heat recovery in the cement industry with KCS34 lets you express the following conclusions:

- The amount of electricity generated can reach 2,725 kW, with a thermal efficiency of 0.218, an exergetic efficiency of 0.552 and a generation cost of 278.03 R\$/MWh;
- The pressure of the working fluid in the turbine inlet has a strong influence on the net power generated. With greater pressure at the turbine inlet, the generated power, the thermal efficiency and the exergetic efficiency increase;
- The net power generated also increases with increasing concentration of ammonia in the working fluid in the evaporator. The ammonia concentration is therefore the most influential variables in the generation of net power in the cycle;
- With the combination of the pressure values at the turbine inlet and the ammonia concentration in the evaporator that were studied, the net power ranged hundreds of kW;
- The influence of pressure on the efficiency is enhanced, causing variation in various percentage points;
- Reducing the temperature difference,  $\Delta T_{19,9}$ , increases net power generation in KCS34. On the other hand, the exergetic efficiency becomes sensitive to this parameter since it impacts on exergy destruction in the evaporator;
- The cost of the generated electricity increases with pressure and decreases with increasing temperature difference in evaporator following the same trend of the generated power;
- The cost model is assertive to reflect that a greater temperature difference in the evaporator will reduce the purchased cost with this equipment and thus causing a lower total cost of the cycle and in the generated electricity;

- In the great region calculated the generation of values may vary in the range between 2,500 and 2,850 kW with generation costs ranging between 262.00 and 286.00 R\$/MWh. This cost range is competitive in the Brazilian market due to the value of the average supply tariff applied by CEMIG, which for the industrial sector in May 2014 was 296.38 R\$/MWh.

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## REFERENCES

- [1] SINIC - SINDICATO NACIONAL DA INSÚSTRIA DE CIMENTO. 21 May. 2015 “Relatório anual 2013”.  
<http://www.snic.org.br/pdf/RelatorioAnual2013final.pdf>.
- [2] Mirolli, M. D. (2006). Cementing Kalina cycle effectiveness. IEEE, 1077-2618/06, p. 60-64.
- [3] Jurgen, R. K. (1986). The promise of the Kalina Cycle. IEEE, 1118-9325/86/0400-0068.
- [4] Stecco, S. S., Desideri, U. (1989). “Optimization of the heat recovery section in combined powerplants”. IEEE, CH2781-3/89/0000-2535, p. 2535-2542.
- [5] Ibrahim, M. B., Kovach, R. M. (1993). A Kalina cycle application for power generation. Energy. Vol. 18, n° 9, p 961-969.
- [6] Saha, B. K., Chakraborty, B. (2017). Utilization of low-grade waste heat-to-energy technologies and policy in Indian industrial sector: a review. Clean Techn Environ Policy. 19:327–347 doi 10.1007/s10098-016-1248-2
- [7] Nag, P. K., Gupta, A. V. S. S. K. S.(1998). Exergy analysis of the Kalina cycle. Applied Thermal Engineering. Vol. 18 n° 6, p. 427-439.
- [8] Koroneos, C. J., Rovas, D. C. (2007). Electricity from geothermal energy with the kalina cycle – an exergy approach. IEEE, 1-4244-0632-3/07, p. 423-428.
- [9] Mirolli, M. D.(2007). Ammonia-water based thermal conversion technology: applications in waste heat recovery for the cement industry. IEEE, 1079-9931/07.
- [10] Rad, E. A., Mohammadi, S. (2018). Energetic and exergetic optimized Rankine cycle for waste heat recovery in a cement factory. Applied Thermal Engineering 132 (2018) 410–422. <https://doi.org/10.1016/j.applthermaleng.2017.12.076>
- [11] Gaozuo, Z., Guozhen, Z., Chunli, W.(2009). A New Application of Waste Heat Recovery Power Generation in Clinker Kiln. IEEE, 978-1-4244-3698-9/02.
- [12] Ganesh, N. S., Srinivas, T.(2010). Optimized Kalina cycle. IEEE, 978-1-4244-9082-0/10.
- [13] Wei, W., Bai, H., Li, N., Zhang, X.(2011). Research advanced of thermodynamic systems with nonaqueous working fluid applied in low temperature energy power generation. IEEE, 978-1-4244-9439-2/11.
- [14] SHARMA, R.A. 5 Mar. (2013). Co-generation & Success Story in Indian Cement Industry. Master Consultancy & Productivity PVT.LTD  
[http://www.energymanagertraining.com/announcements/issue25/winners\\_papers\\_Issue25/18\\_RASharma.pdf](http://www.energymanagertraining.com/announcements/issue25/winners_papers_Issue25/18_RASharma.pdf)
- [15] Santos, L.A.O. (2014). Modelagem de ciclos Kalina para a cogeração com calor residual no setor cimenteiro. MSc Dissertation. PUC Minas. Brazil.
- [16] Kotas, T.J.(1995). The exergy method of thermal plant analysis. Krieger Publishing Company, p. 328, 1<sup>st</sup> edition reprinted
- [17] BANCO CENTRAL. (2015). Conversão de moedas. 4 May. 2015 <<http://www4.bcb.gov.br/pec/conversao/conversao.asp>>.
- [18] BRIDGES, C. (2014). Equipment and fixtures index, percent good valuation factors – Use for lien date January 1. Assessor’s Handbook. Section 581. p. 48.
- [19] EPRI – Energy Project Research Institute. (1986). Technology assessment of advanced power generation system II – Kalina bottoming cycle. EPRI AP-4681. Project 2528-4. Final Report. November
- [20] MINISTÉRIO DE MINAS E ENERGIA. “Informativo tarifário energia elétrica, 18ª edição, segundo quadrimestre de 2014”. 11 Jun. 2015 <<http://www.mme.gov.br/documents/1138781/1538885/Informativo+Tarif%C3%A1rio+Energia+El%C3%A9trica+-+18%C2%BA+edi%C3%A7%C3%A3o+-+Setembro+2014+%28PDF%29/3f4724ee-8aad-4f28-8bdb-6ba4f8611934;jsessionid=0BB8837E463C115F8FE7BD29B2ACC70C.srv155>>.

# Implication of Mining Investment improvement as Effect of Increasing Government Expenditure in Development of Mineral Industry in Indonesia (2009-2016)

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**Abstract**— *Increasing mining investment as an effect of government spending in the development of the mineral industry in Indonesia, aims to obtain mineral value added in the long run according to Law No. 4 of 2009 concerning Mineral and Coal Mining, can be realized with mineral industry clusters in a mining business area (WUP). The method used is Simultaneous Equation Model (SEM).*

*The increase in mining investment has a significant effect on increasing mineral value added, which has positive implications for people's welfare which is manifested in the form of increasing contribution to the mining and quarrying business sector of the Regency GRDP, increasing employment opportunities and industrial CSR towards local communities.*

*The increase in mineral reserves that have a significant effect on increasing mineral value added as an effect of government spending and mining investment has positive implications for the longer duration of mineral production and industrial activities in a mining business area (WUP), so that economic and social transformation can be realized well.*

**Keywords**— *Mining investment, government expenditure and implications, value added, mineral industry cluster.*

## I. INTRODUCTION

The abundance of natural resources in a country, is a gift from Allah SWT, but does not always mean that its added value contributes significantly to a country's Gross Domestic Product (GDP), so that it can have positive implications for people's welfare. Africa and Pakistan are countries with abundant natural resources, but the contribution of their added value is not significant to

African GDP (HLA VOVA, 2015) and Pakistan (Awolusi, 2016; Saadat, 2016).

The foregoing occurs because of the high export of raw minerals, followed by imports of concentrate and metal, which are also high to meet the needs of industrial raw materials, construction materials, energy, telecommunications and so on, so that mineral value added (value added of minerals) does not contribute significantly to GDP (Keynes, 1936).

The phenomenon as above, also occurred in Indonesia before the enactment of Law No. 4 of 2009 concerning Mineral and Coal Mining, where mineral exports in various commodities are very intensive, especially nickel, iron ore, copper and bauxite commodities, but mineral value added from the production side is not significant (Rodeno, 2004; Holler and Stolwy, 1995 ; Hayami, 1987; Smith, 1977).

In other parts, the need for industrial raw materials in the form of concentrate and in the form of metal to fulfill construction, telecommunications and energy needs, can only be fulfilled through imports. Iron steel imports (Prasetio, 2010), alumina imports (Agustinus, 2016), and copper cathodes (Ministry of Industry, 2017) are still quite high, causing mineral value added from the expenditure side to be low (Keynes, 1936).

The study conducted by Lei, Na Cui and Dongyan pan (2013) and Knivila (2007), found that the development of the mineral industry in China, Korea and Taiwan had a significant effect on increasing value added. This, among others, led to the issue of increasing value added of minerals in Indonesia, through industrial development (Pangestu, 1999 in Suyanto, 2011; Solow, 1956; Kuznets, 1956) to be important to study, so that it can have positive implications for welfare of the people.



Transformation of the mineral industry policy from upstream to downstream according to Law No. 4 of 2009 aims to generate value added for economic growth in the long run (Adam, 2014), an appropriate step to increase mineral value added in Indonesia, among others through the implementation of a ban on raw mineral exports, prioritizing the use of minerals in the country before export, and the obligation for every mining business to process the processing and refining of minerals in the country before export.

Even though the purpose of the above policy transformation is correct, the policy up to now has not been able to be implemented maximally, partly due to the problem of the availability of feasible mineral reserves (Wellmer, et al, 2015) in relation to investment and its profitability (Alayi, 2005; Gylfason, 2004) and the need for government support (Wright and Czelusta, 2004).

The problem of the availability of reserves and investments above can actually be reflected by the development of industrial clusters (Bodley, 2013; Porter, 2001; 2000; 1998; Schmitz, 1992; Marsall, 1890), which is a collaboration between several mining business units in a mining business area (WUP) due to the similarity of geographical position, similarity to mineral traps, similarities in output and similarities in geological concentration. This will form a geographic and central corporate agglomeration (Schmitz, 1992), special industrial concentration in certain regions (Menzel and Pomahl, 2009; Marsall, 1890) and can only be realized with Government support (UNIDO, 2001; UNCTAD, 1998), so that it can produce significant mineral value added to the Regency GDP and GRDP, which has positive implications for improving people's welfare.

Table.1: Value Added Mining and Excavation Business Fields against Regency GRDP in Indonesia

No.	Mining Business Area in Indonesia	commodity	Regency GRDP		
			(Million Rupiah)		
			2011	2013	2015
1	Kolaka	Nickel	5,101,045.19	7,261,880.40	7,357,716.
2	South Konawe	Nickel	980,751.37	1,285,068.99	1,545,704.18
3	East Luwu	Iron	7,029,085.57	7,706,179.57	8,831,737.22
4	Solok	Iron	360,217.30	416,374.68	452,713.80
5	Toli-Toli	Copper	58,511.40	71,180.40	91,089.30
6	Pacitan	Copper	746,654.40	497,298.50	536,233.40
7	Ketapang	Bauksit	1,765,134.40	1,707,475.53	1,569,210.94
8	East Kotawaringin	Bauksit	501,523.46	898,691.92	719,109.19

Source: Central Statistics Agency, 2010, 2014, 2016

## II. THEORETICAL REVIEW

Industry is an economic activity that can create an added value (Hasibuan, 2004), and value added itself can be interpreted as a value added from a combination of production factors and raw materials in the production process, and formulated as production value (output) deducted between fees (Central Statistics Agency). In fact, Gross Domestic Product (GDP) can be interpreted as the amount of added value produced by all business units in a particular country, and is the sum of the value of final goods and services produced by all economic units.

Smith (1977), also states that added value is the difference between the final product and the sacrifice that has been made. And, as the growth of the value of a product (commodity) with processing in a production, so that it is a function of production capacity, the amount of raw materials, the number of labor, labor wages, output prices, raw material prices and other inputs (Hayami, et

al, 1987).

However, Rudenno (2004) actually states that the economic value of minerals will vary depending on the type of mineral. Nickel in 1 ton is only 2%, but through the metallurgical process nickel in ferronickel can reach 10% - 30%. This, in line with article 1 paragraph 20 of Law No. 4 of 2009), where mineral processing and refining activities are activities to improve the quality of minerals and / or coal and to utilize and obtain associated minerals.

In fact, the Ministry of Industry (2010) also defines industrial clusters as core industries that are concentrated regionally and globally, dynamically interact with each other, both related industries, supporting industries and supporting services, economic infrastructure and related institutions in increasing efficiency, creating assets collectively and encourage the creation of competitive advantage.

Furthermore, for the development of the mineral industry with industrial clusters, one of them is by applying the Porter's Diamond Model which consists of the availability of natural resources, availability of capital, availability of human resources and availability of infrastructure, which are interrelated with company strategy and competition, demand conditions, factor conditions and related industries and supporters. In addition, there are two additional factors that have an influence, namely chance and government factors, so that the six factors together form a system that is different from one location to another (Potter, 2000). Even so, some industries can succeed in a location because not all factors must be optimal in ensuring the success of an industry.

Furthermore, in order to realize the increase in mineral value above and its implications for improving people's welfare, the increase in government expenditure (government expenditure) that affects investment increases (Keynes, 1935) and increasing mineral reserves is one of the alternative pathways for developing the mineral industry in Indonesia.

#### a. Availability of Mining Investment

Availability of capital or investment is very important for the operation of a mineral industry cluster. Jogianto (2008), states that investment is an investment in certain assets to obtain more value in the future. Mobilizing resources for income in the future (Makmum, 2000).

Investment is considered as a capital formation, which means that the function of profit in the economy, where the government is not an important investor or participant, and foreign investment can be considered as the formation of capital by a company to a foreign country (Smith, 1776), not only important for the development of the mineral industry, but also can encourage economic growth (Napier, 1981; Sollow, 1956).

However, Keynes (1936) also states that demand for investment is inversely proportional to the interest rate. If the interest rate is high, people will save money in the bank rather than investing it, because the expected return that will be obtained from bank interest is greater than the investment, consequently the demand for investment will decrease. The high interest rate reflects the high cost of credit, thus reducing the desire for investment among entrepreneurs. Keynes (1936), also stated that government expenditure has a positive effect on investment, and investment has a positive impact on economic growth (Tambunan, 2003).

An empirical study conducted by Jorgenson, et al (1987), states that the United States economy in the period 1948-1979, 46% of economic growth was caused by capital formation, 31% due to the growth of labor and

human capital and 24 % by technological advancements. Then, Lubis et al (2015) also stated that the mining sector investment is generally dominated by foreign investment, which has a positive and significant effect on GDP, particularly in the mining and quarrying business (Salebu, 2014). Furthermore, in order to realize the increase in mineral value above and its implications for improving people's welfare, the increase in government expenditure that affects investment increases (Keynes, 1936), and increasing mineral reserves is one of the alternative pathways for developing the mineral industry in Indonesia.

#### b. Availability of Mineral Reserves

Reserve of minerals is mineral deposits that have been known for their size, shape, distribution, quantity and quality, and economically, technically, legally, environmentally and socially can be mined when calculating (BSN, 1998). And, is a raw material that is ready to be produced and mined economically (Bankes, 2014; BP Statistical Review of World Energy, 2008).

Reserves consist of probable reserves and proven reserves, where proven reserves are measurable mineral resources based on a feasibility study that all related factors have been fulfilled, so that mining can be carried out economically. Conceptually, reserves consist of the ultimate reserve, which is the amount of reserves in an area of unknown size, and identified reserve whose magnitude can be estimated by the technology that is available at that time, which can increase in size through exploration activities and reduced due to production.

Availability of natural resources is the availability of mineral resource inputs, as natural resources that cannot be renewed (Djojohadikusumo, 1994), whose formation takes thousands of years, such as minerals and rocks (Barlow in Suparmoko, 2006), which decreases (depletion) in the presence production activities, so that one day they will become goods that step, will increase with a new finding from exploration activities (Suparmoko, 2006; Arsegianto, 2000; Vogely, 1981), and become very urgent in the development of the mineral industry, because it determines technical feasibility and feasibility its economy (Stermole, 2000).

#### c. Government Expenditures

Guritno (1999), states that government expenditure is a government policy, where the theory of government expenditure by economists divides into Wagner's legal model and the model of Peacock and Wiseman's theory. Wagner (19th century), even stated that in an economy, if per capita income increases, then government spending will relatively increase, mainly because the government must regulate relations that arise between society,

industry, externalities and market failures.

Bird (1971) in Guritno (1999), states that during the occurrence of social disturbances, there is a diversion of government activities from expenditure before disruption to expenditures related to the disorder. This will be followed by an increase in the percentage of government spending on GDP. And, after the disruption, the percentage of government expenditure on GDP will gradually decrease back to its original state. The transfer effect is a symptom in the short term, but does not occur in the long term.

Rostow and Musgrave (1999), state the development model of government expenditure with three stages of economic development. The initial stage is an important and strategic stage for the government, where large government investment is due to the provision of infrastructure, such as to build mining infrastructure. These government expenditures intend to encourage economic growth with the support of private financing, which is even greater at a later stage.

Musgrave (1999) also states that in a development process, private investment in the percentage of GDP is getting bigger, and the percentage of government investment in the percentage of GNP will be smaller. At a further economic level, Rostow stated that economic development, where government activities shifted from providing infrastructure to spending on social activities, included education and public health services.

Furthermore, the development theory of the role of government is a view that arises from observing economic development by many countries, but is not based on a particular theory (Musgrave and Rostow, 1999). In fact, Sukirno (2000) states that government spending is a government action that regulates the economy in order to create economic stability, expand employment opportunities, enhance economic growth and justice in income distribution. Therefore, an increase in government spending affects the increase in investment and mineral reserves and added value.

Furthermore, Nangarumba (2016) stated that fiscal policy is one of the macro policies whose main authority is in the hands of the government, and represented by the Ministry of Finance, according to Law No. 17 of 2003 concerning State Finance. Fiscal policies generally present the government's choices in determining the amount of expenditure and the amount of income that is explicitly used to influence the economy.

Government interference is still very much needed if the economy is fully regulated in free market activities, not only does the economy not always reach the level of full employment, but also the stability of economic activities cannot be realized. In fact, Keynes in Sukirno (2000) states that wide fluctuations in economic activity from

one period to another have serious implications for employment opportunities, unemployment and price levels, where government spending and increased investment can increase economic growth.

Furthermore, Freebairn (2012) states that government spending in Australia to support infrastructure for transportation expansion, physical infrastructure, social infrastructure in remote mining areas during the mining boom has provided an increase in government revenues of 6%. This means that government spending on infrastructure improvements indirectly affects the increase in added value.

Ismail (2011), an analysis of economic development and fiscal policy with Wagner's theory and Keynesian law using the econometric model, and found that Indonesia's economic growth is influenced by government spending, in the form of work expenditure. Then, Uchenna And Osabuchien (2012) states that macroeconomic policies in Nigeria, with instruments of Government expenditure policies, have responded to fiscal decentralization policies, political instability and economic growth. This, shows the effect of government spending in encouraging added value.

An empirical study of fiscal policy in several developing countries, the impact of distribution is the analysis of certain components of government expenditure such as basic, secondary, tertiary education programs, expenditures to support agricultural infrastructure to be able to produce, the government has obtained from tax revenues distributed (Siddiqui and Malik, 2011).

Then, the copper mining empirical study in Chile which has contributed to the development of the State as a consequence of the Chilean Government which has allocated government expenditure for the development of export-oriented domestic transportation infrastructure, encouraging mining to become more modern, efficient and competitive (Arellano, 2012). This means that government spending on improving infrastructure has an effect on the efficiency of mining, so that it will benefit from efficiency and generate added value for district-level mining and quarrying businesses.

Furthermore, empirical studies of the effects of extraction of natural resources both locally and regionally, where government spending has encouraged the management of natural resources for welfare, the community (Cust and Poelhekke, 2015), and the operation of government fiscal policies significantly affect the direction of economic resource work (Keyness, 1936).

#### **d. Linkage of Government Expenditures to Investment, Mineral Reserves and Value Added of Mineral**

Government expenditures through increasing aggregate

expenditure for the purchase of goods and services and increasing investment (Keynes, 1936), and followed by an increase in private investment (Musgrave, 1999), so that government spending is positively related to the increase in private investment in a business area mining (WUP).

Then, Keynes in Sukirno (2000), also states that fluctuations in economic activity that are wide from one period to another have serious implications for employment opportunities, unemployment and price levels, where government spending and increased investment can influence economic growth, including increasing mining infrastructure (Freebairn, 2012), which can provide increased value added (Uchenna and Osabuchien, 2012).

Furthermore, the effects of local and regional extraction of natural resources, where government spending has encouraged natural resource management for welfare, the community (Cust and Poelhekke, 2015), and the operation of government fiscal policies significantly influence the

direction of economic resource work (Keynes, 1936). Furthermore, Partowidagdo (1999) in Wiriosudarmo (2000) states that government spending for the construction of mining infrastructure and industry has an effect on the development of the mineral industry, gaining significant added value for Regency GRDP and has positive implications for improving people's welfare.

III. RESEARCH METHODOLOGY

Research on the effect of government expenditure in the development of the mineral industry (mineral industry cluster pattern) to increase mineral value added in Indonesia, using quantitative methods with structural equational modeling analysis tools (Kusnadi, 2008) with reference to the relationship between dependent variables (y<sub>3</sub>), interpening variables (y<sub>1</sub> and y<sub>2</sub>) which is an endogenous variable and an independent variable (x) which is an exogenous variable (graphically shown in figure 1).

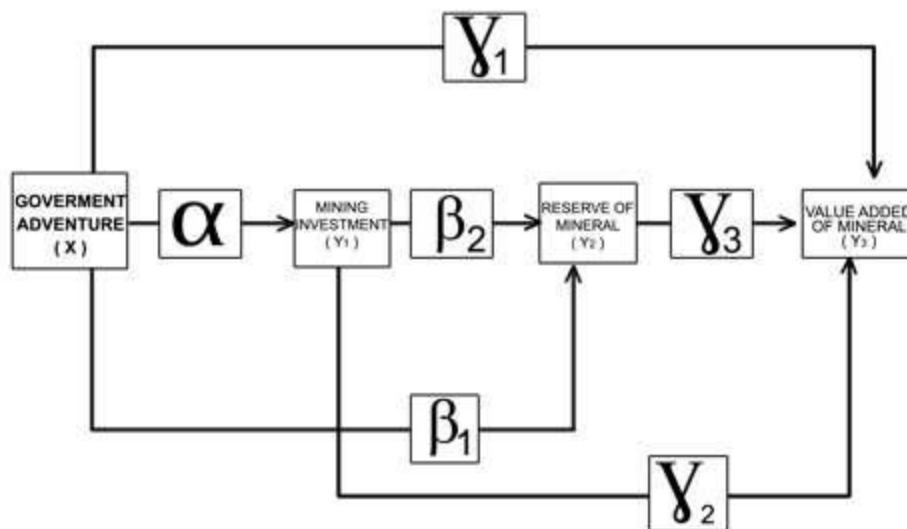


Fig.3.1: The research model influences government spending in developing the mineral industry and value added of mineral in Indonesia

The conceptual framework of the study as an explanation of the relationship between the above variables, can be expressed in the simultaneous equation for estimation of linear regression with the following functions:

- y<sub>1</sub> = f(x, u<sub>1</sub>) (1)
- y<sub>2</sub> = f(y<sub>1</sub>; x, u<sub>2</sub>) (2)
- y<sub>3</sub> = f(y<sub>1</sub>, y<sub>2</sub>; x, u<sub>3</sub>) (3)

Where :

- Y<sub>3</sub>: District-level mining and quarrying business value added, measured in millions of Rupiah
- y<sub>2</sub>: Mineral reserves, measured in tons
- y<sub>1</sub>: Mining investment, measured in millions of rupiah

Then, from equation 1 - 3 above, for non linear equation formulations (CobbDouglass) can be expressed by the equation as follows:

$$Y_1 = e^{\alpha_0} X^{\alpha_1} e^{U_1} \tag{4}$$

$$Y_2 = e^{\beta_0} X^{\beta_1} Y_1^{\beta_2} e^{U_2} \tag{5}$$

$$Y_3 = e^{\gamma_0} X^{\gamma_1} Y_1^{\gamma_2} Y_2^{\gamma_3} e^{U_3} \tag{6}$$

Where α<sub>0</sub>, β<sub>0</sub>, γ<sub>0</sub> are constants, α, β<sub>1</sub>, γ<sub>1</sub> - γ<sub>3</sub> each is a parameter which will be estimated and U<sub>1</sub> - U<sub>3</sub> is an error term. The functional equations for reduced form in the simultaneous equation model (SEM) are as follows:

$$Y_1 = \alpha_0 + \alpha_1 X + \mu_1 \tag{7}$$

$$Y_2 = (\beta_0 + \beta_2 \alpha_0) + (\beta_1 + \beta_2 \alpha_1) X + (\mu_2 + \beta_2 \mu_1) \tag{8}$$

$$Y_3 = (\lambda_0 + \lambda_0 \alpha_0) + \lambda_3 (\beta_0 + \beta_2 \alpha_0) + (\lambda_1 + \lambda_2 \alpha_1 + \beta_1 + \beta_2 \alpha_1) X + (\mu_3 + \lambda_2 \mu_1 + \mu_2 + \beta_2 \mu_1) \tag{9}$$

$$Y_1 = \alpha_{10} + \alpha_{11}X + \mu_{11}$$

$$Y_2 = \beta_0 + \beta_1X + \mu_{12}$$

$$Y_3 = \lambda_0 + \lambda_0X + \mu_{13}$$

Where:

$$\alpha_0 = \alpha_0; \alpha_1 = \alpha_1; \mu_{11} = U_1$$

$$\beta_0 = \beta_0 + \beta_2\alpha_0; \beta_{11} = \beta_1 + \beta_2\alpha_1 \quad \mu_{12} = U_2 + \mu_1$$

$$\lambda_{10} = (\lambda_0 + \lambda_2\alpha_0) + \lambda_3(\beta_0 + \beta_2\alpha_0)$$

$$\lambda_{11} = \lambda_1 + \lambda_2\alpha_1 + \beta_1 + \beta_2\alpha_1$$

$$\mu_{13} = (U_3 + \lambda_1U_1) + (U_2 + \beta_2U_1)$$

#### IV. RESULTS AND DISCUSSION

To analyze the effect of government spending in the form of capital expenditure in the development of the mineral industry and mineral value added in Indonesia, a linear regression analysis was carried out simultaneously, which estimated the magnitude of direct and indirect effects.

The results of the study with linear regression analysis simultaneously, showed a model match test with  $p > 0.05$ , meaning that the model was suitable in the

analysis, so there was no difference between theoretical models and empirical data, where an increase in government expenditure (x) directly had a positive effect on improvement mineral value added (y<sub>3</sub>) with an estimated value of 0.0966.

Then, indirectly an increase in government spending has a significant effect on increasing mining investment (y<sub>1</sub>) of \*\*\*, and has a positive effect on increasing mineral reserves (y<sub>2</sub>) by 0.1039. However, an increase in mining investment (y<sub>1</sub>) has a positive and significant effect on increasing mineral value added by \*\*\*. And, an increase in mining investment (y<sub>1</sub>) has a positive effect on increasing mineral reserves (y<sub>2</sub>) with an estimate of 0.735. Furthermore, an increase in mineral reserves (y<sub>2</sub>) has a significant effect on increasing mineral value added (y<sub>3</sub>) of 0.0026 (shown in Fig.2). The findings above indicate that an increase in government spending directly does not have significant implications related to its effect on increasing mineral value added.

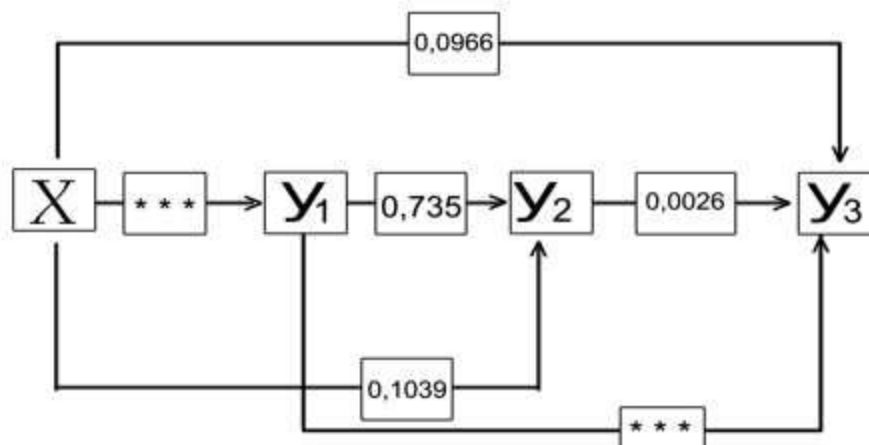


Fig.2: Showing a result of estimate simultaneous of equations model analysis

However, an increase in mining investment as an effect of increased government spending, indirectly has a significant effect on increasing mineral value added. This, has implications for the increase in employment opportunities, both in mining companies that supply the needs of the mineral minerals (input) of the mineral industry as well as the mineral industry itself.

The increase in investment will require a rapid return of investment and profit for industrial clusters in a region, positively implicating in improving corporate social responsibility (CSR), so that the guidance and assistance of companies to move the people's economy, improve public facilities and infrastructure and improve local community education

In addition, an increase in mining investment that has a significant effect on increasing mineral value added has

positive implications for increasing Regency GRDP, so that regional economies and people's welfare where the industrial clusters are located will also increase.

Furthermore, an increase in government spending and an increase in mining investment have a positive and not significant effect on increasing mineral reserves. However, increasing mineral reserves has a positive and significant effect on increasing mineral value added. This has implications for the longer lifespan of mine production in an industrial cluster and the longer period of mineral industry production, which produces concentrate and metal, so that it has further implications for achieving the objectives of economic and social transformation of communities around the mining business area (WUP).

#### V. CONCLUSION

The development of the mineral industry in a mining business area (WUP) aims to obtain mineral value added, and has implications for increasing the contribution of the mining business and excavation of the Regency GRDP in Indonesia in the long run.

Increasing government expenditure in the form of capital expenditure directly has no significant effect on increasing mineral value added, so that it cannot produce significant implications for people's welfare. Increased mining investment which is influenced by increased government spending has positive implications for increasing employment opportunities, increasing corporate social responsibility (CSR), improving regional economies and people's welfare.

Increased mineral reserves that have a positive and significant effect on increasing mineral value added have positive implications for the longer lifespan of mine production, mineral industrial production, and the achievement of the objectives of economic and social transformation of communities around the mining business area (WUP).

#### REFERENCES

- [1] Adam, Lukman 2014, Kebijakan mineral dan batubara di Indonesia, Pusat kajian DPRRI, ekonomi dan kebijakan public
- [2] Alayi, M.A, 2005, The resources curse effect, Resources rich countries and weak Institutions
- [3] Arellano, Jose Pablo ,2012, Copper Mining And Its Impact On Chile's Development, National Account And Balance of Payments, Central Bank of Chile
- [4] Arsegianto, 2000, Ekonomi Minyak dan Gas Bumi, Jurusan TeknikPerminyakan, Fakultas Ilmu Kebumihan dan Teknologi Mineral, Institut Teknologi Bandung,Bandung
- [5] Awolusi, Olawumi D, 2016, Mining sector and economic growth inSouthen African Economic: A panel data analysis, post doctoral fellow, graduate school of business andleadership, University ofKwazulu-natal South Africa
- [6] Badley,Daniel, and Steven Bruch, Andry Ralijaom, Rumhidzah Sithole, 2013, The South African Iron ore cluster, Microeconomic of Competitiveness Harvard Business School
- [7] Bird, R.M dan Vanllaucourt, F, 1998, Fiscal decentralization in Developing countries, Cambridge university press,New York
- [8] BSN, 1998, Klassifikasi Sumberdaya Mineral dan Cadangan,SNI, Amandemen1-SNI 13-4726-1998, ICS 73.020, Badan Standardisasi Nasional
- [9] Cust, James and Poelhekke, Steven, 2015, The local economic impacts of natural resources extraction, annual review of resources economics
- [10] Djojohadikusuma S, 1995, Pembangunan Ekonomi Indonesia, Jakarta,Sinar Harapan
- [11] Djojohadikusumo, Sumitro. 1994. *Perkembangan Pemikiran Ekonomi, Dasar Teori Ekonomi Pertumbuhan dan Ekonomi Pembangunan*. Jakarta: PT Pustaka LP3ES Indonesia
- [12] Fredbaim, John, 2012, Mining booms and government budget, the Australian journal of agricultural and resources economics, 56
- [13] Glyfason, t, 2004, Natural resource and economic growth from dependence to diversification
- [14] Hayami, et al, 1987, Agricultural marketing and processing in upland Java, A prespective from Sinda Village Coarse grains, Univ Al Azhar
- [15] Hasibuan, 2004, Ekonomi Industri, persaingan , monopoli dan regulasi, Universitas Indonesia Hlavova, Ing Natalia,2015, The Impact of mineral resources on Economic growth, International journal of Arts and commerce, ISSN 1929-7106
- [16] Jogiyanto, 2008, Teori portopolio dan analisis Industri, BPFE, Yogyakarta
- [17] Jomgenson, Dale, 1991, Productivity and economic growth, National bureau of economic research, univ of Chicago press
- [18] Kementerian Perindustrian, 2017.Hilirisasi Industri Berbasis Mineral Logam, Kementerian Perindustrian
- [19] Keynes, JM, 1936, The general theory of employment, Interest and money, New York, Harcourt Brace
- [20] Kniivila,Mattleena 2007, Industrial development and economic growth : Implications for poverty reduction and income inequality, Pellervoeconomic research Institute.
- [21] Helsinki, Findl and Kusnadi, 2008, Model-model persamaan structural, Alfabeta, Bandung
- [22] Lei,Yalin, Na Cui, Dongyang Pan, 2013, Economic and Social effectsanalysis of mineral development in China and policy implications, resources policy 38 (448 – 457)
- [23] Lubis, Rizky P. dkk, 2015, Faktor-Faktor yang mempengaruhi investasi asing langsung pada sektor perkebunan di Indonesia, Jurnal bisnis dan manajemen, Institut Pertanian Bogor, 2015, Vol. XVI, No. 2, 80 -89 ISSN 1412 – 3681
- [24] Makmum dan Akhmad Yasin, 2003, Pengaruh Investasi dan tenaga kerja terhadapPDB sektor pertanian, jurnal kajian ekonomi dan keunagan, Vol 7 No. 3 Sepetember
- [25] Mangkusubroto, Guritno, 2001, Ekonomi Publik Edisi 3, Yogyakarta, FE-UGM
- [26] Mangkusubroto, Guritno, 1994, Ekonomi Publik Edisi 3, Yogyakarta, BPFE
- [27] Marshal, A, 1920, Principle of economics, 8<sup>th</sup>

- edition, London, Macmillan
- [28] Musgrave, Richard dan Peggy, 1993, Public Finance In Theory and Practice, Mc Graw-Hill Inc, Fifth Edition London
- [29] Musgrave, Richard dan Peggy, 1989, Public Finance In Theory and Practice, Mc Graw-Hill, Inc, Fifth Edition London
- [30] Nangarumba, Muara, 2016, Analisis pengaruh kebijakan moneter, kebijakan fiskaldan
- [31] penyaluran kredit terhadap pertumbuhan ekonomi di Prov. Jawa Timur Tahun 2006-2016, IESP Vol. 8 No. 2 Nov 2016
- [32] Napier, J.A.L, 1981, Investment criteria and choice of production rate in the planning of gold mine production, Journal of the south afrika Institute of mining and metallurgy
- [33] Pemerintah Indonesia, Undang-Undang No. 4 tahun 2009 Tentang Pertambangan mineral dan batubara Pemerintah Indonesia, Badan Pusat Statistik Tahun 2009 – 2014
- [34] Porter, M.E, 2000, Location, Competition and economic development, local clusters in a global economy, Economic development quarterly 14(1), 15 – 34
- [35] Porter, M.E, 1998, Clusters and the new economics of competition, Harvard Business review, 76(6), pp. 77 – 90
- [36] Porter, M.E, 1990, The competitive advantage of nations, Macmillan, London
- [37] Prasetyo, P. Eko, 2010, Struktur dan kinerja industri besi dan baja Indonesia, Fakultas Ekonomi Universitas Negeri Semarang
- [38] Rudenno, 2004, The mining valuation handbook, 2<sup>nd</sup> edition, Rightbooks an import of John Wiley and Sons Australia, Ltd
- [39] Saadat, Wajih, 2016, Impact of mineral resources on economic growth of Pakistan, Journal of resources development and management, ISSN 2422-8397, Vol.20 – 2016
- [40] Salebu, Jefry Batara, 2014, The impact of foreign direct investment on Indonesia economic growth, MPRA paper No. 72830- 2016
- [41] Schmitz, Hebert, 1992, On the clustering of small firms, IDS bulletin, Vol 23, Issue 3, Juli 1992 pages 64 – 69
- [42] Siddiqui, Masood Mashkoor dan Abdul Malik, 2011, Impact of Government Expenditure on Income Distribution A Theoretical Analysis In The Case Pakistan, International Journal of Economics and Management Science.
- [43] Smith, David, 1977, Growth and Its disorder
- [44] Smith, Adam 1776, An Inquiry into the nature and causes of the wealth of nations, [www.feedbooks.com](http://www.feedbooks.com)
- [45] Stermole, Franklin J, 2000, Economic evaluation and investment decision methods,
- [46] Investment evaluation corporation 2000 Goldenvue Dive Golden, Colorado 80401
- [47] Solow, Robert M, 1956, A Contribution to the theory economic growth, the quarterly journal of economic, vol 70 no.1
- [48] Sukirno, Sadono, 2000, Pengantar Teori Makroekonomi, Jakarta, PT. Raja Grafindo Persada
- [49] Suparmoko. 2006. *Ekonomi Sumberdaya Alam dan Lingkungan (Suatu Pendekatan Teoritis): Edisi 3*. Yogyakarta. BPFE Yogyakarta
- [50] Suyanto, 2011, Perkembangan bisnis dan industri Indonesia 1970 – 2010, Jurnal ilmiah sosial dan humaniora vo. 4 no.1, fakultas bisnis dan ekonomika, univ Surabaya
- [51] Tambunan, 2001, Perekonomian Indonesia, Teori dan temuan empiris, galian Indonesia, Jakarta
- [52] Uchenna, Efobi dan Osabuohien S. Evans, 2012, Governments Expenditure In Nigeria: An Examination of Tri Theoretical Mantras
- [53] UNIDO, 2001, Growth, Industry and Trade of least developed countries, statistics and information branch of Unido, United Nations Industrial Development Organization, May, 2001
- [54] Vovely, William, 1981, Nonfuel mineral and the world economy, chapter 15, World Resources Institute Book Yale University Press
- [55] Wiriosudarmo, 2000, Agenda pertambangan untuk pengembangan kualitas hidup secara berkelanjutan, kerjasama kantor menteri LH dan UNDP
- [56] Wellmer, Friedrich and Christian Hegelikum, 2015, The feedback control cycle of mineral supply, increase of raw material efficiency and sustainability development, Institute for geoscience and natural resources, Germany
- [57] Wright, Gavin and Jesse Czelusta, 2004, Mineral Resources and Economic Development, World Bank Latin American and Caribbean Regional Office Report
- [58] Yunanto, Muhammad, Dampak kebijakan fiscal terhadap sektor Industri, Universitas Gunadarma, Depok Zeytoon, Seyyed Ali and Nejad Moosavian, 2015, Production Function of the Mining Sector of Iran, European Online Journal of Natural and Social Sciences, Special Issue on New Dimension In economic, accounting and management, ISSN 1805-3602, Vol.4.No.1, pp138–453

# Adsorption of Nitrogen Dioxide (NO<sub>2</sub>) for Different Gas Concentrations, Temperatures and Relative Humidities by using Activated Carbon Filter: An Experimental Study

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**Abstract**— Noxious gases can be reduced through activated carbon; nevertheless, this process is very complex due to the changing parameters. Nitrogen dioxides take place in the so-called reactive gases. The nitrogen dioxide concentration existing in the environment can be harmful, in particular for asthmatics and it also has the potential to bring about other serious diseases. For instance, interior diseases are often caused by nitrogen oxide gases. Through this study, we have observed the nitrogen dioxide adsorption on the active carbon for varying air temperatures, gas concentrations and air relative humidities. In this context, it has been examined the effect of all three parameters. While conducting this project, we have used parameters between 1ppm and 30ppm (for NO<sub>2</sub> concentration), 23°C and 33°C (for air temperature), 30% and 90% (for air relative humidity). In order to understand this process, breakthrough curves of NO<sub>2</sub> evaluated from experiments have been used in the present study. Results show that the humidity has not a remarkable effect on the adsorption of NO<sub>2</sub>; however, increasing relative humidity causes to a decrease in the capacity of the activated carbon for NO<sub>2</sub> adsorption. Additionally, NO<sub>2</sub> adsorption is exothermic, therefore it increases the air temperature.

**Keywords**— adsorption of NO<sub>2</sub>, filtration, activated carbon, air pollution, NO<sub>2</sub>.

## I. INTRODUCTION

Our environment is polluted by many different noxious gases owing to the production of -among others- the corrosive exhaust gases NO<sub>x</sub>, NO+NO<sub>2</sub>. These gases have been created through power plants and burning of coals and so on. There are two gases inside NO<sub>x</sub>: one of them is Nitrogen monoxide (NO) and the other one is Nitrogen Dioxide (NO<sub>2</sub>). Besides, N<sub>2</sub> gas is also arisen

out of the break-up of NO<sub>x</sub> gas. This process necessitates a quite high temperature. Nitrogen dioxide (NO<sub>2</sub>) is a corrosive, irritant gas that harms the mucous membrane tissue in the all upper respiratory tract and also irritates the eyes. The indirect effect of NO<sub>2</sub> on human health is its quality as a precursor chemical to fine dust. Constant increased fine dust pollution leads to cardiovascular diseases and illnesses in the respiratory tract and shortens the expectancy of life.

Nitrogen oxides are generated as a result of combustion processes -either man-made or naturally-occurring from gasiform nitrogen and oxygen supplied by combustion air. But also, chemically bonded nitrogen in self-combustible things such as coal, oil, garbage is transformed into its oxides with oxygen from the combustion air. Table 1 justifies that almost all the Nitrogen Oxide (NO) originates from human-driven events like the burning of coal, the usage of gasoline and oil in various forms such as transportation, industries, households, agricultural activities and so on. It follows that the better the combustion it is, the higher the temperature and formation of NO<sub>x</sub> it is. In catalytically non-affected combustion processes, NO develops as a main product with a percentage of between 90-95% of NO<sub>x</sub> [1].

Table.1: Nitrogen oxide emissions according to the sectors (for EEA member countries) [2]

Sources of NO <sub>x</sub>	Proportion
Road transport	42%
Energy production and distribution	20%
Energy use in industry	13%
Commercial institutional and households	14%
Non-Road Transport	7%



Industrial processes	2%
Agriculture	2%

NO<sub>2</sub> amount around the world poses a great danger to human health and environment. According to a study about NO<sub>2</sub> and other waste gases' effect on human health by Chaloulakou et al. (2008), it is ascertained that the regions where the NO<sub>2</sub> rates diminished in Athens, a 2.6% decrease in the people going to hospital has been observed in these regions [3]. Al-Ahmadi et al. (2013) have shown in their studies that the ratio of NO<sub>2</sub> has a triggering effect on cancer [4]. Moreover, Murphy et al. (1964) have seen that NO<sub>2</sub> gas has nonrecoverable damages on animals along with serious harms to human health [5].

It is important to remove the reasons behind the NO<sub>2</sub> production so as to eliminate these damages. However, current technological developments and modern lives of people preclude from the usage of technological devices producing NO<sub>2</sub>. For this reason, minimising the emission of NO<sub>2</sub> and set its ratios back to the levels that does not influence humanity has a vital role in terms of human health and environment since the production processes of NO<sub>2</sub> is impossible to eliminate.

The reduction of NO<sub>2</sub> gas in the available systems is provided with adsorbed filtration systems. The adsorption term denotes to the cleaning of air from NO<sub>2</sub> and other gases with various elements like activated carbon (The adsorption term will be explained briefly). Several studies and experiments have been conducted with regard to the adsorption of NO<sub>x</sub> gases in different variations. Before addressing such processes, a more general explanation of adsorption has to be made. Adsorption means the accretion of fluid substances on a solid surface. The components adsorbed are called adsorptive in a free and flexible state while in a bounded state the components are called adsorbents. The solid matter functioning as adjuvant is called adsorbent. In the physical adsorption the bound of the adsorbing molecules are carried out by electrostatic attractive forces, the so-called van [6]. Because of the small range of those forces, the adsorbents and adsorptive components enter a loose bond which can be dispensed easily. Adsorption is a thermic separating process. It is mainly used for separating specific gas components that are only contained in a very small amount [7].

Zhang et al. (2008) analysed the adsorption behaviour of NO<sub>2</sub> on activated carbon with different temperatures. Additionally, they also examined the ranges of activated carbon particles and as a result, it was seen that the adsorption of NO<sub>2</sub> includes the reduction of NO<sub>2</sub> to NO actuated via the carbon surface oxidation [8].

Dantaset al. (2009) presented the adsorption behaviours of Carbon dioxide (CO<sub>2</sub>) on activated carbon and activated carbon enriched with nitrogen. In this study, adsorption behaviour in a fixed-bed column was analysed. In another study, the experimental parameters were selected between 301K and 428K and total pressure was 1.01 bar. The result showed different adsorption characters. The nitrogen-enriched activated carbon presented lower bed surface than the original activated carbon [9]. Bazan et al. (2016) studied on the elimination of NO<sub>2</sub> with carbonaceous adsorbents acquired with supercritical extraction of marigold residue. Also, the results of this study showed that a right carbon and activation process is important in the adsorbents together with inorganic pollutants [10].

Gao et al. (2011) researched the adsorption of NO<sub>2</sub> on activated carbon by adjusting low temperature. The experiment temperature was determined as 50°C. As a result, they analysed that it had not much effect at a low temperature [11]. Another study presented the NO<sub>2</sub> adsorption and reduction on pitch-based activated carbon fibres. The experiment parameters were determined as 250-1000 ppm concentrations; O<sub>2</sub> was 0-10% and temperature was between 30 °C and 70°C. Pitch-based activated carbon fibres led to soar up of NO quickly; however, the adsorption of NO<sub>2</sub> remained the same up to the breakthrough time at 30 °C temperature. Meanwhile, it was also experienced a decrease in the adsorption and breakthrough time of NO<sub>2</sub> at 70 °C temperature [12]. Nowicki et al. (2013) investigated the activated carbon character and adsorption properties. NO<sub>2</sub> gases were determined as adsorptive. Activated carbon surface area range was between 5 to 2,076 m<sup>2</sup>/g and pore volume is between 0.03 and 1.25 cm<sup>3</sup>/g. The outcomes of their studies have also pointed out that a proper selection of pyrolysis and activation process in the wastes of coffee sector pave the way for high amount of NO<sub>2</sub> production indicating 44.5 mg NO<sub>2</sub> in dry states and 84.1mg NO<sub>2</sub> in wet states [13]. Lee et al. (2003), studied on impregnated activated carbon with KOH (KOH-AC) and examined the ratio of adsorption of NO<sub>x</sub> and SO<sub>2</sub>. The result indicated that the adsorption capacity of NO<sub>x</sub> gas was much more than the capacity of SO<sub>2</sub> gas [14]. Long et al. (2008) made a study of the ammonia adsorption on activated carbon. In here, it was concentrated on two parameters: these are to bring out the effects of temperature and concentration over the adsorption of ammonia. The experimental results depicted that the adsorption rate of ammonia over activated carbon was tended to rise with the increasing concentration in these studies.

The adsorption rate is also tended to rise with the increasing temperature. Long et al. (2008) analysed the change over the carbon surface with dimethylamine on

the adsorption of NO<sub>x</sub> [15]. The wood-based activated carbon was tried with dimethylamine aqueous solution. In order to get it together with the nitrogen groups, it is modified in this way. This modification was considered as NO<sub>2</sub> adsorbents. In this context, breakthrough time and concentration was observed. While examining the nitrogen adsorption, it was also made element and temperature test together with potentiometric titration and the modifications were handled after exposing to NO<sub>2</sub>. As a result, it was seen that the adsorption rate of NO<sub>2</sub> increased; on the other hand, NO release decreased [16]. Toops et al. (2006) analysed the adsorption of NO<sub>x</sub> over Pt/K/Al<sub>2</sub>O<sub>3</sub> with different period of times and temperatures. While the adsorption of NO<sub>x</sub> is 6.4 μmol/m<sup>2</sup> at 150 °C, the adsorption is observed as 1.8 μmol/m<sup>2</sup> at 400 °C in their study [17]. Zhu et al. (2000) investigated the adsorption behaviour of NO on activated carbon at low temperatures (between 30°C and 250 °C), and NO showed a decrease with the increasing temperature in these temperature ranges. Here, the activated carbon was treated with NH<sub>3</sub> [18]. Hofmann and Pietrzak (2011) used waste tires as adsorbents in their experiments and put them through a chemical process between 550 °C and 800 °C. Besides, it was also researched the pyrolysis based on the performances of waste tires adsorbents through the effects of modification such as chemical and physical activation in addition to the room temperatures and dry states. As a consequence, it was understood that the surface of the adsorbent has the indicative feature in the adsorption capacity and also it affected the NO<sub>2</sub> adsorption [19]. Zhang et al. (2008) studied the reduction of NO gas on activated carbons having porous structures and they realized it under 100 °C. In this sense, it can be described that there is not any NO reduction without any existence of oxygen [20]. Kazmierczak-Razna et al. (2016), in their study, tested the pyrolysis analysis, the surface structure and adsorption characteristics on activated carbon. The

outcomes also justified that the appropriate pyrolysis and activation process enables the adsorbents' production within this scope [21]. Sager et al. (2016) presented that NO<sub>2</sub> gas reduction with the help of activated carbon can be advanced via metal oxide nanoparticles infiltration into sorbents at ambient temperatures. The adsorption of NO<sub>2</sub> was reduced in a catalytic way to physiological neutral substances through metal oxides after adsorbed by activated carbon. The amount of reduction was quite slow at usual ambient temperatures [22].

As it was shown in the research above, several experiments and examinations of NO<sub>x</sub> adsorption have been made; however, they are generally studying the NO<sub>x</sub> adsorption for limited parameters. In this study, adsorption capacity of NO<sub>2</sub> by activated carbon is determined. During the experiment, the NO<sub>2</sub> concentration is varied from 5ppm to 50ppm while temperature and relative humidity are varied from 10°C to 20°C and from 30% to 70%, respectively.

## II. TESTING SYSTEM

In this experimental setup, different parameters and materials are used. The aim of the study is to observe the adsorption behaviour of activated carbon while changing the concentration of NO<sub>2</sub>, air temperature and relative humidity. NO<sub>2</sub> gas supplied to the experimental setup as toxic gas. DIN 71460 standard, which describes the cabin air filtration standard, is used in this experiment. Schematic view of the experimental setup is given in Figure 1. Normally, NO<sub>2</sub> is always found in a fluid phase at room temperature. In order to achieve its gas phase, NO<sub>2</sub> was heated prior to dosage in filters. We used 0.79 μg activated carbon, which complies with the average amount of filtered carbon as equivalent. An activated carbon layer was built into the trial lane. Together with filtered air, the dosage introduced from outside the trial lane. The measurements were conducted via using measurement device type AC 31M.

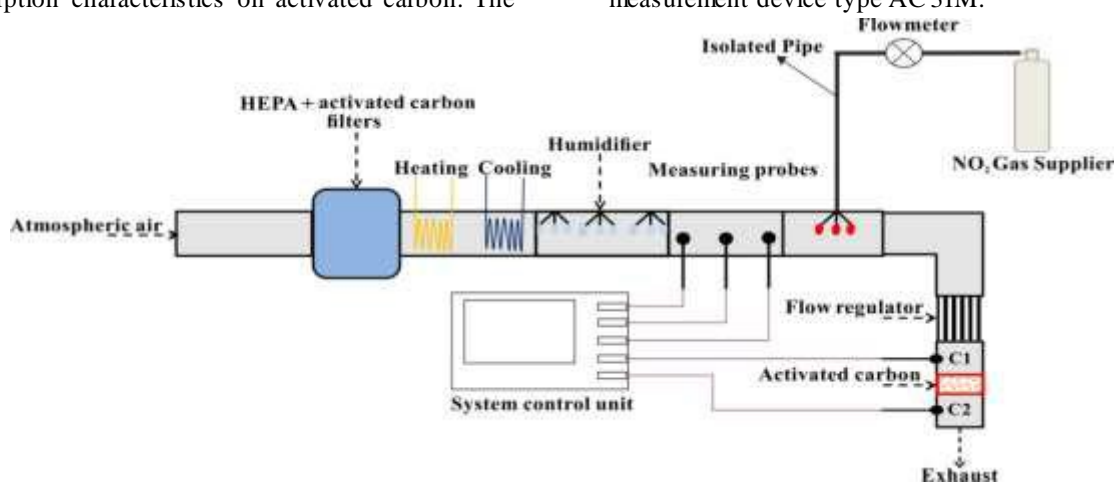


Fig.1: Schematic view of the experimental setup

The adsorption behaviour of the Nitrogen Dioxide ( $\text{NO}_2$ ) on activated carbon is examined at different concentrations and relative humidity as a result of the research. Initially, the experimental parameters, that can be seen in the experimental setup in Figure 1, was set and then the instruments are calibrated and requested amount of  $\text{NO}_2$  gas concentration is injected into the system after reaching the requested ratios of temperature and relative humidity. After filling of activated carbon, the adsorption test starts with transmitting of gas concentration in the experiment on the activated carbon. The gas inlet is called as raw gas while

the gas outlet is called as clean gas. The point where the gas inlet and outlet become equal is called as breakthrough point, that is the adsorption is not going ahead and activated carbon reaches at saturation point.

### III. RESULTS AND DISCUSSION

The results of the experiments are investigated in detail and given in figures. The results of the experiments are investigated in detail and given in figures. The x-axis of the diagram shows the time duration of an experiment in minutes, the y-axis of the diagram shows the change in the raw gas and clean gas concentration range.

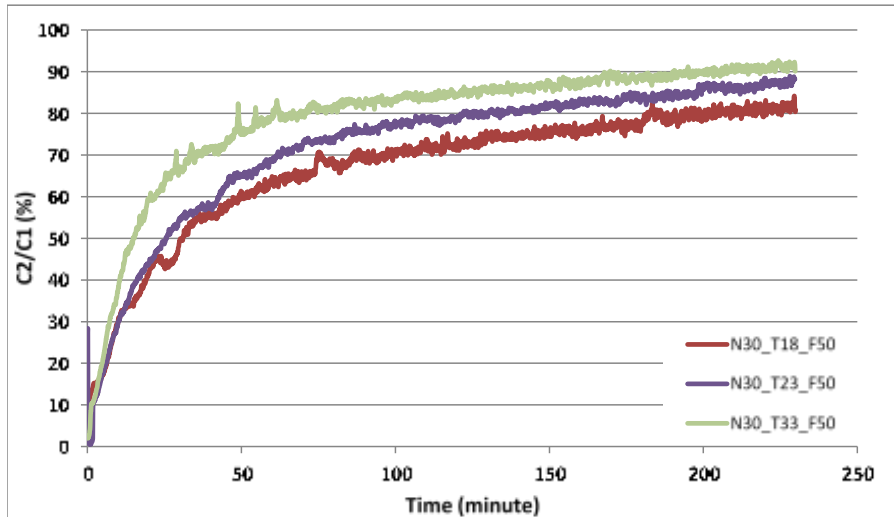


Fig.2: The comparison of the breakthrough curves for air temperatures of 18 °C, 23°C and 33°C at N=30ppm  $\text{NO}_2$  gas concentration, F=50% air relative humidity

The figure above shows the breakthrough curves for 18 °C, 23°C and 33°C at a 30 ppm  $\text{NO}_2$  gas concentration and a constant relative humidity (50%). The experiment here has maintained until 230 minutes, and 18 °C curve has reached the saturation point at about 85 %.

While the figure is reaching a 88% saturation point at 23 °C, it reaches 91% saturation point at 33 °C. A noticeable change in the increase or decrease of temperature can not be seen at 30 ppm.

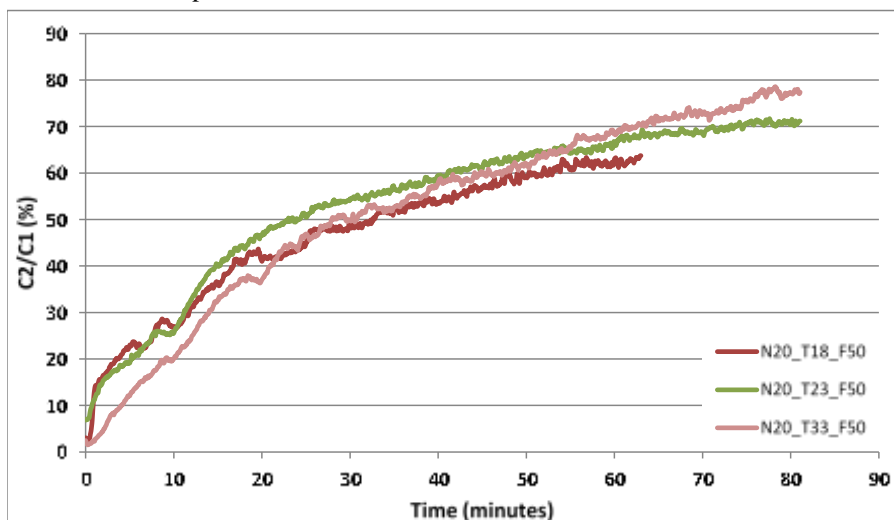


Fig.3: The comparison of the breakthrough curves for air temperatures of 18 °C, 23°C and 33°C at N=20ppm  $\text{NO}_2$  gas concentration, F=50% air relative humidity

Figure 3 shows the breakthrough curves for 18 °C, 23°C and 33°C NO<sub>2</sub> gas concentration at a 20 ppm gas concentration and a constant 50% relative humidity.

The experiment has maintained until 80 minutes and a noticeable change in the increase or decrease of temperature can not be seen at 20 ppm like in the 30 ppm.

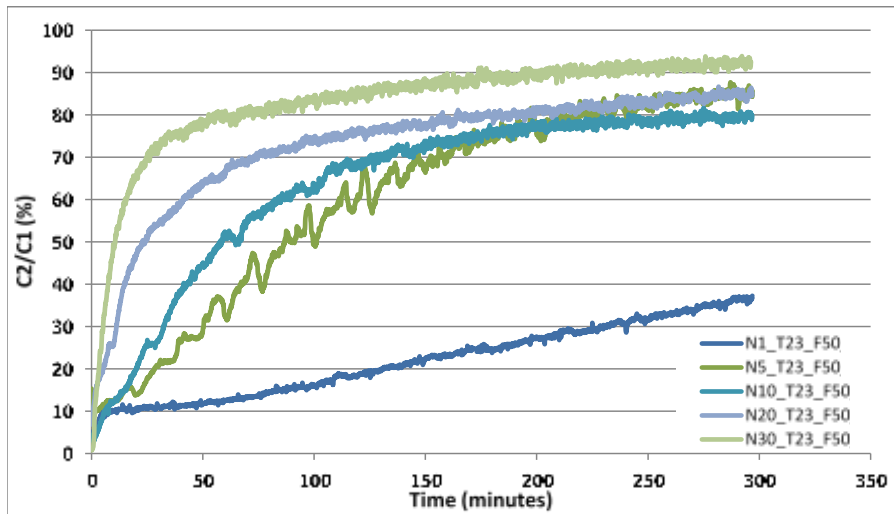


Fig.4: The comparison of the breakthrough curves for varying NO<sub>2</sub> gas concentrations of 1ppm, 5ppm, 10ppm, 20ppm, 30ppm at air temperatures of 23°C and air relative humidity of F=50%

As above it is shown in Figure 4, it is examined adsorption behaviour of NO<sub>2</sub> with changing concentrations and the same temperature and relative humidity. In here, while temperature is taken as 23 °C and relative humidity is 50%, the ratios of the concentration can be seen as 1 ppm, 5ppm, 10 ppm, 20 ppm, 30 ppm. The experiment time is 300 minutes. While it reaches

37% saturation point in 1 ppm of NO<sub>2</sub> at the end of the 300 minutes, it reaches 84% saturation point in 20 ppm of NO<sub>2</sub>. And, it reaches 92% saturation point in 30 ppm of NO<sub>2</sub> at the end of 300 minutes. That is to say, it can be seen that the breakthrough point shortens when the gas concentrations are increased.

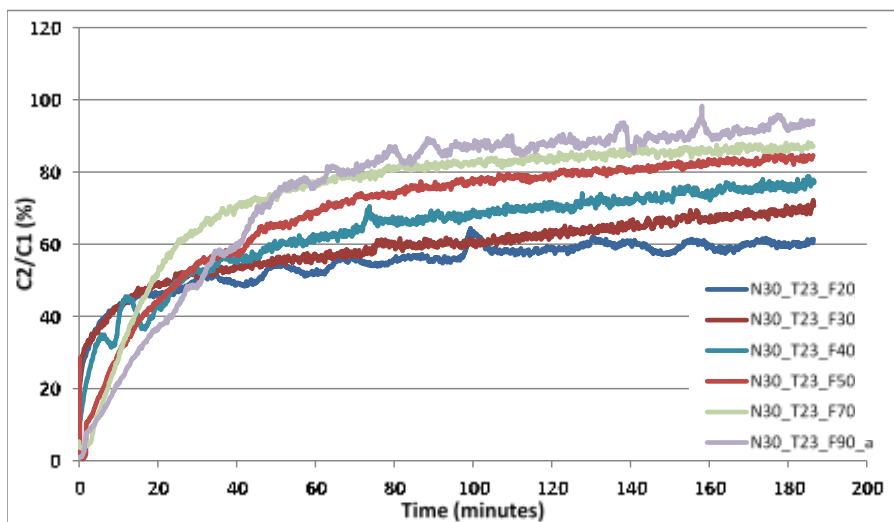


Fig.5: The comparison of the breakthrough curves for a varying air relative humidity from 20% to 90% at NO<sub>2</sub> gas concentrations of 30ppm and air temperatures of 23°C

As in the shown Figure 5, it is examined the adsorption behaviour of NO<sub>2</sub> gas at constant concentrations and constant temperature, but at different relative humidity. And, in this way, we can see the effect of different relative humidity on adsorption. When it is observed at the end of the 185 minutes experiment, it

reaches 60% saturation point at 20% relative humidity, constant temperature and concentration. While it is attained 70% saturation point at 30%, it successes 92% saturation point at 90% relative humidity. With the increasing relative humidity, the time to reach the saturation point shortens and the adsorption is realized

quicker than before. This diagram also shows that if we have higher concentration range, then it is faster than lower concentration at the NO<sub>2</sub> adsorption at same

temperature and relative humidity and concentration range between 5ppm and 30 ppm.

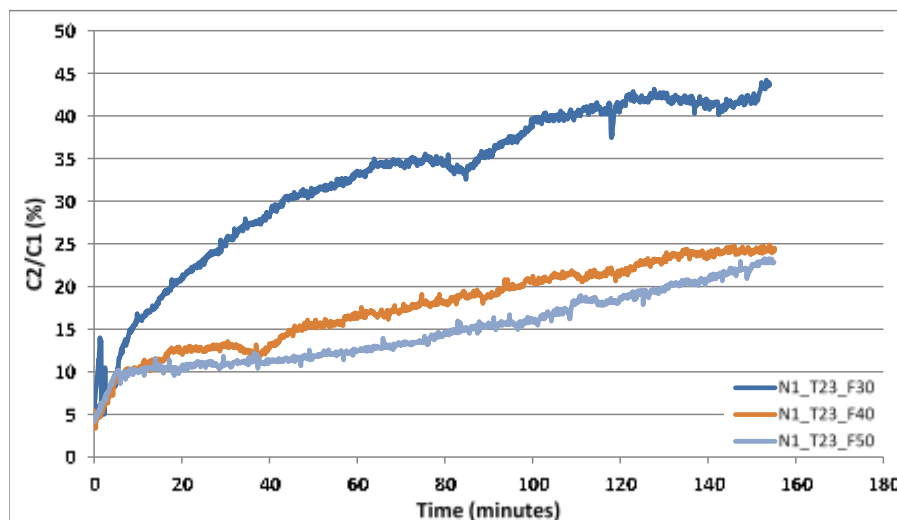


Fig.6: The comparison of the breakthrough curves for a varying air relative humidity from 30% to 50% at NO<sub>2</sub> gas concentrations of 1ppm and air temperatures of 23°C

Figure 6 indicates the adsorption behaviour of NO<sub>2</sub> gas at constant lower concentration, constant temperature and different relative humidity. Here it is taken as 1ppm of NO<sub>2</sub> gas concentration, the temperature as 23 °C and the relative humidity is taken as 30%, 40% and 50%. During 155 minutes experiment, while the time to reach the saturation point is 24% at 50% relative humidity, it is 45% at 30% relative humidity. Here we can see that the time to reach the saturation point increases together with the decreasing relative humidity. This is the direct opposite way of higher concentrations.

#### IV. CONCLUSION

In this study, NO<sub>2</sub> adsorption on active carbon was examined. We experienced that relative air humidity had not a remarkable influence on the adsorption in contrast to other gases like CO<sub>2</sub>, SO<sub>2</sub> etc. Simultaneously, it was demonstrated how a change in temperature had little influence on NO<sub>2</sub> adsorption. After all, the NO<sub>2</sub> adsorption rate increased together with increased concentrations; however, it was analysed that adsorption rate decreased at lower concentrations together with increased relative humidity.

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#### REFERENCES

- [1] European Environment Agency, Publications on Air Quality. (Accessed 19.11.2018). Source: [https://www.eea.europa.eu/publications/#c7=en&c11=5&c14=&c12=&b\\_start=0](https://www.eea.europa.eu/publications/#c7=en&c11=5&c14=&c12=&b_start=0).
- [2] European Environment Agency, Nitrogen Oxides (NOx) Emissions Report. (Accessed in 18.11.2018). Source: <http://www.eea.europa.eu/data-and-maps/indicators/eea-32-nitrogen-oxides-nox-emissions-1/assessment.2010-08-19.0140149032-1>.
- [3] Chaloulakou, A., Mavroidis, I., & Gavriil, I. (2008). Compliance with the annual NO<sub>2</sub> air quality standard in Athens. Required NO<sub>x</sub> levels and expected health implications. *Atmospheric Environment*, 42(3), 454-465.
- [4] Al-Ahmadi, K., & Al-Zahrani, A. (2013). Spatial autocorrelation of cancer incidence in Saudi Arabia. *International journal of environmental research and public health*, 10(12), 7207-7228.
- [5] Murphy, S. D., Ulrich, C. E., Frankowitz, S. H., & Xintaras, C. (1964). Altered function in animals inhaling low concentrations of ozone and nitrogen dioxide. *American Industrial Hygiene Association Journal*, 25(3), 246-253.
- [6] Börger, G. G. (1989). Adsorption aus der Gasphase. *Ingenieurwissenschaftliche Grundlagen und Technische Verfahren*. Von W. Kast. VCH Verlagsgesellschaft, Weinheim 1988. XV, 279 S., geb. DM 220.00.-ISBN 3-527-26719-0. *Angewandte Chemie*, 101(5), 650-651.

- [7] Mahzoul, H., Brilhac, J. F., & Gilot, P. (1999). Experimental and mechanistic study of NO<sub>x</sub> adsorption over NO<sub>x</sub> trap catalysts. *Applied Catalysis B: Environmental*, 20(1), 47-55.
- [8] Zhang, W. J., Bagreev, A., & Rasouli, F. (2008). Reaction of NO<sub>2</sub> with activated carbon at ambient temperature. *Industrial & Engineering Chemistry Research*, 47(13), 4358-4362.
- [9] Dantas, T. L., Amorim, S. M., Luna, F. M. T., Silva Jr, I. J., de Azevedo, D. C., Rodrigues, A. E., & Moreira, R. F. (2009). Adsorption of carbon dioxide onto activated carbon and nitrogen-enriched activated carbon: surface changes, equilibrium, and modeling of fixed-bed adsorption. *Separation Science and Technology*, 45(1), 73-84.
- [10] Bazan, A., Nowicki, P., & Pietrzak, R. (2016). Removal of NO<sub>2</sub> by carbonaceous adsorbents obtained from residue after supercritical extraction of marigold. *Adsorption*, 22(4-6), 465-471.
- [11] Gao, X., Liu, S., Zhang, Y., Luo, Z., Ni, M., & Cen, K. (2011). Adsorption and reduction of NO<sub>2</sub> over activated carbon at low temperature. *Fuel processing technology*, 92(1), 139-146.
- [12] Shirahama, N., Moon, S. H., Choi, K. H., Enjoji, T., Kawano, S., Korai, Y., ... & Mochida, I. (2002). Mechanistic study on adsorption and reduction of NO<sub>2</sub> over activated carbon fibers. *Carbon*, 40(14), 2605-2611.
- [13] Nowicki, P., Skibiszewska, P., & Pietrzak, R. (2013). NO<sub>2</sub> removal on adsorbents prepared from coffee industry waste materials. *Adsorption*, 19(2-4), 521-528.
- [14] Lee, Y. W., Kim, H. J., Park, J. W., Choi, B. U., Choi, D. K., & Park, J. W. (2003). Adsorption and reaction behavior for the simultaneous adsorption of NO-NO<sub>2</sub> and SO<sub>2</sub> on activated carbon impregnated with KOH. *Carbon*, 41(10), 1881-1888.
- [15] Long, X. L., Cheng, H., Xin, Z. L., Xiao, W. D., Li, W., & Yuan, W. K. (2008). Adsorption of ammonia on activated carbon from aqueous solutions. *Environmental Progress*, 27(2), 225-233.
- [16] Deliyanni, E., & Badosz, T. J. (2010). Effect of carbon surface modification with dimethylamine on reactive adsorption of NO<sub>x</sub>. *Langmuir*, 27(5), 1837-1843.
- [17] Toops, T. J., Smith, D. B., & Partridge, W. P. (2006). NO<sub>x</sub> adsorption on Pt/K/Al<sub>2</sub>O<sub>3</sub>. *Catalysis today*, 114(1), 112-124.
- [18] Zhu, Z., Liu, Z., Liu, S., & Niu, H. (2000). Adsorption and reduction of NO over activated coke at low temperature. *Fuel*, 79(6), 651-658.
- [19] Hofman, M., & Pietrzak, R. (2011). Adsorbents obtained from waste tires for NO<sub>2</sub> removal under dry conditions at room temperature. *Chemical engineering journal*, 170(1), 202-208.
- [20] Zhang, W. J., Rabiei, S., Bagreev, A., Zhuang, M. S., & Rasouli, F. (2008). Study of NO adsorption on activated carbons. *Applied Catalysis B: Environmental*, 83(1-2), 63-71.
- [21] Kazmierczak-Razna, J., Nowicki, P., & Pietrzak, R. (2016). Toxic gases removal onto activated carbons obtained from hay with the use of microwave radiation. *Chemical Engineering Research and Design*, 109, 346-353.
- [22] Sager, U., Däuber, E., Bathen, D., Asbach, C., Schmidt, F., Tseng, J. C., ... & Schmidt, W. (2016). Influence of the degree of infiltration of modified activated carbons with CuO/ZnO on the separation of NO<sub>2</sub> at ambient temperatures. *Adsorption Science & Technology*, 34(4-5), 307-319.

# Studies on Development and Testing of Sensor for Automatic Irrigation System

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**Abstract**— In India, agriculture is the main sector for increasing the food production. In India, agriculture depends on the monsoons which is not sufficient source of water. So the irrigation is used in agriculture field. Every type of plant requires different amount of water to grow. To reduce the wastage of water and apply the optimum amount of water to the plants irrigation scheduling is needed. For irrigation scheduling it requires to determine the moisture content present in the soil. So to determine the moisture content the methods are very time consuming and less accurate. This project is an attempt to reduce the time consumption to determine the moisture content and to make it automatic and easy to use. We developed a moisture sensing kit and compared its reading with the gravimetric method. Also we design the automatic motor operating irrigation system on the basis of that moisture sensor reading. That is the motor is on when moisture is less than 50% and continues up to 80%. If moisture is greater than 80% then motor will automatically stopped. Also we provide GSM system with that microcontroller. If moisture is less than 50% then message will be automatically receive on the mobile. The aim of our project is to provide new agriculture technology by programming.

**Keywords**— Moisture sensor, Gravimetric method, Motor, GSM Sim module.

## I. INTRODUCTION

When the population increases, the basic need such as food and water is increasing day by day. Thus there is a need of saving water resources and utilize them in an efficient manner. Hence, water is one of the most important elements in our daily life, thus we must use efficient ways to utilize water and save it for future generations. For that efficient irrigation management is needed. Irrigation water management practices could greatly benefit by the knowing of moisture in the soil.

To determine the soil moisture content in the soil many methods are being used but these methods are time consuming and less accurate. To do the operation in the least time consuming way electronics components should be used. Soil moisture content is the water present in the soil. By measuring soil moisture at regular interval and at different depths within the root zones, information can be

obtained as to the rate at which moisture is being used by the crops at different depths. This provides the practical purpose, irrigation should be applied when moisture content is base for determining when to irrigate and how much water to be applied. For depleted below 50 percent of available moisture.

## II. METHODS TO DETERMINE SOIL MOISTURE

### 2.1. Direct method

#### 2.1.1. Gravimetric methods:

In gravimetric method, basic measurement of soil moisture is made on soil samples of known weight or volume. Soil sample from the particular depths are collected with a soil auger. Soil sample are taken from particular depth at several locations of each soil type. They are collected in the air tight aluminium containers. The soil samples are weighed and they are dried in air oven at 105 °C for about 24 hours until all the moisture is driven off. After removing from oven, kept them for cool to room temperature and weighed again. The difference in their weight is amount of moisture in the soil. The moisture content in soil is calculated by the following formula:-

$$\text{Moisture Content (\%)} = \frac{M_2 - M_3}{M_3 - M_1} * 100$$

Where,

M<sub>1</sub>=Weight of sample box (gm)

M<sub>2</sub>=Weight of wet soil + lid (gm)

M<sub>3</sub>=Weight of dry soil + lid (gm)

#### 2.1.2. Volumetric Methods:

Soil sample is taken with the core sampler or with a tube auger whose volume is known. The amount of water present in soil sample is calculated by drying it in the oven and calculating by following formula.

**Moisture content** = Moisture content in weight x Bulk Density in volume.

#### 2.1.3. Using Methyl Alcohol:

Soil sample is mixed with a known volume of methyl alcohol and then measure the change in specific gravity of alcohol with a hydrometer. This is a shot procedure but it is in common use.

#### 2.1.4. Using calcium chloride:

Soil sample is mixed with the known amount of calcium chloride. Generally calcium chloride reacts with water and removes it in the form of acetylene gas.

## 2.2. Indirect method

In these methods, no water content in the soil is directly measured but the water potential or stress or tension under which the water is held by the soil is measured. The most common instrument used for estimating soil moisture by indirect method are of following-

### 2.2.1. Tensiometer:

Tensiometers provide a direct measure of tenacity with which water is held by soil. It consist of 7.5 cm porous ceramic cup, a protective metallic tube, a vacuum gauge and a hollow metallic tube holding all parts together. At the time of installation, the tensiometer is filled with water from the opening at the top and rubber corked it is used when set up in the soil. Moisture from cup moves out with the drying of soil, creating a vacuum in the tube which is measured with the gauge. Care should be taken to install tensiometer in the active root zone of the crop. When desired tension is reached, soil is irrigated. The vacuum gauge is graduated to indicate tension values up to one atmosphere and is divided into fifty divisions each of 0.2 atm value. The tensiometer works satisfactory up to the 0.85 bars of atmosphere.

### 2.2.2. Gypsum block:

Gypsum blocks resistance units are used for measurement of soil moisture in situ. These were discovered by Bouycos and Mick in 1940. The blocks are made of various materials like gypsum, nylon fiber, glass material, plaster of Paris or combination of these materials. The blocks are generally rectangular in shape. A pair of electrode is usually made of 20 mesh stainless steel wire screen soldered to copper lead wire. The common dimensions of screen electrodes are 33.75 cm long and 0.25 cm in wide. The usual spacing between electrodes is 2 cm. A similar block dimension is 5.5 cm long, 3.75 cm wide and 2 cm thick.

### 2.2.3. Pressure plate and pressure membrane apparatus:

Pressure membrane and pressure plate apparatus is used to estimate field capacity, permanent wilting point and moisture content at different pressures. The apparatus consists of air tight chamber in which porous ceramic pressure plate is placed. The pressure plate and soil samples are saturated and they are placed in the metallic chamber. The required pressure, say 0.33 or 15 bars is applied through a compressor. The water from soil sample which is held at less than the pressure, applied trickles out of the outlet till equilibrium against applied pressure is achieved after that, soil samples are taken out from oven for determining the moisture content.

### 2.2.4. Neutron probe:

Soil moisture can be estimated quickly and continuously another with the neutron moisture meter without disturbing the soil. Another advantage is that soil moisture can be estimated from the large volume of soil. Diameter around the neutron probe in wet soil and 50 cm in the dry soil. It includes the probe and a scalar or rate meter. The probe contains fast neutron source, which may be a mixture of radium and beryllium and beryllium. Access tubes are aluminium tubes of 50 to 100 cm length and are placed in the field where moisture to be estimated.

To determine the soil moisture by the methods listed above requires extensive amount of time, so the alternative for this is to use the electronic Instruments like the instrument called soil moisture sensor. The soil moisture sensor is used to measure volumetric water content from the soil.

## III. MATERIAL AND METHODS

In this study, we are using two methods of determining moisture content-

3.1. Automatic moisture sensing method

3.2. Gravimetric method

Then,

### 3.1. Automatic moisture sensing method

**3.1.1. Material:** For the moisture sensing method Following material is used,

#### 3.1.1.1. Moisture Sensor:

Moisture sensor is a two-probe sensor which is made up of pure nickel. Nickel has fair conductive properties and also strength to get buried in the soil for long time. It will not get corroded in soil. The length of the nickel probes is 9.5 cm and width of each probe is 0.7cm. The distance between the two probes is 0.5cm the tips of sensor probes are designed in the shape of triangle so that can be easily buried in the soil.



Plate No. 3.1: Moisture sensor

#### 3.1.1.2. Microcontroller (Arduino Mega):

The Arduino Mega is a microcontroller based on the ATmega2560. It has 54 digital input pins/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs, a 16 MHz crystal oscillator, a USB connection, the power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with the USB cable or power it with a AC-to-DC adapter or battery to get started.





Plate No. 3.2: Microcontroller (Arduino Mega)

### 3.1.1.3.LCD screen:

LCD screen is an electronic display module. A 16x2 cm LCD display is very basic module and is very commonly used in various devices and circuits.



Plate No. 3.3:LCD Screen

### 3.1.1.4.Breadboard:

A breadboard is the solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their terminals into the holes and then making connections through wires where appropriate. The breadboard has strips of metal underneath the board and connects the holes on the top of board. Note that the top and bottom rows of holes are connected horizontally internally and split in the middle while the remaining holes are connected vertically.

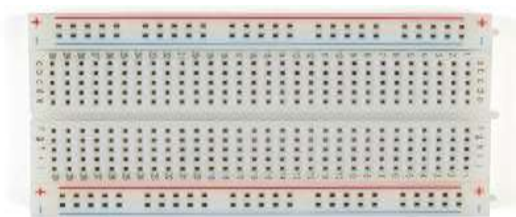


Plate No. 3.4: Breadboard

### 3.1.1.5.Jumper wires:

Jumper wires are simple wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed.



Plate No. 3.5: Jumper Wires

### 3.1.1.6.Relay:

A relay is an electrical switch which opens and closes under the control of another electrical circuit. In the general, the switch is operated by an electromagnet to open or close one or many sets of contacts. A relay is able to control and output circuit of higher power than the input circuit.



Plate No. 3.6: Relay

### 3.1.1.7.GSM module:

It is a specialised type of modem which accepts a SIM cards, and operates over a subscription to a mobile operator, just like a mobile phone. GSM networks operates in a number of different carrier frequency range, with most 2G GSM network operating in the 900 MHz bands. A GSM modem exposes an interface. The mobile operate charges for this message sending and receiving as if it was performed directly on a mobile phone.



Plate No. 3.7: GSM module

### 3.1.1.8.Motors:

This system requires the 12V DC permanent magnet motor.



Plate No. 3.8: Motors

**3.1.2. Methodology:**

1. Join the circuit as shown in the circuit diagram (Plate No.9).

2. Figure (Plate No.10) shows the proper placement of the Soil Moisture Sensor. The prongs must be oriented horizontally, but rotated onto their side like a knife poised to cut food - so that water does not pool on the flat surface of the prongs. The horizontal orientation of the sensor ensures the measurement is made at particular soil depth. The entire sensor can be placed in vertical, but because soil moisture often varies by depth, this is not usually the desired orientation. To position the sensor, use a thin implement such as a trenching shovel to make pilot hole in the soil. Place the sensor into the hole, checking with the entire length of the sensor is covered. Press the soil along either side of the sensor with your fingers. Pressing will be continuing until you have made at least five passes along the sensor. This step is important, as the soil around the sensor surface has the strongest influence on the sensor reading.

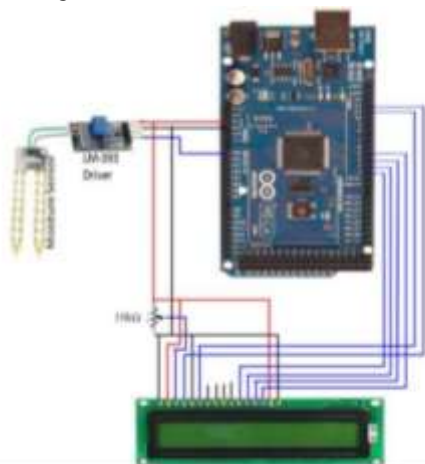


Plate No. 3.9: Circuit Diagram

3. Take the reading displayed on the LCD screen.



Plate No. 3.10: Moisture Sensor under the soil

**3.1.3. Software used:**

The software called Arduino is used. The software requires computer program to do all the operation. The microcontroller analyses all the data collected by the soil moisture sensor with the help of the program dumped in it and it displays the output on LCD screen.

**3.2. Gravimetric Method:****3.2.1. Materials:**

1. Aluminum container
2. Air oven
3. Trowel
4. Weighing machine

**3.2.2. Methodology:**

The soil moisture content may be expressed by weight as the ratio of the mass of water to the dry weight of the soil sample. To determine any of these ratios for specific soil sample, the water mass should be determined by drying the soil to constant weight and measuring the soil sample weight after and before drying. The water mass is the difference between the weights of the wet soil sample and oven dry samples. The criterion for a dry soil sample is the soil sample that has been dried to constant weight in oven at temperature between 100-110 °C (105 °C is typical). It seems that this range of temperature has been based on water boiling temperature and does not consider the soil physical and chemical characteristics.

**3.2.3. Procedure:**

1. Weigh aluminum tin and record this weight.
2. Place a soil sample of about 10gm in the tin and record this weight.
3. Place the sample in the oven 105°C and dry for 24 hours or overnight.
4. Weigh the sample and record this weight.
5. Return the sample to the oven and then dry for several hours, and determine the weight.
6. Repeat above 5 step until there is no difference between any two consecutive measurements of the weight.

**3.2.4. Computation:**

$$\text{Moisture Content} = \frac{M_2 - M_3}{M_3 - M_1} * 100$$

$M_1$  = Weight of sample box (gm)

$M_2$  = Weight of wet soil + lid (gm)

$M_3$  = Weight of dry soil + lid (gm)

**IV. RESULTS**

The moisture sensor is a fork like plate having aluminium inside. The two terminals are connected to microcontroller. Microcontroller is small PCB designed operate the electronic devices by commanding them with the help of programming language. The moisture sensor needs minimum 5v power supply to operate.

**4.1. Moisture Sensor Method:**

The following values of moisture content in soil are taken from the college campus from 3 Oct 2018.

Table No. 4.1: Moisture contents by moisture sensor

Soil type	Dry	Medium	Wet
Reading (%)	11	49	95

The moisture sensor readings in the dry soil is 11%, second reading in the medium wet soil is which is 49% and for third readings of moisture sensor in the wet soil is 95%.

**4.2. Gravimetric method**

The soil sample is taken from the different moisture medium of soil (dry,medium, wet) and at the same time as the moisture sensor reading were taken. The samples are collected in the sample box.

Table No. 4.2: Moisture contents by gravimetric method

Sr. No.	Weight of sample box (M1) (gm)	Weight of wet soil + lead (M2) (gm)	Weight of dry soil +lead (M3) (gm)	Moisture content (%)
1	36	74	70	11
2	35	70	60	40
3	35	71	55	80

The first soil sample of was taken from same place from where the first moisture sensor readings was taken. The resulting moisture content is 11%. The remaining soil samples were taken from the respective places as the moisture sensor readings and soil samples for gravimetric method were taken. the resulting moisture content is 40%, 80% respectively.

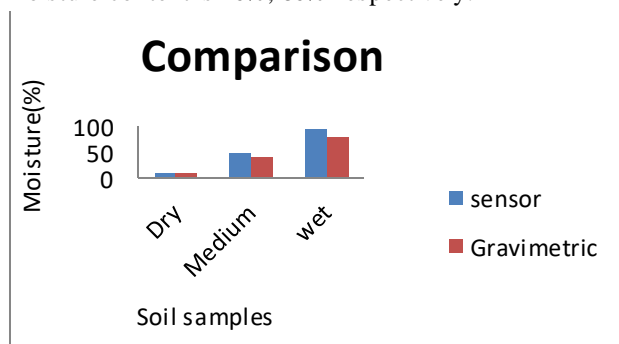


Figure No. 4.1: Comparison Graph

**V. CONCLUSION**

From this project we conclude that:

- 1) Gravimetric method is time consuming method but the moisture sensor gives the reading within 3 to 5 seconds.
- 2) The comparison of these two methods shows that the moisture sensor reading differ from the gravimetric method readings by approximately 10%.
- 3) The readings given by moisture sensor do not differ

constant.

- 4) Moisture sensor kit operation is user friendly.

**REFERENCES**

- [1] Abouatallaha A., Salghia R., Hammoutib B. and Fadlc A. (2011)-“Plant stress measurement of young citrus orchard”. Der PharmaChemica, 3 (6): 341-359.
- [2] Baoping F., Wang Z. and Zhang J. (2001)-“Theory and experiment on temperatureeffect in soil.” Northwest Water Resources & Water Engineering, 12(4), pp. 6-11.
- [3] Bhanarkar M. and Korake P. (2016)-“Soil salinity and moisture measurement systemfor grapes field by wireless sensornetwork.” Cogent Engineering, 3: 1164021
- [4] Costa E.( 2017)- “A self-powered and autonomous fringing field capacitive sensorintegrated into a micro sprinkler spinner to measure soil water content,” Sensors, vol.17, p. 575 .
- [5] Gunturi R. (2013)- “automatic irrigation systembased on the soil moisture”,International journal of advancements in research and technology , Volume 2, issue 4.
- [6] Guneet M., Arora M.(2004)- “Design of Capacitive Sensor for Monitoring MoistureContent of Soil and Analysis of Analog Voltage with Variability in Moisture, in Proc.” RA ECS UIET Panjab University Chandigarh.
- [7] Helmer R. (1997)- “Water sensor feedback control system for surface irrigation”,American Society of cultural engineers , Volume 5, pp 27-29.
- [8] Johnson A., Reddy U., Singh J., Chowdhury S., (1961)- “A Lowanst PortableTemperature Moisture Sensing Unit With ArticialNeural Network Based Signal Conditioning for Smart Irrigation Application”, International Journal on Smart Sensing and Intelligent Systems Vol. 4, NO.1.
- [9] Nandurkar S. and Vijaya R.(1995)-“Design of a Soil Moisture Sensing Unit for SmartIrrigation Application.” International Conference on Emerging Technology Trends on Advanced Engineering Research (ICETT’12).

# Multivariate Analysis Applied to Forestry Agricultural Sciences: The Model-Directed Study

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**Abstract**— This is a literature review that aimed to find articles that exemplify and describe the use of multivariate analysis in different fields of Forest Agricultural Sciences, considering effective practices using multivariate statistical techniques for the simultaneous processing of data. For data collection were selected for the meta-analysis of 70 technical articles of which 54 were employed in the study directed to the use of multivariate techniques applied in the areas of agricultural sciences. The results showed that studies directed to certain areas within the Forest Agricultural Sciences exhibit some regularity in the use of multivariate analysis, and most application analyzes were more usual as the Cluster Analysis (AA) and Principal Component Analysis (PCA). Thus the use of multivariate analysis studies and evaluations of experiments in Agricultural Sciences proved to great value to allow greater clarity and better interpretation of dealing with complex phenomena.

**Keywords**— *Multivariate Analysis, Multivariate Methods, Forest Agricultural Sciences.*

## I. INTRODUCTION

Statistically data analysis is classified into univariate or multivariate, i.e., it variables alone or jointly respectively. According VICINI, 2005 until the advent of computers the data were treated only in isolation, and when a phenomenon depends on many variables such analysis became unfeasible.

Multivariate analysis corresponds to a large number of methods and techniques that utilize, simultaneously, all variables in the theoretical interpretation of the set of obtained data (Neto,

2004). According to Hair et al., (2009) multivariate techniques are popular because they allow organizations to create knowledge, thereby improving their decision-making. Multivariate analysis refers to all the statistical techniques that simultaneously analyze multiple measurements on individuals or objects under investigation.

For Gerhardt, et al., 2001 multivariate analysis comes to data through a set of statistical techniques considering measures many variables simultaneously. And to obtain such results some multivariate methods are applied to data depending on the research objectives, since it is known that an exploratory data analysis, aims to generate hypotheses that is exactly the goal of the multivariate analysis (VICINI, 2005).

Multivariate analysis is a vast field in which even experienced statistical move carefully, because this is a new area of science, much is yet to be discovered. The art of the use of multivariate analysis is the choice of the most appropriate options to detect the standards expected in the data (MAGNUSSON, 2003).

The purpose of their application may be to reduce data or structural simplification, sort and group, to investigate the dependency between variables, prediction and develop hypotheses and test them (JOHNSON; WICHERN, 1992).

Multivariate techniques can meet the specific interests of a forestry company or a research institution, aiming at a particular interest, apart from a property or set of properties. Thus, this study aims to quantify and clarify what and how the main tools of multivariate analysis applied in various areas of study of forest agricultural sciences are used, reviewing a number of literature

articles updated where various techniques of multivariate analysis are used.

**II. REVIEW**

The application of multivariate analysis is a combination of multiple information entered in the experimental unit, so that the selection is based on a complete set of important variables that discriminate between materials that are more promising (Maeda et al., 2001). Since the multivariate techniques have numerous applications, one needs to know about the main of them being applied in the areas of Forest Agricultural Sciences, its functions and objectives. We as the main examples of multivariate techniques, multivariate normal distribution, matrix and vectors, quadratic forms, eigenvalues and eigenvectors, analysis of multivariate variance - MANOVA, the multivariate linear regression models, simultaneous tests on several variables, multivariate distances, component analysis, factors analysis, cluster analysis and discriminant, canonical correlation analysis.

**Factor analysis**

Factor Analysis (FA) aim to reduce the number of initial analysis with the least possible waste of information, taking advantage of a set statistical techniques (VICINI, 2005). CARVALHO, 2013 says that whenever there is a strong correlation with variables is conceivable to group them into a group, since different variable groups have weak correlation.

Factor analysis is applied when there is a large number of variables and correlated, includes principal component analysis and analysis of common factors, in order to identify a smaller number of new alternatives variables, uncorrelated and that somehow, summarize the main information of the original variables finding factors or latent variables (Mingoti, 2005).

According to Carvalho, 2013 generic formula for applying a factor analysis is defined by:

$$X = \mu + \Lambda F + \epsilon \quad (1)$$

Whereas  $X = [X_1 X_2 \dots X_p]^T$  as a real random vector of dimension P, with mean vector  $\mu = [\mu_1 \mu_2 \dots \mu_p]^T$  and covariance matrix  $\Sigma$  variance-defined positive. The model of factorial analysis each observable variable  $X_i$  expressed as a linear function of m random variables  $F_1, F_2, \dots, F_m$  ( $m < p$ ), called common factors, and one factor or error,  $\epsilon_i$ ,  $i = 1, 2, \dots, P$ . Which it is also a random variable that explains the part of the respective variable variance not explained by common factors. Already  $\Lambda$  would be the matrix (PXM), the common factors m and p only factors are not observable.

**Method Kaiser-Meyer-Olkin (KMO)**

Using factor analysis there is an adequacy of data that is very important proposal by Kaiser-Meyer-Olkin (KMO). The KMO test is based on the principle

that the inverse correlation matrix approaches the diagonal matrix, therefore compares the correlations between observed variables Solomon et al., (2012).

According VICINI, 2005 KMO can be obtained by the following equation:

$$KMO = \frac{\sum_i \sum_j r_{ij}^2}{\sum_i \sum_j r_{ij}^2 + \sum_i \sum_j a_{ij}^2} \quad (2)$$

The ratio of the sum of the squares of the correlations of all variables is divided by itself, plus the sum of the squares of the partial correlations of all variables.

At where:

=  $r_{ij}$  is the correlation coefficient between the observed variables i and j.

=  $a_{ij}$  is the partial correlation coefficient between the same variables. The  $a_{ij}$  should be close to zero, because the factors are orthogonal to each other.

So that the data can fit the factor analysis should be noted the following regarding the value found in Kaiser's equation:

*Table.1: Relationship between the KMO and the use of Factor Analysis*

KMO	Recommendation AF
$\geq 0.9$	Great
$\geq 0.8$ and $< 0.9$	Good
$\geq 0.7$ and $< 0.8$	Average
$\geq 0.6$ and $< 0.7$	Acceptable
$\geq 0.5$ and $< 0.6$	weak
$\leq 0.5$	Unacceptable

Source: CARVALHO, 2013

**Sphericity test Bartlett**

Another test used widely in the factor analysis is to Bartlett sphericity test (BTS), which tests the following hypothesis: the correlation matrix is an identity matrix, ie the values of the main diagonal are equal to 1 and the other figures be zero, concluding that its determinant is equal to 1. This means that the variables have no correlation and the null hypothesis can be rejected if the adopted  $\alpha$  is equal to 0.05 or 5% and the value found is less than the value of  $\alpha$ . (Pereira, 2001).

Bartlett's test evaluates the overall significance of the correlation matrix, i.e. tests the null hypothesis that the correlation matrix is an identity matrix Solomon et al., (2012).

**Principal Component Analysis**

The goal of the principal component analysis (PCA) is to address issues such as the generation, selection and interpretation of the investigated components. Intending thereby determine the most

influential variables in the formation of each component (VICINI, 2005).

According to Castro et al., 2013 by the ACP, a random vector can be explained by the variance and covariance structure (composed of random variables  $p$ ) by constructing linear combinations of the original variables.

Through data covariance matrix becomes a major component estimated. For the application of analysis it is necessary to standardize the data so that the whole series will have the same magnitude of values. After obtain the eigenvectors that are values representing the weights of each component in each variable and range of (-1 to 1) and function as correlation coefficients that represents the contribution of each component to explain the total variation of the dataRuhoff et al., (2009).

### Clusters analysis

The Cluster Analysis or Cluster (AA) in multivariate data identifies groups of objects. The goal is

to form groups with homogeneous properties of large heterogeneous samples. Should be sought more homogeneous groups possible and that the differences between them are as large as possible (Hair et al., 2005).

The AA encompasses a variety of techniques and algorithms, and the goal is to find and separate similar data in the same group and are distinct from the data of the other groups (VICINI, 2005).

According Ruhoff et al., 2009 AA seeks to group data elements that are more like each other. The groups are determined so as to obtain homogeneity between the elements of the groups and heterogeneity between them.

### Dendrogram

As a result of AA we get the dendrogram or phenograms also known as graphic tree that is graphic with a summary of the groups obtained by the analysis.

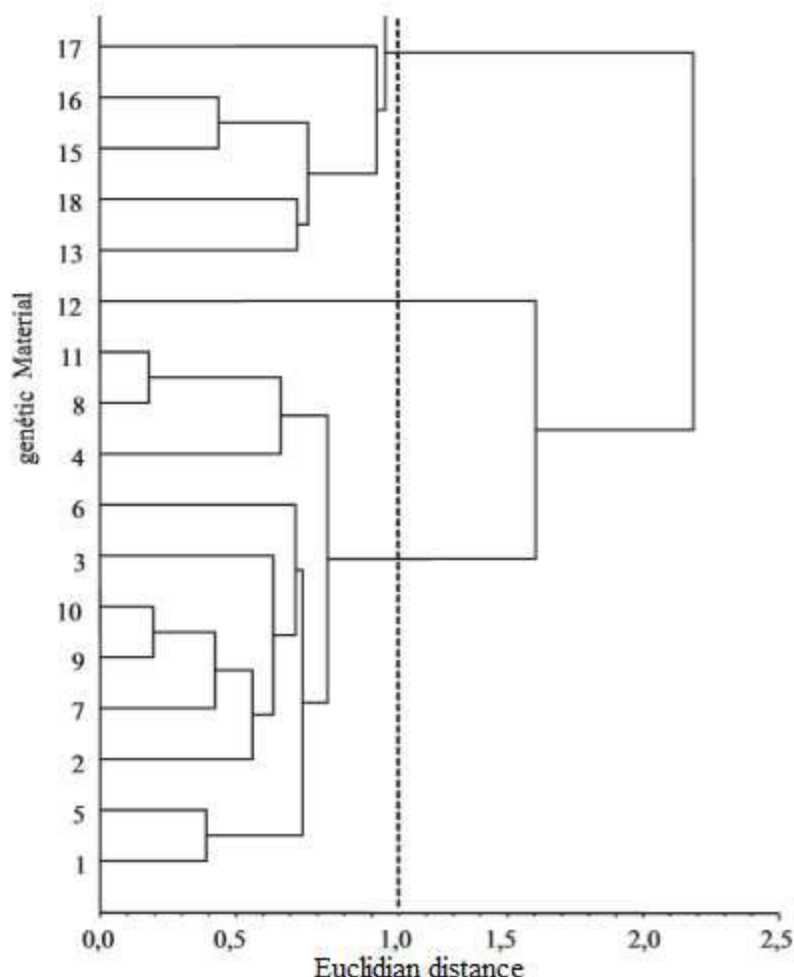


Fig.1: Grouping according to the quality of wood for the production of charcoal, obtained by simple connection method to use the Euclidean distance.

Source: CASTRO et al, 2013.

It is observed in Figure 1 that the genetic material of 11:08 have the greatest similarity dendrogram, by having the smallest Euclidean distance being such as

to form the first group. So then come variables 10:09, and after 1 and 5, and so on, the variables are grouped in descending similarity order, ie 12 variable formed the last

group of the dendrogram, which remained If different from the other groups formed, because this variable has little resemblance to the others.

#### Distance Euclidean

In Cluster Analysis some distance measurement coefficients are important, and among them is the Euclidean distance also known as dissimilarity measure. According PARENTS; SILVA; Ferreira (2012) considering two points A and B, the Euclidean distance can be calculated with the following formula:

$$\text{Distance between A and B} = DAB = \sqrt{\sum p_j = 1} \\ (x_{ja} - x_{jb})^2 \quad (3)$$

In matrix form, this distance is given by:

$$DAB = \sqrt{(x_a - x_b)' \cdot (X_a - X_b)} \quad (4)$$

#### Mahalanobis distance

The similarity between samples (treatment, individuals, populations) correlated to a set of characteristics and the distance between any pairs of sampling units, the degree of dependence between variables must be considered. To quantify distance between two populations when there is data repetition, it is recommended to use the Mahalanobis distance ( $d^2$ ) (VICINI, 2005).

#### Canonical Correlation Analysis

The Canonical Correlation Analysis (CCA) has as its main objective the study of existing linear relationship between two sets of variables. Applying this analysis summarizes the information of each response variables set in linear combinations seeking to maximize the correlation between the two sets (Mingoti, 2005). The ACC is a type of statistical technique in the multivariate analysis which aims according to Protasio et al., 2012 to check associations between groups with different characteristics.

This multivariate analysis model allows to discover the relationship between two groups or sets of variables, increasing the correlation between the vectors of independent and dependent variables Burt, (2015).

#### Multiple Regression Analysis

Multiple regression provides the changes in the dependent variable in accordance with changes in the independent variables. The method is suitable when there is a single analysis dependent variable metric related to two or more independent variables (Hair et al., 2005).

#### Discriminant analysis

The multiple discriminant analysis consists of a set of tools and methods used to distinguish populations groups and classifying new observations in certain groups and used when groups are known a priori (Mingoti, 2005).

#### MANOVA / MANCOVA

The multivariate analysis of variance and covariance is also known as MANOVA (multivariate analysis of variance) and MANCOVA (multivariate analysis of covariance), aim to verify the similarity between multivariate groups simultaneously exploring the relationship between several independent variables and two or more variables dependent metrics (Hair et al, 2005).

### III. RESULTS AND DISCUSSIONS

In this study we selected 54 subjects who treat articles that are inserted in the area of Agricultural Sciences Forest with the application of multiple multivariate statistical methods. The articles selected were published between 1990 and 2018 and in this range in 2015 has been the year with most publications, 8 in total, followed by 2003 and 2012 with 6 each publications. In contrast the years 1990, 2002, 2005, 2011, 2016 and 2017 contributed one article.

Dealing with multivariate analyzes, among the most used in the selected works we can mention among the most important the grouping or cluster analysis used 25 times, followed by Component Analysis Principal 20 times, the factor analysis 10 times, a Canonical Correspondence Analysis which was used 9 times and 8 times Discriminant Analysis.

Since the case of the multivariate analysis used in each study, we observed a pattern between the multivariate method used and certain lines of research in the area has been established. Knowing this we sought to verify this pattern lines separating the search by subject and quantifying which types of multivariate method used was more.

#### Multivariate analysis ins studies involving managements soil

Of the 11 works found in this area can be seen in studies Freitas et al. (2015b) and Mantovanelli et al.(2015) using the same multivariate Cluster Analysis (AA), Principal Component Analysis (PCA) and MANOVA the applicant ACP and the most jobs found in this area as it is noted in studies SILVA; et al., (2010a) SILVA; et al., (2010b), Oliveira; et al., (2015) (JORDAN, 2018) SILVA et al., (2009), BARRETO et al., (2006). In addition to the AA already applicant, it was also used multivariate techniques such as discriminant analysis (DA), Canonical Correspondence Analysis (CCA) and factor analysis as noted in the articles of Gerhardt; et al. (2001), Baretta;Baretta; Cardoso(2008) and BENITES et al., (2010).

#### Multivariate Analysis in environmental studies

This area of study other 12 works were selected of which can be seen the use of factor analysis the most recurrent among multivariate methods as noted in the study Scatena, (2005), Campos et al., (2015), Cunha et

al., (2008) Parents; Silva; Ferreira (2012), Pinto; Col., (2014), Silva; Feather; Souza (2015). Other analyzes Multivariate as Regression Analysis Calijuri et al. (2009), Discriminant Analysis Braga et al. (2009), Clustered SILVA Analysis, (2003) were also used to a lesser extent in this area of study.

Articles of BERTOSI, (2013), BERTOSI et al., (2013), HUGO et al., (2012), applying multivariate analysis data indicators of water quality, it is noted that all studies Valley ACP main multivariate analysis to analyze the data.

#### **Technical analysis of multivariate in experiments involving forests and Forest products of origin**

In this part of 31 studies not fit this line of research which were separated in sub-items for better visualization of multivariate analysis applied in the aforementioned area of study.

Considering the application of multivariate analysis of floristic data analysis 7 items fall into this issue where there was no standard in the use of multivariate methods getting use well distributed in this type of study, it was noted that HIGUGHI et al., (2012 ) and Higuchi et al., (2013) took advantage of the ACP and the AA to analyze your data and dealing with similar themes applied in different areas in areas of Santa Catarina methods have adapted perfectly to the proposed studies. In PEIXOTO work (2004) in Rio de Janeiro and Narvaes; LONGHI; BRENA, (2008) in Rio Grande do Sul, also because it is similar studies in different areas of the same multivariate technique can be applied to both studies and AA managed to separate the similar data in different groups where using the dendrogram and Euclidean distance data were easily spotted. Still treating the flora analysis Souza et al., (2003a) and BERTANI (2001) took advantage of the ACC to analyze the floristic diversity in riparian forests. Lastly SOLOMON; JUNIOR; SANTANA, (2012) used the factor analysis to carry out the floristic analysis of primary forest for restoration of a mined area.

In studies dealing with the quality of wood for energy purposes, each author made use of different multivariate statistics for the analysis of data as can be seen in Protasio et al., (2012) with only the ACC could verify the associations between the group formed by the characteristics of Eucalyptus clones with the characteristics of the group formed by her charcoal obtained. Already Castro et al., (2013) used three multivariate analysis they being the ACC ACP and AA that through them it can be concluded that the properties of charcoal are strongly correlated to the wood, especially the apparent density of charcoal and the gravimetric yield. GADELHA et al. (2015) has focused his study of this same area MANOVA multivariate method used to

evaluate which clones of eucalyptus is the production for energy purposes.

In plant stratification 3 selected studies make use of the same methodology for the processing AA and AD as can be seen in the articles of SOUZA et al., (2003b), Souza et al. (2006) and Souza et al. (2012) and multivariate classification of the forest classes of volumetric stocks proved to be an efficient method for laminating homogeneous areas in the three types of forest, which can be constituted by extracts, compartments, site classes and annual production units .

Reforestation of mined areas CUNHA et al. (2003) and / or degraded LOSCHI et al., (2011) there was a similarity in the use of multivariate ACC that despite distinct areas there was a similarity in the results presented by the same analysis. Oliveira et al. (2016) made use of the ACP which showed efficient use of multivariate analysis in response to a high variance data, is used as a tool for annual use, may best reference ecological standards of the area, can be used to identify indicators of forest restoration.

In studies aimed at planting was unanimous the use of AA as noted in Article developed by Grigolo et al. (2018). In four studies selected 3 of them also used the ACP to complement the study as noted in studies of NETO et al., (2018) and Ruhoff et al. (2009). The use of principal components showed that higher yields are correlated with proper growth of the shoot, in conditions of lower bulk density, providing high dry matter production of roots (FREDDI; FERRAUDO; CENTURION, 2008).

In studies involving forests of the 11 selected articles met similarity in the use of multivariate analysis in studies Rovedder et al., (2014) and LÚCIO et al. (2006) They used the ACP to reduce the maximum number of variables that could represent possible and most of the variance found. However, studies Almeida et al. (2015) and CANUTO et al., (2015) used the AA to separate the samples that have greater similarity in different groups and thus can make a better analysis of the sampled data. In the study by MACHADO (2004) Rectified Correspondence Analysis, LONGHIL et al., (2009) Regression Analysis, Silva et al., (2012) Factor Analysis, MARTINS; SAUCER; OLIVEIRA, (2002) and MANOVA Canonical Correspondence Analysis (ACC), TRUGILHO; LIME; MORI (2003) ACC Oliveira et al. (2017) Discriminant analysis (DA), Souza et al. (1990) AD and Cluster Analysis, We can not show a pattern in the use of multivariate analysis where each author made use of a different method to analyze your data.

#### **IV. CONCLUSION**

Presented results it is seen that studies directed to certain areas within the Forest Agricultural Sciences have



certain regularity in the use of multivariate analysis, making use of the same techniques to observe its data. And that because of the use of multivariate analysis deduce from some knowledge, very complex methods are rarely used in the searched items in exchange for simpler analysis that were most useful as the Cluster Analysis (AA) and Principal Components Analysis (PCA) which were the most widely used. But the determining factor in the choice of multivariate analysis applied is the purpose of the analysis, which generally applies in the simultaneous analysis of multiple sets of factors when it needs to reduce data, identify relationships between variables, split group of similar factors among others.

The use of multivariate analysis studies and evaluations of experiments in Agricultural Sciences proved to great value to allow greater clarity and better interpretability of dealing with complex phenomena.

#### REFERENCES

- [1] ALMEIDA, C.C.; ARAUJO, M.M.; LONGHI, S.J.; ROVEDDER, A.P.; SCCOTI, M.S.V.; D'AVILA, M.; AIMI, S.C.; TONETTO, T.S. **Análise de agrupamentos em remanescente de floresta estacional decidual**. Santa Maria/RS, CI. FL., V.25, N.3, p.781-789, 2015.
- [2] BARRETO, T.G.; NETTO, S.P.; CORTE, A.P.D.; RODRIGUES, A.L.; SANQUETTA, C.R. **Influência das características químicas do solo na dinâmica de crescimento de um fragmento florestal**. Cruz das almas/BA, Magistra, V.28, N.1, p.1-12, 2006.
- [3] BARETTA, D., BARETTA, C. R. D. M., & CARDOSO, E. J. B. N. **Análise multivariada de atributos microbiológicos e químicos do solo em florestas com araucariaangustifolia**. Revista Brasileira Ci. Solo, 32:2683-2691, 2008, Número Especial.
- [4] BENITES, V. M.; MOUTTA, R. O.; COUTINHO, H. L. C.; BALIEIRO, F. C. **Análise discriminante de solos sob diferentes usos em área de mata atlântica a partir de atributos da matéria orgânica**. Revista Árvore, v. 34, n. 4, p. 685-690, 2010.
- [5] BERTOSSI; APA, CECÍLIO; RA, NVESE; MA, GARCIA; GO. **QUALIDADE DA ÁGUA EM MICROBACIAS HIDROGRÁFICAS COM DIFERENTES COBERTURAS DO SOLO NO SUL DO ESPÍRITO SANTO**. Revista Árvore, Viçosa-MG, v.37, n.1, p.107-117, 2013
- [6] BERTANI; Daniela Fessel, RODRIGUES; Ricardo Ribeiro, BATISTA; João Luiz Ferreira, SHEPHERD; George John. **Análise temporal da heterogeneidade florística e estrutural em uma floresta ribeirinha**. Revta brasil. Bot., São Paulo, V.24, n.1, p.11-23, mar. 2001
- [7] BERTOSSI; Ana Paula Almeida et al. **Seleção e agrupamento de indicadores da qualidade de águas utilizando Estatística Multivariada**. Ciências Agrárias, Londrina, v. 34, n. 5, p. 2025-2036, set./out. 2013
- [8] BRAGA, F. A. et. al. **Características ambientais determinantes da capacidade produtiva de sítios cultivados com eucalipto**. Revista Brasileira de Ciência do Solo, vol. 23, núm. 2, pp. 291-298, 2009.
- [9] Canuto, Daniela Silvia de Oliveira, et al. **"Genetic characterization of a progeny test of Dipteryx alata Vog., from a forest fragment of Estação Ecológica Paulo de Faria, São Paulo State, Brazil."** *Hoehnea* 42.4 (2015): 641-648.
- [10] CALIJURI; Maria Lúcia, SANTIAGO; Aníbal da Fonseca, CAMARGO; Rodrigo de Arruda, NETO; Ronan Fernandes Moreira. **Estudo de indicadores de saúde ambiental e de saneamento em cidade do Norte do Brasil**. v.14 n.1, jan/mar 2009 p.19-28
- [11] CAMPOS, Samuel Alex Coelho; FERREIRA, Marcelo Dias Paes; COELHO, Alexandre Bragança; LIMA, João Eustáquio de. **Degradação ambiental agropecuária no bioma caatinga**. Rev. Econ. NE [online], Fortaleza, 2015, v. 46, n. 3, p. 155-170.
- [12] CARVALHO; Francisco Ricardo Duarte. **Análise Fatorial**. Faculdade de Ciências e Tecnologia, Universidade de Coimbra, Portugal, 2013. 61 p.: il.
- [13] CASTRO, Ana Flávia Neves Mendes et al. **Análise multivariada para seleção de clones de eucalipto destinados à produção de carvão vegetal**. *Pesq. agropec. bras.* [online]. 2013, vol.48, n.6, pp.627-635.
- [14] CUNHA, Nina Rosa da Silveira; LIMA, João Eustáquio de; GOMES, Marília Fernandes de Maciel e BRAGA, Marcelo José. **A intensidade da exploração agropecuária como indicador da degradação ambiental na região dos Cerrados, Brasil**. *Rev. Econ. Sociol. Rural* [online]. 2008, vol.46, n.2, pp.291-323.
- [15] CUNHA, L.O.; FONTES, M.A.L; OLIVEIRA, A.D.; OLIVEIRA FILHO, A.T. **Análise multivariada da vegetação como ferramenta para avaliar a reabilitação de dunas litorâneas mineradas em Matara, Paraíba, Brasil**. Viçosa/MG, R. Árvore, V.27, p.503-515, 2003.
- [16] FREITAS, L. de; CASAGRANDE, J. C.; OLIVEIRA, I. A. de; CAMPOS, M. C; C.; SILVA, L. S. S. **Técnicas multivariadas na avaliação de atributos de um Latossolo vermelho submetido a diferentes manejos**. Revista Brasileira de Ciências Agrárias, v. 10, n. 1, p. 17-26, 2015b.

- [17] FREDDI, Onã da Silva; FERRAUDO, Antonio Sergio e CENTURION, José Frederico. **Análise multivariada na compactação de um latossolo vermelho cultivado com milho**. Rev. Bras. Ciênc. Solo [online]. 2008, vol.32, n.3, pp.953-961.
- [18] GADELHA; Fernando Henrique de Lima et al. **Produtividade de clones de eucaliptos em diferentes sistemas de manejo para fins energéticos**. Pesq. flor. bras., Colombo, v. 35, n. 83, p. 263-270, jul./set. 2015
- [19] GERHARDT, E.J. et al. **Contribuição da análise multivariada na classificação de sítios em povoamentos de araucariaangustifolia (bert.) O. Ktze., baseada nos fatores físicos e morfológicos do solo e no conteúdo de nutrientes da serapilheira**. Ciência Florestal, v. 11, n. 2, 2001.
- [20] Grigolo, Sibila, et al. **"Implicações da análise univariada e multivariada na dissimilaridade de acessos de feijão comum"**. Revista de Ciências Agroveterinárias 17.3 (2018): 351-360.
- [21] HAIR JUNIOR, J. F.; ANDERSON, R. E.; TATHAM, R. L.; BLACK, W. C. **Análise multivariada de dados**. 5. ed. Porto Alegre: Bookman, 2005.
- [22] HAIR, J.F.JR.; BLACK, W.C.; BABIN, B.J.; ANDERSON, R.E.; TATHAN, R.L. **Análise multivariada de dados**. 6ª edição, Porto Alegre/RS, Artmed editora, 2009, 688 pág.
- [23] HIGUCHI P., Silva, A. C., FERREIRA, T. S., SOUZA, S. T., GOMES, J. P., SILVA, K. M., SANTOS, K. F., LINKE C., PAULINO, P. S. **Influência de variáveis ambientais sobre o padrão estrutural e florístico do componente arbóreo, em um fragmento de floresta ombrófila mista montana em Lages, SC**. Ciência Florestal, Santa Maria, v. 22, n. 1, p. 79-90, jan.-mar., 2012.
- [24] HIGUCHI, P., Silva, A. C., SOUZA, S. T., GOMES, J. P., SILVA, K., ALMEIDA, J. A., BORTOLUZZI, R. L. C., MANTOVANI, A., FERREIRA, T. S. **Florística e estrutura do componente arbóreo e análise ambiental de um fragmento de floresta ombrófila mista Alto-Montana no Município de Painel, SC**. Ciência Florestal, Santa Maria, v. 23, n. 1, p. 153-164, jan.-mar., 2013.
- [25] HUGO A. S. et al. **Aplicação da análise estatística multivariada no estudo da qualidade da água do Rio Pomba, MG**. R. Bras. Eng. Agríc. Ambiental, v.16, n.5, p.558-563, 2012.
- [26] JOHNSON, R. A.; WICHERN, D. W. **Applied multivariate statistical analysis**. 3. ed. Englewood Cliffs: Prentice Hall, 1992.
- [27] JORDÃO, Half Weinberg Corrêa. **Atributos químicos de solos sob ambientes naturais antropizados no município de Humaitá, AM**. 2018. 52f. Dissertação (Mestrado em Agronomia Tropical) – Universidade Federal do Amazonas, Manaus, 2018.
- [28] LONGHIL; SJ, et. al. **Fatores ecológicos determinantes na ocorrência de Araucaria angustifolia e Podocarpus lambertii, na Floresta Ombrófila Mista da FLONA de São Francisco de Paula, RS, Brasil**. Ciência Rural, Santa Maria, 2009
- [29] LOSHI, R. A. et al. **INTERAÇÕES ESPÉCIE-AMBIENTE NA COLONIZAÇÃO DE UMA VOÇOROCA EM ITUMIRIM, MINAS GERAIS**. Cerne, Lavras, v. 17, n. 2, p. 161-180, abr./jun. 2011
- [30] LUCIO D. C., et. al., **Abordagem multivariada em análise de sementes de espécies florestais exóticas CERNE**, vol. 12, núm. 1, janeiro-março, 2006, pp. 27-37 Universidade Federal de Lavras - Lavras, Brasil.
- [31] LUÍS; Idálio Esperança. **Análise de Correlação Canônica: Extensões e Aplicações**, Universidade Aberta, Lisboa, Portugal, 2015.
- [32] MACHADO, E. L. M. **Análise comparativa da estrutura e flora do compartimento arbóreo-arbustivo de um remanescente florestal na fazenda beira lago, lavras, MG**. Revista Árvore, Viçosa-MG, v.28, n.4, p.499-516, 2004.
- [33] MAÊDA, J. M. et al. **Critérios de seleção uni e multivariados no melhoramento genético da Virola surinamensis Warb. Floresta e Ambiente**, Viçosa, v. 8, n. 1, p. 61-69, 2001.
- [34] MAGNUSSON, W. E.; MOURÃO, G. **Estatística sem matemática: a ligação entre as questões e a análise**. Curitiba: 2003.
- [35] MARTINS, I. S.; PIRES, I. E.; OLIVEIRA, M. C. **Divergência genética em progênies de uma população de eucalyptus camaldulensis dehnh**. V. 9, n.1, p.81 – 89: Floresta e Ambiente. 2002.
- [36] MANTOVANELLI, B. C.; SILVA, D. A. P. da; CAMPO, M. C.C.; GOMES, R. P. G.; SOARES, M. D. R.; SANTOS, L. A. C. dos. **Avaliação dos atributos do solo sob diferentes usos na região de Humaitá, Amazonas**. Revista de Ciências Agrárias, v. 58, n. 2, p. 122-130, 2015.
- [37] MINGOTI, S. A. **Análise de dados através de métodos de estatística multivariada: uma abordagem aplicada**. Belo Horizonte: Editora UFMG, 2005
- [38] NARVAES; Igor da Silva, LONGHI; Solon Jonas, BRENA; Doádi Antônio. **FLORÍSTICA E CLASSIFICAÇÃO DA REGENERAÇÃO NATURAL EM FLORESTA OMBRÓFILA MISTA NA FLORESTA NACIONAL DE SÃO**

- FRANCISCO DE PAULA, RS. *Ciência Florestal*, Santa Maria, v. 18, n. 2, p. 233-245, abr.-jun., 2008
- [39] NETO, M. M. J. **Estatística multivariada**. *Revista de Filosofia e Ensino*. 9 maio 2004. Disponível em: <[http://www.criticanarede.com/cien\\_estatistica.html](http://www.criticanarede.com/cien_estatistica.html)>. Acesso em: 28 de outubro de 2018.
- [40] NETO; Thaís de Andrade Corrêa et al. **RELAÇÃO FAUNA DO SOLO-PAISAGEM EM PLANTIO DE EUCALIPTO EM TOPOSSEQUÊNCIA**. *FLORESTA*, Curitiba, PR, v. 48, n. 2, p. 213-224, abr./jun 2018
- [41] OLIVEIRA, I. A. de; CAMPOS, M. C.; FREITAS, L. de; SOARES, M. D. R. **Caracterização de solos sob diferentes usos na região sul do Amazonas**. *Acta Amazonica*, v. 45, n. 1, p. 1-12, 2015.
- [42] OLIVEIRA et. al., **Uso da análise multivariada para estabelecer relações ecológicas em uma área de restauração florestal**. *Rev. TREE DIMENSIONAL*, ProFloresta - Goiânia, v.1 n.2; p. 201, 70,2016.
- [43] OLIVEIRA, L.C.L.Q.; JARDIM, F.C.S.; GOMES, J.M.; RAMOS, E.M.L.S. **Classificação ecológica de espécies arbóreas por meio da análise da distribuição diamétrica**. *Res. Espacios*, V.38, N.42, p.3. 2017.
- [44] PAIS, Paloma Santana Moreira; SILVA, Felipe de Figueiredo e FERREIRA, Douglas Marcos. **Degradação ambiental no estado da bahia: uma aplicação da análise multivariada**. *Rev. GeoNordeste* [online]. n.1 (2012), Ano XXIII, pp.1-21.
- [45] PEIXOTO, G. L. **Composição florística do componente arbóreo de um trecho de floresta atlântica na área de proteção ambiental da serra da capoeira grande, Rio de Janeiro, RJ, Brasil**. *Acta bot. bras.* p. 151-160. 2004.
- [46] PEREIRA, J. C. R. **Análise de dados qualitativos: estratégias metodológicas para as ciências da saúde, humanas e sociais**. São Paulo: Edusp, 2001.
- [47] PINTO, Nelson Guilherme Machado1; CORONEL, Daniel Arruda. **Degradação ambiental do Rio Grande do Sul: uma análise dos municípios e mesorregiões**. *Rev.Bras.de Agroecologia*. pp 3-17 2014.
- [48] PROTÁSIO; Thiago de Paula, TRUGILHO; Paulo Fernando, NEVES; Thiago Andrade, VIEIRA; Carlos Magno Melo. **Análise de correlação canônica entre características da madeira e do carvão vegetal de *Eucalyptus***. *Sci. For.*, Piracicaba, v. 40, n. 95, p. 317-326, 2012
- [49] ROVEDDER, A.P.M.; ALMEIDA, C.M.; ARAUJO, M.M.; TONETTO, T.S.; SCOTTI, M.S.V. **Relação solo-vegetação em remanescente da floresta estacional decidual na região central do Rio Grande Sul**. *Santa Maria/RS, Ciência Rural*, V. 44, N.12, P.2178-2185, 2014.
- [50] RUHOFF, Anderson Luis et al. **Análise Multivariada do Processo de Evapotranspiração em Áreas de Cerrado e Cana-de-Açúcar**. *RBRH - Revista Brasileira de Recursos Hídricos* Vol. 14 n.4 Out/Dez 2009, pp.137-146.
- [51] SALOMÃO, R.P.; JÚNIOR, S.B.; SANTANA, A.C. **Análise da florística e estrutura de floresta primária visando a seleção de espécies chaves, através de análise multivariada, para a restauração de áreas mineradas em unidades de conservação**. *Viçosa/MG, Revista Árvore*, V.36, N.6, p.989-1007, 2012.
- [52] SILVA, João dos Santos Vila da. **Análise multivariada em zoneamento para planejamento ambiental; estudo de caso: bacia hidrográfica do alto rio Taquari MS/MT**. Campinas, SP: [s.n.], 2003.
- [53] SILVA, Luciana Gomes da et al. **Atributos físicos, químicos e biológicos de um Latossolo de cerrado em plantio de espécies florestais**. *Pesq. agropec. bras.* [online]. 2009, vol.44, n.6, pp.613-620.
- [54] SILVA, M. O.; FREIRE, M. B. G dos S.; MENDES, A. M. S.; FREIRE, F. J.; CAMPOS, M. C. C.; AMORIM, L. B. **Discriminação de diferentes classes de solos irrigados com águas salinas, na região de Mossoró (RN), com o uso de análise multivariada**. *Ambiência*, v. 6 n. 2 p. 261-270, 2010a.
- [55] SILVA, S. A.; LIMA, J. S. S.; XAVIER, A. C.; TEIXEIRA, M. M. **Variabilidade espacial de atributos químicos de um Latossolo Vermelho-Amarelo húmico cultivado com café**. *Revista Brasileira de Ciência do Solo*, v. 34, n. 1, p. 15-22, 2010b.
- [56] SILVA, Miriam Rodrigues da et al. **Análise fatorial multivariada aplicada a caracterização de áreas de ocorrência de babaçu (*Attalea speciosa* Mart. ex Spreng) na bacia do Rio Cocal**. *Soc. nat.* [online]. 2012, vol.24, n.2, pp.267-282.
- [57] SILVA, A.H.L.; PENA, H.W.A.; SOUZA, I.C.M. **Análise multivariada e a identificação dos fatores causadores do desflorestamento no Xingu no Estado do Pará, Amazônia Oriental**. *Res. Delos*, V.8, N.23, 2015.
- [58] SOUZA, A.L.; HOSOKAWA, R.T.; KIRCHER, F.F.; MACHADO, S.A. **Análise multivariada para manejo de floresta natural na reserva florestal de Linhares, Espírito Santo, análises de agrupamento e discriminante**. *Res. Árvore*, 1990
- [59] SOUZA, J. S., F. D. B. E, FONTES, M. A. L., OLIVEIRA FILHO, A. T. e BOTEZELLI, L.

- Análise das variações florísticas e estruturais da comunidade arbórea de um fragmento de floresta semidecídua às margens do Rio capivari, Lavras-MG.** Revista *Árvore*, Viçosa-MG, v.27, n.2, p.185-206, 2003a.
- [60] SOUZA, D. R., SOUZA, A. L., GAMA, J. R. V e LEITE, H. G., **Emprego de análise multivariada para estratificação vertical de florestas inequiduais.** Revista *Árvore*, Viçosa-MG, v.27, n.1, p.59-63, 2003b.
- [61] SOUZA, A. L. e SOUZA, D. R. **Análise multivariada para estratificação volumétrica de uma floresta ombrófila densa de terra firme, Amazônia oriental.** Revista *Árvore*, Viçosa-MG, v.30, n.1, p.49-54, 2006.
- [62] SOUZA; Deoclides Ricardo de, SOUZA; Agostinho Lopes de, GAMA; João Ricardo Vasconcellos, LEITE; Hélio Garcia. **EMPREGO DE ANÁLISE MULTIVARIADA PARA ESTRATIFICAÇÃO VERTICAL DE FLORESTAS INEQUIDUAIS.** R. *Árvore*, Viçosa-MG, v.27, n.1, p.59-63, 2003 **conservação.** Viçosa/MG, Revista *Árvore*, V.36, N.6, p.989-1007, 2012.
- [63] Scatena ML. **Ações em educação ambiental: análise multivariada da percepção ambiental em diferentes grupos sociais como instrumentos de apoio à gestão de pequenas bacias: estudo de caso nas microbacia do córrego da Capitua, Macedônia, SP** [tese]. São Carlos (SP): Escola de Engenharia de São Carlos, Universidade de São Paulo; 2005.
- [64] TRUGILHO, P.F.; LIMA, J.T.; MORI, F.A. **Correlação canônica das características químicas e físicas da madeira de clones de *Eucalyptus grandis* e *Eucalyptus saligna*.** *Cerne*, v.9, p.66-80, 2003
- [65] VICINI; Lorena. **Análise multivariada da teoria à prática.** Santa Maria: UFSM, CCNE, 2005. 215 p.: il.

# Analysis of UV-B Absorption by Fiber Plastic/Glass with Various Colors using UV-VIS Spectrometer

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**Abstract** — Sunlight is the main source of light for living things on earth. Sunlight contains various spectra of electromagnetic waves including ultraviolet and visible light. Various effects of UV B radiation are already known. This study aims to determine the absorption characteristics of UV-B of several transparent materials. The transparent materials used in this study are fiber plastic and mica film plastic in blue, green and natural. To find out the absorption spectrum of the transparent material, the researcher used a UV-Vis spectrometer. Measurement data shows that glass fiber and the blue mica film POP-1 materials have very strong UV-B absorption which is more than 90%. While other mica film materials have various UV-B absorption at the beginning and at the end of the various UV-B spectrum with 70% values. Blue Mica film POP-1 material has absorption of about 94%. Green NIPON mica film material has 86% absorption at the beginning of the spectrum and about 82% at the end. The absorption of materials towards UV-B radiation is not linear with the increased wavelength.

**Keywords**— UV-Vis Spectrometer Absorption, Fiber Plastic, Mica Film plastic.

## I. INTRODUCTION

Sun is the biggest main source of universe that will never run out (Rahman dan Prajitno, 2013: 1).

The fact about the depletion of the ozone layer in the atmosphere (Madronich et al., In Haapala et al., 2010: 370; Herman et al., In Flint and Caldwell, 1995: 107;) has an impact on increasing levels of ultraviolet exposure that reaches the earth's surface which has been widely conveyed in research in recent decades (McKenzie at al., in Holzinger and Lütz, 2006: 191; Seidlitz et al., in Holzinger and Lütz, 2006: 191). The concentration of the ozone layer is most influential in the UV-B region which includes ultraviolet whose energy is high enough (Caldwell et al. In Hollósy, 2002: 179). UV-B can cause cancer through mutations in DNA cells (Panchuau and Tiwari, 2008: 128-136). The same thing was also

conveyed by Kataria et al. (2014: 2) that the disruptive effects of UV-B radiation on photosynthesis and its production level in plants are well aware.

This study is to describe the UV-B absorption to some transparent materials with various colors.

## II. METHOD OF RESEARCH

### ➤ Research Variables

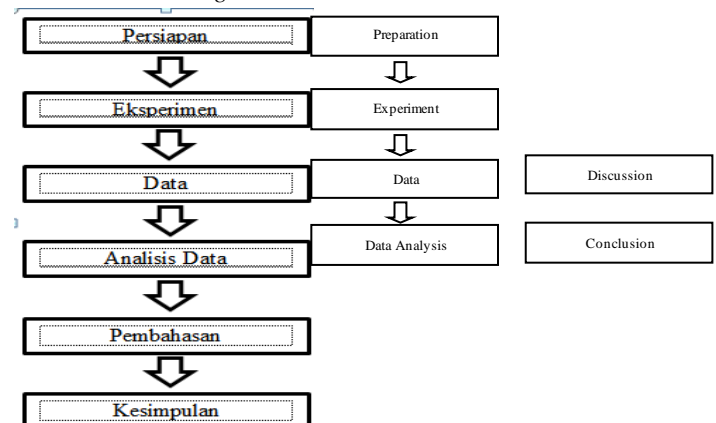
- Free variables: type of material, color of material, brand of sample
- Dependent variable: absorbance of the material.
- Control variable: light intensity from the spectrometer light source.

### ➤ Tools and materials

- Spectrometer
- Transparent material of fiber glass: CHLADIANPLAST and Square brand with 3 kinds of colors, dark blue, dark green, and natural.
- Transparent material for plastic mica film: POP-1 and NIPON brands in blue, green and natural.

### ➤ Research Flow

Figure 1. Research Flow



### ➤ Research Step

Research steps are as follows:

- a. Prepare the tools and materials

Things to do before conduction research are:

1. The spectrometer should be in calibrated already
  2. Prepare the transparent materials with 2 cm x 2 cm of size
- b. Research

After the tools and materials are prepared, the research can be done by measuring the absorbance of each color and material.

- c. Data Analysis

The data obtained from the spectrometer is analyzed and calculated in Excel of MS. office then the data is processed and presented in graphical form so that it is easy to discuss.

- d. Discussion

After analyzing the data, the researcher knows the characteristics of the material and can discuss the characteristics in accordance with the theories that have existed before or produce something different.

- e. Conclusion

Later, the researcher concludes the finding of the research

#### ➤ Data presentation Technique

Data measurement of spectrometer is presented in the form of graphic as follows:

*Figure 2. Graphic of absorption measurement data*

### III. FINDINGS AND DISCUSSION

Measurement of data in this study is carried out in June 2017 at the Analytical Chemistry Laboratory of the Chemical Program of the FMIPA Bandung Institute of Technology. From the measurement data that has been processed in Microsoft Excel software and presented in graphical form as shown in Figure 3.

Based on the graph in Figure 3, we can know the absorption characteristics of each transparent material in the UV-B spectrum range. Fiber Glass Square material shows the absorption character that goes up and down around the value of 4 to 3.5 absorbance scale except in the natural fiber glass square material which has value absorption about 2 absorbance scales. It can be said that these ingredients have a fairly uniform absorption throughout the UV-B spectrum.

Meanwhile the fiber glass CHLADIANPLAST material has absorption characteristic with various values. The characteristic of the blue CHLADIANPLAST fiber glass material is almost similar to the color fiber glass Square material that has going up and down value between 4 up to 3.5 absorbance scale. Meanwhile the green CHLADIANPLAST fiber glass material has absorption with a value of around 3 at the beginning of

the UV-B spectrum and then propagates down to close to the 2.7 absorbance scales in the range of UV-B spectrum which eventually returns up to close to the 3 absorbance scales in the end of the UV-B spectrum. In contrast to natural CHLADIANPLAST fiber glass material which has a slightly steep absorption characteristic that has value of 1.7 absorbance at the beginning of the UV-B spectrum and drops to close to 1.3 at a wavelength of 288 nm then decreases again until it approaches the value of 1 absorbance scale at the end of the UV-B spectrum.

In mica film materials, the absorption character tends to decrease along the UV-B spectrum. At the beginning of the UV-B spectrum, the values range from 0.59 to 0.45 absorbance scale are green POP-1 brand mica film material with a value of 0.59 absorbance scale, natural color POP-1 mica film material with a value of 0.45 absorbance scale, blue NIPON brand mica film material with 0.57 absorbance scale, and natural color NIPON brand mica film material with a value of 0.4 absorbance scale. Up to the end of the spectrum UV-B shows varies values which are slightly between 0.45-0.15, they are green POP-1 mica film brand material with a value of 0.4 absorbance scale, natural color POP-1 mica film material with value of 0, 2 absorbance scales, blue NIPON brand mica film material 0.3 absorbance scale, and natural color NIPON brand mica film material with a value of 1.4 absorbance scale. A somewhat different thing is found in the blue POP-1 mica film material and the green NIPON mica film. The blue Mica film POP-1 material has a value of almost 1.2 at the beginning of the UV-B spectrum and then decreases gently in the middle of the UV-B spectrum to close to 1 in the absorbance scale and rises again to 1.2 in the absorbance scale. Meanwhile the green NIPON mica film has a value of 0.8 at the beginning of the UV-B spectrum and tends to decrease until the end of the UV-B spectrum with a value of 0.7 absorbance scale.

In all types of materials, all natural color ingredients have a lower absorption than those similar materials with other colors. This is due to the presence of dyes which influence the absorption of the colored materials. All ingredients can be said to have absorption characteristic of the UV-B spectrum which is relatively even though each ingredient has different fluctuations, can tend to decrease or go up and down indefinitely. However, each ingredient has absorption with different values.

All brand and color fiber glass material examined in this study have very strong UV-B absorption with a value of more than 1, which means that these materials absorb more than 90% of UV-B radiation. The same thing is in the blue POP-1 mica film material which has more than 90% UV-B absorption. Almost all fiber glass

materials but natural CHLADIANPLAST fiber glass have UV-B absorption up to around 99%. Meanwhile mica film materials have absorption values of around 0.5 or below which means that this material only has UV-B absorption of about 70% while the remaining 30% or more is transmitted. 30% can be very large if you see the nature of UV-B which has high energy and can be dangerous. For the blue POP-1 mica film material and green NIPON mica film material have higher absorption value than the majority of other mica film materials. Blue POP-1 mica film material has a value of almost 1.2 at the beginning of the UV-B spectrum which is equivalent to UV-B absorption of 94% and then sloping downward in the middle of the UV-B spectrum to close to the value of 1 absorbance scale or absorb UV-B 90% and back up to 1.2 absorbance scale at the end of the UV-B spectrum. Meanwhile the green NIPON mica film has a value of 0.8 at the beginning of the UV-B spectrum which is equivalent to UV-B absorption of more than 86% and tends to decrease until the end of the UV-B spectrum which has UV-B absorption of 82% or has 0.7 value of absorbance scale.

From the graph, we can find that for materials with different types of thickness cannot be used as a definite measurement that materials with smaller thickness will have smaller absorption as well. This can be seen in blue POP-1 mica film plastic material and natural color CLADIANPLAST fiber plastic material where both of these materials have almost the same absorption even at the end of the UV-B spectrum of thinner POP-1 mica film which has greater absorption than absorption of natural fiber glass CHLADIANPLAST.

The absorption characteristic material towards UV-B radiation is non-linear with the increase of wavelength along the UV-B spectrum range. In all types of materials and each color have unique and distinctive fluctuations.

#### IV. CONCLUSION AND SUGGESTION

Based on the above discussion, it can be concluded that the UV-B absorption of all blue fiber glass and mica film POP-1 materials are very strong of more than 90%. Whereas other mica film materials have UV-B absorption which are varies at the beginning and at the end of the UV-B varied spectrum with value of about 70%. Blue POP-1 mica film material has absorption of about 94%. Green NIPON mica film material has absorption of around 86% at the beginning of the spectrum and around 82% at the end.

The absorption characteristic of material towards UV-B radiation is non-linear with the increased wavelength that has unique and special fluctuations. However, it can be said to have a uniform absorption

along UV-B spectrum. Materials that have natural colors have a lower absorption than similar materials that have other colors.

This study uses several brands that are available on the market from different factories with the way they are that differs the samples that cannot be avoided such as the unequal thickness, dyes that can be different, and differences in surface texture. In order to deepen knowledge about this topic, further research needs to consider the influence of the surface texture of the transparent material and try samples that have the same thickness and coloring.

#### REFERENCES

- [1] Flint, S. D. Dan Caldwell, M. M. 1996 Scaling Plant Ultraviolet Spectral Responses from Laboratory Action Spectra to Field Spectral Weighting Factors. *J. Plant Physiol.* Vol. 148: 107-114.
- [2] Haapala, Morsky, Saarnio, Suokanerva, dan Kyro. 2010. Long-Term Effect of Elevated UV-B Radiation on Photosynthesis and Ultrastructure of Eriophorum Russeolum and Warnstorfia Exannulata. *Science of Total Environment.* Vol. 409: 370-377.
- [3] Hollósy, F. 2002. Effects of Ultraviolet Radiation on Plant Cells. *Micron.* Vol. 179-197.
- [4] Holzinger, A. Dan Lütz, C. 2006. Algae and UV Irradiation: Effects on Ultrastructure and Related Metabolic Funtion. *Micron.* Vol 37: 190-207.
- [5] Kataria, S., Jajoo, A., Guruprasad, K. N. 2014. Impact of Increasing Ultraviolet-B (UV-B) Radiation on Photosynthetic Proseses. *Journal of Photochemistry and Photobiology B. Biology.* At elsevier: 1-46.
- [6] Panchuau, Z. dan Tiwari, R. C. 2008 Ultraviolet Light-it's Effects and Applications. *Science Vision.* Vol. 8 (4): 128-136.
- [7] Rahman, H. dan Prajitno, Gontiang. 2013. Pengaruh Pemberian Space (Bantalan) Untuk Mendapatkan Kestabilan Arus dan Tegangan Prototipe DSSC dengan Ekstraksi Kulit Buah Manggis (Garcinia Mangostana L.) Sebagai Dye Sensitizer. *Jurnal Sains dan Seni POMITS.* Vol. 1 (2): 1-7.

# An Analysis of the Demand for the Consumption of Rice Substitutes in Households in the Province of Maluku

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**Abstract**— *The aim of this Research is to analyse the partial relationships between the variables of the price of rice substitutes, the price of rice, income per household and the number of household members against the variables of household food availability and household food consumption patterns in Maluku Province. This research was carried out in Maluku Province using a sample of 200 people. Data used in this research is the primary data based on questionnaires and interviews with respondents and using secondary data taken from SUSENAS data covering a research period from 1995 through to 2014. The analysis used to test the hypothesis is the regression analysis using the SPSS application. The results of this research demonstrate that the variables of the price of rice substitutes, the price of rice, household income and the number of household members has a significant influence on the variables of the household food availability and the pattern of household food consumption in Maluku Province.*

**Keywords**— *The Price of Rice Substitutes, The Price of Rice, Income Per Household, Number of Household Members, Household Food Availability, Pattern of Household Food Consumption, Maluku.*

## I. INTRODUCTION

At this moment the world is facing two great crises, that is the food crisis and the energy crisis. The food crisis has been triggered by the phenomena of global warming and the uneven distribution of food. While the energy crisis has been triggered by the great reduction of reserves of fossil fuel energy (Louhenapessy, 2010). Food is a basic need of the people that has to be fulfilled so that it is a human right for all people to obtain food. The increase in

the population and the quality of life of the people causes the demand for food to continuously increase. Robert Maltus (in Abdurachim, 1973 and Hafisah, 2006) explained that the increase in population was not in proportion to the growth of world food supply, where food materials will increase according to arithmetical progression while the population will increase according to geometrical progression, which causes scarcity in the supply of food in the world. Therefore, the need for food for all the people of Indonesia has to become one of the priorities in national development.

The definition of food security since the world food conference in 1971 until the 90's continued to experience change starting from global and national levels, to the household and individual scales that can be seen from the food first perspective to the livelihood perspective and from objective indicators to subjective perception (Maxwell and Frankenberger, 1992).

Indonesia is a country with a large population and covers a vast area so that the problem of food security is an important agenda in the development of the economy. Data demonstrates that food security situation in Indonesia at this time is still weak. This can be seen from the following conditions: (a) the number of population experiencing food insecurity (consumption level of less than 90 percent of the recommended 2,000 cal/cap/day) and extreme food insecurity (consumption level of less than 70 percent of the recommendation) is still quite large, that is 36.85 million and 15.48 million people in 2002; (b) the number of toddlers who are experiencing malnutrition is still quite large, i.e. 5.02 million and 5.12 million toddlers in 2002 and 2003 (Khomsan, 2003). Data from Susenas (2010) also shows that consumption level of rice of the



population of Indonesia in 2009 was the highest in the world, i.e. 102.2 kilogram/capita/year or almost twice the average consumption of rice of world population which is only 60 kilogram/capita/year. This data shows that endeavours to create food security in Indonesia need to be carried out.

In Indonesia, food is associated with rice because rice is the main staple food. Based on the writer's research, data shows that rice is the staple food of more than 95 percent of the population in Indonesia. This situation makes their consumption pattern dominated by rice commodities. Therefore, the government is always endeavouring to increase the availability of the main food especially rice. This can be seen from the government policies related to food are still focused on the commodity of rice. Besides that, the government also carries out strict control concerning the availability of rice and is not unwilling to import rice. The consumption dependence of the people of Indonesia on rice needs to be quickly overcome in order to increase food security. Therefore, alternative food sources, such as local foods can become the solution to overcome the problem of food security in Indonesia which is a country that possesses various other types of food such as sago, corn and various other types of tubers that can become the source of food for the people. Food besides rice has local historical and cultural roots so that the majority of the people of Indonesia, especially in Eastern Indonesia are used to consuming local food such as tubers, corn and sago. This indicates really that alternative food sources can become a consumption alternative for the people of Eastern Indonesia and rice can be focused to supply the needs in Java.

The policy of implementing food security by making use of local foods is the right step, because of the availability of local foods in each area and the ease by which they can be developed. For example, the people of Papua and Maluku are able to consume sweet potatoes as the staple food to replace rice. Nusa Tenggara Timur and North Sulawesi as the main producers of corn can consume corn as the staple food to replace rice. Another commodity which also has the possibility as a staple food to replace rice is sago which is widely available in Eastern Indonesia and Sumatera (Nainggolan, 2004).

Bustaman and Susanto (2007) explain that the farming of sago in Maluku Province can be utilised as a food source and has been proven to be the solution to the local food problem in this area. The people in the Maluku Province generally consume sago and other local foods as a source of staple foods in the past. According to Louhenapessy (2007), in the 1980's, 33% of the people of Maluku Province still used sago as the staple food, 50% used sago and tubers and only 17% used rice as the staple

food. However, Girsang (2014) states that the consumption of sago and other local food in Maluku Province has started to decrease while the consumption of rice has increased significantly in the last decade. Data from Susenas (2009) shows that there has been a shift in the consumption patterns of the people of Maluku Province who used to consume local food to consuming rice, where in 2005 the total of number of rice consumption was 68,52 kg/cap/year and has continued to increase in 2009 to 85 kg/cap/year.

In Maluku Province, there are approximately 52,000 ha of sago forests which have the potential to produce more than 268 kg of carbohydrate per capita per year for 1.55 million population of Maluku. Factors that influence the food consumption patterns in one region are the availability of the local food commodities. The availability of local foods has become the main important factor because it is one of the three main pillars of food security. The availability of food is linked to the supply of food to fulfill the needs of the whole community, both from the point of quantity, quality, variety, and safety. The distribution factor functions to create a distribution system that is effective and efficient in order to guarantee that the community can procure food in the reasonable quantity, quality and continuity with prices that are affordable. The consumption factor functions so that the pattern of the national utilisation of food fulfills the kaidah quality, variety, nutritional value, safety and halal norms (Rossi, 2010).

The food consumption patterns of the community generally are influenced by social and cultural factors, demography and lifestyle factors, including the relationship to the risk of certain degenerative illnesses. The food consumption patterns of the community also are significantly related to the food insecurity or food security conditions of the community. Evaluating food consumption patterns is one method that can be used to understand the food and nutrition situation of a community. One method used to evaluate the qualitative nature of food consumption patterns can be reflected in and demonstrate the sufficiency of individual dietary intake by evaluating the variety and quality of the nutritional value of the food. Rice is the main source of energy that is consumed in Indonesia, while the main source of energy of rice substitutes is obtained from cassava (Yudaningrum, 2011). The main difference in food consumption is obtained from the consumption levels of the community, which show that the consumption of rice in the villages is much higher than the consumption of rice in the cities.

## II. LITERATURE REVIEW

### Conceptual and Theoretic Review Concerning Demand

The theory of consumer demand is based on the theory of consumer behaviour. Consumer behaviour is the direct behaviour that is involved in the procuring, consumption and the finishing off of the product and services, including the decision making process before and after the action reveals consumer behaviour in determining the consumption of goods. While the level of personal demand is the desire of the consumer to purchase certain goods at various price levels over a certain period of time. Therefore, the demand for a number of goods has a great influence on the price of those goods. The higher the price of the goods means that the demand for certain goods will decrease, and the reverse is also true. General demand theory describes how a consumer consumes a certain number of goods at a certain price level. If the price is high, then the quantity of goods consumed decreases on the other hand if the price is low, then the quantity of goods consumed rises *ceteris paribus*. In the consumption process the consumer uses the income that he has obtained from the production process. The problem is how does a consumer allocate his income to procure a certain number of goods so that the consumer will achieve maximum satisfaction. This is because the main aim of the consumer in the consumption process is to achieve maximum satisfaction.

### Household Consumption of Rice Substitutes Expenses

The consumption patterns of the community describes the allocation and composition or form of consumption that is generally valid for members of the community. Consumption can be defined as an activity in satisfying the needs or desires at this time in order to increase prosperity. Thus, the allocation of consumption is very dependant on the definition and perception of the community concerning needs and the obstacles they face. The life of urban communities demands a consumption lifestyle that is totally fast and instant. The consumption behaviour that is of urban communities no longer considers the function or use of goods that are purchased rather they take into account the social status attached to the particular goods. Urban household consumption patterns are caused by the busy lifestyle of each member of the household especially when the mother goes to work, then household consumption patterns that are applied when the members of the household get together in one place and order various types of fast food, without waiting long and also saves time on eating.

### Household Food Availability

Food availability for the community does not guarantee food security household, this is because the purchasing power of the community is not able to afford the food or

the household does not have access to the food although it is readily available in the market. Therefore, household food availability is more determined by the ability of the household to control their food needs. The ability to control is more influenced by the ability of the household in their own ability to produce food and their ability to purchase food in the market. Therefore, ability to buy food becomes the source of household food security, which is more dependant on household purchasing power (Pakpahan, *et al.*, 1993). In order to achieve food security food availability is needed in sufficient numbers and quality, distributed with affordable prices and safe to be consumed by every citizen to support daily activities all the time. (Saliem *et al.*, 2002).

### The Price of Rice Substitutes

Sago, corn and tubers are rice substitutes that are utilized in Indonesia. The use of rice substitutes is based on the availability of food in a region originates from the produce local family farmers and then developed into a local food habit or regional household consumption patterns at a low cost. In fact diverse household food consumption patterns have been in existence for a long time, but as a result of excessively dominant and intensive government policies in the field of rapid rice production, covering all aspects of the industry resulting in a shift from consuming rice substitutes to consuming rice (Ariani, 2010). This has occurred in Maluku where sago and other local food consumption patterns have decreased, while the consumption of imported rice has increased significantly. Besides the community consumption patterns, another factor that also has influenced this situation is the price of rice substitutes. The results of research Ilham *et al.* (2006) show that the definite price of rice substitutes will encourage the community or household to have alternative food consumption in order to protect the stability and availability of food at the community level.

### The Price of Rice

The price of food is an important point for the household when deciding which types of food to be consumed. In this case, the majority of the population of Indonesia consume rice because the price is subsidized by central government. The normal price of rice is Rp 10,000 per kg (USD 1 per kg), but the central government subsidized the price of rice up till 80 percent so that the cost for each household is around Rp 2,000 per kg. However, subsidized rice has been allocated by village officials to all rural households and has failed to solve the problem of the target group of poor households. Therefore every household receives around 5 kg per month.

### Household Income

Generally, household needs can be divided into two large categories, that is food and non food needs. Thus at certain

income levels, households will allocate their income to fulfill these two needs. Naturally the amount of food needed by an individual or a household will reach saturation point while non food needs including the quality of food is not limited in the same way. Thus, the size of income (that which is produced and total expenses) which are spent for food of a household can be used as an indicator of household prosperity (Tri Bastuti and Mewa Ariani, 2007). The size of income will determine the types of food consumed by a household. The types of food consumed by the household will determine household consumption patterns (Sumarwan dan Sukandar, 1998). Income becomes an important factor in determining household expenses, including food consumption patterns. If income increase then household consumption patterns will be more diverse so that consumption of food with high levels of nutrition will increase (Yudaningrum, 2011) so household food availability will be stable.

**Number Members in a Household**

The amount of financial responsibilities is a characteristic related to the increase in income yang berhubungan, including expenses and household food consumption, the more the number of household members then the costs will increase thus expenses and consumption will increase (Arida dan Fadhiela, 2015). At the family level the smaller the number of family members, the smaller the needs that have to be fulfilled by

the family, and the reverse is true. So that in a family whose household members are many then the needs that have to be fulfilled will also be greater (Adiana dan Karmini, 2012). Further it is said that the greater the financial responsibilities of a family is one of the factors that influences the household consumption patterns. The more the members of a household, then the consumption patterns will be more diverse because each member of the household may not have the same taste in food. The number of family members is linked to the household income that eventually influences household consumption patterns.

**III. RESEARCH METHODS**

The location of the research is in Maluku Province, with samples taken in Ambon, Central Maluku Regency, West Seram Regency and East Seram Regency. Samples were taken from 200 respondents with the same number of respondents taken in each Regency. This research is quantitative and qualitative in nature. The types of data used in this research are secondary data from the national socio-economic survey (SUSENAS), several publications of the Central Bureau of Statistics (BPS), reports and publications from the Ministry of Agriculture of the Republic of Indonesia, and publications from the National Food Security Board and the Maluku Province Regional Food Security Board.

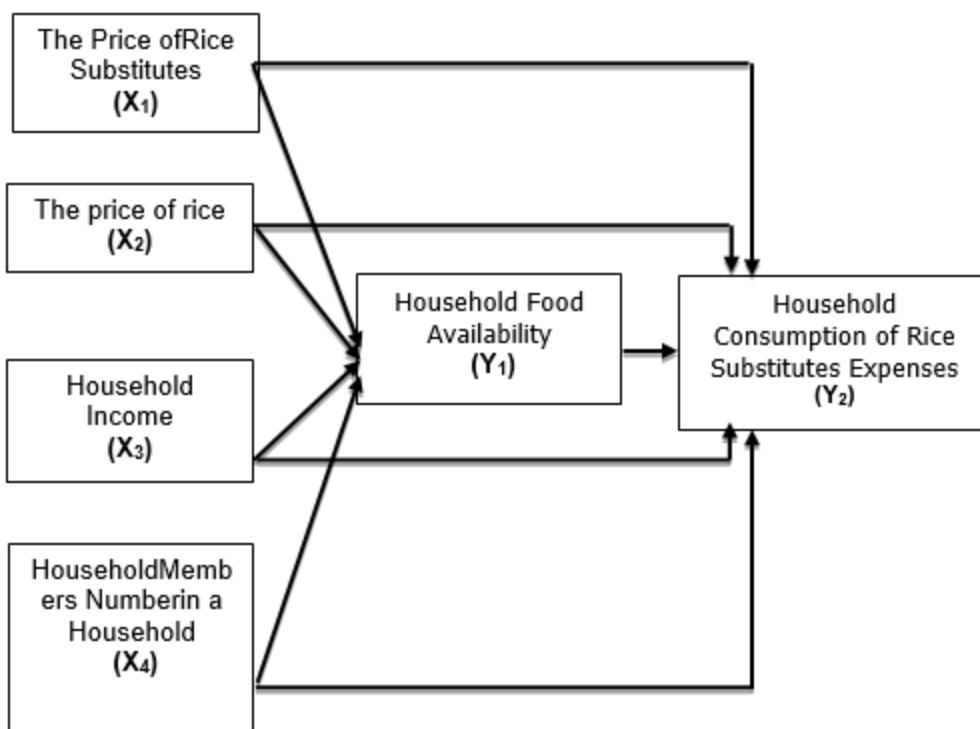


Fig.1: Conceptual Model Design

Primary data was obtained from questionnaires that were distributed to respondents and interviews. The number of population of the area of research is 539,254 people, spread through three regencies and one municipality, West Seram Regency, Central Maluku Regency, East Seram Regency and the City of Ambon as the capital city of Maluku Province. 200 people were used as the Sample in this research, each regency and city represented by 50 respondents. Variables used in this research analysis model were (a). Household Food Availability; (b). Household Consumption Patterns; (c). The Price of Rice substitutes; (d). The Price of Rice; (e). Household Income; (f). Number of Household Members.

#### IV. RESULTS AND DISCUSSION

The price of rice substitute is one of the variables used in this research analysis model, this is because it is believed that the price of rice substitute calculated in rupiah can give an overview of the readiness and ability of a household to prepare food stocks in a month. Thus the price of rice substitute variable in this research can be defined as the value of money from the types of rice substitutes that can be calculated in rupiah.

The price of rice substitute is a price substitution for the price of rice. This is because if the price of rice is high then household respondents can make a substitution in the consumption process that is to consume other types of food besides rice, such as sago, tubers, nuts and other types of food.

Table.5.1: Allocation of Household Income of Respondents for the Consumption of Rice Substitutes In the Area of Research 2017

Household Income	Total	Percentage
≤ 30,000	80	40
31,000 – 40,000	25	12.5
41,000 – 50,000	44	22
≥ 50,000	51	25.5
Total	200	100

Source: Processed Primary Data

Table-5.1 shows the household income groups for rice substitute consumption in a month in the area of research. From the data above it is known that households that allocate less than ≤ Rp. 30,000 as 80 households or 40% of the total respondents. Households that allocate income between Rp. 31,000 – Rp. 40,000 and between Rp. 41,000 – 50,000 for rice substitute consumption are 25 households 12.5% of the total household respondents and 22 households or 22% of the

total households. While the allocation of income ≥ Rp. 50,000 are 51 households or 25.5% of the total household respondents.

Information from Table-5.1 can be analysed further that if 40% of households in the research area allocate income in order to consume rice substitutes, because this has a closely related to household consumption patterns of respondents in Maluku who tend to consume rice substitutes besides rice. It was also discovered that the choice of such income allocation was because the rice substitutes were cheaper than the price of rice besides the factor of the availability of rice substitutes were much more easily accessed both in urban and rural areas.

Other phenomena that can be analysed is the households that allocate income rice substitute consumption ≥ Rp. 50,000 was 25.5% which is second. This was not according to what had been hoped theoretically that every increase in the price of rice substitute should be followed by a reduction in the household demand for rice substitute products that should influence the availability of household rice substitutes. But the results of correlation and facts in the area of research demonstrate a parallel comparison, with the understanding that if there is a rise in the price of rice substitute then it is followed by an increase in the consumption of rice substitute in order to add to the availability of household rice substitute in the area of research.

According to micro economic theory it is known that the law of demand states that if the prices of a product rises, then the number of products consumed will tend to fall (*ceteris paribus*). But the facts in the field show a different situation that is a deviation of behavior of household respondents in carrying out consumption activity. According to the opinion of the researchers a form of paradox occurs in Maluku, this is in fact is in accordance with the findings of Sir Robert Giffen in Northern Ireland that in micro economic theory is called the *Giffen paradox*. The price is the value associated with certain goods or products that is used as a calculation tool in the economic transaction process. Based on this understanding then the price of rice in this research defined as the value in rupiah that is associated with rice products that function as a calculation tool in the transaction process. The price of rice is one important variable in this research, because rice is one of the strategic foods in Maluku besides rice substitutes, because in various studies and analyses concerning food then rice always becomes the material of research, study and analysis.

Table.5.2: Income allocation Household Respondents For Rice Consumption in the Research Area 2017 (Price per Sack and Price per Kg)

Price per Sack	Household Respondents	Percentage
≤ Rp. 250,000	92	46
≥ Rp. 250,000	108	54
< Rp. 10,000	55	27.5
≥ Rp. 10,000	145	72.5

Source: Processed Primary Data

Table-5.2 clearly shows the actual situation in the area of research that household respondents who consume rice at the price level of rice/kg ≥ Rp. 10,000 is 72.5% or 145 households greater than the number of household respondents who consume rice at the price level of ≤ Rp. 10,000 which was only 27.5% 55 households. It is known that the perception of households in this research area tend to consume rice of a better quality with certain brand names compared to cheaper rice at a lower price. This means it can be concluded that household respondents both rural and urban possess an awareness concerning the consumption of rice that is healthier and of better quality to maintain carbohydrate nutrition rates to fulfill their needs. Another reason households in the research area consume better quality rice although a higher price has to be paid is because the relatively high purchasing power of the household respondents so that income allocation can be directed to consume good quality rice.

Table.5.3: Income of Household Respondents In Research Area in Maluku, 2017

Total Income for Household Members	Total	Percentage
1,000,000 – 4,999,999	54	27
5,000,000 – 9,999,999	55	28
≥ 10,000,000	91	45
Total	200	100

Source: Processed Primary Data

Table-5.3 provides information that households 54 household atau 27% of total household respondents have an income at a level between Rp. 1,000,000 – Rp. 4,999,999. While 55 households or 28% of the total respondents Sedangkan household have an income level of between Rp. 5,000,000 – Rp. 9,999,999 and 91 households or 45% of the total household respondents who have an income level in one month more than Rp. 10,000,000. Income as shown in table-5.1 is the income

Besides income allocation of household respondents, consumption of rice can be seen from the price per sack (25 kg). Thus it is known that households in the research area that consume rice with a price per sack level (25 kg) at ≥ Rp. 250,000 amounted to 108 households or 54% of the total household respondents. While household respondents that consume rice at the price level per sack (25 kg) ≤ Rp. 250,000 only amounted to 46% of the total household respondents or 92 household respondents. From the information from the table above it can be concluded that this occurs because of the awareness of the household respondents concerning consumption and the income factor as explained above.

Household income, wages and salaries based on the work hours that have been completed, overtime, all bonuses and allowances, calculation of time when off work, bonus that is not a regular payment, rewards; and the value of payments in kind. There are two components, that is: (1) for usual work hours or for work that has been completed, and (2) for overtime. All other income components were added together on aggregate. The income indicator used was rupiah (Rp). The source of income of the respondents came from farming and nonfarming jobs. According to research results, the majority of income of household respondents in Maluku comes from basic work as farmers. Besides farmers, household respondents also obtained income income as fishermen and breeders. Other forms of work included unskilled labourers, construction labourers, own business and carpenters. In the following table the size of the average income of household respondents in a month can be seen. of household respondents that originates from farming and non-farming work. This is because the great variety in the characteristics of the household members in these four Regencies / City of the sample area.

The diminishing availability of rice substitutes for the household respondents certainly implications that are not good for the consumption activities of household members in a month. The understanding being that the total number of rice substitutes that are consumed have diminished meaning that the nutrition factor that originates from these rice substitutes will also diminish and long term will greatly influence the quality of the health of the members of the household in the research area. However on the other hand there is another phenomena that has been discovered in this research area, that is, when the income of the household respondents rises, it does not have a significant influence on on the household consumption patterns, this is because the additional income is not followed by an increase in consumption of rice substitutes related to endeavours to increase the availability of rice substitutes of households in the research area.

From the observation results it is known that a rise in income for the household respondents often changes their household consumption expenses where decisions on consumption habits shift from consumption of rice or the consumption of rice substitutes such as the use of money to pay bills to a third party, the purchasing of electronic goods, and also other third party needs. This of course has a close relationship to the change in the consumption behavior of household respondents according to the needs of each household in the research area. This situation is also caused by the rise in income of households in the research area that are not always followed with an increase in the consumption of rice substitutes in order to add to the availability of rice substitutes for the household respondents.

Other findings in the four Regencies/City in Maluku as the research area are that besides farming and laboring that jobs beside the main occupation of household respondents are very sparse which causes the income of the majority of household respondents to be low. Low household income can affect the level of food consumption of the household. But households with high income also do not guarantee food availability in decent amounts in each household or does not meet the minimum standard. This situation can be caused by household consumption habits in the consumption process, or it can be caused by the low level of education of the head of the household so that knowledge and insight concerning how to carry out the consumption process that fulfills the standard nutrition requirements correctly and accurately according to the needs of the members of the household in a month. Although not every head of household gets income from non-farming work, but income from non-farming work is needed to fulfill the needs of the household. While the housewife, who does not have any job except organize the housework, is expected to help the head of the household in working.

The total of financial responsibilities is a characteristic that is related to an increase in income, including expenses and household food consumption. The more the number of members of the household need costs are greater so that expenses and consumption will be greater. Members of a household consist of the husband (head of the household), wife and child. The greater the numbers of members of the household, then the expenses and food needs will also be greater. The results of this research concerning the members of the household that was carried out in four Regencies / City in Maluku can be seen in Table-5.4 below, that explains that 54 households consisting of between 3 – 4 household members is 27% of the total household respondents, while there were 117 households consisting of between 4 - 6 household members

or 58% of the total household respondents and 29 households consisting of more than 6 household members or at a 14%.

The information in table-5.4 explains that the average household in the research area included 4 - 6 members consisting of husband, wife, child and other family members that were the financial responsibility of the head of the family. Of course the number of household members has great implications on the household food availability in the research area.

Table.5.4: Number of Members of Household Respondents In the Research area in Maluku, 2017

No	Number of Household Members	Total	Percentage
1	1 – 3	54	27
2	4 - 6	117	58
3	6+	29	14
	Total	200	100

Source: Processed Primary Data

This is because the head of the household has to allocate his income for the consumption of rice and rice substitutes as previously described. Differences occurred in the proportion of rice and rice substitutes consumption in the research area both in urban and rural area which was actually influenced by on three main factors, that is the habits in the food consumption patterns, the level of income and the number of household members in households of the respondents.

#### The Results of Analysis of the Relationship between Variables

In describing the results of the research carried out by providing an overview of the results of quantitative calculations according to the model that was used in this research. In analyzing the data to discover the influence of the price of rice substitutes (X1), the price of rice (X2), household income (X3), household members (X4) have a real statistical relationship (significant) towards the dependent variable of food availability (Y1), thus a basic mathematical function is formed where Y1 is the food availability in Maluku, X1, the price of rice substitutes, X2, the price of rice, X3, household income, and X4, household members, according to the time period of when the research was carried out.  $\alpha_0$  is the constant or intercept, is the coefficient regression that is sought, and shows the variable error, and above estimation model used the OLS (Ordinary Least Square) approach.

Table.5.5: The Results of the Linear Regression Equation Y1

Dependent Variable	Independent Variable	Parameter	Unstandardized Coefficients		Results Analysis		Comments
			B	Std. Error	t-Statistic	Sig.	
KPRT	PRS (X1)	$\alpha_1$	-1.134	.926	-1.225	0.222	Not Significant
	PR (X2)	$\alpha_2$	-2.847	1.005	-2.832	0.005	Significant
	HI (X3)	$\alpha_3$	.011	.001	15.390	0.000	Significant
	HM (X4)	$\alpha_4$	2466.559	1195.718	-2.063	0.040	Significant
Constant = 69,323.971 R square = 0.560 F-statistic = 61.987 Sig. F-statistic = 0.000							

In the results of the analysis the regression equation as seen above was obtained so an interpretation can be made as follows. The above equation provides information that the price level of rice substitutes (X1), the price of rice (X2), household income (X3), household members (X4) have a positive relationship to food availability in Maluku (Y1). When the price of rice substitutes (X1), the price of rice (X2), household income (X3), household members (X4) = 0, or experiences no change in the household then the value of food availability in Maluku (Y1) = C = 69,323.971. Thus the results of the data analysis (based on appendix 2):  $Y1 = 69,323.97 - 1,134 X1 - 2,847 X2 + 0.011 X3 - 2466.59 X4$ . Every single rupiah rise/reduction of the rice substitutes (X1) has a positive effect 69,323.971 towards the constant value ( $\alpha_0$ ). The implication being the higher the price of rice substitutes (X1) the higher the value of food availability in Maluku (Y1).

The constant 69,323.971 demonstrates that if there is no increase in the value/price of rice substitutes (X1), the price of rice (X2), household income (X3), and household members (X4) the value of food availability in Maluku (Y1) amounts to 69,323.971. The coefficient regression being -1,134 for X1, - 2,847 for X2, 0.011 for X3 and -2466.59 X4 demonstrates that every additional value unit (price or person) X1, X2, X3 and X4, will produce a rise of -1,134-2,847, 0.011, and -2466.59 across the board.

Based on an analysis of the results it is known that the coefficient determination is 0.560 that demonstrates that the variables of price rice substitutes (X1), the price of rice (X2), household income (X3), and household members

(X4) together influence the food availability in Maluku variable (Y1) by 56 percent, and the remaining 44 percent is determined by other variables outside of this estimation model.

In order to find out the relation between the variables of household food availability (Y1), price of rice substitutes (X1), the price of rice (X2), household income of consumer (X3), and the number of household members (X4), towards household food consumption patterns of the community (Y2), therefore a second model was formed with a basic mathematical function of  $= f(X1, X2, X3, X4, Y1)$ .

From this mathematical function a double linear regression equation as a basic model to form the following equations, where Y2 rice substitutes household consumption expenses, Y1 food availability in Maluku, X1 price of rice substitutes, X2 the price of rice, X3 household income, and X4 household members, according to the time period of when the research was carried out.  $\beta_0$  the constant or intercept,  $\beta_1 \dots \beta_5$  the coefficient regression that is being sought, and shows the variable error, and the above estimation model used the OLS (Ordinary Least Square) approach.

The estimation results of the equation on the following page, can provide information that the level of food availability in Maluku (Y1), the price of rice substitutes (X1), the price of rice (X2), household income (X3), household members (X4) have a positive relation to the dengan rice substitutes consumption expenses in Maluku (Y2).

Table.5.6: Results of Linear Regression Equation Y2

Dependent Variable	Independent Variable	Parameter	Unstandardized Coefficients		Analysis Results		Comment
			B	Std. Error	t-Statistic	Sig.	
PKRT	PRS	$\beta_1$	.496	.061	8.149	0.000	Significant
	PR	$\beta_2$	1.003	.789	1.271	0.205	Not Significant
	HI	$\beta_3$	-.937	.871	-1.076	0.283	Not Significant
	HE	$\beta_4$	.005	.001	5.288	0.000	Significant
	MH	$\beta_5$	3641.467	1026.384	3.548	0.000	Significant
Constant = -225.193 R square = 0.647 F-statistic = 71.036 Sig. F-statistic = 0.000							

When food availability in Maluku (Y1), the price of rice substitutes (X1), the price of rice (X2), household income (X3), household members (X4) = 0, then the value of the constant consumption rice substitutes expenses in Maluku (Y2) = C = -225.93. Every increase/decrease in food availability in Maluku (Y1) produces a positive effect of .496 towards the constant value ( $\alpha_0$ ). The implication being, the higher the level of food availability in Maluku (Y1) then the value of consumption patterns in Maluku (Y2) will become greater. This phenomenon is in accordance with the data findings in the field during the period of research that describes the increase in food availability in Maluku (Y1), which is always followed by a greater amount or rise in the total household rice substitutes consumption expenses in Maluku (Y2).

Secondly, every single rupiah rise or fall of the price of rice substitutes (X1) does not have an effect on the constant value ( $\alpha_0$ ). The implication being that the higher the price of rice substitutes (X1) then the household rice substitutes consumption expenses in Maluku (Y2) is not effected. So that it can be concluded that the price of rice substitutes cannot be used to measure household rice substitutes consumption expenses.

Thirdly, every one rupiah rise/fall in the price of rice (X2) has no effect on the constant value ( $\alpha_0$ ). The implication being, the higher the price of rice (X1) then the value of household rice substitutes consumption expense in Maluku (Y2) is not effected. So that it can be concluded that the price of rice cannot be used to measure household rice substitutes consumption expenses.

Fourthly, when household income (X3) = Rp.1, then rice household substitutes consumption expenses in Maluku (Y2) = Rp. 005 and so on. This condition is according to what

was expected that every increase in household income (X3), is always followed by an increase in household rice substitutes consumption expenses in Maluku (Y2). This phenomenon is also in accordance with data findings in the field during the period of research which describes the rise in household income (X3) that is always followed by a greater amount or increase in the total household rice substitutes consumption expenses in Maluku (Y2).

Fifthly when the number of household members (X4) = 1 person, then household rice substitutes consumption expenses in Maluku (Y2) = Rp. 3,641,467. When the household members (X4) = 2 people the food consumption pattern in Maluku (Y2) = Rp.7,282,934 and so on. This condition is in accordance with the expectations that the increase in the household members (X4) always follows with a greater increase in household rice substitutes consumption expenses in Maluku (Y2). This phenomenon is also in accordance with data findings in the field during the period of research describes the increase in household members (X4) of one person is always followed by a greater amount/increase in the total household rice substitutes consumption expenses in Maluku (Y2).

Constant -225,193 states that if there is no increase in the values of food availability in Maluku (Y1), the price of rice substitutes (X1), the price of rice (X2), household income (X3), and household members (X4) then the value of household consumption patterns in Maluku (Y2) will be -225,193. The coefficient regression of .496 for Y1, 1.003 for X1, -.937 for X2, .005 for X3 and X4 3,641,467 states that each additional unit value (price or person) Y1, X1, X2, X3 dan X4, will have an effect of .496, 1.003, -.937, .005 and 3,641,467 put together.



Based on the results analysis it is known that the coefficient determination is 0.647 that demonstrates that the variables of food availability in Maluku (Y1), the price of rice substitutes (X1), the price of rice (X2), household income (X3), and household members (X4) put together effect the food availability in Maluku variable (Y1) of 64.7 percent, and the remaining 35.3 percent is determined by variables outside this estimation model.

## V. CONCLUSION

With reference to the results and the discussion that has been put forward in the previous chapter, then it can furthermore be concluded as follows:

1. The price of rice substitutes has a direct influence on household food availability in Maluku Province. An increase in the price of rice substitutes in Maluku Province is always followed by an increase in the total household food availability. Besides this, the price of rice substitutes has a direct effect on household rice substitutes consumption expenses. An increase in the price of rice substitutes in Maluku Province is followed by an increase in household rice substitutes consumption expenses.
2. The price of rice has a direct influence on household food availability in Maluku Province. An increase in the price of rice in Maluku Province is also followed by an increase in the total of household food availability. Besides this, the price of rice directly influences the household rice substitutes consumption expenses. An increase in the price of rice in Maluku Province is followed by an increase in household rice substitutes consumption expenses.
3. Household income directly influences household food availability in Maluku Province. An increase in household income in Maluku Province is also followed by an increase in the total household availability. Besides this, household income directly influences the total of household rice substitutes consumption expenses. An increase in household income in Maluku Province is followed by an increase in household rice substitutes consumption expenses.
4. The number of household members directly influences household food availability in Maluku Province. If the number of household members increase then it is always followed by an increase in the total of household food availability. Besides this, the number of household members directly influences the household rice substitutes consumption expenses. If the number of household members increase then it will be followed by a rise in the level of household rice substitutes consumption expenses.

## REFERENCES

- [1] Abdurachim I., 1973. Pengantar Masalah Penduduk. Penerbit Alumi Bandung.
- [2] Adiana, Pande Putu Erwin dan Ni Luh Karmini. 2012. Pengaruh Pendapatan, Jumlah Anggota Keluarga dan Pendidikan Terhadap Pola Konsumsi Rumah Tangga Miskin di Kecamatan Gianyar.
- [3] Ahmad, Israr dan Khan, Ali-ud-din. 2014. *An Empirical Study into the Relation of Income and Consumption Using Cross-Sectional Data*. ASSE 2014 Zone I Conference, April 3-5, 2014. University of Bridgeport, CT, USA.
- [4] Alimoeso, Sutarto. 2009. Menuju Lumbung Pangan Dunia. Jakarta : Gibon Books.
- [5] Amang, B. and Silitonga., 1990. Kebijakan Harga, Subsidi dan Diversifikasi Produksi dan Konsumsi Pangan. Konpermas X PERHEPI, Jakarta.
- [6] Arifin, Bustanul. 2009. Tantangan Baru Ekonomi Pangan. Economic Review Bulan Juni No. 216.
- [7] Ariani, et al. 2007. Kinerja dan Prospek Pemberdayaan Rumah Tangga Rawan Pangan dalam Era Desentralisasi. Kerjasama Penelitian Biro Perencanaan, Departemen Pertanian dan UNESCAP-CAPSA, Bogor.
- [8] Ariani, Mewa. 2010. Diversifikasi Konsumsi Pangan Pokok Mendukung Swasembada Beras. Prosiding Pekan Serealia Nasional ISBN : 978-979-8940-29-3. Balai Pengkajian Teknologi Pertanian, Banten.
- [9] Arida, Agustina dan Keumala Fadhiela. 2015. Analisis Ketahanan Pangan Rumah Tangga Berdasarkan Proporsi Pengeluaran Pangan dan Konsumsi Energi. Jurnal Agresep Vol 16. No. 1, 2015.
- [10] Benita, Dian, Darsono, Moh. Harisudin, 2012. Ketersediaan Pangan Pokok dan Pola Konsumsi pada Rumah Tangga Petani di Kabupaten Wonogiri. Jurnal Agribisnis. Universitas Sebelas Maret. Vol. 1 No.1, 2012.
- [11] Bustaman, S. dan Susanto, N. A., 2007. Prospek dan Strategi Pengembangan Sagu Untuk Mendukung Ketahanan Pangan Lokal di Propinsi Maluku. Jurnal Ekonomi Pembangunan, Vol. XV. No. 2. 2007.
- [12] Bustanil Arifin. (2008). *From Remarkable Success Stories to Troubling Present: The Case of BULOG in Indonesia*. In: *From Parastatal to Private Trade: Lessons from Asian Agriculture* (Eds. RASHID, S., GULATI, A. and CUMMINGS, R. W.), pp.137-164, The Johns Hopkins University Press, Baltimore, Maryland, USA.
- [13] Dewan Food security Propinsi Maluku. 2015. Laporan Kegiatan Pengendalian Harga Pangan Pokok di Propinsi Maluku.

- [14] Engel, J.F., R.D. Blackwell, dan P.W. Miniard, 1994. Perilaku Konsumen. Penerbit Binarupa Aksara, Jakarta.
- [15] Girsang, Wardis., 2014. *Socio-Economic Factors That Have Influenced the Decline of Sago Consumption in Small Island :A Case in Rural Maluku, Indonesia. Reaserch Center For The Pacific Islands.* Kagoshima University, Japan.
- [16] Hafisah, Jafar, 2006. Pertanian dan Pangan. Revitalisasi Pertanian dan Dialog Perdebatan. Penerbit Buku. Kompas, Jakarta
- [17] Hanafie, Rina. 2010. Peran Pangan Pokok Lokal Tradisional Dalam Diversifikasi Konsumsi Pangan. J-SEP Vol. 4 No. 2. Juli 2010.
- [18] Hetharia, M.E., 2006. Kembali Makan Sagu (Masalah dan Tantangan). Prosiding Sagu dalam Revitalisasi Pertanian Maluku. Ambon, 29-31 Mei 2006. Kerjasama Pemerintah Propinsi Maluku dengan Fakultas Pertanian, Universitas Pattimura. Badan Penerbit Fakultas Pertanian Universitas Pattimura, pp. 52-59.
- [19] Ilham, N., H. Siregar, dan D.S. Priyarsono, 2006. Efektivitas Kebijakan Harga Pangan Terhadap Food security. Jurnal Agro Ekonomi 24 (2): 157-177.
- [20] Imanuddin. 2007. *Family Sago Consumption in Relation to Preference and Perception of the Family about Social Value of Sago in Konawa Distric, Southeast Sulawesi Province, Master Thesis, 64 pp., Public Health Science, Universitas Gadjah Mada, Yogyakarta.*
- [21] Iskandar, Andi Nuhung, 2006. Bedah Terapi Pertanian Nasional. Peran Strategi dan Revitalisasi. PT. Bhuana Ilmu Populer Kelompok Gramedia – Jakarta.
- [22] Jutomo, Lewi. 1998. Pola Konsumsi Pangan dan Susunan Menu Harian Etnik Timor di Kecamatan Amarasi. Media Gizi dan Keluarga. Tahun XXII. No. 1.
- [23] Khomsan, A. 1996. Ketersediaan dan Distribusi Pangan Dalam rangka Mendukung Ketahanan Pangan Rumah Tangga. Makalah disampaikan pada Lokakarya Ketahanan Pangan Rumah Tangga., Tanggal 26 – 30 May 1997 di Yogyakarta.
- [24] -----, 2003. Pangan dan Gizi Untuk Kesehatan. PT. RajaGrafindo Persada. Jakarta.
- Kurnia, R. S., Agustono, Rahayu, W. 2008. Analisis Peran Lumbung Desa Terhadap Ketersediaan Pangan Pokok Rumah Tangga Petani. SEPA. Vol. 4. No. 2. Februari 2008. pp. 103-112.
- [25] Latumaerissa, Julius, R. 2003. Teori Ekonomi Mikro. Penerbit Luthfanzah, Surabaya. 2003.
- [26] Lazuardi Saga, Lintan., 2008. *Lifestyle Pola Makan Dalam Individu dan Keluarga.* Makalah, Surabaya : FISIP, Unair. Tidak diterbitkan.
- [27] Lina dan Rosyid. 1997. Perilaku Konsumtif Berdasarkan *Locus of Control* Pada Remaja Putri. Jurnal Psikologika Ed. 4, Tahun II, Yogyakarta. UGM.
- [25] Louhenapessy, J. E., (2007). Potensi dan Pengelolaan Sagu di Maluku. Prosiding Sagu dalam Revitalisasi Pertanian Maluku. Ambon, 29-31 May. pp. 10-16.
- [26] -----, (2010). Sagu. Harapan dan Tantangan. Penerbit PT. Bumi Aksara, Jakarta. 2010.
- [27] Mantra, Ida Bagus. 2003. Demografi Umum. Penerbit : Pustaka Raja, Jakarta.
- [28] Maxwell, S., and Frankenberger, T. (1992). *Household Food Security Concepts, Indicators and Measurements.* New York, ny. USA : Unicef and Ifad.
- [29] Moniharapon, Gabriel, Martha Turukay dan Johanna Luhukay, 2013. Perubahan Pola Konsumsi Pangan Rumah Tangga dari Mengkonsumsi Pangan Lokal ke Pangan Beras Pada Kecamatan Leitimur Selatan Kota Ambon. Jurnal Agribisnis Kepulauan Vol. 1 No. 4. Oktober 2013.
- [30] Mufidah, Nur Lailatul. 2006. Pola Konsumsi Masyarakat Perkotaan : Studi Deskriptif Pemanfaatan *Foodcourt* oleh Keluarga. Jurnal BioKultur, Vol. I No. 2.
- [31] Nainggolan, K. 2004. Strategi dan Kebijakan Pangan Tradisional dalam Rangka Ketahanan Pangan. Seminar Nasional Peningkatan Daya Saing Pangan Tradisional. Balai Research dan Pengembangan Pascapanen Pertanian Bogor.
- [32] Nurul Fitriana Buana Putri, 2011. Pergeseran Konsumsi Pangan Pokok dari Non Beras Menjadi Beras pada Rumah Tangga Miskin. Program Studi Agribisnis Fakultas Pertanian, Universitas Sebelas Maret, Surakarta.
- [33] Pakpahan, A., H.P. Saliem, S.H. Suhartini dan N. Syafa'at. 1993. Ketahanan Masyarakat Berpendapatan Rendah. Monograph Series No. 14. Pusat Penelitian dan Pengembangan Sosial Ekonomi Pertanian. Bogor.
- [34] Pujoharso, Cahyo. 2013. Aplikasi Teori Konsumsi Keynes Terhadap Pola Konsumsi Makanan Masyarakat Indonesia. Artikel Ilmiah.
- [35] Purwani, E. Y., Widaningrum, Tahir, R. and Muslich. 2006. *Effect of Heat Moisture Treatment of Sago Strach on Its Noodle Quality.* Indonesia Journal of Agricultural Science, 7: 8-14.

- Prajoko, Agung., 1992. Keanekaragaman Konsumsi Pangan Rumah Tangga Kota-Desa Antar Propinsi di Pulau Jawa. IPB, Bogor.
- [36] Hanafie, Rina. 2010. Peran Pangan Pokok Lokal Tradisional dalam Diversifikasi Konsumsi Pangan. *JurnalSEP*. Vol. 4. No.2. 2 July 2010. Universitas Widyagama Malang.
- [37] Rinawati, Yantu, M.R., Rustam Abd. Rauf. 2014. Pengaruh Pendapatan Terhadap Konsumsi Masyarakat Tani Padi Sawah di Desa Karawana, Kecamatan Dolo, Kabupaten Sigi. *Jurnal Agrotekbis* 2 (6) : 652-659. ISSN : 2338-3011.
- [38] Riyadi. 2003. Kebiasaan Makan Masyarakat dalam Kaitannya dengan Penganekaragaman Konsumsi Pangan. Prosiding Simposium Pangan dan Gizi serta Kongres IV Bergizi dan Pangan Indonesia, Jakarta.
- [39] Rossi Prabowo. (2010). Kebijakan Pemerintah Dalam Mewujudkan Pertahan Makanan di Indonesia. *Jurnal Ilmu Pertanian*. Vol. 6. No. 2 MediaArgo.
- [40] Sage, C. (2002). *Food Security and Environment*. In Page and Redclift, ed. (2002) *Human Security and The Environmen: International Comparisons*. Cheltenham : Edward Elgar, pp. 128-153.
- [41] Saliem, H.P., M. Ariani, Y. Marisa dan T. B. Purwantini. 2002. Analisis Kerawanan Pangan Wilayah Dalam Perspektif Desentralisasi Pembangunan. Laporan Hasil Research Pusat Research dan Pengembangan Social Ekonomi Pertanian. Bogor.
- [42] Sumarwan, U. dan Sukandar, D. 1998. Analisa Pertahan Makanan Keluarga dan Kesejahteraan Keluarga. *Media Gizi dan Keluarga*. Tahun XXII. No. 1.
- [43] Sumodiningrat G., 2001. Menuju Swasembada Pangan. *Revolusi Hijau II. Introduksi Manajemen Dalam pertanian*. Penerbit RBI, Jakarta.
- [44] Suswono. 2011. *The Indonesia Food Security in The Perspective of Global Economy and National Sovereignty. Paper Presented in International Seminar on The Future of Global Food Security Safety: Issues and Justification*. IPB Convention Center, Bogor, Indonesia.
- [45] Suyastiri, Ni Made, YP. 2008. Diversivikasi Konsumsi Pangan Pokok Berbasis Potensi Lokal Dalam Mewujudkan Pertahan Makanan Rumah Tangga Pedesaan di Kecamatan Semin Kabupaten Gunung Kidul. *Jurnal Ekonomi Pembangunan*. Vol. 13 No. 1.
- [46] Suryana, A. 2006. Strategi Kebijakan Research dan Pengembangan Palawija. Prosiding Seminar Nasional Pengembangan Agribisnis Berbasis Palawija di Indonesia. Perannya dalam Peningkatkan Pertahan Makanan dan Pengentasan Kemiskinan. Bogor, 13 Juli 2006. *Economic and Social Commission for Asia and The Pacific, UNESCAP-CAPSA*, Bogor.
- [47] Tri Bastuti Purwantini dan Mewa Ariani. 2007. Pola Konsumsi Pangan Pada Rumah Tangga Petani Padi. Pusat Analisis Social Ekonomi dan Kebijakan Pertanian dan Balai Pengkajian Teknologi Pertanian.
- [48] Yamamoto, S. 2013. *Food Security on Chuuk Atoll, Federated States of Micronesia Proceeding of the Ninth International Small Island Conference* (Tual and Langgur, Maluku, Indonesia).
- [49] Yudaningrum, Agnes. 2011. Analisis Hubungan Proporsi Pengeluaran dan Consumption Pangan dengan Pertahanan Makanan Rumah Tanga Petani di Kabupaten Kulon Progo. Skripsi. Fakultas Pertanian, Universitas Sebelas Maret, Surakarta.

# A Comparative View of the Main Frameworks in Organizational Modeling Process

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**Abstract**—In the perspective of organizational context, the present paper deals with the different types of architecture of BPM (Business Process Modeling). As objectives, it is proposed to formulate a conceptual comparative view of the main architectures present in the scientific literature. As for the methodology, bibliographical and webibliomining research are employed in a qualitative and quantitative approach to the subject. As a result, the comparative view of the UML, BPMN, CIMOSA, IDEF, ARIS, IEM, GRAI, GERAM and EKD architectures is developed, in terms of temporal aspects, socio-technical characteristics, visualization and analysis, among other factors which offers substantial argument to decide what framework is better in each scenario.

**Keywords**— *Business Process Modeling; Organizational Modeling Techniques; Reference Architectures.*

## I. INTRODUCTION

Corporate modeling, or modeling of organizational processes, or still business processes, have become extremely relevant tools for the management of modern organizations, which are inserted in a competitive market with increasingly demanding clients.

In this context, identifying and assimilating the workflow of organizational environments is a necessary condition for the development of processes improvement, which, in turn, generate benefits such as efficiency gains, quality and flexibility; as well as other aspects conducive to sustainable competitive advantages.

In the definition of Conforti, Dumas, García-Bañuelos and Rosa (2016), a process encompasses elements of work (action) and resources (people, equipment, information) in order to achieve a result for a specific consumer.

In this context, business process modeling is the practice of science to verify how this work and resources are arranged in an organization to identify opportunities for improvement and, consequently, positive results. This resource disposition refers to the way in which modeling is organized, that is, its architecture.

There is a large number of researches in the scientific literature on business process modeling architectures. In the view of Rosa, Van Der Aalst, Dumas and Milani (2017), this theme has become a mature discipline, exhibiting a well defined set principles, methods and tools that combine knowledge of information technology, management sciences and industrial engineering with the aim of continuously improving business processes.

Exploring the concepts, we can identify several methodologies and architectures that characterize the different applications of the process modeling theme such as: BPMN (Business Process Model and Notation); UML (Unified Modeling Language); ARIS (Architecture of Integrated Information Systems); CIMOSA (Computer Integrated Manufacturing Open System Architecture); IDEF (Integration DEFinition); among others. Such a variety engenders an aspect of complexity in choice by a method that is efficient to promote the goal of process improvement in organizations.

The objective of this paper is to propose a comparative and conceptual analysis, using webibliomining, that provides an overview of the state of the art of the literature about the main reference architectures in BPM in the scientific environment, seeking a better understanding of its performance regarding organizational processes and organizational management environment.

In addition to the webibliomining data, the systematic quantitative and qualitative approach of scientific research and recent empirical studies of relevant authors of literature is based on the proposal of a conceptual comparative analysis adapted from the work developed by the authors Barat, Kulkarni, Clark and Barn (2016).

Therefore, this paper is organized as follows: Section 2 provides the Theoretical Framework that serves as an elementary basis for sustaining the development of the theme throughout the article; In section 3, the Methodological Resources are presented with the intention of engendering scientific ballast and listing the stages of the research in a coherent way; Section 4 encompasses the

Webibliomining Analysis performed on the subject of modeling architectures. Section 5 presents the duly grounded Conclusion of the topic discussed; finally, the bibliographic references are presented at the end of the paper.

## II. LITERATURE REVIEW

The theoretical reference of the present paper is centered in ascertaining the main aspects and characteristics of the architectures of modeling of business processes more common to the scientific literature, obtained with the aid of extensive systematized bibliographical research. In this context, the modeling techniques will be emphasized: BPMN; UML; ARIS; CIMOSA; and IDEF.

As secondary approaches, due to the lower popularity in the literature, the following sub-topic entitled "Other business process modeling architectures" is briefly

discussed in the following methodologies: IEM (Integrated Enterprise Modeling); GERAM (Generalized Enterprise Reference Architecture and Methodology); EKD (Enterprise Knowledge Development); e GRAI (Graphs with Results and Actions Inter-related).

### 2.1. BPMN

BPMN is considered a highly efficient generic modeling architecture for modeling business processes across multiple domains of interest, relying on a considerable amount of tools and techniques that facilitate process management activities. As for its symbology, or flow architecture, we have the elements: start event; end event; c) task; gateways, decision structures; and flow arrow of the model. An example of the application of this symbology is given in figure 01.

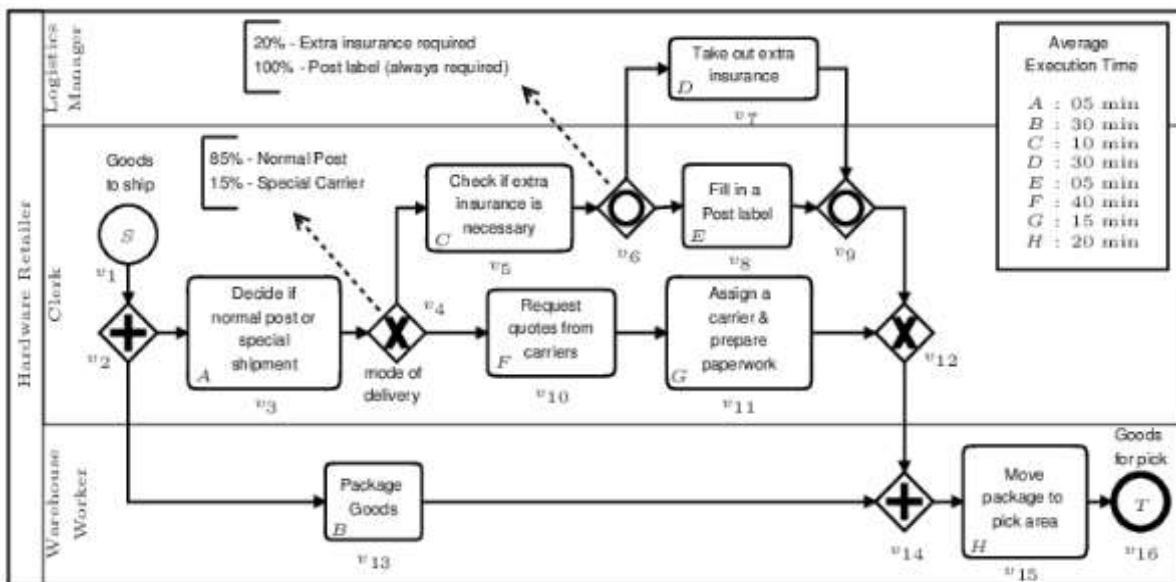


Fig.1: Example of BPMN

Source: Braghetto, Ferreira & Vincent (2011)

In the study promoted by Yan et al. (2018) about the compliance levels of procedures used for the redesign of clinical processes, one can verify the flexible semantics of the BPMN architecture, which facilitates the analysis of complex protocols. In this same work, the flexibility aspect of BPMN is also exalted when adapting matrices of time X tasks (very commonly used in the clinical sector) to a BPMN model of heuristic characteristic.

Another proof of BPMN's flexibility in its application to different domains of interest is set forth in the research by Chinosi & Trombetta (2012), which affirms BPMN as the standard to graphically represent processes that occur in virtually all types ranging from cooking recipes to the Nobel Prize-awarding process,

incident management, e-mail voting systems, travel booking procedures, and more.

Mending, Recker, Reijers, and Leopold (2018) explain that BPMN covers the areas of process documentation and scenario improvement (process optimization) using technical process modeling applications such as workflow engineering, simulation, or service composition web. Such techniques consist of a core of major graphics and a set of additional "configurations".

Since the same authors define that the graphic set is sufficient to describe the essence of business processes, since it aims to generate intuitive models; While the additional set provides constructs to support advanced process modeling concepts (which require more detail by

their complexity), such as orchestration and process choreography, workflow specification, event-based decision making, and exception handling .

Haisjackl, Soffer, and Lime Weber (2018) have shown that individuals are more likely to use the overview strategy to understand and assimilate BPMN models, thus confirming the fact of efficient graphical representation in this modeling technique, once that the data and the relationships between data are presented in an agile way, one can have a quick view of the whole system.

Thus, in the BPMN architecture, processes are modeled by information flows. This is due to the fact that a flow of information transits between departments and is controlled by different stakeholders involved in the company, rather than being tied to a specific system.

Therefore, the flexible and dynamic nature of the BPMN models applied to the real processes and their clear relation with the concept of "horizontalization" in matrix management in a company, or simply, process management, is perceived.-

## 2.2. UML

In a brief introductory definition of UML, Fowler (2014) explains the modeling technique as being a set of graphical

notations, supported by a base that helps in the description of the domain of interest and in the design of software systems, those that are built using the object-oriented style; Larman (2002) can be defined as a diagram notation used to specify, construct, and document the artifacts of systems.

The authors Karim, Liawatimena, Trisetarso, Abbas and Suparta (2017) support the concept that the UML architecture is based on structural, behavioral and interaction elements that provide a standard notation for the preparation of architecture plans for systems projects information, including conceptual aspects such as business processes and system functions.

According to its creators Booch, Rumbaugh and Jacobson (2006), there was a clear purpose to encourage the standardization of language to aid in the development and modeling of software project structures through UML diagrams.

Ambler (2004) and Larman (2002) establish the class diagram as the most relevant diagram to represent a system model. if the classes (components of the system), their attributes (characteristics) and their methods (actions) are described, the relations of interaction between objects in the class diagram are also evident (figure 02).

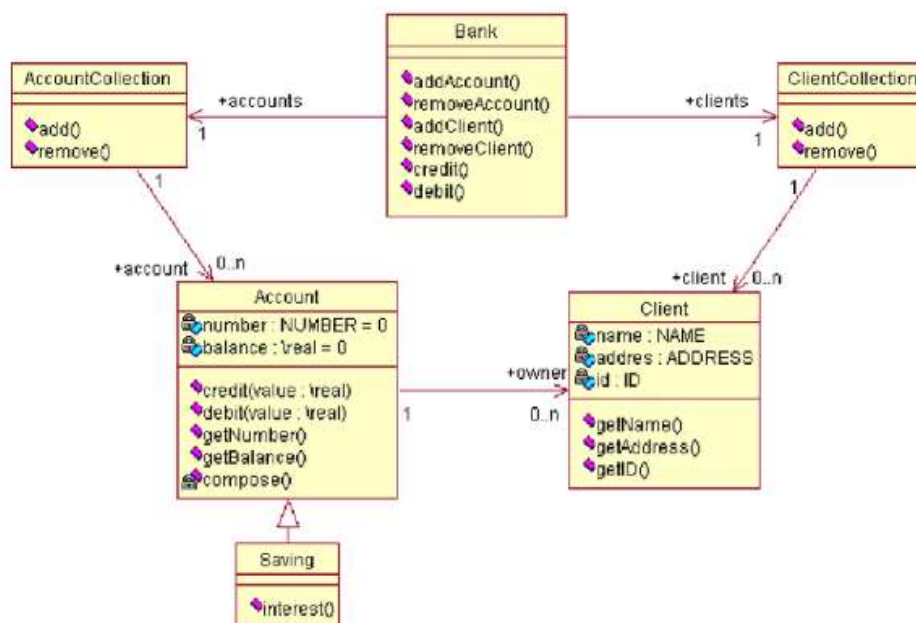


Fig.2: UML Class Diagram

Source: Moura Borges & Mota (2003)

Pessini, Santander, Silva, Andrade and Schemberger (2017), explaining the aspects of agility and simplicity in modeling, explain that the methodology used in UML logic and its visual resources make discussions at a strategic organizational level about a given project more

efficient in which information has to be debated and adapted to the guidelines given by different professionals with different degrees of intelligence in software and systems programming. Figure 03 shows a diagram of UML use cases.

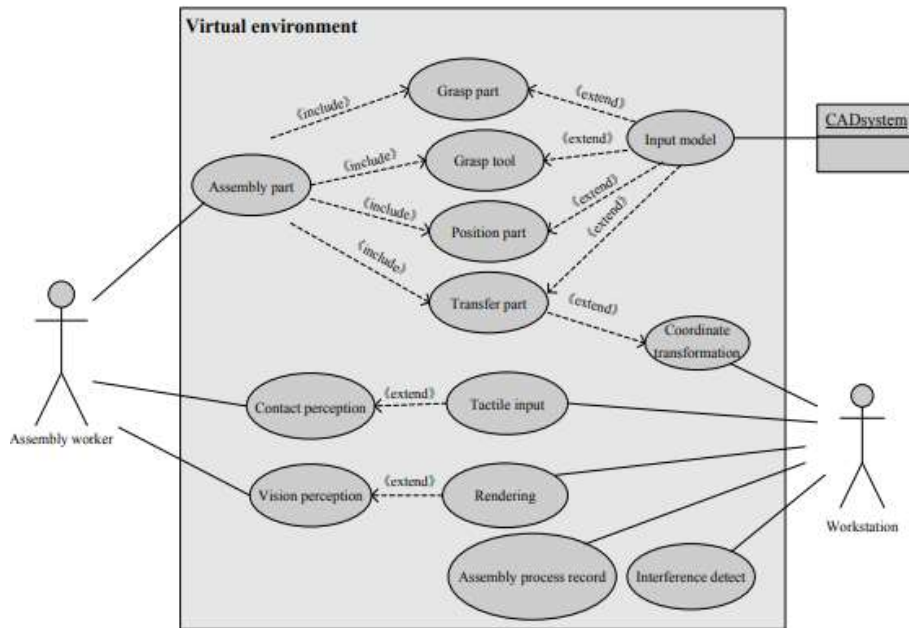


Fig.3: UML Use Case Diagram

Source: Yu, Gu, Liu, Sun, Qian & Guo (2017)

### 2.3. ARIS

The Event Driven Process Chain (EPC), a simplified part of the ARIS methodology, displays flowcharts developed to model business processes that are easily understood and

used, their basic elements being data, process and functions, as shown in the schematic representation of Figure 04.

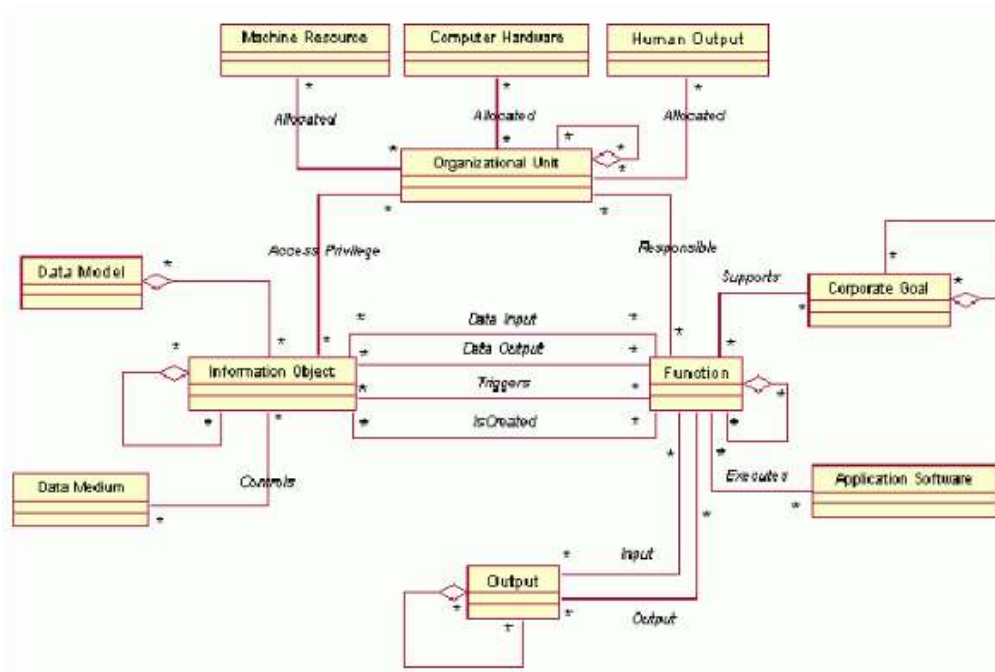


Fig.4: ARIS Architecture Framework

Source: Tbaishat (2017)

Panayiotou, Stavrou & Gayialis (2017), in their work of applying the ARIS architecture to design supply chain processes in small and medium enterprises, affirm that this technique of process modeling originated from as a

proposal for simplification in the face of increasing complexity in process modeling of business, due to the increase in the number of business process modeling methods available.

The same authors also highlight the different perspectives that can be applied to the ARIS architecture, which in the specific case study covered different views of the supply chain as: processes and activities, organization, information systems, risk management and decision making. Therefore, the dynamism aspect is assumed as inherent to this modeling technique.

Rosa et al. (2017) explain that the architecture used by ARIS explains the flow of control of a process in terms of logical and temporal dependence of activities and this makes its graphical modeling intuitive. Such language is focused on the capture and understanding of processes for scope of projects and to discuss business requirements and process improvement initiatives with specialists in the domains of interest.

## 2.4. CIMOSA

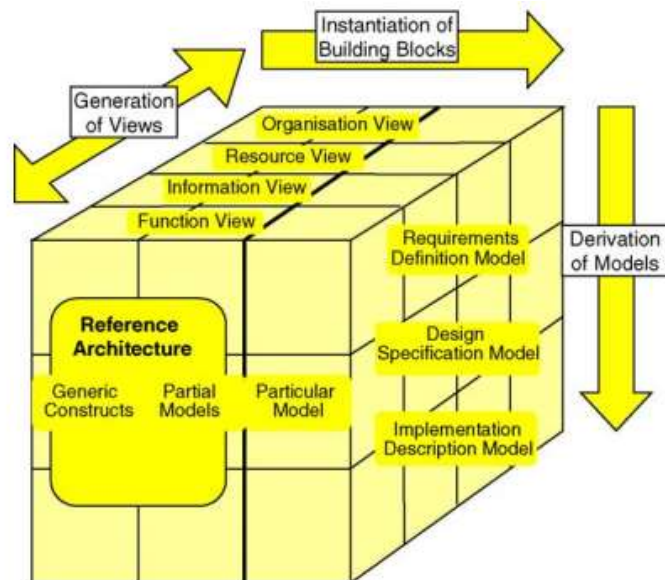


Fig 05. CIMOSA Architecture Perspectives

Source: Anis, Spadoni and Vernadat. (2004)

In CIMOSA, modeling aspects are based on the organization's events. According to Weichhart, Stary and Vernadat (2017) the purpose of this modeling method is to describe the functions that are carried out in the company and its attributes at the level of detail desired by the user, thus differentiating themselves from the traditional business process modeling methods; which are basically guided by the functional decomposition, that is, the division of the functions of the system modeled into sub functions.--.

## 2.5. IDEF

Likewise other architectures, IDEF presents diagrams and process flows in an organized way, allowing the

The authors Latiffianti, Siswanto, Wiratno and Saputra (2017), who promoted a business process mapping with CIMOSA in companies with the objective of effective management of their value chains, explain that this modeling technique was initially designed for companies based in the Computer Manufacturing Integrated (CIM) system but is also suitable for other types of manufacturing systems (as proven in its case study).

The same authors divide CIMOSA architecture into two parts: a particular architecture, which is defined as a set of models documenting the business environment; and a reference architecture used to assist users in the process of constructing their own particular architecture with a set of models describing the various aspects of the company at different levels of modeling. The general aspects of the CIMOSA architecture can be checked in figure 05.

identification of opportunities for improvement in the process.

Bevilacqua, Mazzuto and Paciarotti (2014) explain that the notation allows a complex analysis of the processes, considering their inputs, outputs, constraints and interactions. In this way, it is possible to structure a real-world logic model representing the behavior of the client and the way in which the client executes its actions in the system.

The IDEF modeling architecture is designed for business processes and sequences of a system, providing two perspectives, the process schema and the object schema. The concept of diagramming present in IDEF consists of two elementary aspects: a set of boxes



(representatives of functions / activities); and arrows (representatives of driving data or objects).

The arrows are input, control and output (Input, Control, Output) mechanisms. However, such arrows do

not lead to information flows, only data or objects to perform the functions and activities related to them. The structure of the IDEF architecture is given in figure 06.

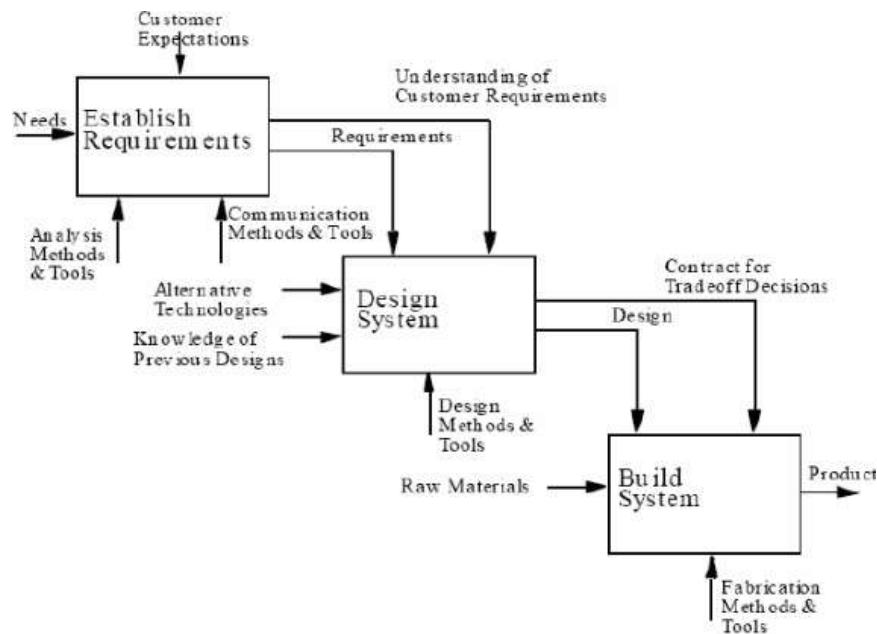


Fig.6: IDEF Architecture

Source: Šerifi, Dašić & Dašić (2008)

Sychenko, Mironov and Białoń (2017) present a case study where IDEF is used in a domain of interest related to the repair of maintenance equipment of an electricity supply substation and define the modeling architecture as grouped methods for the representation of requirements necessary for the development of information systems, and can be used to develop tools, techniques and processes for industrial integration.

The same authors emphasize in their case study the fact that IDEF allows the user to represent in a simplified way the main functions of input, output and mechanisms for the elaboration of activities and the controls that must be followed using the process diagram.

## 2.6. Other Modeling Architectures

The IEM framework, or integrated enterprise modeling architecture, uses an object-oriented approach and adapts it to the corporate description. An oriented division of all the elements of a company forms the core of the IEM in the generic classes of the object: "product", "resource" and "order".

Jin & Jäkel (2018) state that such classes can gradually receive complete and specified data (encouraging modeling), making it possible to show both the typical business line and the subclasses of company-specific products, orders and resources. Structures (eg lists

of parts or organizational charts) can be shown as relational characteristics of classes.

As for the EKD modeling architecture, the authors Bubenko, Persson and Stirna (2001) define it as a methodology that aims to support both organizational change efforts and the development of information systems that effectively support the development of the organization.

Stirna & Persson (2009) complement the EKD architecture as a supplier in a systematic and controlled way to analyze, understand, develop and document an organization and its components using organizational modeling.

Briefly discussing GRAI's methodology (or method of engineering), we can see its presence in Business Process Modeling centered on the product manufacturing cycle, primarily involving the design part, emphasizing design, performance and functional aspects.

Lakhoua & Rahmouni (2011) explain the GRAI architecture as a systemic, collaborative and participatory approach that is adapted to the engineering design department modeling in order to support the structuring of both coordination decisions and design activity.

According to Bernus, Noran & Molina (2015), GERAM architecture, the last one addressed in the referential of this article, aims to generalize the

contributions of several existing and emerging corporate modeling techniques, establishing the completeness and adequacy of these to form the basis for developing process improvement (since management can choose to combine the elements of more than one modeling technique and use them in combination).

According to Romero & Vernadat (2016), GERAM was developed to foster the use of all business reference architectures together (generalization). Therefore, it is assumed that they must have comparable characteristics and features.

Although there are other business process modeling architectures with relevant aspects for the development of the literature of the subject, it is believed to have chosen the most popular and diverse methodologies to compose this theoretical framework in order to promote a comprehensive and enriching discussion about the characteristics and process modeling elements to be addressed.

### III. METHODOLOGICAL ASPECTS

In this paper, a qualitative research was carried out. The principle of representativeness presented by Bardin (2011) (quoted by Santos, 2012) was obeyed, where a representative sample of relevant content from a consulted bibliographic universe was extracted rigorously. The quantitative approach also characterizes this work in the webibliomining review where the Web of Science database, an important source of scientific studies of international relevance, was used.

For the theoretical framework formulation, it has been prioritized the most recent publications in the literature, focusing on published works from the year of 2015. Such chronological limit was broken for topics where no relevant publications were found or even where there were no publications of said subjects in the predetermined range. An example of this was some modeling architectures such as GERAM and IEM that have lost significant relevance in recent years.

Elementary quotations that offered a concise basis of understanding for the themes also had greater freedom outside the chronological limit because they represent information of high relevance and therefore enriching the body of the present article.

#### 3.1. Webibliomining development

For the systematic webibliomining scheme formulation, the CAPES journal platform was used through the consultation in the renowned Web of Science database. It was done research using the following terms:

- a) 'BPMN' AND 'Architecture'
- b) 'UML' AND 'Architecture'
- c) 'ARIS' AND 'Architecture'

- d) 'CIMOSA' AND 'Architecture'
- e) 'IDEF' AND 'Architecture'
- f) 'IEM' AND 'Architecture'
- g) 'EKD' AND 'Architecture'
- h) 'GRAI' AND 'Architecture'
- i) 'GERAM' AND 'Architecture'

It was used the search feature by topics, where we generated results that contained the terms searched in the title, keywords and abstract. The temporal filter was applied until 2017 aiming to collect only complete annual metrics. The results were also filtered to only detect articles from peer-reviewed journals. The results are displayed in section 4.

### IV. WEBIBLIOMINING ANALYSIS

Analyzing the general aspects about the business process modeling architectures addressed in this article, one can promote the first classification in the proposed comparative view. Dividing these techniques into the classes of information systems: BPMN; UML; ARIS; IDEF; CIMOSA; EKD; and EMI. And in manufacturing support systems: GRAI; and GERAM.

However, all the reference architectures in process modeling considered in this article are treated in an equal degree of comparability seeking a better understanding of the performance of such architectures regarding organizational processes and organizational management environment. Through the results analysis of the Web of Science database, it was promoted the acquisition of the webibliomining data components of the reference architectures in process modeling treated in this article.

A total of 369 articles were detected, with more than half of them (57%) dealing with the UML architecture. The BPMN and CIMOSA architectures represented their popularity in the scientific literature with 12% of articles, both. The percentage relation of the articles referring to the architectures can be checked in figure 07.

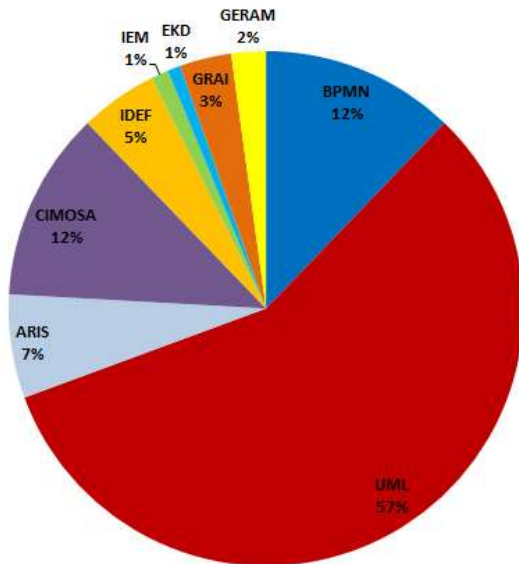


Fig.7: Percentage ratio of archival articles found in webibliomining

Table 01 shows the quantitative in descending order of such articles detected in webibliomining, followed by the predominant study area in which the studies of the modeling architecture in question are concentrated. The indicators of the authors and countries that published the most, as well as the percentage of articles in the English language make up the data analysis.

From the analysis of table 01, the UML, BPMN and CIMOSA architectures can be clearly noticed as the three most numerous publications about the researched subject. Conversely, GRAI, GERAM, IEM and EKD display low numbers of detected articles.

Table.1: Classification of the modeling techniques regarding the aspects

Modeling Architecture	Papers Cited	Study Field	Author with most publications	Country with most publication	Paper in English
UML	211	Computer Science	Trujillo, J.	USA	98,6%
BPMN	45	Computer Science	Chiotti, O. Lorre, J. P.	Germany	97,8%
CIMOSA	44	Computer Science	West, A.	England	100%
ARIS	24	Computer Science	Scheer, A. W.	Germany	95,8%
IDEF	28	Engineering	Venkateswaran,	USA	95%
GRAI	12	Computer Science	Doumeings, G.	France	100%
GERAM	8	Computer Science	Bernus, P.	Australia	100%
IEM	4	Engineering	X	Germany	100%
EKD	3	Engineering	X	USA	100%

**Caption: X = Insufficient Data**

The predominant area of study, in which the architectures are inserted, is that of Computer Science, with the exception of IDEF, IEM and EKD, which are predominantly inserted in the field of engineering. This fact can be explained by the fact that the approach of these architectures is more focused on the operational environment, while other architectures such as UML and CIMOSA are more focused on software engineering.

There is no surprise about the dominance of the English language in publications. However, the countries with the largest publication are diverse and varied, with

Germany and USA being the most frequent representatives.

#### 4.1. Temporal aspects

In the evolutionary aspect of the webibliomining analysis of the publications of the modeling architectures treated in this article, the three modeling architectures with the highest number of published articles were observed with more attention: BPMN, UML and CIMOSA. Their graphs relating to publication histories are given in figure 08, 09 and 10.

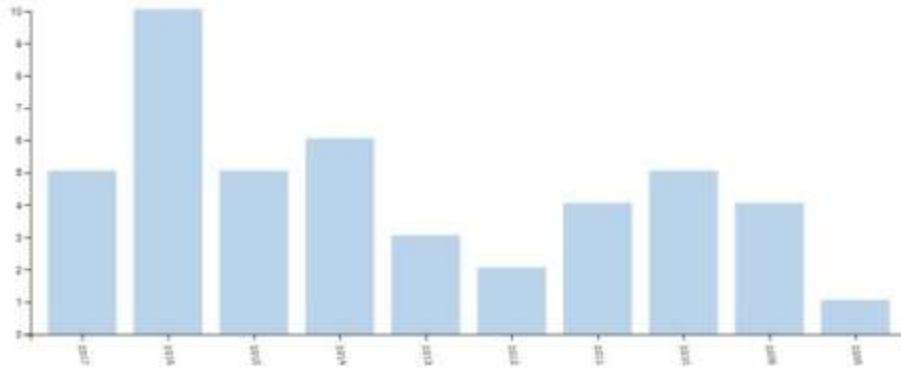


Fig.8: BPMN: Publications beetwen (2005 – 2017)

As can be seen in figure 08, publications related to the terms 'architecture' and 'BPMN' show a certain variability reaching its peak in 2016, with 10 published papers, and the lowest value in 2005 with only one article, find papers in the years 2008, 2007 and 2006.

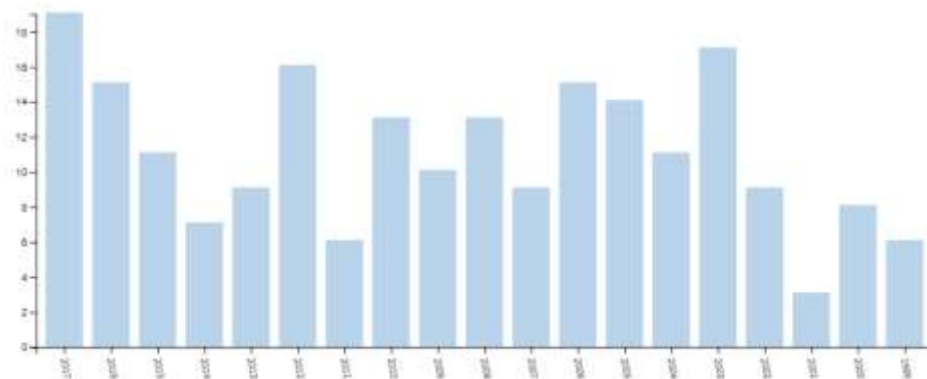


Fig.9: UML: Publications beetwen (1999 – 2017)

The publications on the terms 'architecture' and 'UML' (figure 09) show a larger quantitative with the first article dating from 1999. There is still a variable trend in the graph and its peak in 2017 with 19 published articles.

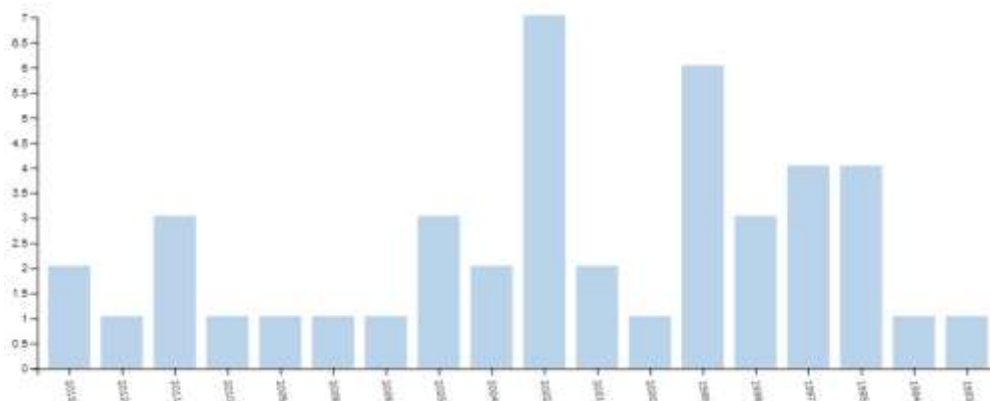


Fig.10: CIMOSA: Publications between (1993 – 2017)

The interpretation of the graph of figure 10 suggests some decadence of the themes related to the CIMOSA modeling architecture in the scientific literature because there are no articles published in the Web of Science database in the years 2014, 2015, 2016 and 2017. The peak of publications is in the year 2002, where 7 articles were published.

The architectures ARIS and IDEF, with 24 and 18 published articles, respectively, exhibit low number of publications per year and can be classified as secondary architectures. Regarding IEM architectures; EKD; GRAI and GERAM, the publication gaps are significant during the period considered, suggesting a strong unpopularity in the scientific academic environment.

**4.2. Comparative analysis of modeling architectures**

In this topic, a systematic mapping study is promoted, relating the most relevant business process modeling techniques of the scientific literature. This study provided a comparative view of these architectures in relation to the aspects of the model, socio-technical characteristics and visualization and analysis elements of the model.

Regarding the comparative evaluation of the modeling architectures in the aspects of the model, the authors considered the following interpretation of the factors: Why (purpose of the model); What (model structuring); As (behavioral specification of the model); and Who (specification of stakeholders, actors of the process). In table 02, the evaluation in question can be observed.

*Table.2: Classification of modeling architectures regarding aspects*

Modeling Architecture	Model Aspects			
	Why?	What?	How?	Who?
BPMN	N	I	I	OK
UML	I	OK	OK	OK
ARIS	I	OK	OK	OK
CIMOSA	I	OK	OK	OK
IDEF	I	OK	OK	I
IEM	N	OK	OK	OK
EKD	OK	I	OK	OK
GRAI	N	I	OK	OK
GERAM	OK	OK	OK	OK

**Caption: Ok = Adequate; I = Insufficient; Ñ = Not Appropriate**

GERAM is perceived as the modeling architecture that fulfills all the requirements of the model according to the authors with excellence. However, as stated by Bernus, Noran & Molina (2015) and Romero & Vernadat (2016), the creation of this reference architecture was an effort by developers of business process modeling to generalize contributions from other underlying architectures. Even the part of languages (and notation) UML and BPMN can be implemented in GERAM to represent systems.

As for the BPMN, one can see its incongruity in the question "Why", where the motivation to be promoting the modeling is not clearly structured to the participants of the process. This is corroborated by Van Der Aalst (2011), who says that the BPMN architecture focuses mainly on the information provided by process participants, through workshops or interviews, in order to trace the flow of the process. In this way, the flowchart is focused, and little

attention is paid to the real motivation and modeling objectives (process improvement).

In tables 03 and 04, the analysis is enriched when considering the socio-technical characteristics of the modeling architectures, in which the following factors are considered: Modularity (each unit of the model must encapsulate a specific objective, structure and behavior); Decomposition (referring to the capacity of the model to be broken down into parts); Responsiveness (ability to respond adequately to your environment); Autonomy (ability to react an external stimulus on its own); Intention (develop according to your goal); Adaptability (ability to adapt to a particular context or specific situation); Uncertainty (providing means for developing the model in an unknown context); Temporal (indefinite delay time between an action and its response).

*Table.3: Classification of modeling architectures regarding socio-technical characteristics*

Modeling Architecture	Model Aspects			
	Modularity	Decomposition	Responsivity	Autonomy
BPMN	OK (How?)	OK (How?)	OK	I
UML	OK	OK	N	N
ARIS	OK	OK	OK	OK
CIMOSA	I	Ñ	Ñ	Ñ
IDEF	OK	I	Ñ	Ñ
IEM	Ñ	Ñ	Ñ	Ñ
EKD	OK	Ñ	Ñ	Ñ

GRAI	I	Ñ	Ñ	Ñ
GERAM	I	Ñ	Ñ	Ñ

**Caption: Ok = Adequate; I = Insufficient; Ñ = Not Appropriate**

Table.4: Classification of modeling architectures regarding socio-technical characteristics (continuation)

Modeling Architecture	Model Aspects			
	Intention	Adaptability	Uncertainty	Temporal
BPMN	N	N	N	N
UML	N	N	N	N
ARIS	I	N	N	N
CIMOSA	I	Ñ	Ñ	Ñ
IDEF	I	Ñ	Ñ	Ñ
IEM	Ñ	Ñ	Ñ	Ñ
EKD	OK	Ñ	Ñ	Ñ
GRAI	Ñ	Ñ	Ñ	Ñ
GERAM	OK	Ñ	Ñ	Ñ

**Caption: Ok = Adequate; I = Insufficient; Ñ = Not Appropriate**

Once again one can notice the BPMN having its "How" aspect addressed in the characteristics of modularity and decomposition. UML diagramming notation, as defined by Larman (2002), shows a better degree of modularity and decomposition by being able to abstract (represent in a model) reality in different parts, which are its set of diagrams in the case. Similar to UML, the ARIS architecture is able to represent the system in different component parts of its model.

The GRAI reference architecture, which does not show significant popularity in the scientific literature, can be interpreted as simplistic and lagged when analyzed of its socio-technical characteristics compared to other more traditional modeling techniques.

According to Oertwig, Jochem and Knothe (2017), IEM does not offer sufficient adaptability to new industry requirements as a business modeling technique. These authors cite the example of materials management, information and cash flows, the pursuit of sustainable

corporate development, which presents an additional challenge to decision makers.

In the last analysis, we have the comparison of the business process modeling architectures in the light of the aspects: Visualization (support for visualization of the model); Executability (machine interpretability, support for simulation / execution); Quantitative analysis; Qualitative Analysis. The comparative relation of these characteristics is given in table 05.

Observing the executable aspects of modeling in relation to the UML architecture, Zur Muehlen & Recker (2013) affirm that in its diagrammatic part, there is not enough expressivity to describe executable computational functions, because its semantics is not defined as it would be necessary for that purpose. This fact becomes intuitive when one observes the purpose of the UML to be a notation of aid to the modeling. Differently from this concept one observes the exposed executability of the BPMN in relation to its unique module "How".

Table.5: Classification of modeling architectures regarding their visualization and analysis

Modeling Architecture	Analysis			
	Visualization	Executability	Quantitative Analysis	Qualitative Analysis
BPMN	OK	OK (How?)	OK (How?)	OK (How?)
UML	Ok	Ñ	Ñ	Ñ
ARIS	Ok	Ok (How?)	Ñ	Ok (How?)
CIMOSA	Ok	Ñ	Ñ	Ñ

<b>IDEF</b>	Ok	Ñ	Ñ	Ñ
<b>IEM</b>	I	Ñ	Ñ	Ñ
<b>EKD</b>	Ok	Ñ	Ñ	Ñ
<b>GRAI</b>	Ok	Ñ	Ñ	Ñ
<b>GERAM</b>	Ok	Ñ	Ñ	Ñ
<b>Caption: Ok = Adequate; I = Insufficient; Ñ = Not Appropriate</b>				

As for the qualitative and quantitative analyzes, we have the authors Yilmaz & Stima (2015), who affirm that the syntax and semantics of EKD are not well defined formally and rigorously, being able to generate models ambiguous and difficult to interpret, mainly in systems, and it is not possible to verify the consistency and completeness of the model.

ARIS architecture, according to Ghatrei (2015), supports the analysis (qualitative) when exposing the sequencing of entities of the model; corroborating, therefore, with the results shown in table 05.

Finally, the control flow perspective (sequencing / ordering of activities) is often the basis of business process modeling architectures, as can be observed in BPMN, ARIS, UML (activity diagram). Other views, such as resource orientation (modeling focused on equipment, systems, organizational units, etc.) and the perspective of time and function (role / activities) are less explored in the scientific literature. This fact makes it possible to find expressive amounts of BPMN content and little material on EMI or EKD.

## V. CONCLUSION

In this paper, it was reflected on the reference architectures in business process modeling with the objective of elucidating a conceptual comparative view that could sketch, through comparative analysis and relevant scientific research of the subject, an understanding of the function of such architectures organizational processes and their management environment.

Several reference architectures in process modeling have been cited and theoretically based, from the most important ones in the literature such as BPMN and UML to the least cited as IEM, GERAM and EKD, a fact that corroborates the methodological weight of the article and gives it scientific relevance.

It is concluded that the comparative analyzes shown foster the conceptual view of the state of the art of the literature about the architectures of business process modeling. Contributing, in this way, to researchers in future studies within the theme.

The purpose of the present paper is that research should be more aligned with the original goal of promoting ways to improve business processes rather than improving

process models. The focus was directed to the analysis of the aspects, characteristics and functionalities of the models and their direct relation with the organizational processes.

Finally, as a limitation to the research, it is cited the use of only one database, Web of Science, which despite presenting dense and relevant content, may have left out of this paper articles that would be enriching the subject.

## REFERENCES

- [1] Abdmouleh, A., Spadoni, M., and François Vernadat, F. (2004). "Distributed client/server architecture for CIMOSA-based enterprise components." *Computers in industry*. 55.3 239-253.
- [2] Ambler, S. W. (2004). *The object primer: Agile model-driven development with UML 2.0*. Cambridge University Press.
- [3] Barat, S., Kulkarni, V., Clark, T., & Barn, B. (2016). Enterprise modeling as a decision making aid: A systematic mapping study. In *IFIP Working Conference on The Practice of Enterprise Modeling* (pp. 289-298). Springer, Cham.
- [4] Bernus, P., Noran, O., & Molina, A. (2015). Enterprise architecture: Twenty years of the GERAM framework. *Annual Reviews in Control*, 39, 83-93.
- [5] Bevilacqua, M., Mazzuto, G., & Paciarotti, C. (2014). A combined IDEF0 and FMEA approach to healthcare management reengineering. *International Journal of Procurement Management*, 8(1-2), 25-43.
- [6] Booch, G., Rumbaugh, J., & Jacobson, I. (2006). *UML: guia do usuário*. Elsevier Brasil.
- [7] Braghetto, K. R., Ferreira, J. E., & Vincent, J. M. (2011, October). Performance evaluation of business processes through a formal transformation to SAN. In *European Performance Engineering Workshop* (pp. 42-56). Springer, Berlin, Heidelberg.
- [8] Bubenko, J. A., Persson, A., & Stima, J. (2001). *User guide of the knowledge management approach using enterprise knowledge patterns*. Stockholm (Sweden), Department of Computer and Systems Science, Royal Institute of Technology.
- [9] Chinosi, M., & Trombetta, A. (2012). BPMN: An introduction to the standard. *Computer Standards & Interfaces*, 34(1), 124-134.

- [10] Conforti, R., Dumas, M., García-Bañuelos, L., & La Rosa, M. (2016). BPMN miner: automated discovery of BPMN process models with hierarchical structure. *Information Systems*, 56, 284-303.
- [11] Fowler, M. (2014). *UML Essencial: um breve guia para linguagem padrão*. Bookman Editora.
- [12] Ghatrei, S. (2015). ARIS Enterprise Architecture's Usage Reviews. *Lecture Notes on Software Engineering*, 3(1), 57.
- [13] Haisjackl, C., Soffer, P., Lim, S. Y., & Weber, B. (2018). How do humans inspect BPMN models: an exploratory study. *Software & Systems Modeling*, 17(2), 655-673.
- [14] Jin, G., & Jäkel, F. W. (2018). Execution and evaluation of enterprise models in IEM/MO 2 GO based on Petri net. *The International Journal of Advanced Manufacturing Technology*, 96(9-12), 4517-4537.
- [15] Karim, S., Liawatimena, S., Trisetyarso, A., Abbas, B. S., & Suparta, W. (2017). Automating functional and structural software size measurement based on XML structure of UML sequence diagram. In *Cybernetics and Computational Intelligence (CyberneticsCom)*, 2017 IEEE International Conference on (pp. 24-28). IEEE.
- [16] Lakhoua, M. N., & Rahmouni, M. (2011). Investigation of the methods of the enterprise modeling. *African Journal of Business Management*, 5(16), 6845.
- [17] Larman, C. (2002). *Utilizando UML e padrões*. Bookman Editora.
- [18] Latiffianti, E., Siswanto, N., Wiratno, S. E., & Saputra, Y. A. (2017). CIMOSA process classification for business process mapping in non-manufacturing firms: A case study. In *AIP Conference Proceedings* (Vol. 1902, No. 1, p. 020040). AIP Publishing.
- [19] Mendling, J., Recker, J., Reijers, H. A., & Leopold, H. (2018). An Empirical Review of the Connection Between Model Viewer Characteristics and the Comprehension of Conceptual Process Models. *Information Systems Frontiers*, 1-25.
- [20] Moura, P., Borges, R., & Mota, A. (2003). Experimenting formal methods through UML. In *Proceedings of the Brazilian Workshop on Formal Methods*.
- [21] Panayiotou, N. A., Stavrou, V. P., & Gayialis, S. P. (2017). The application of a business process modeling architecture in the supply chain of a manufacturing company: A case study. In *Operational Research in Business and Economics* (pp. 1-16). Springer, Cham.
- [22] Pessini, T., Santander, V. F. A., da Silva, I. F., de Andrade, S. C., & Schemberger, E. E. (2017). BP2UC: De Processos de Negócios Modelados com BPMN Simplificado para Casos de Uso UML. *Revista Eletrônica Científica Inovação e Tecnologia*, 1(15), 2.
- [23] Romero, D., & Vernadat, F. (2016). Enterprise information systems state of the art: Past, present and future trends. *Computers in Industry*, 79, 3-13.
- [24] Rosa, M. L., Van Der Aalst, W. M., Dumas, M., & Milani, F. P. (2017). Business process variability modeling: A survey. *ACM Computing Surveys (CSUR)*, 50(1), 2.
- [25] Santos, F. M. D. (2012). Análise de conteúdo: a visão de Laurence Bardin.
- [26] Šerifi, V., Dašić, P., & Dašić, J. (2008). Functional and information model of expert specialization using IDEF standard. *Journal of Modelling and Optimization in the Machines Building Fields (MOCM)*, 14(2), 268-279.
- [27] Stirna, J., & Persson, A. (2009). Anti-patterns as a means of focusing on critical quality aspects in enterprise modeling. In *Enterprise, Business-Process and Information Systems Modeling* (pp. 407-418). Springer, Berlin, Heidelberg.
- [28] Sychenko, V., Mironov, D., & Białoń, A. (2017). Structural-functional model of maintenance and repair of the traction substations equipment. *TTS Technika Transportu Szynowego*, 24.
- [29] Tbaishat, D. (2017). Business process modelling using ARIS: process architecture. *Library Management*, 38(2/3), 88-107.
- [30] Teniente, E., & Weidlich, M. (Eds.). (2018). *Business Process Management Workshops: BPM 2017 International Workshops, Barcelona, Spain, September 10-11, 2017, Revised Papers (Vol. 308)*. Springer.
- [31] Van der Aalst, W. M. (2011). Process Discovery: An Introduction. In *Process Mining* (pp. 125-156). Springer, Berlin, Heidelberg.
- [32] Van der Aalst, W. M., Rosa, M., & Santoro, F. M. (2016). Business process management. *Business & Information Systems Engineering*, 58(1), 1.
- [33] Vernadat, F. B. (2003). Enterprise modelling and integration. In *Enterprise Inter-and Intra-Organizational Integration* (pp. 25-33). Springer, Boston, MA.
- [34] Weichhart, G., Stary, C., & Vernadat, F. (2017). Enterprise modelling for interoperable and knowledge-based enterprises. *International Journal of Production Research*, 1-23.
- [35] Yan H., Pieter V.G., Member, IEEE, Kaymak U., IEEE, Xudong L., Lei J., Choo C., Hendrikus H.M. Korsten and Huilong D. (2018). Aligning event logs to task-time matrix clinical pathways in BPMN for



variance analysis. *IEEE journal of biomedical and health informatics*, 22(2), 311-317.

- [36] Yilmaz, N., & Stima, J. (2015). Factors influencing productization of enterprise modeling: a qualitative inquiry into the scandinavian strand of methods and tools. In *IFIP Working Conference on The Practice of Enterprise Modeling* (pp. 193-208). Springer, Cham.
- [37] Zur Muehlen, M., & Recker, J. (2013). How much language is enough? Theoretical and practical use of the business process modeling notation. In *Seminal Contributions to Information Systems Engineering* (pp. 429-443). Springer, Berlin, Heidelberg.

# IoT Based Industrial Production Monitoring System Using Wireless Sensor Networks

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**Abstract**— *The objective of the work is to monitoring the production lines in industry using wireless sensor networks. This work presents the benefits of an automated data collection and display system for production lines. It involves wireless sensor networks for monitoring the productions in industry. Condition monitoring reduces human inspection requirements through automated monitoring, reduces maintenance through detecting faults before they escalate and improves safety and reliability. This work can monitor productions using temperature, voltage and current sensors with support of microcontroller. The relay is acts like a switch to monitor the production lines. In this work, Global System for Mobile communication technique is used to transferring the collected data. The collection of data, it is transferred into computerize spreadsheet in the remote office by authorized personnel for reporting purpose. The system will generate an automated report which stays in place and the management only needs to act base on the results. This work is cost effective automatic data collection is the alternative to manual data collection. It significantly improves the accuracy of the valuable reports for the management. It also reduces the time for identifying the fault using this technique*

**Keywords**—*Global System, Microcontroller, Wireless Sensor Networks.*

## I. INTRODUCTION

In this modern world multinational business companies were increasing rapidly. The Single businessman wants to monitor all the production Status in each industry with manual presence. In this work the business man can monitors all the production status through PC or Mobile in the corporate office itself. Mobile phones have become a widespread means of communication. It becomes a part of everyday life with ever more people enjoying the service and extra freedom they provide. It works on the basis of Global System for Mobile Communication [1]. A subscriber from any systems can access telecommunication services by using a subscriber identity

module card in a handset suitable for the network on the visited system [2].

The short message service allows text messages to be sent and received to and from mobile telephones. The text can comprise words or numbers or an alphanumeric combination. Because simple person to person messaging is such an important component of total SMS traffic volumes, anything that simplifies message generation as well as extended utility of the SMS being sent is an important enabler of short message service. Such extended utility of SMS fulfills certain important requirements. This system is developed to control the functions of a device from a remote area through the SMS of a mobile phone using Microcontroller [3], [4].

The monitoring systems equipped with sensors and wireless communication can reduce the costs to a small percentage of conventional monitoring systems, and will increase its field of application. Due to the detailed information of the structural behavior of bridges obtained from the monitoring system, maintenance costs could also be reduced, since inspection methods can be applied more efficiently [5]. Only after certain changes in the structural behavior have been identified, will inspection be necessary, and proper repair could be done immediately after the occurrence of the defect. This reduces the risk of further damage. The analysis of measured data and the knowledge of continuous changes of structural behavior will improve the life time prognosis of civil structures, and reduce the overall maintenance costs of buildings and transport networks. The data has to be continuously transmitted to the supervisor. Each sensor device which is itself a complete, small measurement and communication system has to be powered and cost optimized. Using multi-hop techniques, the data of the sensor network can be transmitted over short distances of some 10 m from each hop to a base station on site. At the base station the data items are collected and stored in a database for subsequent analysis. This data can then be accessed by a remote user. If the central unit detects a hazardous condition by analyzing the data, it raises an alarm message [6], [7].

The central unit also allows for wireless administration, calibration and reprogramming of the sensor nodes in order to keep the whole system flexible. Each mote is composed of one or more sensors, a data acquisition and processing unit, a wireless transceiver and a battery power supply. The acquisition and processing unit usually is equipped with a low power microcontroller offering an integrated analogue to digital converter and sufficient data memory to store the measurements. This unit also incorporates signal conditioning circuitry interfacing the sensors to the ADC [8].

The advancement in wireless communications and electronics has enabled the development of low-cost sensor networks. The sensor networks can be used for various application areas. For different application areas; there are different technical issues that researchers are currently resolving. The current state of art-sensor networks is captured in this article, where solutions are discussed under their related protocol stack layer sections. This article also points out the open research issues and intends to spark new interests and developments in this field [9].

## II. PROPOSED SYSTEM

The electronic system need low voltage DC power supply in different electronic circuits operated in different power supplies, the ratings depending upon load current and voltage. The load current depending on load resistance i.e load current is inversely proportional to load resistance. So the matched designation of power supply is very important to every electronic circuit [10]. In this circuits need two power supplies .All ICs are worked on regulated DC power 5v with GND. The relay derive worked on dc 12v with GND .This unit consist of transformer, rectifier, filter and regulator.

The AC voltage typically 230v RMS is connected to a transformer which steps that AC voltage down to the level of the desired AC voltage [11], [12].

The diode rectifier then provides a bridge rectified voltage that is initially filtered by a simple capacitor filter to produce a DC voltage. This resulting DC voltage usually has some ripple or Ac voltage variations. The regulator circuit can use this DC input to provide DC voltage that not only has much less ripple voltage but also remains the same DC value even the DC voltage varies somewhat the load connected to the output DC voltages changes. The Dc level obtained from a sinusoidal input can be improved 100% using a process called full wave rectification. It uses 4 diodes in a bridge configuration. From the basic bridge configuration the two diodes (say D2 & D3) are conducting while the other two diodes (D1 & D4) are in “off” state during the period  $t = 0$  to  $T/2$ . Accordingly for the negative of the input the conducting diodes are D1&D4. Thus the polarity across the load is the same. The Figure1 shows the proposed system circuit diagram.

The filter circuit used here is the capacitor filter circuit where a capacitor is connected at the rectifier output, and a DC is obtained across it .The filtered waveform is essentially a DC voltage with negligible ripples, which is ultimately fed to the load. The output voltage from the capacitor is more filtered and finally regulated. The voltage regulator is a device, which maintains the output voltage constant irrespective of the changes in supply variations, load variation and temperature changes. Here we use one fixed voltage regulator namely LM7805.The IC 7805 is a+5 voltage regulator [13].

This powerful 200 nanosecond instruction execution yet easy-to-program only 35 single word instructions CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC architecture into a 40 package and is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices. The PIC16F877A features 256 bytes of EEPROM data memory, self programming, an ICD, 2Comparators, 8channels of10-bit Analog-to-Digital converter, 2 capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface or the 2-wire Inter-Integrated Circuit bus and a Universal Asynchronous Receiver Transmitter [14].

The program memory contains the programs that are written by the user. The program counter executes these stored commands one by one. Usually PIC16F877 devices have a 13 bit wide program counter that is capable of addressing 8K×14 bit program memory space. This memory is primarily used for storing the programs that are written to be used by the PIC. These devices also have 8K\*14 bits of flash memory that can be electrically

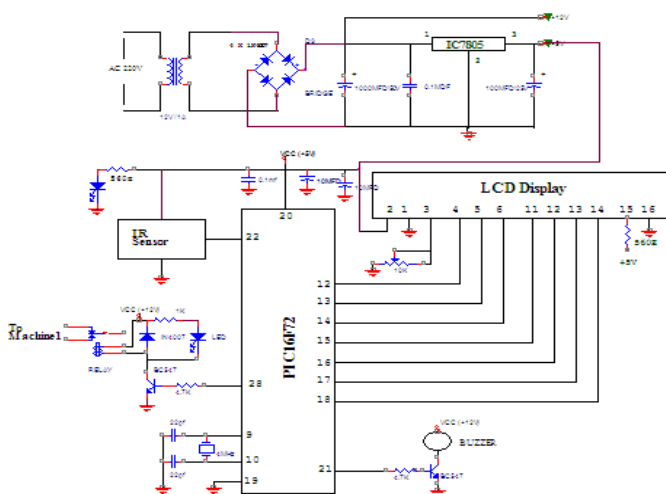


Fig.1: Proposed System Circuit Diagram

erasable/reprogrammed. Each time write a new program to the controller, we must delete the old one at that time. The banked arrangement is necessary because there are only 7 bits are available in the instruction word for the addressing of a register, which gives only 128 addresses [15].

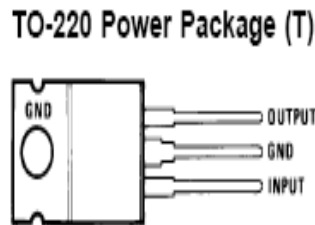


Fig.2: Voltage Regulator

The selection of the banks are determined by control bits RP1, RP0 in the STATUS registers Together the RP1, RP0 and the specified 7 bits effectively form a 9 bit address. The first 32 locations of Banks 1 and 2, and the first 16 locations of Banks 2 and 3 are reserved for the mapping of the Special Function Registers. The EEPROM data memory allows single-byte read and writes. The Flash program memory allows single-word reads and four-word block writes. Program memory write operations automatically perform an erase-before write on blocks of four words. A byte write in data EEPROM memory automatically erases the location and writes the new data. The write time is controlled by an on-chip timer. The write/erase voltages are generated by an on-chip charge pump, rated to operate over the voltage range of the device for byte or word operations [16]. Figure 2 shows voltage regulator.

The LM341 and LM78MXX series of three-terminal positive voltage regulators employ built-in current limiting, thermal shutdown, and safe-operating area protection which make them virtually immune to damage from output overloads. With adequate heat sinking, they can deliver in excess of 0.5A output current. Typical applications would include local (on-card) regulators which can eliminate the noise and degraded performance associated with single-point regulation [17].

The relay is an electrical switch that opens and closes under control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. It was invented by Joseph Henry in 1835. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered, in a broad sense, to be a form of electrical amplifier [18]. When a current flows through the coil, the resulting magnetic field attracts an armature that is mechanically linked to a moving contact. The movement either makes or breaks a connection with a

fixed contact. When the current to the coil is switched off, the armature is returned by a force approximately half as long as the magnetic force to its relaxed position. Usually this is a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low voltage application, this is to reduce noise [19].

In a high voltage or high current application, this is to reduce arcing. If the coil is energized with DC, a diode is frequently installed across the coil, to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a spike of voltage and might cause damage to circuit components. If the coil is designed to be energized with AC, a small copper ring can be crimped to the end of the solenoid. This "shading ring" creates a small out-of-phase current, which increases the minimum pull on the armature during the AC cycle [20], [21].

### III. SOFTWARE IMPLEMENTATION

MPLAB is a Windows program package that makes writing and developing a program easier. It could best be described as developing environment for some standard program language that is intended for programming a PC computer. Some operations which were done from the instruction line with a large number of parameters until the discovery of IDE "Integrated Development Environment" are now made easier by using the MPLAB [22]. [23]. Still, our tastes differ, so even today some programmers prefer the standard editors and compilers from instruction line. In any case, the written program is legible, and well documented help is also available.

- Grouping the projects files into one project (Project Manager)
- Generating and processing a program (Text Editor)
- Simulator of the written program used for simulating program

#### Requirements

- PC compatible computer 486 or higher
- Microsoft Windows 3.1x or Windows 95 and new versions of the Windows
- Operating system.
- VGA graphic card
- 8MB memory (32MB recommended).
- 20MB space on hard disc
- Mouse

#### Hitech c

The HI-TECH C Compiler is a set of software, which translates programs written in the C language to executable machine code programs. Versions are available which compile programs for operation under the host operating system, or which produce programs for

execution in embedded systems without an operating system [24].

#### Features

1. A single batch file or command file will compile, assemble and link entire programs.
2. The compiler performs strong type checking and issues warnings about various constructs which may represent programming errors.
3. The generated code is extremely small and fast in execution.
4. A full run-time library is provided implementing all standard C input/output and other functions.
5. The source code for all run-time routines is provided.
6. A powerful general purpose macro assembler is included. Programs may be generated to execute under the host operating system, or customized for installation in ROM.

#### Security systems:

Cameras can be installed at various locations in the shopping center with each camera covering a specific range of area and with the help of the GSM remote control the entire shopping center can be monitored from one location. The range of vision can be changed by controlling the angle of camera by the remote control. Such type of security system can also be used to provide security in homes, banks, research labs etc [25].

#### Temperature Monitoring:

In hospitals, it is very important to maintain an optimum temperature in the Operation Theater, the I.C.U and the morgue. In such cases, Internet remote control can be used to adjust the air conditioner settings and thus continuously monitor the temperature from any location. Such remote temperature monitoring is also useful in the case of sterilizing medical equipment, as also for food preservation, in blood banks etc [26].

#### Process Control:

In large Aquaculture centers, the GSM controlled system has been used to monitor and control important parameters such as temperature of water, pH and oxygen content, using different types of sensors. This can be expanded to processes which require careful monitoring like those for extracting medicines, fluids using microorganisms, etc. In industries and offices, this remote control system can be used to control various machines or appliances from any location and thus helps in automation of the system. SMS stands for Short Message Service. It is a technology that enables the sending and receiving of messages between mobile phones. SMS first appeared in Europe in 1992. It was included in the GSM (Global System for Mobile Communications) standards right at the beginning. Later it was ported to wireless technologies like CDMA and TDMA. The GSM and SMS standards

were originally developed by ETSI. ETSI is the abbreviation for European Telecommunications Standards Institute [27], [28].

Now the 3GPP (Third Generation Partnership Project) is responsible for the development and maintenance of the GSM and SMS standards. As suggested by the name "Short Message Service", the data that can be held by an SMS message is very limited. One SMS message can contain at most 140 bytes (1120 bits) of data, so one SMS message can contain up to: 160 characters if 7-bit character encoding is used. (7-bit character encoding is suitable for encoding Latin characters like English alphabets.) 70 characters if 16-bit Unicode UCS2 character encoding is used. (SMS text messages containing non-Latin characters like Chinese characters should use 16-bit character encoding.) SMS text messaging supports languages internationally. The burden in a CT metering circuit is essentially the amount of impedance (largely resistive) present [29].

Typical burden ratings for IEC CTs are 1.5VA, 3VA, 5VA, 10VA, 15VA, 20VA, 30VA, 45VA & 60VA with ANSI/IEEE B-0.1, B-0.2, B-0.5, B-1.0, B-2.0 and B-4.0. This means a CT with a burden rating of B-0.2 can tolerate up to 0.2  $\Omega$  of impedance in the metering circuit before its output current is no longer a fixed ratio to the primary current. Items that contribute to the burden of a current measurement circuit are switch blocks meters and intermediate conductors. The most common source of excess burden in a current measurement circuit is the conductor between the meter and the CT. Often, substation meters are located significant distances from the meter cabinets and the excessive length of small gauge conductor creates a large resistance. This problem can be solved by using CT with 1 ampere secondary's which will produce less voltage drop between a CT and its metering devices (used for remote measurement) [30].

Rating factor is a factor by which the nominal full load current of a CT can be multiplied to determine its absolute maximum measurable primary current. Conversely, the minimum primary current a CT can accurately measure is "light load," or 10% of the nominal current (there are, however, special CTs designed to measure accurately currents as small as 2% of the nominal current). The rating factor of a CT is largely dependent upon ambient temperature. Most CTs have rating factors for 35 degrees Celsius and 55 degrees Celsius. It works fine with all languages supported by Unicode, including Arabic, Chinese, Japanese and Korean. Besides text, SMS messages can also carry binary data.

It is possible to send ringtones, pictures, operator logos, wallpapers, animations, business cards (e.g. VCards) and WAP configurations to a mobile phone with

SMS messages. One major advantage of SMS is that it is supported by 100% GSM mobile phones. Almost all subscription plans provided by wireless carriers include inexpensive SMS messaging service. Unlike SMS, mobile technologies such as WAP and mobile Java are not supported on many old mobile phone models. GSM-900 uses 890–915 MHz to send information from the mobile station to the base station (uplink) and 935–960 MHz for the other direction (downlink), providing 124 RF channels (channel numbers 1 to 124) spaced at 200 kHz. Duplex spacing of 45 MHz is used. In some countries the GSM-900 band has been extended to cover a larger frequency range. This 'extended GSM', E-GSM, uses 880–915 MHz (uplink) and 925–960 MHz (downlink), adding 50 channels (channel numbers 975 to 1023 and 0) to the original GSM-900 band. Time division multiplexing is used to allow eight full-rate or sixteen half-rate speech channels per radio frequency channel. There are eight radio timeslots (giving eight burst periods) grouped into what is called a TDMA frame. Half rate channels use alternate frames in the same timeslot. The channel data rate for all 8 channels is 270.833 kbit/s, and the frame duration is 4.615 ms. The transmission power in the handset is limited to a maximum of 2 watts in GSM850/900 and 1 watt in GSM1800/1900 [31].

The GSM has used a variety of voice codecs to squeeze 3.1 kHz audio into between 5.6 and 13 kbit/s. Originally, two codecs, named after the types of data channel they were allocated, were used, called Half Rate (5.6 kbit/s) and Full Rate (13 kbit/s). These used a system based upon linear predictive coding (LPC). In addition to being efficient with bitrates, these codecs also made it easier to identify more important parts of the audio, allowing the air interface layer to prioritize and better protect these parts of the signal. GSM was further enhanced in 1997 [12] with the Enhanced Full Rate (EFR) codec, a 12.2 kbit/s codec that uses a full rate channel. Finally, with the development of UMTS, EFR was refactored into a variable-rate codec called AMR-Narrowband, which is high quality and robust against interference when used on full rate channels, and less robust but still relatively high quality when used in good radio conditions on half-rate channels. There are five different cell sizes in a GSM network—macro, micro, pico, femto and umbrella cells. The coverage area of each cell varies according to the implementation environment. Macro cells can be regarded as cells where the base station antenna is installed on a mast or a building above average roof top level. Micro cells are cells whose antenna height is under average roof top level; they are typically used in urban areas. Picocells are small cells whose coverage diameter is a few dozen meters; they are mainly used indoors. Femtocells are cells designed for use in residential or small business

environments and connect to the service provider's network via a broadband internet connection. Umbrella cells are used to cover shadowed regions of smaller cells and fill in gaps in coverage between those cells [32].

The cell horizontal radius varies depending on antenna height, antenna gain and propagation conditions from a couple of hundred meters to several tens of kilometers. The longest distance the GSM specification supports in practical use is 35 kilometers (22 mi). There are also several implementations of the concept of an extended cell, where the cell radius could be double or even more, depending on the antenna system, the type of terrain and the timing advance. Indoor coverage is also supported by GSM and may be achieved by using an indoor picocell base station, or an indoor repeater with distributed indoor antennas fed through power splitters, to deliver the radio signals from an antenna outdoors to the separate indoor distributed antenna system. These are typically deployed when a lot of call capacity is needed indoors, for example in shopping centers or airports. However, this is not a prerequisite, since indoor coverage is also provided by in-building penetration of the radio signals from nearby cells. The modulation used in GSM is Gaussian minimum-shift keying (GMSK), a kind of continuous-phase frequency shift keying. In GMSK, the signal to be modulated onto the carrier is first smoothed with a Gaussian low-pass filter prior to being fed to a frequency modulator, which greatly reduces the interference to neighboring channels (adjacent channel interference) [33], [34].

#### IV. NETWORK STRUCTURE

The network behind the GSM system seen by the customer is large and complicated in order to provide all of the services which are required. It is divided into a number of sections and these are each covered in separate articles.

- The Base Station Subsystem (the base stations and their controllers)
- The Network and Switching Subsystem (the part of the network most similar to a fixed network). This is sometimes also just called the core network.
- The GPRS Core Network (the optional part which allows packet based Internet connections).
- All of the elements in the system combine to produce many GSM services such as voice calls and SMS.

The circuit is designed to control the buzzer. The buzzer ON and OFF is controlled by the pair of switching transistors (BC 547). The buzzer is connected in the Q2 transistor collector terminal. When high pulse signal is given to base of the Q1 transistors, the transistor is

conducting and close the collector and emitter terminal so zero signals is given to base of the Q2 transistor. Hence Q2 transistor and buzzer is turned OFF state. When low pulse is given to base of transistor Q1 transistor, the transistor is turned OFF. Now 12v is given to base of Q2 transistor so the transistor is conducting and buzzer is energized and produces the sound signal [35], [36].

One of the SMS technology is that one SMS message can only carry a very limited amount of data. To overcome this drawback, an extension called concatenated SMS (also known as long SMS) was developed. A concatenated SMS text message can contain more than 160 English characters. Concatenated SMS works like this: The sender's mobile phone breaks down a long message into smaller parts and sends each of them as a single SMS message. When these SMS messages reach the destination, the recipient mobile phone will combine them back to one long message. The drawback of concatenated SMS is that it is less widely supported than SMS on wireless devices [37]-[39].

## V. RESULTS AND DISCUSSION

### IOT Output



Fig.3: Login Screen



Fig.4: Monitor Screen

The Figure 3 shows login screen. An LCD consists of two glass panels, with the liquid crystal material sandwiched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed. Polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle. The Figure 4 shows monitor screen. One each polariser is

placed outside the two glass panels. These polarisers would rotate the light rays passing through them to a definite angle, in a particular direction. When the LCD is in the off state, light rays are rotated by the two polarisers and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent. When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarisers, which would result in activating / highlighting the desired characters.

The LCD's are lightweight with only a few millimetres thickness. Since the LCD's consume less power, they are compatible with low power electronic circuits, and can be powered for long durations. The LCD's don't generate light and so light is needed to read the display. By using backlighting, reading is possible in the dark. The LCD's have long life and a wide operating temperature range. Changing the display size or the layout size is relatively simple which makes the LCD's more customer friendly. The LCDs used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The recent advances in technology have resulted in better legibility, more information displaying capability and a wider temperature range. These have resulted in the LCDs being extensively used in telecommunications and entertainment electronics. The LCDs have even started replacing the cathode ray tubes (CRTs) used for the display of text and graphics, and also in small TV applications.

## VI. CONCLUSION

The Production monitoring system developed is an essential production tool in industries for both the management and the production team. The Production monitoring system captures and distributes unadulterated production information at all levels along the production process without human intervention. The data collected is crucial and this could be collected by using a real time production monitoring system. With the collected data, realistic production goals can be achieved when proper analysis is done and implementation is practiced. Events occurring can also be displayed with the help of a Production monitoring system. Production faults can be rectified instantly. A Production monitoring system enables the production team to operate efficiently optimizing all available resources towards a better production in the above sequence that it is clearly a Production monitoring system along the production of the human intervention data information of real time production hardware modules collected data

## REFERENCES

- [1] Design and prototype of a six-legged walking insect robot Servet Soyguder and H asan Alli Mechanical Engineering Department, Firat Un iversity, Elazig, Turkey Industrial Robot: An International l Journal Volume 34 · Number 5 · 2007 · 412–422
- [2] R.Nagarajan and M,Saravanan, “Performance Analysis of Multicarrier PWM Strategies for Cascaded Multilevel Inverter,” European Journal of Scientific Research (EJSR), Vol.92 No.4, pp. 608-625, Dec. 2012.
- [3] Mechanical Design of A Quadruped Robot for Horizontal Ground to Vertical Wall Movement Abd Alsalam Sh. I. Alsalameh Shamsudin H.M. Amin Rosbi Mamat Center for Artificial Intelligence and Robotics (CAIRO) Faculty of Electrical Engineering University Technology Malaysia
- [4] R.Nagarajan and M,Saravanan, “A Carrier - Based Pulse Width Modulation Control Strategies for Cascaded Multilevel Inverter,” International Review on Modeling and Simulations (IRMOS), Vol 6.No1, pp-8-19, Feb. 2013.
- [5] A study of availability and exit usability of Theo Jansen mechanism toward climbing over bumps Kazuma Komoda (PY)1, and Hiroaki Wagatsuma 1 Department of Brain Science and Engineering, Kyushu I institute of Technology 2 RIKEN Brain Science Institute
- [6] R.Nagarajan and M, Saravanan, “Comparison of PWM Control Techniques for Cascaded Multilevel Inverter” International Review of Automatic control (IRACO), Vol.5, No.6, pp. 815-828. Nov. 2012.
- [7] G. Vidhya Krishnan, R.Nagarajan, T. Durka, M.Kalaiselvi, M.Pushpa and S. Shanmuga priya, "Vehicle Communication System Using Li-Fi Technology," International Journal of Engineering And Computer Science (IJECS), Volume 6, Issue 3, pp. 20651-20657, March 2017.
- [8] Artificial active whiskers for guiding underwater autonomous walking robots T. Rooney\_, M.J.Pearson, J. Welsby, I. Horsfield, R. Sewell, S. Dogramadzi Bristol Robotics Laboratory, University of the West of England, Bristol, BS161QD, UK
- [9] M.Dharani Devi and R.Nagarajan, “Implementation of Different PWM Control Strategies for Cascaded MLI,” Journal of Network Communications and Emerging Technologies (JNCET), Volume 7, Issue 7, pp. 49- 55, July-2017.
- [10] R.Prabhu, R.Nagarajan, N.Karthick and S.Suresh, “Implementation of Direct Sequence Spread Spectrum Communication System Using FPGA,” International Journal of Advanced Engineering, Management and Science (IJAEMS), Vol-3.Issue-5, pp. 488-496, May. 2017
- [11] Soyguder S, Alli H; Design and prototype of a six legged walking. International Journal of Industrial Robot, 2007; 34(5): 412–422.
- [12] R. Banupriya, R.Nagarajan, M.Malarvizhi and M.Dharani Devi, “Multicarrier - Based PWM Control Strategies for Five - Level CMLI.” Journal of Network Communications and Emerging Technologies (JNCET), Vol. 7, Issue 11, November - 2017, pp. 33-39.
- [13] M.Dharani Devi, M.Malarvizhi and R.Nagarajan, “Development of Multicarrier SPWM Techniques for Cascaded MLI.” International Journal of Computational Engineering Research (IJCER), Vol. 7, Issue 10, October 2017, pp. 44-52.
- [14] J.Chandramohan, R.Nagarajan, K.Satheeshkumar, N.Ajithkumar, P.A.Gopinath and S.Ranjithkumar, "Intelligent Smart Home Automation and Security System Using Arduino and Wi-fi," International Journal of Engineering And Computer Science (IJECS), Volume 6, Issue 3, pp. 20694-20698, March, 2017.
- [15] Lovasz E Ch, Pop C, Pop F, Dolga F; Novel Solution for Leg Mechanism. Int. J. of Applied Mechanics and Engineering, 2014; 19(4): 699-708.
- [16] K. Anandhi and Dr. R. Nagarajan, “Mutex-Heart: Fail Safe Dual Chamber Cardiac Pacemaker Device with Rate Responsive Control and Cryptographic Security,” IJSRD- International Journal for Scientific Research & Development. Vol. 3, Issue- 2, pp. 489-493, 2015.
- [17] Inoue H, Noritsugu T; Development of Walking Assist Machine Using Linkage Mechanism.
- [18] J.Chandramohan, R.Nagarajan, M.Ashok kumar, T.Dineshkumar, G.Kannan and R.Prakash, “Attendance Monitoring System of Students Based on Biometric and GPS Tracking System,” International Journal of Advanced Engineering, Management and Science (IJAEMS), Vol-3.Issue-3, pp. 241-246, Mar. 2017.
- [19] A study of availability and extensibility of Theo Jansen mechanism toward climbing over bumps Kazuma Komoda (PY)1, and Hiroaki Wagatsuma 1 Department of Brain Science.
- [20] R Rameshkumar and R Nagarajan, “Sine Multicarrier SPWM Technique for Seven Level Cascaded Inverter,” CiiT-Programmable Device Circuits and Systems. Vol. 5, Issue- 6, 2013.
- [21] Dr.R.Nagarajan, S.Sathishkumar, K.Balasubramani, C.Boobalan, S.Naveen and N.Sridhar. “Chopper Fed Speed Control of DC Motor Using PI Controller,” IOSR- Journal of Electrical and Electronics



- Engineering (IOSR-JEEE), Volume 11, Issue 3, Ver. I, pp. 65-69, May – Jun. 2016.
- [22] R.Nagarajan and M,Saravanan “Staircase Multicarrier SPWM Technique for Nine Level Cascaded Inverter,” 2013 International Conference on Power, Energy and Control (ICPEC), IEEE Press, pp-668-675. 2013.
- [23] A study of availability and extensibility of Theo Jansen mechanism toward climbing over bumps Kazuma Komoda (PY) and Hiroaki Wagatsuma 1 Department of Brain Science.
- [24] N.Karthick, R.Nagarajan, S.Suresh and R.Prabhu, "Implementation of Railway Track Crack Detection and Protection," International Journal Of Engineering And Computer Science (IJECS), Volume 6, Issue 5, May 2017, pp. 21476-21481, DOI: 10.18535/ijeecs/v6i5.47
- [25] M.Padmavathi and R.Nagarajan, “Smart Intelligent ATM Using LABVIEW,” International Journal of Emerging Technologies in Engineering Research (IJETER), Volume 5, Issue 5, pp. 41- 45, May-2017.
- [26] R.Nagarajan and M, Saravanan. “Performance Analysis of a Novel Reduced Switch Cascaded Multilevel Inverter,” Journal of Power Electronics, Vol.14, No.1, pp. 48-60, Jan.2014.
- [27] Soyguder S, Alli H; Design and prototype of a six legged walking. International Journal of Industrial Robot, 2007; 34(5): 412–422
- [28] R.Nagarajan, S.Sathishkumar, S.Deepika, G.Keerthana, J.K.Kiruthika and R.Nandhini, "Implementation of Chopper Fed Speed Control of Separately Excited DC Motor Using PI Controller", International Journal of Engineering And Computer Science (IJECS), Volume 6, Issue 3, pp. 20629-20633, March, 2017.
- [29] Lovasz E Ch, Pop C, Pop F, Dolga F; Novel Solution for Leg Mechanism. Int. J. of Applied Mechanics and Engineering, 2014; 19(4): 699-708.
- [30] R.Nagarajan, R.Yuvaraj, V.Hemalatha, S.Logapriya, A.Mekala and S.Priyanga, "Implementation of PV - Based Boost Converter Using PI Controller with PSO Algorithm," International Journal of Engineering And Computer Science (IJECS), Volume 6, Issue 3, pp. 20479-20484, March, 2017.
- [31] Ms. C. Hemalatha, Mr. R. Nagarajan, P. Suresh, G. Ganesh Shankar and A. Vijay, “Brushless DC Motor Controlled by using Internet of Things,” IJSTE - International Journal of Science Technology & Engineering, Volume -3.Issue-09, pp. 373-377, March- 2017.
- [32] R.Nagarajan, J.Chandramohan, S.Sathishkumar, S.Anantharaj, G.Jayakumar, M.Visnukumar and R.Viswanathan, “Implementation of PI Controller for Boost Converter in PV System,” International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE). Vol.11, Issue.XII, pp. 6-10, December. 2016.
- [33] M.Elangovan, R.Yuvara, S.Sathishkumar and R.Nagarajan, “Modelling and Simulation of High Gain Hybrid Boost Converter,” International Journal of Emerging Technologies in Engineering Research (IJETER), Volume 5, Issue 6, pp. 9- 14, June-2017
- [34] R.Nagarajan, J.Chandramohan, R.Yuvaraj, S.Sathishkumar and S.Chandran, “Performance Analysis of Synchronous SEPIC Converter for a Stand-Alone PV System,” International Journal of Emerging Technologies in Engineering Research (IJETER), Vol. 5, Issue - 5, pp. 12-16, May-2017
- [35] S.Suresh, R.Nagarajan, L.Sakthivel, V.Logesh, C.Mohandass and G.Tamilselvan, “Transmission Line Fault Monitoring and Identification System by Using Internet of Things,” International Journal of Advanced Engineering Research and Science (IJAERS), Vol - 4.Issue - 4, pp. 9-14, Apr- 2017.
- [36] M. Sridhar, S.Sathishkumar, R.Nagarajan and R.Yuvaraj, “An Integrated High Gain Boost Resonant Converter for PV System,” International Journal of Emerging Technologies in Engineering Research (IJETER), Volume 5, Issue 6, pp. 54- 59, June-2017.
- [37] Inoue H, Noritsugu T; Development of Walking Assist Machine Using Linkage Mechanism. An International Journal of Robotics and Mechatronics, 2010; 22(2): 189-196
- [38] M.Meenakshi, R.Nagarajan, R. Banupriya and M.Dharani Devi, “Stepped Multicarrier SPWM Techniques for Seven - Level Cascaded Inverter,” International Journal of Emerging Technologies in Engineering Research (IJETER), Volume 5, Issue 12, pp. 43- 49, December-2017.
- [39] S.Suresh, R.Nagarajan, R.Prabhu and N.Karthick, "Energy Efficient E0 Algorithm for Wireless Transceivers," International Journal of Engineering and Computer Science (IJECS), Volume 6, Issue 7, July 2017, pp. 21982-21985, DOI: 10.18535/ijeecs/v6i7.15.

# A Literature Study of Wind Analysis on High Rise Building

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**Abstract**— Recently modern architecture means something regularity and irregularity in geometry. Everyone wants to win the race of designing beautiful and complex structures and with issue of scarcity of land it is today's necessity to go higher and higher vertical and construct high rise structures. But as we go higher wind excitation becomes one of the most precarious force acting on the surface of the structure and if the plan geometry is irregular it can induce torsion which can be life-threatening to the structure, so it is essential to analyze and understand such forces during designing. In this study the behavior of high rise building against the wind force in wind zone 2nd, L shape is studied and analyzed for specific heights. Also direction of wind plays very vital role in behavior of structure.

**Keywords**— Wind pressure, High rise Structure, L shape geometry, Residential Building, Stress.

## I. INTRODUCTION

In India residents are increasing gradually and the necessary land for living. It is a key requirement to survive anywhere. For that reason multi story building are best choice for construction in Metro cities where a smaller amount of property is presented. As designer knows multi story structure provides large floor area in small area and it is beneficial also. Hence, it is required to assemble high rise structure. If high rise structures are constructed than many structural troubles come to pass, such as lateral load effect, lateral displacement and stiffness etc. Normally for high rise structure wind and earth quake load effects are prevailing. Therefore for high rise structure it is essential to have knowledge of different loads and its effect on structure. There is many type of effect worked on structure and causes for failure. The effect of lateral load is very important to consider such as earthquake and wind loads. In some cases the wind load is important than earthquake load which depends on place and zone factor distinct by codes. Wind load or wind effect is as dangerous as earthquake as previous study say. Defining wind there are two aspects first one is

helpful which is to produce power and gives relief in hot and humid environment and second one is parasitic which comes out to be factor believe for engineers. As a designer engineer wants to be safe his structure This wind effect will cause and produce wind induce movement in the structure. As high rise buildings move onward the envelope to larger heights, the structural designers are not only faced with difficulty to choosing a structural elements to take the lateral load such as wind load and earthquake load but also insuring the design criteria that meets reliability and serviceability requirement under difficult wind environment. Wind load take action as lateral weight on buildings which is act as along and across wind. In IS Code 875 (Part3)-1987, the basic wind speed are specified in map and categorized by zones. The shape and size of building is very significant in wind analysis, because the wind pressure is mainly depends on the exposed area of building in opposition to wind speed.

## II. LITERATURE SURVEY

**Arvind Y. Vyavahare<sup>1</sup>, Godbole. P.N<sup>2</sup>, Trupti Nikose<sup>3</sup>, 2012,** As author study that Tall buildings are slender flexible structures in nature and require to be examine to settle on the significance of wind speed induced excitation along and across the path of wind in specific zone. The Indian codal provision of practice for wind load on any buildings and structures (code IS-875 Part-3 1987) gives a procedure to determine along wind response of tall structures, while the across wind response and intervention effect are not included in the code at present. A article 'Review of Indian Wind Code IS 875 (Part 3) 1987' has been set by IIT Kanpur under GSDMA project gives recommendations to gain across wind reaction of tall buildings and structure as per process given in Australian/New Zealand standard 'Structural Design Actions – Part 2 Wind Action (AS/NZS 1170-2 : 2002) In the Australian codal provision to obtain the cross wind response it is necessary to compute the coefficient (C<sub>f</sub>) for which figures and expressions are specified for selected (h:b:d) ratios. In this paper use of Artificial

Neural Network (ANN) has been made to generalize the above process from the limited available data, so that across wind response can be obtained for a building with given (h:b:d) ratio.

**Shaikh Muffassir<sup>1</sup>, L.G. Kalurkar<sup>2</sup>, 2016**, This study shows The high rise structure or building is the necessity of metro cities. The multi story high rise RC building are more large and less elastic in nature as judge against to compound structures. This study investigates the similarity or comparison between RCC and composite structure under the effect of wind, additional to it compound structure also includes unlike plan configurations. this study has total 15 number of building model are arranged and analysis for wind load by using ETABS 2015 software. The various software are work on wind and earthquake analysis but we goes for software ETABS 2015. The wind analysis is performed for unlike heights such 20m, 50m and 80m respectively. In adding together, the comparative study concludes that the compound structure are bigger elastic in nature and more at risk as compare to RCC structure and the compound option is better than RCC for multi story structure. Whole study is observed in software analysis. In addition, the comparison of unlike plan configuration shows that the response of parameter such as story displacement, story stiffness, base reaction and time period under effect of wind. The reason of this analysis is to conclude the most efficient shape of construction in horizontal zone.

**N. Lakshmanan, S. Gomathinayagam\*, P. Harikrishna, A. Abraham and S. Chitra Ganapathi, 2009**, Long-term data on hourly wind speed from 70 meteorological centres of India Meteorological Department have been collected. The daily gust wind data have been processed for annual upper limit wind speed (in kmph) for each site. Using the Gumbel probability paper approach the intense value quantiles have been derived. A design basis wind speed for each site for a return period of 50 years has also been evaluated. The sitespecific changes in the design wind speeds in the contemporary wind zone map for the design of buildings/structures are highlighted and revision to the map is suggested..

**Tharaka Gunawardena<sup>1</sup>, Shiromal Fernando<sup>2</sup>, Priyan Mendis<sup>1</sup>, Bhatiya Waduge<sup>2</sup>, Dilina Hettiarachchi<sup>2</sup>, 2017**, Urban habitats around the world are becoming more congested with rising populations and the need for tall buildings is as high as ever. Sri Lanka is experiencing this reality at present as Colombo's skyline expands rapidly with a large number of upcoming complex high-rise buildings. The response of tall buildings to wind forces is a critical design criterion and it requires both conventional force based designs as well as performance based solutions. This paper discusses these challenges and the engineering solutions that they require

to successfully design a tall building which is not only stable, safe and strong under wind loads but also performs excellently providing usable and highly functional design. **Umakant Arya<sup>1</sup>, Aslam Hussain<sup>2</sup>, Waseem Khan<sup>3</sup>, (2014)**,

In this study paper, the investigative result of wind speed and structural response of building frame on sloping ground has been studied and analyze. Considering various frame geometries and slope of grounds. Combination of static and wind loads are considered. There is many type of sloping ground. For combination, 60 cases in different wind zones and three different heights of building frames are analyzed. STAAD-Pro software has been used for analysis purpose. Results are collected in terms of Storey-wise drift, Shear force, moment, axial force, support reaction, and Displacement which are critically analyzed to count the effects of a variety of slope of ground.

**K.R.C. Reddy<sup>1</sup> (2015)** In different type of high rise structure chimney has its own importance. Along wind analysis of tall reinforced concrete chimneys by casual vibration approach and Codal methods of India (IS 4998 (part 1)), America (ACI 307) and Australia (AS/NZS 1170.2) are offered in this paper. For the analysis based on casual vibration approach, the RC chimney is model as multi-degree-of freedom system subjected to static load due to mean constituent of wind pace and dynamic load due to changeable component of speed. The changeable component of wind speed at a point is careful as temporal random process. subsequently, the codal procedures for along-wind analysis of tall RC chimneys from Indian, American and Australian codes are reviewed. Four RC chimneys are analyzed using these methods to achieve their responses. It is found that the codal methods of along-wind analysis are basic, are not prepared to estimation the deflection of the chimneys and producing mixed results. The simplifying assumptions used in these codes are discussed.

### III. EXPECTED OUTCOMES AND NEED OF THE STUDY

The wind analysis on multi-storey building in wind zone second, the structures situated in indore (m.p.). The main purpose of this study is to analyse the highest multistory building in Indore.

- ▶ Analyzing different building with their different height for wind analysis
- ▶ To determine various results for high rise building after the wind forces applied.
- ▶ The comparative study of different number of RCC and composite structures.

#### IV. PROBLEM FORMULATION AND OBJECTIVE

The performance of RC structures before and after the application of wind forces.. In this study we are introducing new and the highest building of the indore for get better performance of building during the wind.the study to be done in wind zone second and the highest building in the region is the uniqueness of the study.

The specific aims and objectives of the project can thus be mentioned as:

- a. Analysis of wind on G+19 storied RC Residential building as per IS codal provided with different shapes .
- b. Analysis of wind G+19 storied RC Residential building with different stories.
- c. Analysis of wind G+19 storied RC Residential building story drift , base reaction and displacement

#### V. CONCLUSION

On performing the extensive survey of the literature available n building structure it can be concluded that due to a wide variety of buildings, the in depth understanding in the field of wind Analysis and design of building structures is inadequate. The IS codes has provided certain guideline on the basis of which the building structures can be designed when subjected to wind loads. The literature survey in the performance and behavior of building structures when subjected to wind loads suggests that the requirement of establishing a methodology for studying the response of building structure to winded loads has become essential. Many researchers has performed work over various types of building. on the different types of buildings and find out the important parameter which is useful for understanding the behavior of wind forces.

#### REFERENCES

- [1] Syed Fahad Ali and S.A. Bhalchandra, Study on seismic Analysis of RCC and steel-concrete composite structure and cost comparison with different support condition, International journal for scientific research and development,
- [2] Sanhik Kar Majumder and Priyabrata Guha, Comparison between wind and seismic load on different types of structures, International journal of engineering science invention
- [3] U.Y.Jeong, Advance in tall building design under strong winds, Structural congress ASCE, 2015
- [4] Code IS: 456(2000), Indian Standard Code of Practice for Plan and Reinforcement concrete (Fourth Revisions), Bureau of Indian Standards (BIS), New Delhi.
- [5] Ravinder Ahlawat and Ashok K. Ahuja, (2015), "Wind loads on 'T' plan shape tall buildings". Journal of Academia and Industrial Research (JAIR) ISSN: 2278-5213.
- [6] Ravinder Ahlawat and Ashok K. Ahuja, (2015), "Wind loads on 'Y' plan shape tall building". International Journal Of Engineering and Applied Sciences (IJEAS) ISSN: 2394-3661.
- [7] Md. Rashedul Kabir, Debasish Sen, Md. Mashfiqul Islam, (2015), "Response of multi-storey regular and irregular buildings of identical weight under static and dynamic loading in context of Bangladesh". International Journal Of Civil and Structural Engineering, ISSN 0976 – 4399
- [8] Jawad Ahmed, H S Vidyadhar, "Wind Analysis and Design of Multi Bay Multi Storey 3D RC Frame", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181.
- [9] Hossein Moravej, Mahdi Hatami, Reza Naghshbandi, Yaser Mousavi Siamakani , "Wind load analysis of buildings in hill-shape zone", Int. Journal of Applied Sciences and Engineering Research, Vol. 4, Issue 1, 2015.
- [10] Indian standard codal 875: part 2,3,5- 1987, "Code of practice for Design loads (other than earthquake) for buildings and structures."
- [11] Indian standard codal 456: 2000, "Indian Standard code of practice for general structural use of plain and reinforced
- [12] D.R. Panchal and P.M. Marathe, Comparative Study of RCC, steel and composite (G+30 storey) building, Institute Of Technology, Nirmal University, Ahmadabad, December,
- [13] Abhay Guleria, Structural Analysis of a Multi story buildings using ETABS for Different plan configuration, International journal of engineering research and technology.
- [14] Mahesh Suresh Kumawat and L.G.Kalurkar, Analysis and design of multi story building using composite structure, International Journal of Research in Engineering and Technology,3(2),
- [15] Codal provision IS: 875(Part 3)-1987, Indian Standard Code of Practice for Design loads (other than Earthquake) for Buildings and Structures, Bureau of Indian Standards, New Delhi..
- [16] Ming Gu, "Study on wind loads and responses of tall buildings and structures" The Seventh Asia-Pacific Conference on Wind Engineering, Nov. 2009, Taipei, Taiwan.
- [17] J. A. Amin and A. K. Ahuja (2008), "Experimental study of wind pressures on irregular plan shape buildings". BBAA
- [18] International Colloquium on: Bluff Bodies Aerodynamics & Applications Milano, Italy.

# Optimization of skylight composition for cooling and lighting energy efficiency (Case Study: G-building ITATS)

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**Abstract** — *The increasing concern on sustainable and environmentally friendly design over the past three decades has encouraged architects to look back at their own tradition in creating built environments. They realize that building should bear connection with place. In the tropics, buildings should respond to the climate. High solar radiation and temperature are particularly critical from the point of view of architecture design. Multi-storey buildings are especially vulnerable as far as heat is concerned. Greater area of the facade is exposed and will be the main source of heat input, which in turns will have an impact on energy use and comfort. Careful considerations on the design of envelope and roof are proved to be of advantage in terms of energy performance.*

*This research aims to find the optimum composition of skylight and opaque roof for atrium of middle-rise wide span buildings, especially in relation to cooling energy and daylighting. Sample of middle-rise office buildings in Surabaya were taken random. Simulation was conducted to predict energy performance for cooling energy and daylight distribution of the building. Energy performance of the buildings were found to bear some relations to the percentage of fenestration roof in atrium.*

**Keywords**— *Atrium, Cooling Energy, Daylight, Energy Efficient, Middle-rise, Tropics.*

## I. INTRODUCTION

Indonesia is a develop country with high density of population. In Indonesia, the biggest energy uses comes from commercial sector such as mall, hotel, and office building. Commercial building consumes about 52% energy of total energy use and 60 % of the energy use allocated for air conditioning system. High temperature, humidity and solar irradiance are the problem of thermal comfort in warm humid country like Indonesia. About 55% of heat gain in the building comes from building

façade, it means there'll be significant saving of energy use when architect design the building façade carefully. Climate should be considered when the architect's design any building <sup>[1]</sup>.

Energy consumption of building can be cut by a good design, compact massing and landscaping, perfect façade material choice, and climate must be a factor to determine all of that. Tropical climate especially warm humid area, has a lot advantages and challenges for the architect <sup>[1&2]</sup>. Indonesia for example, it's tropical country with warm humid character. Sun is shining all year in this country, it can be an unlimited energy for us, and at the same moment can be source of heat gain in the building which is make the cooling load higher and make the energy consumption of air conditioning increase. Overheating external façade can be happen because of wrong choice of façade material. Architect supposed to be careful when design great opening in façade or atrium because poor thermal performance of fenestration wall or roof <sup>[3]</sup>. Most of fenestration envelope material such as clear glass, fiber glass, or poly carbonate has huge u-value and little decrement factor. It means the material accept a lot of heat and transfer it a lot in to the building. This is not good.

Previous research said octagonal building consume less energy compared by another building form in the same volume <sup>[4]</sup>. Another research tell more compact the design of the building cooling energy consumption will be less too <sup>[5]</sup>. Bulky building consumes less cooling energy than multiple building in same volume.

Day lighting can be another problem in bulky building design. Usually day light transmit only in to the perimeter area, need more strategies to enter the sun light into the building such as light shelf, atrium, high area of opening, light pipe, and so on. The common and simplest solution to enrich the penetration of sun light of the building is creating atrium and skylight. Roof is one of building envelope which is transfer a great heat into the building

[6], so it's being important to design carefully and consider about material composition for atrium roof.

## II. METHODOLOGY

This research aims to analyze composition of roof material especially for atrium in wide span middle-rise building to optimization cooling energy on it. This research use experimental method with simulation to test the correlation between percentage of fenestration roof and cooling energy consumption. Calculation of cooling load in the building and simulation of each type of heat gain of the building is used to evaluate thermal energy performance of the building

This research will compare some models of atrium roof based on sample has been chosen before. In this experiment there is a base case (the existing model) and modification on percentage of fenestration roof in that atrium. This simulation use software Ecotect 2011. Base case of this experiment is existing model of G building ITATS, atrium with 50% of fenestration roof. Previous research [6] test the building performance with 10%, 20%, 30% and 40% WWR (Windows to wall ratio). This research will use that percentage for fenestration roof.

## III. RESULT AND DISCUSSION

G building of ITATS is a building used for collage such as office department, Architecture studio and classroom. This building has 4 storey and 4 department ue this building for educational process: department of architecture, civil engineering, product design, and environmental engineering. This building is bulky, it has 31 m wide (fig.1). There are A lot of opening on its envelope so a lot of day light enter the building.

Ground floor of this building used as office of the departments, and communal area. Space under the atrium used as hall. This hall is multifunction, regularly student held exhibition of their work in this hall. Band competition, sport, and fresh student orientation usually held on this place. Fig 2 shows interior and exterior of the G building of ITATS. Varies daylight needed in each function of rooms in this floor. Canteen needs approximately 300 lux of daylight. Office departments need about 400 lux of daylight. Workshop which need high detail work needs 900 lux for lighting

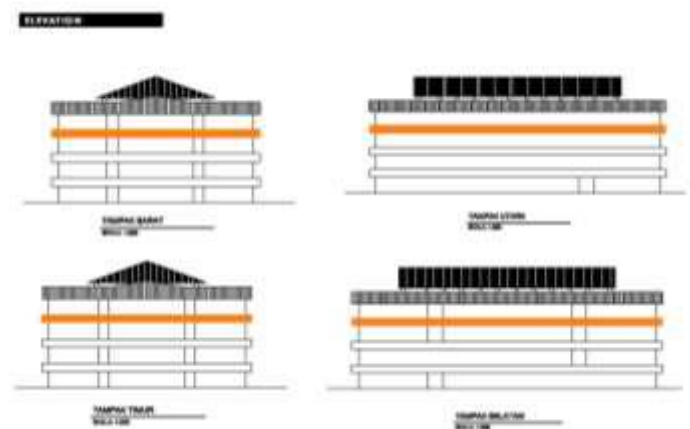
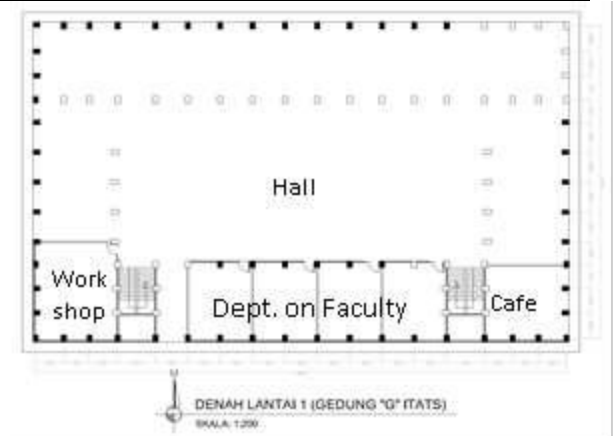


Fig. 1: Plan and elevation of G building of ITATS

1<sup>st</sup> floor of this building used as classrooms. Level of daylight for this room approximately 400 lux, and for thermal comfort temperature supposed to be in 24-27°C and 40-60% Relative humidity. 2<sup>nd</sup> floor of this building used for architecture studio. This room needs more daylight for better performance. It needs about 600 lux. There some classrooms and laboratories In this floor which require different amount of daylight. Unfortunately opening design for each room are same. 3<sup>rd</sup> floor of this building used as product design studio, library, and laboratory. This is the top floor of the building and perimeter room doesn't have any ceiling. On top of the perimeter use concrete roof without any insulation. It makes this floor has the worst thermal performance.





Fig. 2: Interior and façade of the case study

### 3.1 Composition of Skylight and Daylight Performance

Generally the amount of daylight which is enter the building decrease proportionally by the decrease of the percentage of fenestration roof on the atrium, but the total of daylight are not really different (table 1). This happen because the WWR of each room are wide enough so each room have a good daylight distribution.

Table.1: Daylight Factor on G building

Floor	Room	Standar DF (%)	Daylight Factor (%)				
			BC	Mod.1	Mod.2	Mod.3	Mod.4
GF	Canteen	4	4.8	4.8	4.8	4.8	4.8
	Office Dept	4	4.7	4.8	4.5	4.3	4.3
	Workshop	9	6.7	6.7	6.7	6.7	6.7
	Hall	4	10.7	10.7	9.0	8.7	7.0
1st	Class room	4	9.0	8.9	8.5	8.4	8.0
	Class room	4	8.7	8.5	8.5	8.3	8.0
2nd	LAB	9	8.5	8.8	8.8	8.0	8.0
	Studio	6	9.0	9.3	9.3	9.0	9.0
3rd	Class room	4	9.0	8.9	8.5	8.4	8.0
	Library	4	9.0	9.8	9.8	9.7	9.5
	Workshop	9	8.7	9.5	9.5	9.3	9.0
Average			8.1	8.3	8.0	7.8	7.5

The data obtained in the base case is the result of field measurements, it does not show too much difference with the simulation results. The lighting on the ground floor looks less than another floor. The higher the floor, the more amount of natural lighting that enters the room. This is reasonable because the higher the floor of the building,

the fewer barriers or obstruction around the building can block light from entering the building.

On the ground floor besides being blocked by surrounding buildings, there are also some trees planted not far from the windows so that it reduces the number of daylight. Generally, daylight which enter the rooms in ground floor has fulfill the standard (fig. 3). Lighting at workshops that entered around 600 lux, quite a lot actually, it's just that it is less than the standard requirement for workshops so additional lighting is needed in this room. It is better to add a few light points to help the glassware when needed to assemble goods (add task lighting, not general lighting).

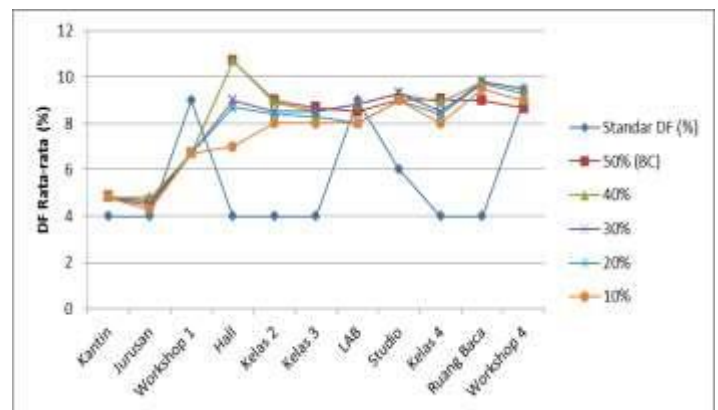


Fig 3: Daylight Factor (DF) in each model

In Hall, the amount of natural lighting entering is still very high even though the use of skylights in the atrium has been reduced, this is caused by:

1. The atrium roof uses a skylight type, so that the incoming sunlight is mostly a direct beam that is strong enough. So even though the amount of small translucent roof still allows more direct light to enter
2. The use of white and glossy ceramics also affects the reflectance of light that has entered. White and shiny layers cause more sunlight to be reflected in the room so that the potential for glare in the room is greater.
3. Open space around the hall (Fig.1) allows the amount of light from the north side and more buildings to enter, moreover other buildings are only on the south and east sides of the building. The north and west sides do not have any obstruction, allowing more sunlight to enter the hall.

Classrooms on 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> floor do not experience many changes with a reduction in the percentage of translucent roofs in the atrium. The amount of incoming lighting is almost double the required standard. The good thing is that the lighting distribution on the 2nd floor is evenly distributed so it does not have the potential to cause glare in the room if the building user looks at the window (figure 4). The excessive amount of lighting in this class causes users to have difficulty seeing the

presentation on the LCD screen. On the other hand, this classroom is sure to not use lights during the day when the weather is sunny.

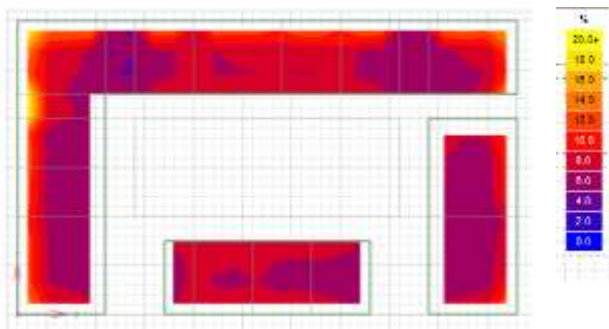


Fig 4: Daylighting distribution on 2<sup>nd</sup> floor

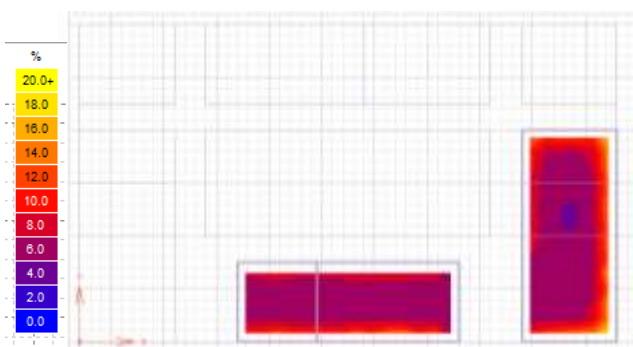


Fig. 5: Daylighting distribution in LAB on the 3<sup>rd</sup> floor

Laboratory and Workshops on the 3rd and 4th floors have sufficient amount of lighting. The distribution of natural lighting is fairly evenly distributed in the room (Figure 5 & 6), most of the side near the window, both the outer and near the atrium windows have sufficient lighting. The central area of this room is darker than the surroundings.

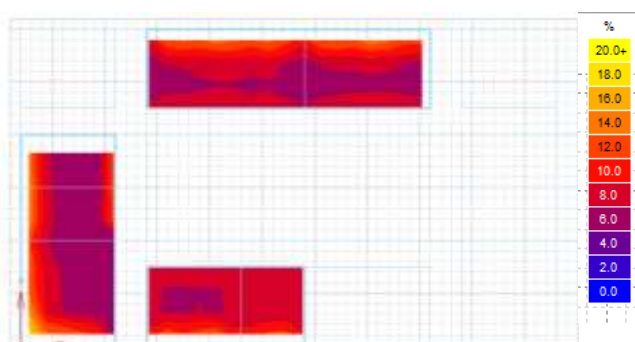


Fig 6: Daylighting distribution in workshop on 3<sup>rd</sup> floor

From the picture of the distribution of indoor lighting and the simulation results in the graph in Figure 4.3 it can be concluded that the reduction in the number of translucent roofs at the atrium does not have a large effect on the building's perimeter, but gives a significant influence on the room just below the atrium. This happens because:

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1. The amount of WWR in a building that is large enough to allow light to enter from the translucent wall. Skylights are not the only source of light in the room in building G
2. Skylights help equalize the amount of light entering the room so that the quality of natural lighting in buildings is also better

### 3.2 Skylight Composition and Thermal

The cooling energy in building G is far above the standard (Fig.7). To be low energy building, commercial buildings must consume maximum cooling energy of 47kWh / m<sup>2</sup> / Year or maximum total operational energy of 200kWh / m<sup>2</sup> / Year. Building G consumes 10x cooling energy higher than the standard it should. It can be concluded that the energy performance of cooling in this building is very poor.

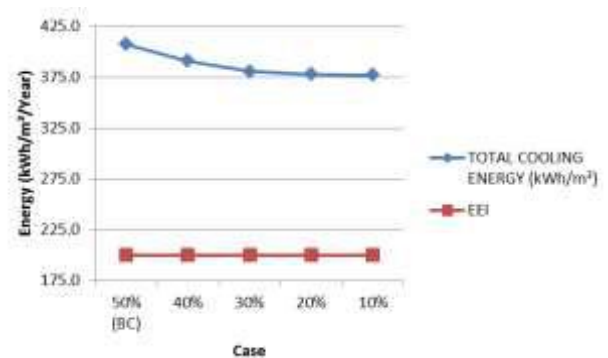


Fig 7. Energy consumption on each case

The amount of cooling energy in this building is caused by large heat propagation into the building. Most of the heat entering the building is transferred through the conduction stream (Fig.8).  $sQ_c$  is conduction heat flow, the heat flow flows from the building envelope that occurs 24 hours. To minimize  $sQ_c$  we have to design the walls and roof carefully. Too many windows on the wall, translucent roofs that are too large in the atrium, high u-value walls and roofs can cause a rise in conduction heat.

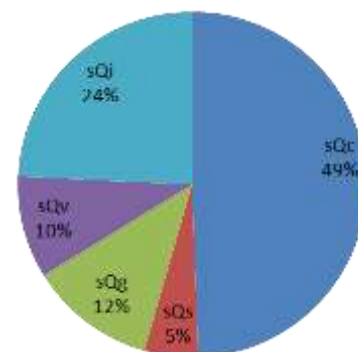


Fig.8: Gain breakdown in base case



sQi is the second highest heat flow from Fig.8. sQi means internal heat gain, heat from electricity and activity in the building. Electricity in this building is divided into three groups: Lighting, Air Conditioning, and electrical equipment. Thus the operational hours are long, the increase in the internal heat of this building increases. Incorrect window design is also the next factor to improve sQi. Actually, there are no windows in this building, only translucent walls. There is no window which means there is no air flow, and the wide area of the translucent wall makes the heat penetrating into the building still occurs and continues to increase again because there is no air flow to dissipate the heat. The only way to create thermal comfort in a windowless building is to use an air conditioning system. This means increased power consumption and internal heat gain.

The third highest type of heat in this building is radiation-induced heat. Irradiance Heat Gain is divided into two:

1. Direct Irradiance Gain (sQg) is radiation that comes and enters the building directly. Usually this type of heat flow occurs on transparent walls and roofs.

2. Indirect irradiance gain (sQs) is the radiation heat gain through an opaque surface. Sun radiation hits an opaque surface, and there are some that are reflected and absorbed. The heat absorbed will be transmitted to the building in a few moments depending on the material lag time

In this building sQg is much higher than sQs. There is a lot of solar radiation coming into this building from translucent surfaces. This atrium has a skylight of 50%, making the amount of direct irradiance that enters the building even higher. To be lower, the composition of transparent surfaces must be reduced. The amount of radiation that hits the surface of the building on the horizontal side is also relatively large.

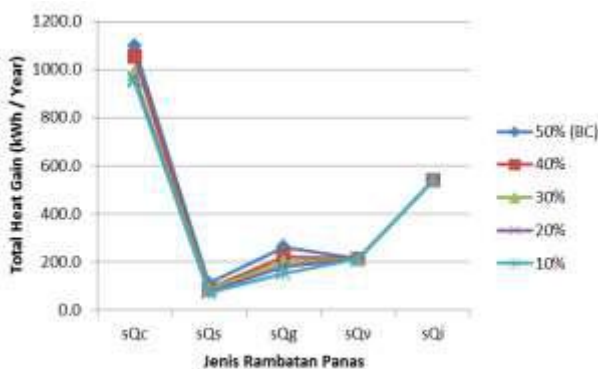


Fig.9: Gain breakdown on each model

sQv is heat that enters due to ventilation, or heat entering the building through the building's air flow (convection). This building does not have a window does not mean it has no air flow at all. All rooms use AC which usually has an exchange value of 2 ACH, so the ventilation obtained by this building comes from this AC system

flow. This building uses air conditioning in total, so the ventilation gain of the building is quite low.

Reducing the extent of translucent roofs turns out to have little impact on conduction and radiation heat flow directly into the building (Fig.9). internal heat and conduction heat do not change because the volume of the room and user activity do not change.

Although the amount of cooling load is very high because there are too many transparent fields on the wall, energy must still be used as much as possible on the building without sacrificing thermal or visual comfort in the building. Figure 10 shows a comparison of the inner chamber temperature that can be created by each case for the same outer space temperature. Skylight buildings up to 20% are able to provide lower indoor temperatures than outdoor temperature.

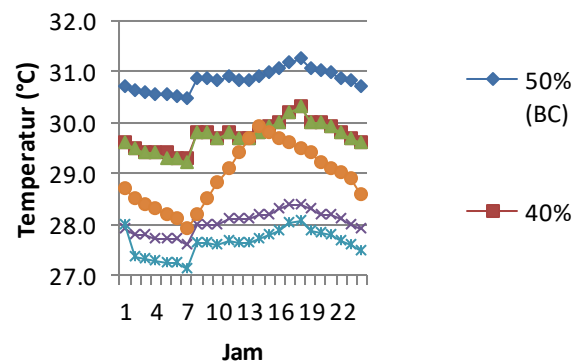


Fig 10: Indoor air temperature G building of ITATS in each case

#### IV. CONCLUSION

The natural lighting performance in the G building of ITATS is quite good, but the thermal performance of the building is very bad. Many transparent fields on the wall make this building include too much heat. Clear glass used in windows also has poor quality for thermal so that the energy needed for the building is very large. Reducing the number of transparent roofs at the atrium up to 20% can help reduce cooling loads without reducing visual comfort in the building.

The use of blinds or curtains on the window is highly recommended, especially in classrooms because the lighting needs there are not too high while the amount of light entering is quite large. Although the percentage of small skylights that enter the class is still very large due to the large number of openings in the wall.

#### REFERENCES

[1] Yeang Ken (1996), Bioclimatic Skyscraper. London: Artemis London Limited  
 [2] Baker Nick dan Koen Steemers, (2005), *Energy and Environmental in Architecture*, Taylor & Francis Group, New York

- [3] Knowles, R.L. (2003), “The Solar Envelope: Its Meaning for Energy and Buildings”, *Journal of Energy and Buildings*
- [4] Laksmiyanti Dian (2016), Kinerja Bentuk Bangunan Perkantoran Bertingkat Menengah Di Surabaya Terhadap Efisiensi Energi Pendinginan, *Jurnal IPTEK ITATS vol:20 no 1*.
- [5] Crawford Robert H, Czerniakowski Isabella, Fuller Robert J (2010), A comprehensive framework for assessing the life cycle energy of building construction assemblies, *Journal Science Direct, Architectural Science Review 53 (2010) 288–296*.
- [6] Heerwagen Dean (2004), *Passive and Active Environmental Controls Informing The Schematic Design of Building*, Mc Graw Hill, New York
- [7] Markus T.A, Morris E.N (1980), *Buildings, Climate and Energy*, Pitman Publishing Limited, London
- [8] Olgyay, V (1972). *Design with Climate- Bioclimatic approach to architectural regionalism*, Princeton University Press, New Jersey
- [9] Lenchner Norbert (2007), *Heating, Cooling and Lighting*, PT. Raja Grafindo Persda, Jakarta
- [10] Szokolay, S.V. (1987), *Thermal Design of Buildings*. RAI A Education Division, Canberra, Australia.

# Effect of the Substitution of Agricultural Uses by Forest on the Hydrological Processes in a Tropical Watershed. Analysis through Hydrological Simulation

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**Abstract** — *Forests play an important role in watershed hydrology, regulating the transfer of water within the system. Their role in maintaining the hydrological regime of watersheds is still a controversial issue. Due to the uncertainty, our first objective was to identify, through GIS techniques, “Environmentally Sensitive Areas” (ESAs) in the Pinhal watershed, subsequently, to simulate land use scenarios with the Soil and Water Assessment Tool model. In one of these scenarios, we considered these areas as protected by forest cover. This scenario we compared to the current scenario regarding watershed sediment yield and hydrological processes. The results showed a reduction in sediment yield of 54% between the two scenarios, whereas watershed water yield was reduced by 19.3%.*

**Keywords**— *hydrologic modelling; land use change; reforestation; SWAT, surface runoff; water yield.*

## I. INTRODUCTION

Abandonment of former agricultural and pasture land has led to spontaneous regeneration and active planting of new forests (Molin, 2014). Forests has many diverse environmental functions and knowledge on how forests affect the various aspects of water is essential to assess the role of forest cover on watersheds' hydrological regime (Lima, 2012). Forests are often regarded as effective to stabilize and maintain the river flow rates and this is one of the reasons why revegetation is repeatedly recommended to recover watersheds (Wei & Zhang, 2010). Some of the hydrological functions usually ascribed to forests, however, such as increase rivers water availability, are disputable and lack a technical and scientific basis. We observe, however, that this is still a worldwide controversy, especially regarding the establishment of water conservation and sustainable use of natural resources policies.

In this line of research, a large collection of data in the scientific literature, resulting from the systematic monitoring of catchments all over the world. Catchment studies may be grouped broadly into three main types (Bosch & Hewlett, 1982): (a) correlation studies in which the streamflow is compared between different catchments, (b) single catchment studies and of which (c) paired catchment experimental studies stands out (Bosch & Hewlett, 1982; Cosandey, 1995; Brown, 2005, Bart & Hope, 2010; Webb & Jarrett, 2013; Rodríguez-Martínez & Santiago, 2017). Some works with paired catchment showed the effect of forest cover on water yield, where natural vegetation has been removed and/or replaced by planted forests (Bosch & Hewlett, 1982; Bruijnzeel, 1990, 2004; Buytaert et al., 2006). The paired catchment technique would be arguably the best methodology to evaluate the hydrological functions normally assigned to forests, applicable to basins with very similar characteristics (Bosch & Hewlett, 1982; Brown, 2005). It is always preferable that paired catchment should be as near as possible, to have similar physical aspects, climate, vegetation and use and occupation (Best et al., 2003). Despite the advantages of using paired catchment to study the impact of vegetation changes on water yield, this kind of study takes time, since a watershed's hydrological response to tree cutting or reforestation is a medium to long-term process. It is also impossible to test other configurations of land management and use, and according to Zhang et al. Zhang et al (2017), the results from small catchment (e.g. paired catchment studies) cannot always be extrapolated to large basins.

Another option to predict the impact of land-use changes on the quantity and quality of water in a watershed, e.g., vegetation replacement, is the use of hydrological models. According to Sun et al. (2006), mathematical models are probably the best tools to analyze

complex non-linear relationships between the water yield of forests and major environmental factors.

The large number of existing models applied to watersheds shows the advancement of this technology. There are many hydrological models that simulate the quality and quantity of streamflow, each one with strengths and weaknesses that must be considered according to the user's needs and the characteristics of the study area. As an example, the Soil and Water Assessment Tool (SWAT) model allows great flexibility when configuring watersheds (Abbaspour et al., 2015). The model was developed to predict the effect of different management scenarios in the quality and quantity of water, sediment yield and pollutant loads in agricultural watersheds (Srinivasan & Arnold, 1994; Peterson & Hamlett, 1998). SWAT discretize watersheds in subbasins based on relief, soil and land use, preserving thus spatially distributed parameters of the entire watershed and homogeneous characteristics within the watershed (Srinivasan & Arnold, 1994).

The SWAT model is internationally recognized as a solid interdisciplinary watershed-modeling tool, as demonstrated in annual international conferences and papers submitted to scientific journals (Kuwajima et al., 2011). SWAT's many uses have shown promising results, e.g., hydrological assessments, impacts of climate change, evaluation of best management practices, estimation of pollutant load, determining of the effects of land-use change, sediment yield, etc (Machado & Vettorazzi, 2003; Machado et. al. 2003; Koch et al., 2012; Lessa et al., 2014; Abbaspour et al., 2015; Dechmi & Skhiri, 2013; Liu et al., 2015; Zhang et al., 2014; Rocha et al., 2015; Lin et al., 2015, Tuo et al., 2018; Wang et al., 2018; Mutenyio et al., 2013; Sajikumar & Remya, 2015; Giri et al., 2018).

Due to the uncertainty of forests' role in the quantity and quality (sediment loading) of water resource and the

possibility of creating different scenarios that are difficult to test at watershed level, this paper's objective is first to identify "Environmentally Sensitive Areas" (ESAs) in the watershed under study and, subsequently, to simulate land use scenarios comparing them regarding sediment yield and hydrological processes. The Pinhal watershed is important as supply of drinking water for the Limeira city and it is in state of environmental degradation (e.g., improper land use, areas severely eroded and soil loss). The results of this study will provide valuable information for future implementing the Payments for Ecosystem Services (PES) in the watershed.

## II. METHODOLOGY

### 2.1. Study Area

Pinhal watershed is located in State of São Paulo, Brazil. It consists of approximately 300 square kilometers (Fig. 1). It has a humid subtropical climate – Cwa, according to the Köeppen classification, with a hot and humid summer and cold and dry winter, and average annual temperature of 25°C. Average annual precipitation is approximately 1400 mm.

Sugarcane cultivation occupies most of the watershed area (42.3%), whereas citrus cultivation occupies approximately 30% of the area. Much of the original forest vegetation has been destroyed in the process of land use and occupation, now scattered along the streams (9%). The urban area occupies 6.7%, located at the western side of Pinhal watershed. The predominant soils in watershed are ferralsols (72%) and cambisols (19%).

The Pinhal watershed is important as supply of drinking water and due to it is state of environmental degradation. In addition, the initiative taken by City Council of Limeira to reverse the degradation of forest and the adverse effect of land use changes is implementing the Payments for Ecosystem Services (PES).

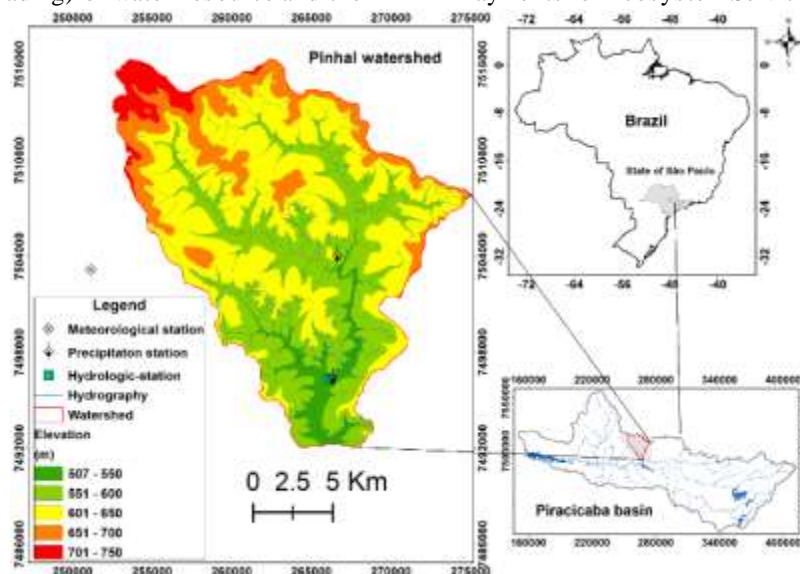


Fig. 1. Locations of the Pinhal watershed and gauging stations.

## 2.2. The SWAT model and input data

SWAT, version 2012, was used in the simulation of the Pinhal watershed's scenarios. The model requires as input data daily precipitation, maximum and minimum air temperatures, solar radiation, wind speed and relative humidity. These data were obtained from UNICAMP's School of Technology's weather station, located in Limeira, state of São Paulo, at UTM coordinates 251,145 m (W) and 7,503,161 (S). Rainfall data were obtained from two other rainfall stations (Fig. 1). Other data include Digital Elevation Model (DEM), land use and soil maps.

Land use properties were obtained directly from the SWAT model database and the physical-hydrological soil parameters of Agronomic Institute of Campinas (IAC). Table 1 summarizes the input data used for the current study. Inputting data into SWAT is made via an interface developed between SWAT and GIS ArcGis (Arnold et al., 2012). The interface divides the watershed in subbasins from the DEM. We discretized the Pinhal watershed in 25 subbasins up to the hydrologic station localized at UTM coordinates 266,175 m (W) and 7,496,308 (S) (Fig. 1).

Table.1: Data sources for the Pinhal watersheds and input data for SWAT model.

Input data	Data description	scale	Data sources
Land use	Land-use classification - agricultural land, forest, pasture, urban and water	25,000	Secretary of the Environment of the State of São Paulo, 2013 ( <a href="http://www2.ambiente.sp.gov.br/cpla/mapa-de-uso-e-ocupacao-da-terra-ugrhi-5-pcj/">http://www2.ambiente.sp.gov.br/cpla/mapa-de-uso-e-ocupacao-da-terra-ugrhi-5-pcj/</a> )
Soil	Soil types and physical properties	100,000	São Paulo Forest Institute ( <a href="http://iflorestal.sp.gov.br/2017/09/26/mapa-pedologico-do-estado-de-sao-paulo-revisado-e-ampliado/">http://iflorestal.sp.gov.br/2017/09/26/mapa-pedologico-do-estado-de-sao-paulo-revisado-e-ampliado/</a> )
Topography	Digital Elevation Model (DEM)	10,000	Geographic and Cartographic Institute of São Paulo (IGC)
Hydrological and Meteorological	precipitation, minimum and maximum temperature, solar radiation, wind speed	Daily	ANA ( <a href="http://www.snirh.gov.br/hidroweb/publico/mapa_hidroweb.jsf">http://www.snirh.gov.br/hidroweb/publico/mapa_hidroweb.jsf</a> ) UNICAMP ( <a href="https://www.ft.unicamp.br/dadosmeteorologicos">https://www.ft.unicamp.br/dadosmeteorologicos</a> )

## 2.3. Model evaluation

The warm-up, calibration, validation and uncertainty analyses of the SWAT model was done in the period 2010 to 2014 in the SWAT-CUP 2012 program with the SUFI-2 (Sequential Uncertainty Fitting) calibration algorithm. The SUFI-2 algorithm has the capability to account for all sources of uncertainty within the parameter ranges such as uncertainty in driving variables (e.g. rainfall), conceptual model, parameters, and measured data (Abbaspour et al., 2007). Based on the relevant literature, parameters related to management/soil [CN2 (dimensionless), SOL\_K (mm/h), SOL\_AWC (mm/mm), SOL\_ALB (dimensionless)]; groundwater parameters [ALPHA\_BF (1/day), GW\_DELAY (day), GWQMIN (mm), SURLAG (dimensionless), GW\_REVAP (dimensionless), REVAPMN (mm)]; subbasins/HRU parameters [ESCO (dimensionless), EPCO (dimensionless), SURLAG (days), SLSUBBSN (m), CANMX (mm H2O)] and main channel parameters [CH\_N2 (dimensionless), CH\_K2 (mm/hr)], were submitted to the sensitivity analysis to parameterize the most sensitive and make necessary adjustments in their values. This step was performed iteratively, according to the calibration procedure (Abbaspour et al., 2015). The Nash-Sutcliffe model's efficiency coefficient (NSE -

Equation 1) was used to evaluate the simulation's results. NSE can range from  $-\infty$  to 1, where 1 is the optimal value. Values above 0.75 can be considered very well (Moriasi et al., 2007). The PBIAS (Equation 2) also was used to evaluate the simulation's results (Gupta et al., 1999).

$$NSE = 1 - \frac{\sum_{i=1}^n (Q_{OBSi} - Q_{SIMi})^2}{\sum_{i=1}^n (Q_{OBSi} - \bar{Q}_{OBS})^2} \quad (1)$$

$$PBIAS [\%] = \left( \frac{\sum_{i=1}^n (Q_{OBSi} - Q_{SIMi})}{\sum_{i=1}^n (Q_{OBSi})} \right) * 100 \quad (2)$$

Where,  $Q_{OBSi}$  and  $Q_{SIMi}$  correspond to the observed and simulated streamflow, respectively, on day  $i$  ( $m^3/s$ ), and  $\bar{Q}_{OBS}$  corresponds to the observed average streamflow, in ( $m^3/s$ ), and  $n$  corresponds to the number of events. The calibrated SWAT model was used to simulate monthly average hydrological processes under land use change scenarios.

## 2.4. Identification of Environmentally Sensitive Areas (ESAs)

The concept of "Environmentally Sensitive Areas" (ESAs) was created approximately 30 years ago due to increased soil and water degradation and the degree of severity of degradation (Rubio, 1995). ESAs are areas that contain natural or cultural features important for a

functioning ecosystem (Ndubisi et al., 1995; Gourlay, 1998).

To identify ESAs in the Pinhal watershed within the context of environmental degradation, we reclassified the results from Adami et al. (2012) and identified three types of ESAs: Critical, Fragile and Potential according to Rubio (1995). Adami et al. (2012) made an agroenvironmental analysis of the Pinhal watershed via a Geographic Information System (GIS). They used indicators of relief (slope, which was sliced into categories and fragility degrees), soil (ranking of soil classes according to their fragility) and land use and cover (reclassified according to their protection degree, with higher grades given to classes with greater soil cover) to determine the capacity of natural resources and environmental fragility. The empirical analysis was used to identify areas that require more attention for improving environmental conditions. The results of the procedures employed by the authors in their study are shown in Fig. 2. Additional information in Adami et al. (2012).

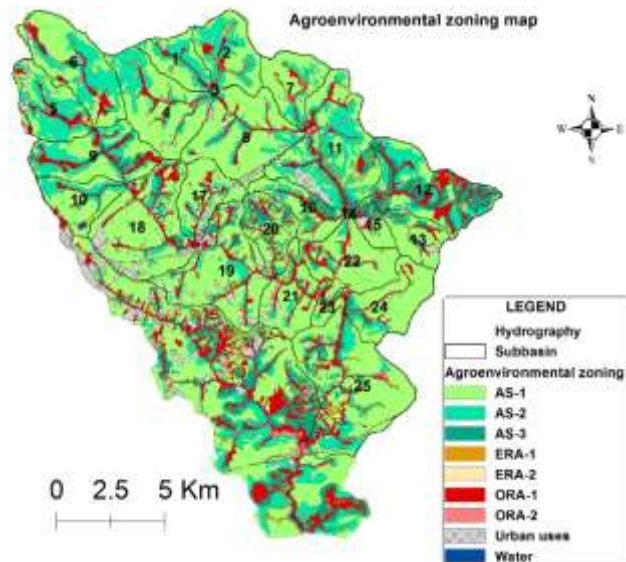


Fig. 2. Map of the agroenvironmental zoning of the Pinhal watershed by Adami et al. (2012).

**Definitions:** **AS:** Agricultural subareas - these subareas are all sites identified and mapped with agricultural activities, as long as they are compatible with the conditions of protection of the water resources. **ERA:** Environmental Recuperation Area - are areas with usage or occupations that are compromising the quantity and quality of water, requiring urgent corrective interventions. **ORA:** Occupation Restriction Area - they are those defined as permanent preservation according to the Federal, State and Municipal legislation, within the limits of the Protection and Recuperation Area of Water Resources (PRAWR). These areas should be considered of private preservation of fauna and flora remaining in the watershed. Priorities should be given for the production of water, through investments and the application of [www.ijaers.com](http://www.ijaers.com)

economic instruments and compensation provided by the current legislation. Thus, we reclassified ORA 1, 2 and ERA 1, 2 as Critical ESAs; AS 2, 3 in Fragile ESAs and AS 1 in Potential ESAs.

## 2.5. Scenario simulation

We made two scenario simulations using the SWAT model interfaced with GIS ArcGis, aiming to verify the effect of land use change on sediment yield (sediment transported from subbasins to the main channel over time, ton/ha) and the hydrological processes (surface runoff (mm), evapotranspiration (mm), soil water content (mm), water yield (mm). Where the water yield (WYLD) is the net amount of water that leaves the sub-basin and contributes to streamflow in the reach during the time step ( $WYLD = SURQ + LATQ + GW\_Q - TLOSS - \text{pond abstractions}$ ). SURQ is the surface runoff contribution to streamflow during time step (mm H<sub>2</sub>O). LATQ is the lateral flow contribution to streamflow during time step (mm H<sub>2</sub>O). GW\_Q is the groundwater contribution to streamflow (mm). Water from the shallow aquifer that returns to the reach during the time step. TLOSS is the average daily rate of water loss from reach by transmission through the streambed during time step (m<sup>3</sup>/s) (Arnold et al., 2012).

In a scenario, we did Critical and Fragile ESAs with forest cover and overlapping on the land use map. This scenario was compared to the baseline scenario. Thus, these simulations illustrate the application and integration of hydrological and water quality models with GIS to evaluate watershed management scenarios, modifying only land use layer and management practices.

We used the change of the analysed events as statistical criterion to evaluate sediment yield and compare the hydrological behavior of the watershed in different scenarios, Equation 3:

$$\text{Change} [\%] = \left( \frac{\sum_{i=1}^n (S_{ESA} - S_{CU})}{\sum_{i=1}^n (S_{CU})} \right) * 100 \quad (3)$$

Where,  $S_{ESA}$  the results of the alternative scenario (Critical and Fragile ESAs with forest cover) and  $S_{CU}$  represents current scenario events (baseline) in the period. For this method, the higher the value of change (+ or -), the greater the difference in sediment yield and changes in hydrological processes between scenarios.

## III. RESULTS AND DISCUSSION

### 3.1. Model evaluation

The purpose of the model calibration is to better parameterize a model to a given set of local conditions, thus to improve the simulation accuracy. Model validation is to check whether the model can predict flow for another range of time periods or conditions than those for which the model was calibrated (Li et al., 2015).

From the definition of the parameters to be calibrated and validated, SWAT-CUP defines the parameters most

sensitive. It required 4 iterations of 500 simulations each to achieve the final optimization. The most sensitive parameters were SOL\_AWC, CN2, SOL\_K and ALPHA\_BF (Table 2). Unlike studies of Strauch et al. (2012, 2013) for another Brazilian watershed, CN2 was not the most sensitive parameter. In the Pinhal watershed predominates Oxisol soil (72%) that has high permeability and, therefore, the sensitive parameters were those related to soil (SOL\_AWC, SOL\_K, ESCO) and groundwater (ALPHA\_BF, GW\_DELAY). These fitted values were used to adjust the model inputs for the scenario's simulation.

The Fig. 3 shows the monthly streamflow simulated and observed data in the calibration (2012-2013) and validation (2014) period. The graphic shows a pattern of variation similar between simulated and observed. The peak streamflow reflected the greatest precipitation events, but the base streamflow simulated were underestimated when the rainfall volume decreased. The NSE was 0.90 for calibration and 0.88 for validation period. Validation at the Pinhal watershed also indicates a good performance of the model. NSE values between 0.7 and 1 indicate a very good performance of the model Moriasi et al (2007).

As for the PBIAS result for the flow values, the model underestimated the flows by 3.1% in the calibration and 3.8% in the validation.  $PBIAS \leq \pm 10$  indicates a very good accuracy of the model (Van Liew et al., 2007). These results show that the model after calibration and validation can accurately simulate the sediment yield and hydrological processes in the Pinhal watershed for two scenarios.

Table 2. Parameters used in the sensitivity analysis.

Parameters	Sensitivity	t-Stat	P-Value	Fitted Value
R__SOL_AWC	1	8.35	0.00	-0.01
R__CN2	2	6.45	0.00	0.03
R__SOL_K	3	-3.45	0.00	-0.10
V__ALPHA_BF	4	1.74	0.08	1.00
V__EPCO	5	-1.20	0.23	0.81
V__GW_DELAY	6	-1.06	0.29	47.06
V__ESCO	7	-1.00	0.32	0.12
V__CH_K2	8	-0.90	0.37	110.94
R__SOL_ALB	9	0.73	0.46	0.14
R__SLSUBBSN	10	-0.72	0.47	0.35
V__CH_N2	11	0.63	0.53	0.13
V__GWQMN	12	-0.60	0.55	4816.90
V__REVAPMN	13	0.45	0.65	295.98
V__GW_REVAP	14	-0.44	0.66	0.05
V__SURLAG	15	-0.20	0.84	0.38
V__CANMX	16	0.03	0.98	8.14

Parameter definitions: **SOL\_AWC**: Available water capacity of the soil layer; **CN2**: Initial SCS runoff curve number for moisture condition II; **SOL\_K**: Saturated hydraulic conductivity of soil layer; **ALPHA\_BF**: Baseflow alpha factor; **EPCO**: Plant uptake compensation factor; **GW\_DELAY**: Groundwater delay; **ESCO**: Soil evaporation compensation factor; **CH\_K2**: Effective hydraulic conductivity in main channel alluvium; **SOL\_ALB**: Moist soil albedo of soil layer; **SLSUBBSN**: Average slope length; **CH\_N2**: Manning's "n" value for the main channel; **GWQMN**: Threshold depth of water in the shallow aquifer for return flow to occur; **REVAPMN**: Groundwater "revap" coefficient; **GW\_REVAP**: Groundwater "revap" coefficient; **SURLAG**: Surface runoff lag time; **CANMX**: Maximum canopy storage. R\_\_: the parameter was adjusted by multiplying by the existing value; V\_\_: existing parameter value was replaced by the new value.

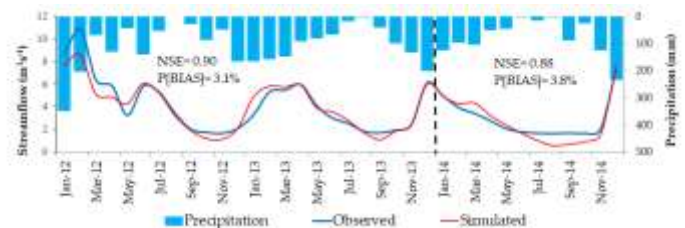


Fig. 3. Comparison of the observed and simulated streamflow in the Pinhal watershed. The calibration period was done in the years of the 2012-2013 and validation was done in the year of 2014.

### 3.2. Environmentally Sensitive Areas (ESAs)

ESAs identified in the Pinhal watershed are shown in Fig. 4. 16% of the watershed area is degraded due to improper land use. These areas are severely eroded and have high rates of surface runoff and soil loss (Adami et al., 2012). In this case, there may be higher peak streamflow and sedimentation of water bodies (Critical ESAs). In 25% of the area, we have identified regions where any change in the delicate balance between the environment and human activities may result in environmental degradation of the ecosystem (Fragile ESAs). 54% of the total watershed area is classified as Potential ESAs. Agricultural activities in these areas although following land use capability standards and requiring simple soil conservation practices to control erosion, care in the use of pesticides in sugarcane and citrus crops.

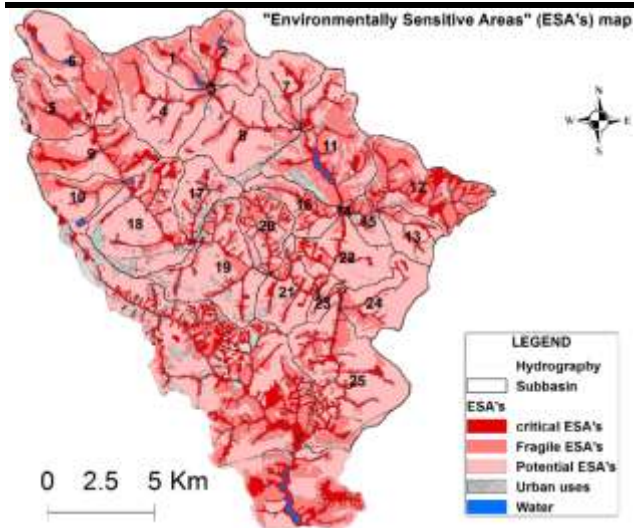


Fig. 4. ESAs (Environmentally Sensitive Areas) Map in the Pinhal watershed. 16% of the watershed area is critical ESAs and 25% is Fragile ESAs.

### 3.3. Land use change between scenarios

In this study, two different land use change scenarios, current and ESAs' scenarios were established to assess the impacts of the land use/cover change in the sediment yield and on hydrological processes.

Fig. 5 presents the land use map for the two scenarios and Table 3, the total and relative areas of occupation of each land cover in the Pinhal watershed for the current use scenario (baseline) and for the scenario of ESAs recomposed with forest vegetation. From the current scenario to the ESAs' scenario, there is a reduction of areas occupied with sugarcane, citrus and pasture and, consequently, an increase of areas occupied with forest vegetation. Sugarcane occupied the largest area in the watershed and in the ESAs' scenario; there was a reduction of 46.30% in this area. Orange occupies the second largest area in the current use scenario and in the new scenario, it was reduced by 18.8%, whereas pasture was reduced by 44.43%. The area for other uses has been reduced by 42.61%. Some subbasins increased forest cover compared to others: subbasins number 11, 12, 13, 14, 15 and 16.

Table 3. Land use and occupation change between the two scenarios (current use and ESAs) in the Pinhal watershed.

Land-use	Current use		ESAs scenario		Change	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Sugarcane	12566	42.2	6748	22.7	-5818	-46.30
Orange	8866	29.8	7199	24.2	-1667	-18.80
Pasture	2341	7.9	1301	4.4	-1040	-44.43
Forest	2662	8.9	12609	42.4	9947	373.67

Other uses	3337	11.2	1915	6.4	-1422	-42.61
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We present in Fig. 6 the variation of land use change in subbasins scale between the two scenarios. The decrease in pasture and sugarcane areas, where soils are exposed to erosion during soil management, and the increase of forest vegetation area, which would exert significant impacts in the sediment yield and on water yield in watershed.

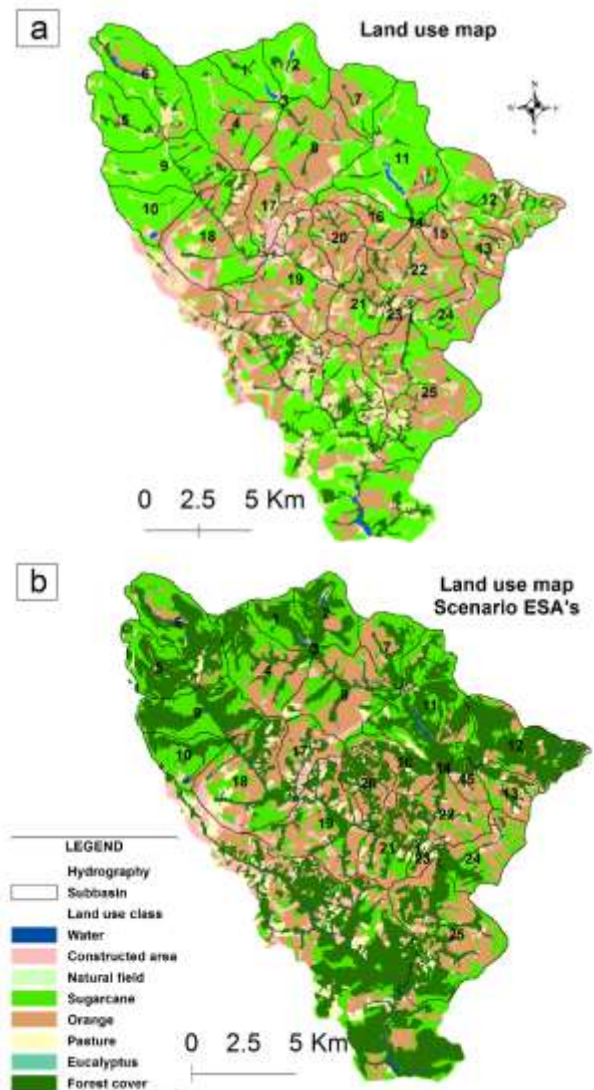
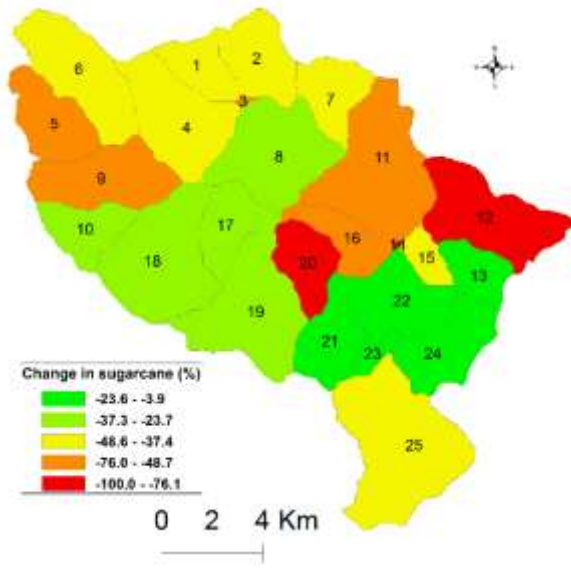
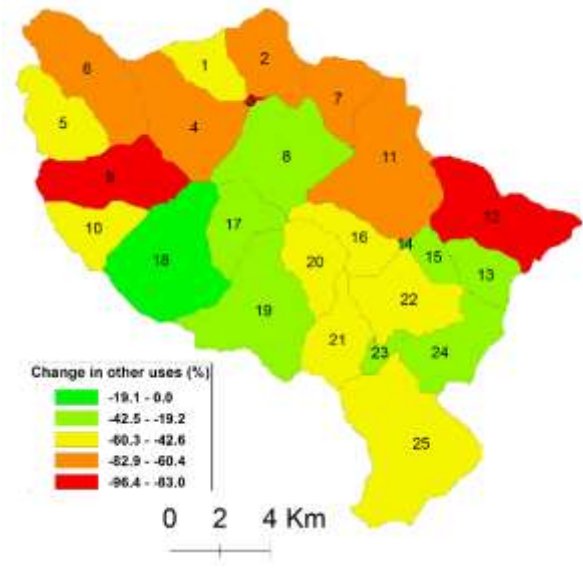


Fig. 5. Land use map: (a) current scenario and (b) ESAs' scenario - Critical and Fragile ESAs with forest cover overlapping current land use on the Pinhal watershed.

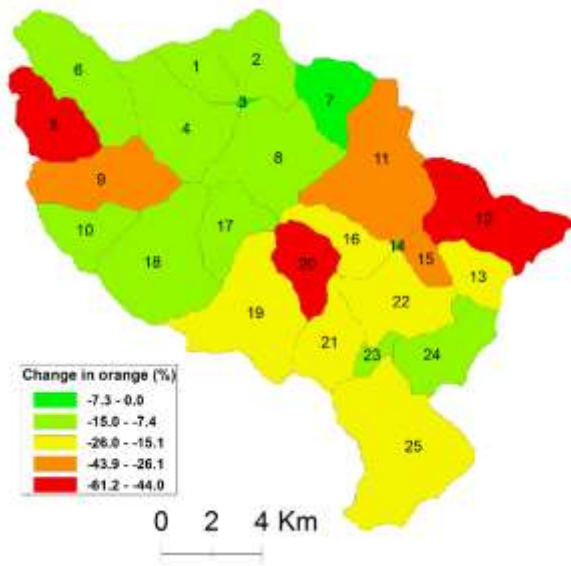




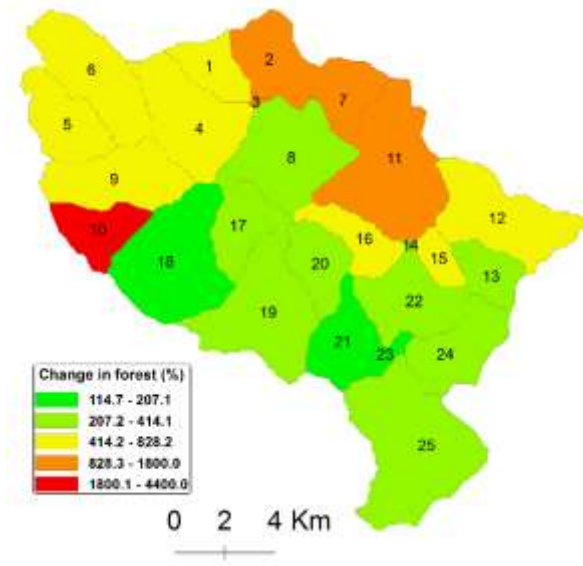
(a)



(d)

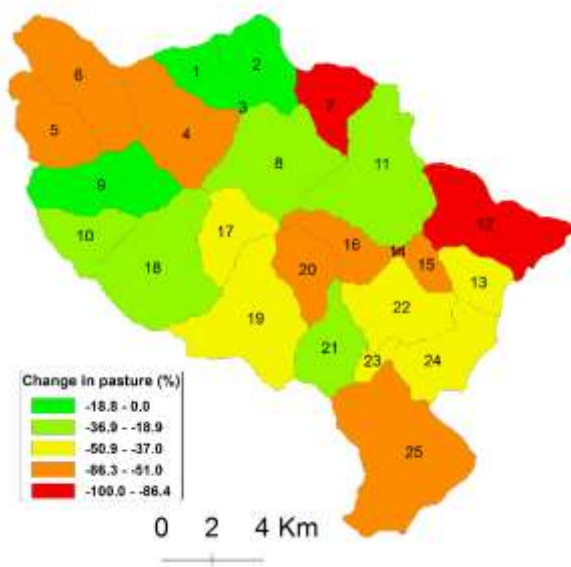


(b)



(e)

Fig. 6. Spatial variations of land use types at subbasins scale between two scenarios. (a) sugarcane; (b) orange; (c) pasture; (d) other uses; (e) forest.



(c)

### 3.4. . Sediment Yield

The results of the monthly sediment yield presented in Fig. 7 represent the erosion and sedimentation processes occurring throughout Pinhal watershed during the simulation period (2012 to 2014). With the scenario change, reduction in sediment yield was -54% (PBIAS) compared to the current use scenario. This reduction occurred mostly in subbasins located in leptosols and cambisols (Fig. 8). These are not deep soils. Cambisols in the watershed area occur in undulate relief. These are poorly developed soils, with incipient B horizon. One of cambisols' main features is their shallowness and often high content of gravel. High silt content and low depth are responsible for this low soil permeability (Teramoto, 1995). The biggest issue, however, is erosion risk. Cambisols have restrictions of agricultural use, for their

high erodibility, high risk of degradation and poor trafficability. These soils occupy 19% of the watershed's total area. In the current use scenario, 22.4% of this soil area is being occupied with forest vegetation. In the ESAs' scenario, this percentage increased to 68.3% (Table 4). Leptosols occupy approximately 4% of the watershed's total area and are located in areas of greater declivity. They are in a geomorphologically unstable zone in which erosion affects soil development, and they are constantly renewed through superficial erosion (Teramoto, 1995; Oliveira, 1999). Extensive areas are occupied with sugarcane, pasture and orange (62.3%) cultivation on these soils. In the current scenario, 24.3% of the leptosols is covered with forest vegetation. In the ESAs' scenario, this percentage is 95.7% (Table 4).

The climatological regime has significant importance in the sediment yield in area cultivated with sugarcane in southeast Brazil. It is harvested from May to November and its growth period (December and January) coincides with the beginning of the rainfall season. The pastures in Brazil are generally poorly managed and degraded. Increased forest vegetation on both soils explains the 54% reduction (PBIAS) in sediment yield in the watershed, when we compare the two scenarios. The spatial location of agricultural areas in relation to relief, soil and climate is important to control erosion in watersheds (Grunwald & Frede, 1999).



Fig. 7. Monthly Sediment yield between the two scenarios on the Pinhal watershed in the 2012-2014 period.

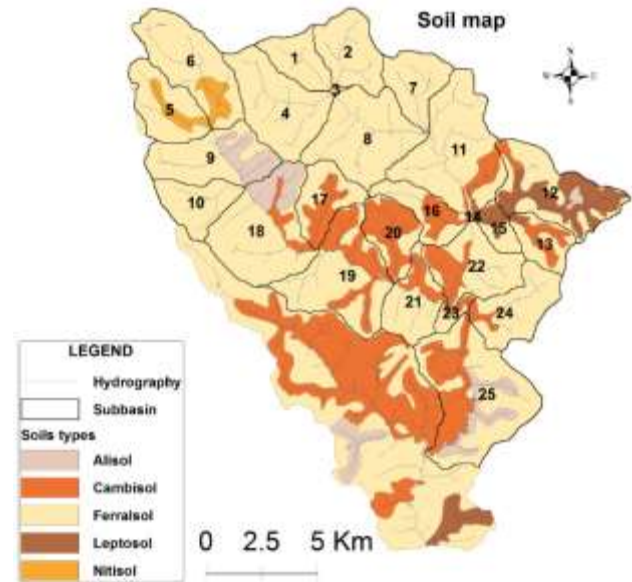


Fig. 8. Pinhal watershed's soil map (Source: Oliveira, 1999). Legend accord to WRB (World Reference Base for Soils Resources).

Table 4: Cross tab between scenarios and soils in the Pinhal watershed.

Land use type	Cambisols				Leptosols			
	Current use		ESAs scenario		Current use		ESAs scenario	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
<b>Forest</b>	1278	22.4	3894	68.3	275	24.3	1089	95.7
<b>Pasture</b>	947	16.6	399	7.0	169	14.9	10	0.9
<b>Sugarcane</b>	997	17.5	142	2.5	350	30.9	8	0.7
<b>Other uses</b>	2476	43.5	1263	22.2	339	29.9	31	2.7
<b>Total</b>	5698	100	5698	100	1138	100	1138	100

Spatially analysis of sediment yield for 25 subbasins in the current use scenario showed a maximum of 80.2 t/ha, with an average of 14.6 t/ha (Fig. 9). Maximum sediment yield occurred in the upper Pinhal watershed, a more degraded area, whereas in the subbasins in the lower Pinhal watershed aggradation occurs, with lower sediment yield values. In the ESAs' scenario, replacement with forest vegetation in Environmentally Sensitive Areas lead to an average sediment yield of 5.2 t/ha per year, with a maximum of 14.2 t/ha. Average soil loss in subbasins was near tolerable soil loss rates, which according to Leinz & Leonardos (1977) is 7.9 ton/ha for alisols and 4.2 tons/ha

for leptosol. According to Fig. 5, the lowest rates of sediment yield occurred in subbasins with greater forest cover. As the SWAT model simulates many processes in the watershed, some parameters may affect several processes (Arnold et al., 2012). With reduction of surface runoff in -45.8% (PBIAS) between scenarios (Table 5) due to greater soil protection, sediment yield has also been directly affected. Sediment yield change between the two scenarios is presented in Fig. 10. This difference is greater in upstream subbasins and in those with greater forest cover (subbasins 11, 14, 15 and 16), according to Fig. 5b.

### 3.5. Hydrological processes

It is widely reported that land use and cover changes can affect the quantity and quality of water resources of a watershed. We analyzed the surface runoff (mm), water yield (mm), evapotranspiration (mm) and soil water content (mm) data to evaluate the impact of these changes on the watershed's hydrological processes. The results showed that the effects of land use/cover change on hydrological processes varied with the seasons and precipitation, and the variation trend was similar to that of the precipitation (Fig. 11).

Monthly values for the 2012-2014 period were then compared between the two scenarios and the results showed increased forest cover in the watershed (+373.67%), decreased surface runoff (SR), soil water content (SW), water yield (WY) and increased evapotranspiration (ET) (Table 5). As shown in Fig. 11b, surface runoff reduced most significantly in wet season (October to March), when the precipitation is much more intensive. As both surface runoff and baseflow are the main components that contribute to water yield, we expected greater infiltration rate in the ESAs' scenario. Higher infiltration rate will increase baseflow, because in this scenario, areas previously occupied with other land uses were now occupied with forest. Infiltration rate in forest areas is greater than in other land covers, e.g., sugarcane and pasture areas (Liu et al., 2013). On the other hand, forest evapotranspiration will consume more water (Zhang et al., 2016; Morán-Tejeda et al., 2012) (change of evapotranspiration equal to +3.5%), because it is known that the forest is the surface with highest rates of evapotranspiration, higher than all the other vegetation types and also higher than a liquid's surface (Birkinshaw et al., 2011). Roots, especially of larger trees, increase water absorption from the baseflow and, consequently, decrease water yield in the watershed, as the water content in the soil decreased in the studied period (-14.1%). Studies conducted by Huang et al. (2003), Zhang et al. (2008), Cui et al. (2012) showed that the increased forest cover in watersheds decreased water yield. Differently, with the scenario change, this type of land cover provides greater resistance to surface runoff and, consequently, this component had a lower contribution to water yield in the watershed (-19.3%).

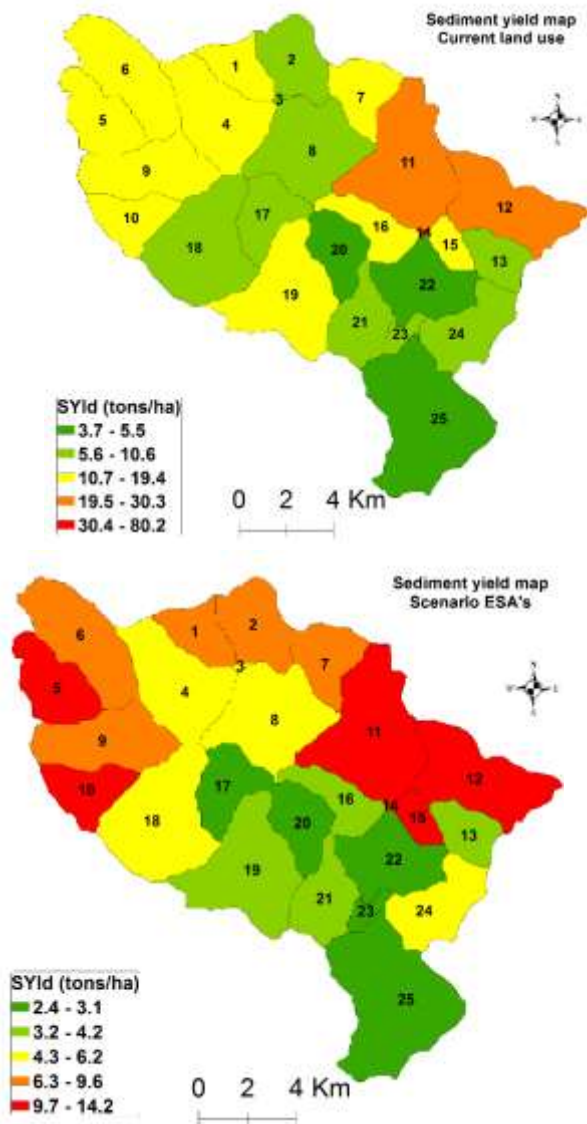


Fig. 9. Spatial distribution of average annual sediment yield at subbasins scale for the two scenarios: current and ESAs.

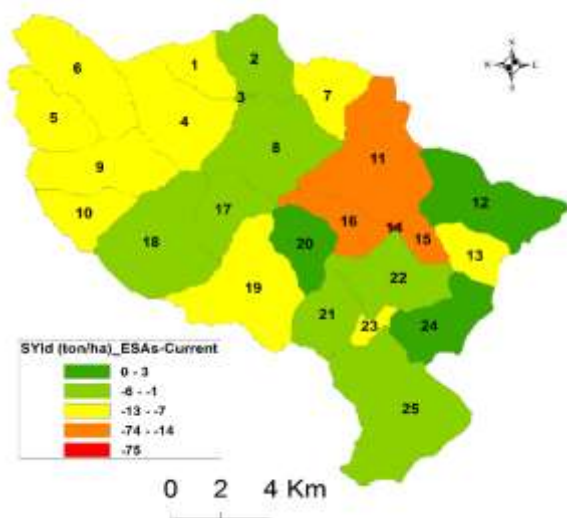


Fig. 10. Percent changes  $((SESA-Scu)/Scu \times 100)$  of average annual sediment yield at subbasins scale between the two scenarios.

Table 5. Change of hydrological variables analyzed between the two scenarios (current use and ESAs) in the Pinhal watershed (2012-2014).

Variable	Current use	ESAs scenario	Change (%)	Change wet season (%)	Change dry season (%)
Surface runoff (mm)	570.4	309.1	-45.8	-44.0	-52.3
Evapotranspiration (mm)	1993.2	2062.3	+3.5	+1.3	+8.2
Soil water content (mm)	8279.8	7113.5	-14.1	-13.3	-14.9
Water yield (mm)	1471.4	1187.9	-19.3	-22.3	-14.7

We too analyzed the influence of land use change in the hydrological processes in the wet and dry seasons. Comparing evapotranspiration demand in the wet season (October to March) and dry period (April to September), the change between the two scenarios is even greater (Table 5, Fig. 12). The change was +1.3% (wet season). In the wet season, the available water in the soil (Table 5, Fig. 13a) compensates the increased evapotranspiration demand of vegetation, even with increased forest cover (ESAs' scenario). In the dry period, when soil water content is lower, change between scenarios was bigger (-14.9%) (Table 5, Fig. 13b). Change between scenarios for the evapotranspiration too was bigger (+8.2%, Table 5). Forest vegetation access more easily underground water than small-sized vegetation, having, therefore, greater evapotranspiration demand and reducing water yield in the watershed. Based on results obtained from more than 90 experimental catchment in different parts of the world, Bosch & Hewlett (1982) asserted that deforestation decreases evapotranspiration, which results in more water available in the soil and in streamflow. On the other hand, reforestation decreases streamflow at watershed scale. It is worth mentioning, however, that these results vary from place to place and are often unpredictable (Brown et al., 2005).

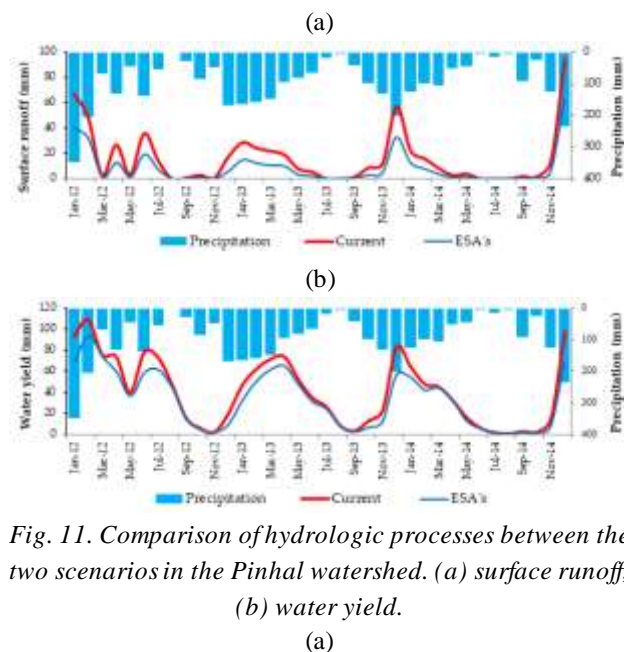
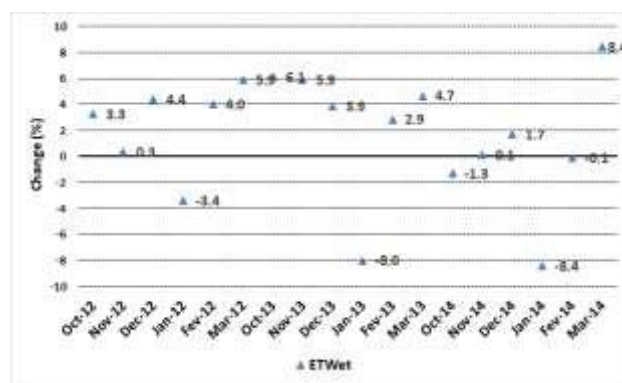


Fig. 11. Comparison of hydrologic processes between the two scenarios in the Pinhal watershed. (a) surface runoff; (b) water yield.



(b)

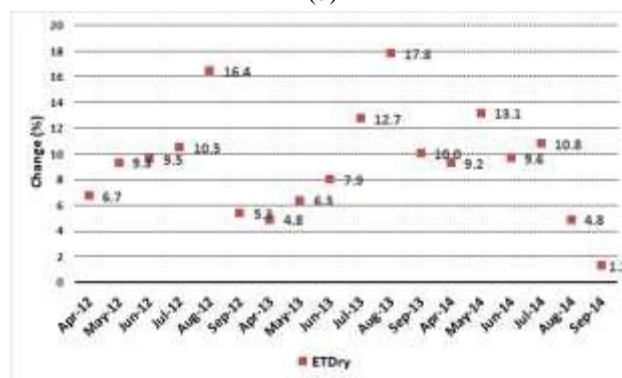
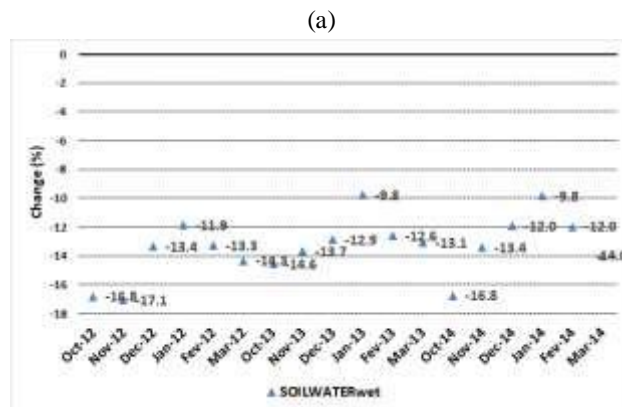


Fig. 12. Percent changes  $((S_{ESA}-S_{Cu})/S_{Cu} \times 100)$  of evapotranspiration in the wet season (a) (ETWet - October to March) and dry season (b) (ETDry - April to September) for land use change scenarios in the 2012-2014 period.



(b)

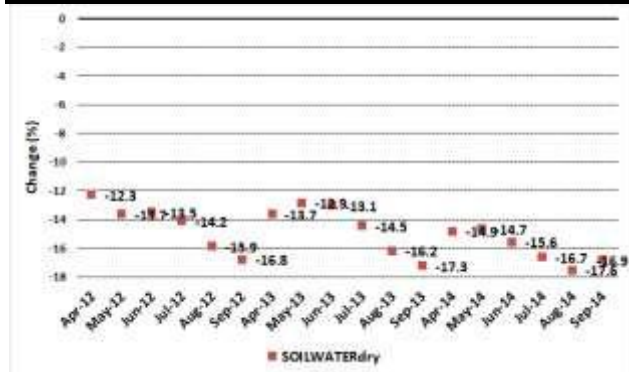
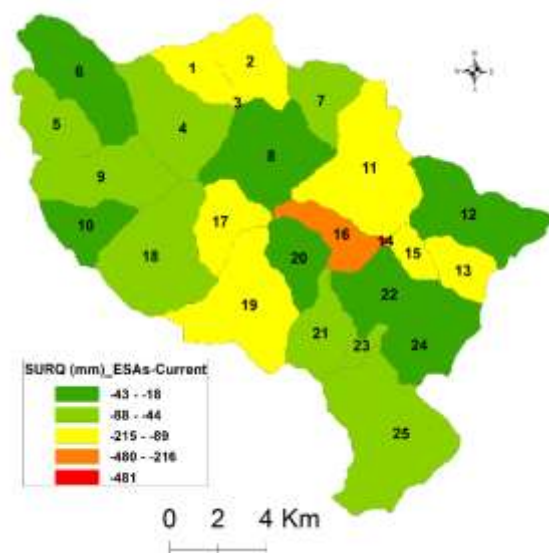


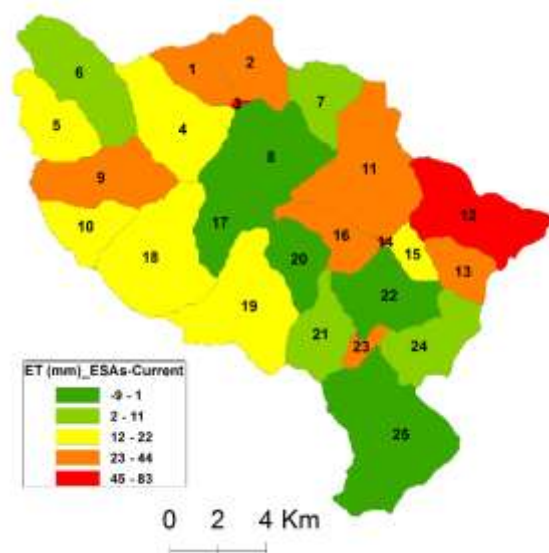
Fig. 13. Percent changes  $((S_{ESA}-S_{cu})/S_{cu} \times 100)$  in the soil water content between wet season (a) (SOILWATERwet - October to March) and dry season (b) (SOILWATERdry - April to September) for land use change scenarios in the 2012-2014 period.

Fig. 14 shows the change in mean annual hydrological processes (surface runoff, evapotranspiration, soil water content and water yields) at subbasins scale between scenarios. The percentage changes caused by land use changes range from -481% to 43%, from -9% to 83%, from -200% to -1% and from -412% to -8%, respectively. The influence of land-use change (Fig. 5) on the hydrological process is more visible in some of the subbasins than others. The dominant hydrological processes and associated drivers are variable across spatial scales (Zhang et al., 2017). Bigger variations occurred in subbasins with greater forest cover when compared the current scenario with the ESAs' scenario. The subbasins 11, 13, 14, 15 and 16, undergoes more pronounced hydrological processes variations than the other. In these subbasins undergoes more significant changes in land use between scenarios. At subbasin 12, change of land use was biggest (Fig. 5). Consequently, evapotranspiration change between scenarios was also higher (Fig. 14b). In this subbasin prevails leptosol soil (Fig. 8). It's shallow soil, with low water storage capacity. Therefore, the change in soil water content was not as pronounced as in the other subbasins with more significant changes in land use between scenarios (Fig. 14c).

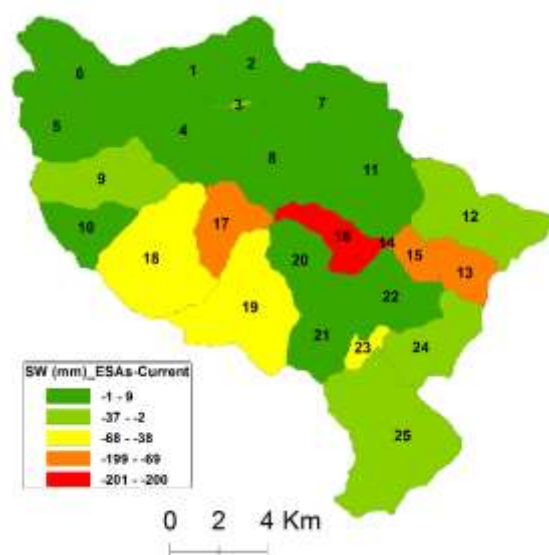
According to Andreassian (2004), watersheds' hydrological processes is the result of complex interactions between climate (wet versus dry years), plants' physiological properties (e.g., leaf area and successional stages) and soil type. These and other factors together make hydrological effects of forests a markedly different scenario Singh & Mishra (2012).



(a)



(b)



(c)

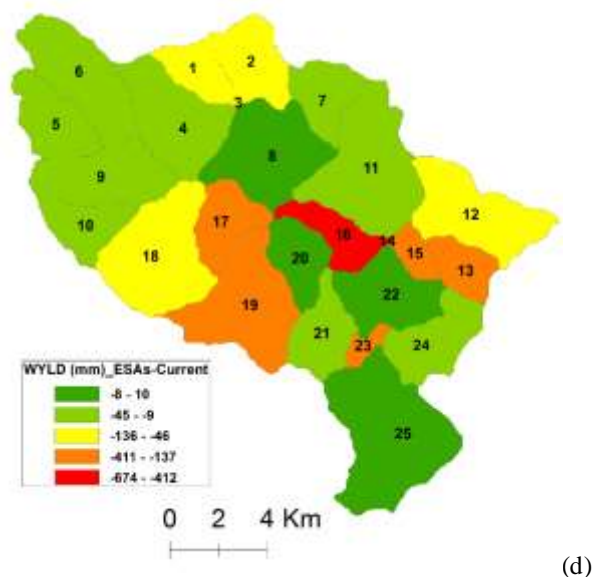


Fig. 14. Spatial change  $((S_{ESA}-S_{cu})/S_{cu} \times 100)$  of the hydrological processes at subbasins between the two scenarios. (a) SURQ (surface runoff - mm); (b) ET (evapotranspiration - mm); (c) SW (soil water content - mm); (d) WYLD (water yield - mm).

#### IV. CONCLUSION

In this study, the ecohydrological SWAT model was used to simulate land use change scenarios and comparing them regarding sediment yield and hydrological processes. The performance of the model for the simulation of the streamflow was very good, indicating that the model was able to represent the hydrological processes of the basin under study, and can be used in scenarios analysis. Although reducing sediment yield from the simulation of land use change for the forest (PBIAS = -54%), for it offers the soil greater protection, its influence on increasing and maintaining streamflow is questionable, because the results obtained from this study also showed that increased forest cover decreased water yield in the watershed in -19.3% (PBIAS) due mostly to its greater evapotranspiration capacity (+3.5%). This demand being even greater during the dry season. Simulation results lead us to conclude that the impacts of land use change on hydrological processes are complex and their consequences are not equal in the subbasins with the same intensity. Thus, its application can help to determine the policies for land use at the Pinhal watershed, and for the management of water resources in the region. However, the hydrological responses to forest cover change between large and small watersheds can be quite different.

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#### REFERENCES

- [1] Abbaspour, K. C.; Yang J.; Maximov, I.; Siber, R.; Bogner, K.; Mieleitner, J.; Zobrist, J.; Srinivasan, R. 2007. Modelling hydrology and water quality in the pre-alpine/alpine Thur watershed using SWAT. *J. Hydrol.*, 2007, 333(2-4), 413-430.
- [2] Abbaspour, K.C.; Rouholahnejad, E.; Vaghefi, S.; Srinivasan, R.; Yang, H.; Kløve, B. A continental-scale hydrology and water quality model for Europe: Calibration and uncertainty of a high-resolution largescale SWAT model. *J. Hydrol.*, 2015, v. 524, n. 5, p. 733-752. <https://doi.org/10.1016/j.jhydrol.2015.03.027>
- [3] Adami, S. F.; Coelho, R. M.; Chiba, M. K.; Moraes, J. F. L. Environmental fragility and susceptibility mapping using geographic information systems: applications on Pinhal watershed (Limeira, State of São Paulo). *Acta Scientiarum Tech.*, 2012, 34, 433-440.
- [4] Andreassian, V. Waters and forests: from historical controversy to scientific debate. *J. Hydrol.*, 2004, 291, 1-27.
- [5] Arnold, J.G., Moriasi, D.N., Gassman, P.W., Abbaspour, K.C., White, M.J., Srinivasan, R., Santhi, C., Harmel, R.D., Van Griensven, A., Van Liew, M.W., Kannan, N., Jha, M.K. SWAT: model use, calibration, and validation. *Trans. ASABE*, 2012, 55 (4), 1491-1508.
- [6] Arnold, J.G., Srinivasan, R., Muttiah, R.S., Williams, J.R., 1998. Large area hydrologic modelling and assessment part I: model development. *J. Am. Water Resour. Assoc.* 34 (1), 73-89.
- [7] Bart, R.; Hope, A. Streamflow response to fire in large catchments of a Mediterranean-climate region using paired-catchment experiments. *J. Hydrol.*, 2010, 388 (3-4), 370-378, <http://dx.doi.org/10.1016/j.jhydrol.2010.05.016>.
- [8] Best A., Zhang, L., McMahon T., Western, A., Vertessy R. 2003. A critical review of paired catchment studies with reference to seasonal flow and climatic variability. Australia, CSIRO Land and Water Technical. MDBC Publication, 2003, 56 p. (*Technical Report 25/03*).
- [9] Birkinshaw, S. J.; Bathurst, J. C.; Iroumé, A.; Palacios, H. The effect of forest cover on peak flow and sediment discharge—an integrated field and modelling study in central-southern Chile. *Hydrol. Process.*, 2011, 25, 1284-1297.

- [10] Bosch, J.M.; Hewlett, J.D. A review of catchment experiments to determine the effect of vegetation changes on water yield and evapotranspiration. *J. Hydrol.*, 1982, 55 (1/4), 3-23.
- [11] Brown, A. E.; Zhang B., L.; McMahon, T. A. Western, A. W.; Vertessy, R. A. A review of paired catchment studies for determining changes in water yield resulting from alterations in vegetation. *J. Hydrol.*, 2005, 310, 28-61, <https://doi.org/10.1016/j.jhydrol.2004.12.010>
- [12] Bruijnzeel, L.A. Hydrological functions of tropical forests: not seeing the soil for the trees? *Agri., Ecos. and Envir.*, 2004, 104, 185-228.
- [13] Bruijnzeel, L.A. Hydrology of Moist Tropical Forests and Effects of Conversion: a State of Knowledge Review. Humid Tropics Programme, IHP-UNESCO, Paris, and Vrije Universiteit, Amsterdam, 1990, 224 pp.
- [14] Buytaert, W.; Céleri, R.; De Bièvre, B., Cisneros, F.; Wyseure, G.; Deckers, J.; Hofstede, R. Human impact on the hydrology of the Andean páramos. *Earth-Science Reviews*, 2006, 79 53-72.
- [15] Cosandey, C. La forêt réduit-elle l'écoulement annuel? *Annales de Géographie*, 1995, 581-582, 7-25.
- [16] Cui, X.; Liu, S.; Wei, X. Impacts of forest changes on hydrology: a case study of large watersheds in the upper reaches of Minjiang River watershed in China. *Hydrol. Earth Syst. Sci.*, 2012, 16, 4279-4290.
- [17] Dechmi, F.; Skhiri, A. Evaluation of best management practices under intensive irrigation using SWAT model. *Agric. Water Manag.*, 2013, vol. 123, issue C, pages 55-64.
- [18] Giri, S.; Arbab, N. N.; Lathrop, R. G. Water security assessment of current and future scenarios through an integrated modeling framework in the Neshanic River Watershed. *J. Hydrol.*, 2018, 563, 1025-1041. <https://doi.org/10.1016/j.jhydrol.2018.05.046>
- [19] Gourlay, D.; Slee, B. Public preferences for landscape features: a case study of two Scottish environmental sensitive areas. *J. Rural Studies*, 1998, 14, 2, 249-263.
- [20] Grunwald, S. & Frede, H.G. Using the modified agricultural non-point source pollution model in German watersheds. *Catena*, 1999, 37:319-328.
- [21] Gupta, H.V., Sorooshian, S., & Yapo, P.O. Status of automatic calibration for hydrologic models: Comparison with multilevel expert calibration. *J. Hydrol. Eng.*, 1999, 4(2), 135-143. DOI: 10.1061/(ASCE)1084-0699.
- [22] Huang, M.; Zhang, L.; Gallichand, J. Runoff responses to afforestation in a watershed of the Loess Plateau, China. *Hydrol. Process.*, 2003, 17, 2599-2609.
- [23] Koch, F.J.; Van Griensven, A.; Uhlenbrook, S.; Tekleab, S.; Teferi, E. The Effects of Land use Change on Hydrological Responses in the Choke Mountain Range (Ethiopia) - A new Approach Addressing Land Use Dynamics in the Model SWAT. International Environmental Modelling and Software Society (iEMSs) 2012. International Congress on Environmental Modelling and Software Managing Resources of a Limited Planet, Sixth Biennial Meeting, Leipzig, Germany, 2012.
- [24] Kuwajima, J.I.; Arantes, D.M.; Estigoni, M.V.; Mauad, F.F. Proposta da aplicação do modelo SWAT como ferramenta complementar de gerenciamento de recursos hídricos e estimativa de assoreamento em reservatórios. In: XIV World Water Congress, 2011, Porto de Galinhas, PE, Brazil, 2011. Adaptive Water Management: Looking to the future, p. 134-134. (In Portuguese)
- [25] Leinz, V.; Leonardos, O. H. Glossário geológico. 2. ed. São Paulo: Companhia Editora Nacional, 1977. 236p. (In Portuguese)
- [26] Lessa, L.G.F.; Silva, A.F.; Zimback, C.R.L.; Machado, R.E.; Lima, S.L. Spatial distribution of sediment and water yield, applying geostatistical tools. *J. Envir. Sci. and Water Res.*, 2014, 3(3), 32-39.
- [27] Li, Z.; Deng, X.; Wu, F.; Hasan, S. S. Scenario Analysis for Water Resources in Response to Land Use Change in the Middle and Upper Reaches of the Heihe River Basin. *Sustainability*, 2015, 7, 3086-3108, doi:10.3390/su7033086.
- [28] Lima, W.P.; Ferraz, S.F. B.; Rodrigues, C.B.; Voigtlander, M. Assessing the Hydrological Effects of Forest Plantations in Brazil. In: Philip J. Boon; Paul J. Raven. (Org.). *River Conservation and Management*. West Sussex: John Wiley & Sons, Ltd, 2012, v. 1, p. 57-66, Online ISBN:9781119961819.
- [29] Lin, B.; Chen, X.; Yao, H.; Chen, Y.; Liu, M.; Gao, L.; James, A. Analyses of land use change impacts on catchment runoff using different time indicators based on SWAT model. *Ecol. Indic.*, 2015, 58, 55-63.
- [30] Liu, Y., Yang, W., Yu, Z., Lung, I., & Gharabaghi, B. Estimating sediment yield from upland and channel Erosion at a watershed scale using SWAT. *Water Res. Manag.*, 2015, 29, Issue 5, 1399-1412.
- [31] Liu, Z.; Lang, N.; Wang, K. Infiltration Characteristics under Different Land Uses in Yuanmou Dry-Hot Valley Area. In Proceedings of the 2nd International Conference on Green Communications and Networks 2012 (GCN 2012): Volume 1; Yang, Y., Ma, M., Eds.; Springer: Berlin, Germany, 2013; 223, 567-572.
- [32] Machado, R.E.; Vettorazzi, C.A. Sediment yield simulation for the Marins watershed, State of São

- Paulo, Brazil. *Rev. Bras. Ciênc. Solo* [online], 2003, v.27, n.4, 735-741. ISSN 1806-9657. (In Portuguese)
- [33] Machado, R.E.; Vettorazzi, C.A.; Cruciani, D.E. Simulação de Escoamento em uma Microbacia Hidrográfica utilizando Técnicas de Modelagem e Geoprocessamento. *Rev. Bras. de Rec. Híd.*, 2003, v.8, n.1, p. 147-155. (In Portuguese)
- [34] Molin, P.G. Dynamic modeling of native vegetation in the Piracicaba River basin and its effects on ecosystem services. Ph.D. Thesis, ESALQ/USP, Piracicaba, Brazil, 2014.
- [35] Morán-Tejeda E, Ceballos-Barbancho A, Llorente-Pinto JM, López-Moreno JI. Land-cover changes and recent hydrological evolution in the Duero Basin (Spain). *Reg. Environ. Change*. 2012, 12(1), 17-33. doi: 10.1007/s10113-011-0236-7
- [36] Moriasi, D.N.; Arnold, J.G.; Van Liew, M.W.; Bingner, R.L.; Harmel, R.D.; Veith, T.L. Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. *Trans. ASABE*, 2007, 50, 3, 885-900.
- [37] Mutenyo I, Nejadhashemi AP, Woznicki AS, Giri S. Evaluation of Swat Performance on a Mountainous Watershed in Tropical Africa. *Hydrol Current Res*, 2013, S14:001. doi: 10.4172/2157-7587.S14-001
- [38] Ndubisi, F.; De Meo, T.; Ditto, N.D. Environmentally sensitive area: a template for developing greenway corridors. *Lands. Urb. Plann.*, 1995, 33, 159-177.
- [39] Oliveira, J. B. Solos da folha de Piracicaba. Campinas, Instituto Agrônomo, 1999. 173p. (Boletim Científico, 48). (In Portuguese)
- [40] Peterson, J.R.; Hamlett, J.M. Hydrologic calibration of the SWAT model in a watershed containing fragipan soils. *J. Amer. Water Resour. Assoc.*, 1998, v.34, n.3, p.531-544.
- [41] Rocha, J.; Roebeling, P.; Rial-Rivas, M.E. Assessing the impacts of sustainable agricultural practices for water quality improvements in the Vouga catchment (Portugal) using the SWAT model. *Sci. Total Environ.*, 2015, 536, 48-58, <http://dx.doi.org/10.1016/j.scitotenv.2015.07.038>.
- [42] Rodríguez-Martínez, J.; Santiago, M. The effects of forest cover on base flow of streams in the mountainous interior of Puerto Rico, U.S. Geological Survey Scientific Investigations Report, 2017, 2016-5142, 19 p., <https://doi.org/10.3133/sir20165142>.
- [43] Rubio, J.L. Desertification: evolution of a concept. In: Fantechi, R.; Peter, D.; Balabanis, P.; Rubio, J.L. (Eds.) EUR 15415 Desertification in a European Physical and Socio-economic Aspects, Brussels, Luxembourg. Office Publications of the European Communities, 1995, 5-13.
- [44] Sajikumar N.; Remya R. S. Impact of land cover and land use change on runoff characteristics. *J. of Envir. Manag.*, 161 (2015) 460-468.
- [45] Singh, S. & Mishra, A. Spatiotemporal analysis of the effects of forest covers on water yield in the Western Ghats of peninsular India. *J. Hydrol.*, 2012, 446-447, 24-34.
- [46] Strauch, M.; Bernhofer, C.; Koide, S.; Volk, M.; Lorz, C.; Makeschin, F. Using precipitation data ensemble for uncertainty analysis in SWAT streamflow simulation. *J. Hydrol.*, 2012, 414, 413-424.
- [47] Strauch, M.; Lima, J. E.; Volk, M.; Lorz, C.; Makeschin, F. The impact of Best Management Practices on simulated streamflow and sediment load in a Central Brazilian catchment. *J. Environ. Manag.*, 2013, 127, S24-S36.
- [48] Sun, G.; Zhou, G.; Zhang, Z.; Wei, X.; McNulty, S.G.; Vose, J. Potential water yield reduction due to forestation across China. *J. Hydrol.*, 2006, 328, 548-558.
- [49] Teramoto, E.R. Relações solo, substrato geológico e superfícies geomórficas na microbacia do ribeirão Marins. Master's Thesis, ESALQ/USP, Piracicaba, Brazil, 1995. (In Portuguese)
- [50] Tuo, Y.; Marcolini, G.; Disse, M.; Chiogna, G. A multi-objective approach to improve SWAT model calibration in alpine catchments. *J. Hydrol.*, 2018, 559, 347-360.
- [51] Van Liew, M.W.; Veith, T.L.; Bosch, D.D.; Arnold, J.G. Suitability of SWAT for the conservation effects assessment project: a comparison on USDA-ARS watersheds. *J. Hydrol. Res.*, 2007, 12(2), 173- 189.
- [52] Wang, Q.; Liu, R.; Men, C.; Guo, L.; Miao, Y. Effects of dynamic land use inputs on improvement of SWAT model performance and uncertainty analysis of outputs. *J. Hydrol.*, 2018, 563, 874-886.
- [53] Webb, A.A., Jarrett, B.W. Hydrological response to wildfire, integrated logging and dry mixed species eucalypt forest regeneration: The Yambulla experiment. *For. Ecol. Manage.*, 2013, 306, 107-117.
- [54] Wei, X.; Zhang, M. Quantifying streamflow change caused by forest disturbance at a large spatial scale: A single watershed study. *Water Resour. Res.*, 2010, 46, doi:10.1029/2010WR009250.
- [55] Zhang L, Nan Z, Yu W, Ge Y. Hydrological Responses to Land-Use Change Scenarios under Constant and Changed Climatic Conditions. *Environ. Manage.*, 2016; 57(2), 412-31. doi: 10.1007/s00267-015-0620-z PMID: 26429363
- [56] Zhang, M.; Liu, N.; Harper, R.; Li, Q.; Liu, K.; Wei, X.; Ning, D.; Hou, Y.; Liu, S. A global review on hydrological responses to forest change across multiple spatial scales: Importance of scale, climate,



- forest type and hydrological regime. *J. Hydrol.*, 2017, 546, 44-59.  
<https://doi.org/10.1016/j.jhydrol.2016.12.040>.
- [57] Zhang, P.; Liu, R.; Bao, Y.; Wang, J.; Yu, W.; Shen, Z. Uncertainty of SWAT model at different DEM resolutions in a large mountainous watershed. *Water Res.*, 2014, 53, 132-144  
<http://dx.doi.org/10.1016/j.watres.2014.01.018>.
- [58] Zhang, Y., Liu, S., Wei, X., Liu, J., And Zhang, G. Potential impact of afforestation on water yield in the subalpine region of Southwestern china, *J. Am. Water Resour. Assoc.*, 2008, 44, 1144-1153.