Physical-Chemical and Microbiological Evaluation from Domiciliary Reservoirs

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Abstract— *The main constituent of all living being is water, however the threats caused by the improper actions of human beings to this liquid of great importance evidence losses to the humanity, knowing soon the interference of several procedures applied on the water treatment and their influence on the final quality of the product, the present study was executed to verify the influence of the domestic reservoirs on the physical chemical and microbiological properties of the water used for human consumption in the city of Barra do Choça, by means of collections at strategic points for the accomplishment of the aforementioned analyzes, with emphasis on the detection of possible changes caused by incorrect storage. The physical and chemical parameters analyzed were: electrical conductivity, hydrogen potential (hP), turbidity, alkalinity, fluorine, iron and chlorine. The microorganisms analyzed were E. coli, fecal and total coliforms and heterotrophic, recommended by APHA based on the standard methods for the examination of (the) water and wastewater 22nd ed. The data obtained were compared to the values established by Ordinance No. 2914/11. Thus, a descriptive analysis was accomplished and the method of Cluster was applied, that shows an arrangement of the groups that have similarity and in the found results demonstrate discrepancy in the results of Fluorine and electrical conductivity, by having (tendo) as relevance that in the most of the applied parameters are within the accepted normality, in relation to microbiological analysis shows that 33% of the water in the reservoir is out of the standard and that in 50% of the reservoirs the contamination by heterotrophic bacterium, demonstrating that the reservoir without its correct applications is a deteriorating factor of water quality.*

Keywords— water quality, home reservoir, physical and chemical aspects, microbiological.

I. INTRODUCTION

Water is the most important substance in nature, depending on it all the forms of life, by being essential for the maintenance of life on earth. For a long time, it has been a key point of the main discussions related to its utilization and by being scarce (Cunha et al, 2010). We temporally understand that water is a colorless, tasteless and odorless liquid besides being the natural liquid that is most part of our daily lives.

For being a universal liquid, it has great importance for living beings, in this way the water needs to be potable and with sufficient quantity to meet the demand of the population (Pereira, 2010). Its properties are related to the crucial needs of the individuals, from the composition of liquids and tissues to the functions prosecuted in metabolic and reproductive activities (Silva et al, 2014).

However, the misuse of water as well as the population increase that according to UNESCO (2012) it is estimated that the world urban population will increase significantly from 3,4 to 6,3 billion people between 2009 and 2050 (Lopes et al, 2014) it has been allowing the reduction of available water resources, by resulting in shortage, since the most part of this good is improper for consumption, 95,1% is salt, 4,7% of glaciers and only 0,147% suitable for consumption (Navarr0 et al, 2014; Barreto &Bitar, 2011).

Moreover, accessible water for human consumption has been becoming inadequate due to pollution that is considered as any peculiar change that occurs in the environment that affects the existence of ecosystems. It occurs by anthropogenic pollution or by natural phenomena such as eruption and it presents a wide range of pollutants.

It is notorious the preoccupation of all countries related to the monitoring of the water destined to the consumption of the society seeking out its quality (Schwarzenbach, R. P. et al, 2010). For suppling the daily demand forwater reservoirs have been used, especially in urban areas due to the exchanges in its supply. It is worth pointing out that the reservoirs must ensure the quality of thedaily required water, but for this it is necessary sanitation with an appropriate frequency.

The absence of minimal care with hygiene and maintenance of specific containers, in other words, the lack of cleaning of the homereservoirsoffer risks to the health of the population, since diseases may be transmitted. In this direction, it is important to explain that the properties of water depend on the purpose to which it refers (Terpstra, P et al, 1998). Therefore, for the preservation of health, it is defined by the competent bodies parameters of potability. Such standards establish the elements that can be tolerated in public water supply as well as their limits. In Brazil, these standards were defined by the Ministry of Health through Ordinance nº 2914 of December 2011.

Some measures are essential to maintain water quality, among them the effectiveness of all phases of the water treatment stationby including the family reservation (Drewes, J. E, Fox P. 2000). By evidencing that all the care in the water distribution network for the achievement of aquality water will be insignificant if the product stock has been improperly executed.

Towards the imminent contamination of water by human waste (Mattioda et al., 2010/ SILVA. Et. al, 2010), the water quality monitoring is recommended through the use of microbiological variables that test the presence of total and fecal coliforms, Enteroccoci and Escherichia coli, as positive, it proves that the water is contaminated with feces and, consequentlyit indicates the probability of propagating waterborne diseases (Vasconcellos, 2006). Byemphasizing that considers the presence of Escherichiacoli an essential indicator for proofing impurities and recent pollution.

Physical and chemical analyzes allow to identify if the water is at ideal levels that are not harmful to the human health and the ecosystem. Through the resolutions and ordinances in force, it is possible to make the comparatives and determine if the samples collected are within the standards stipulated for good quality of water. All the collections are done by respecting analytical techniques of high precision and sensitivity (Parron, 2011).

For measuring the chemical and physical and microbiological characteristics of water, some methodologies elaborated by the American Public Health Association (APHA) are used. Thus, some parameters that determine its potability are required, such as turbidity, temperature, electrical conductivity, hP and dissolved oxygen (Ministry Of Health, 2006).

In order to evaluate the data, it has been useful multivariate statistics with the Analysis of Cluster, which are widely used in water quality monitoring data (Fernandes et al, 2010; Tanrived & Dermikiran et al, 2010; Guedes et al. This kind of analysis reduces the observational data and allows the interpretation of several components individually, because it may indicate associations between simples and / or variables, besides allowing the identification of possible factors and sources that have influenced the water system (Lopes et al, 2014; Bouzadeano et al, 2018; Palácio et al, 2011; Guedes et al, 2012; Varol et al, 2012).

In this sense, the purpose of this work is to evaluate the physical and chemical and microbiological parameters of domestic reservoirs of water have used for human consumption and the possible impacts on human health of the population of Barra do Choça – Ba.

II. METODOLOGY
PLACE OF STUDY

The research was conducted in the region of Barra do Choça, located in Bahia where the water is transferred from Serra Preta and Biquinha dam located in this city, by serving as a supply zone for other regions and, in general, for the supply of water for residential, agricultural and industrial uses, in which common activities related to human consumption are involved, such as, among others: consumption itself, use for hygiene and preparation of food after treatment.

TYPE OF STUDY

The methods to be used for the research project allow to evidence a qualitative and quantitative approach, whichsearchfor making a subjective analysis for a comprehension of the problem to be debated. By making use of a numerical presentation through statistical analysis through field research.

DATA COLLECTIONS

The collections consisted of a sampling of tap water in randomly selected houses in different

neighborhoods. The points of water collection were determined by the overlap of the city map of Barra do Choça with those ones of the water reservoirs presented by Embasa, the points were selected by taking into account the low and high distribution zones, the location of the treatment unit water and the interferences of the tubings in the quality of the water distributed. It sought the choice of 3 strategically located points, one in the near, intermediate and the other distant, in order to represent a significant sample of the water distributed to the population.

At each point, 6 samples were collected, 2 of each residence coming from the public faucet (Group 1 - control) and another from the faucet previously disinfected with alcohol 70% from the home reservoir (Group 2). The choice of residence has depended on its location and the existence of a home reservoir.

However, the samples destined to the studies for physical and chemical analysis were placed in polyethylene flasks with one liter and a half of capacity and for microbiological analysis in 100 ml plastic bottles properly sterilized and sealed with 0.1 ml of sodium

thiosulphate for neutralizing the residual chlorine present in the water, according to the literature, they were sealed and packed in styrofoam boxes and taken immediately to the FAINOR chemistry laboratory and the microbiological were taken to the UESB Control and Quality Laboratory. The methods (physical and chemical and microbiological) used in this work are all recommended by the American Public Health Association (Apha, 1998).

STUDY OF VARIABLES

Physical and chemical and microbiological determinations were performed because from the water conveyance and by following the assumptions of current legislation, such as Ordinance MS N°. 2,914 and MS Decree N°. 1,469, the water to be consumed cannot offer health risks, and it is necessary to perform procedures concerned to the quality monitoring thereby to ensure the necessary potability.

PHYSICAL AND CHEMICAL DETERMINATIONS

Table 1: Physical and chemical determinations and description of the method used.

Determination of hP	The h of the samples was determined by direct reading on a QUIMIS Q400AS benchtop hP meter.
Determination of turbidity	To determine the turbidity, a microprocessor turbidimeter Q279P from QUIMIS was used. Turbidity was obtained by direct reading in uT.
Determination of Alkalinity	The method used was titration with H2SO4 0,2 N and orange methyl as indicator and 1 drop of sodium thiosulfate to neutralize the chlorine.
Determination of fluorine content	The fluorine present in the samples was determined by the SPADNS method with the aid of a Colorimeter.
Determination of free and total residual chlorine content	Following literature data the analysis of free residual chlorine content was performed by reaction with orthotolidine and reading in portable colorimeter (DLH-2000, Dellab).
Determination of iron content	The iron content in the sample was determined by the ortho-phenanthroline method using a Colorimeter.

Source: Own research (2018/2019)

MICROBIOLOGICAL DETERMINATIONS

For determinations of the microbiological analyzes was based on the multitube method, a very useful technique to evaluate total and fecal coliforms and Escherichia coli, by being also known as Probable Number Method (Greghi, 2005; Rattiet al., 2011).

The technique is based on homogenizing aliquots of the product after its dilution and by transferring into test tubes containing lauryl tryptose culture medium and the inverted Durham tube, after that they are incubated, and thereafter, the positive tubes are identified by turbidity of the production of gas in the Durham tube, by the number of positive tubes in the used dilutions, the

NMP is determined, based on the statistical tables have known as the Hoskins table (Apha, 1998).

This method is widely used as a standard, since it is recommended by health surveillance, Funasa and other regulatory agencies. Therefore, the multiple tube method was done in two parts: firstly, a presumptive test in which the sample was used with lauryl tryptose broth, that is a rich and specific medium for bacterium of the coliform group that is able to cause a turbidity in the medium and by forming gases, which is easily detectable by the Durham tube within 24/48 hours by incubation for ± 35 ° C (Brazil, 2013; Rattiet al., 2011).

The second stage is realized a confirmatory test by using small amounts of the positive stocks Bile bright green stocks selective 2% for Escherichia coli, by being incubated at 44.5 ° C for 24 hours, by being the turbidity of the Escherichia broth coli in gas by forming tubes if positive for fecal coliforms.

The counting of heterotrophic bacteria was also performed because it is useful in assessing the integrity of the water distributionsystem and home reservoirs, however, it has transferred 1 ml of the sample to a petri dish, added the medium culture, homogenized the contents of the board in circular movements for 10 consecutive times, and after the solidification of the medium, it has incubated the board in an inverted position at 35 ºC, for 48 hours, after that performed the reading by making the counting of the colonies.

DATA ANALYSIS

For the interpretation of the research results, a qualitative and quantitative analysis was performed through a spreadsheet in Excel version 2016, in which a descriptive analysis (mean and standard deviation) of the physical and chemical variables was initially performed. Then, the Analisys of Cluster was performed in SPSS version 25, that is useful for verifying the similarities of the points, demonstrated through groupings in the dendrogram.

The Analisys of Cluster has the purpose of comparing results by joining homogeneous or heterogeneous groups by using for that classification criteria. It should be noted that several types of grouping methods are found in the literature and they are classified into hierarchical and nonhierarchical in what the researcher must determine which is the most appropriate to their design, since the different types of existing techniques direct to different solutions. (Ablbuquerque, M.A. et al., 2006).

For obtaining an agglomeration technique opts for a specific method. In this work the Ward method will be used for the hierarchical agglomeration that is characterized by stipulating a hierarchy or structure in a form of a tree, in which the results will gather by associations, by resulting in a graphic reproduction called dendrogram, in which the similar ones, according to the studied variables, are grouped together (entre si) (Seidel, E.J et al, 2008).

III. RESULTS AND DISCUSSION

Based on the statistical analysis performed, it is noted that there was considerable divergence among the three collection points delimited in the sector, and there is interference in the quality of the water from the water pipe. Thus, the results in table 1 show that all parameters presented significant variability, by being more prominent in group A (home reservoir), with exception of the free chlorine variable that has showed more accentuatedin group B (public water systemdistribution).

Table 2. Descriptive statistics of the physical and chemical variables of water samples from taps connected to the domestic reservoirs (A) and directly from the water system distribution (B)

Group	Variable	Media	Standard Deviation	Mínimum	Maximum
A	pH	6,628	0,32424	6,19	7,24
	Turbidity	0,6306	0,38519	0,02	1,16
	conductivity	146,19	12,1634	128,8	175,4
	Alkalinity	22,489	5,416117	16	34
	Freechlorine	0,2939	0,04165	0,22	0,36
	Total chlorine	0,335	0,06229	0,22	0,47
	Fluorine	1,0725	0,77495	0	2
	Iron	0,07846	0,07177	0	0,24
	Iron II	0,00167	0,00373	0	0,01
	Iron III	0,077	0,07616	0,01	0,24
B	pH	6,45353	0,14392	5,97	6,87
	Turbidity	0,81118	0,109068	0,54	2,09
	condutivity	149,38	5,975988	139,8	158,6
	Alkalinity	19,1444	3,133905	16	26
	Freechlorine	0,39722	0,14548	0,12	0,61
	Total chlorine	0,57647	0,06542	0,18	0,82
	Fluorine	1,22167	0,22822	0,21	2
	Iron	0,04571	0,008165	0,01	0,14

| Iron II | 0,00455 | 0,004714 | 0 | 0,15 |
| Iron III | 0,03824 | 0,025218 | 0,01 | 0,15 |

Source: Own research (2018/2019)

Afterwards, the Analysis of Cluster was performed to verify the influence, connection and dissimilarity that one parameter has with another one. The values of hP, electrical conductivity, turbidity, alkalinity and the contents of free chlorine, total chlorine, fluorine, iron, iron II and iron III, measured according to the methodology, wereprocessed by using the grouping method of Ward.

Previously, the values of the aforementioned variables were normalized by means of Z-scores transformation, in order to have a more homogeneous distribution with the same weight. In the initial matrix, the similarity coefficients represent the degree of analogy among the samples, causing a hierarchical arranging, through groupings ordered according to the respective degrees of similarity. (Santos, J. S; Souza, F.M; Santos, M.L.P, 2013)
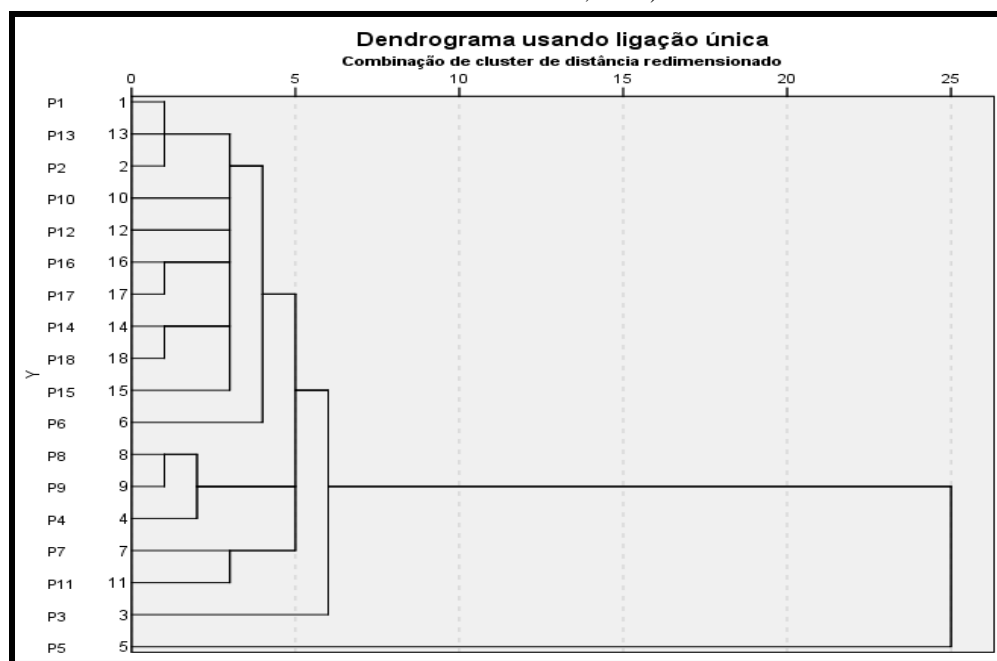

Fig.1: Dendrogram of the Analysis of Cluster grouped by the results of the water samples collected in the domestic reservoirs.

Source: SPSS program version 25.

In the dendrogram of Figure 1, the physical and chemical variables of the collected water grouped distinctly on alevelof distance by 25. Then, it is observed a larger grouping of points P1, P2, P2, P12, P16, P17, P14, P18 and P15 which, except for points 1 and 2, are characterized by being located in the lower part zone of the city that represents the intermediate zone, and the points P6, P8, P9, P4, P7, P11, P3 and P5, with the exception of point 11 constitute the zone nearer and farthest from Embasa and is located in the high zone of the city.

This grouping is explained by the similarity of the samples collected at the intermediate points that are located in the lowest zone of the city, as well as those ones that are at the highest points, because first the water distribution system fills the lower zone,and as this tube is

filled it fills the highest zone of the city which is represented by the farthest points from Embasa and finally the closest points from Embasa.

However, it is possible to verify the existence of possible problems in the distribution and this may be due to the type of water distribution system presented, formation of incrustations in the pipe, type of reservoir used and their influence in the conservation and maintenance of the water received. By emphasizing that the water for domestic supply usually passes through water treatment plants in order to make it suitable for human consumption, however, in spite of the treatment received the water that arrives in the residences can suffer pertinent contaminationsthere is distribution and an expropriated storage in the reservoirs (Bom, 2002).

Soon, not at least, the water distribution system helps on the final stage of a water supply system, by forming the tubing that transports the water to the homes. Having as priority to move the water that has passed through the treatment to the reservoirs and taps byensuring its potability. Thus, according to the arrangement of the main conduits, two types of water distribution system can be basically defined: branched one and spotted one (Brazil, 2006).

The type of water distribution system presented in this work is the branched one that presents as main limitations to its use the almost complete shutdown of almost all of the supply during possible maintenance of the main conduits and also by the significant reduction of residual chlorine concentrations at the ends of the water distribution system.

This is noticeable in the dendogram, since it shows the greater grouping of the low zone, thus demonstrating the similarity between the points since they have pertinent characteristics to the group where the distribution for these points is firstly made, after that the distribution is directed to the high zone that is distributed between the farthest points from the Embasa and the nearest oneby showing a dissimilarity and between the same, that is, groupings more distant from each other.

Among the mentioned complications we have the home reservoirs that may be a deteriorating agent of the water quality distributed to the community, as there is no sanitary process every six months or whenever there is a suspicion of contamination (Lima, 1978; Ministry Of Health, 2016). And also, the time that this water remains

stored, that is, the time of detention in the reservoirs can favor the growth of bacterium and in chlorinated waters can represent a fall of residual chlorine (oxidizing agent) by favoring the nitrification (Brazil, 2006).

Conniving with the factors have already mentioned, the reduction of chlorine can alter the quality of the water stored as a result of the contact of the water with the concrete of the walls of the reservoirs, and this is done through the different concentrations of calcium carbonate in the water and the contact surface of the wall of the home reservoir, by statinga deterioration of the concrete, which that causes the formation of a rough surface that favors the adhesion of pathogenic microorganisms and other ones, besides compromising their structure. In this question, points 3 and 5 stand out because the reservoir used is made by concrete, not having similarity to the other ones, by showing through the dendogram a greater distancing compared to the other ones arriving at a distance level 25, the same occurs for the point 11 that although it is from the low zone, does not group the same ones, by having as similarity the same reason of the aforementioned points.

However, through the results obtained in relation to the physical and chemical parameters indicate that most of the collected water is in compliance with the current legislations, except for the fluorine parameters and conductivity that have shown outside of the values standardizedby Ordinance Nº. 2.914 / 11 and Ordinance Nº 518/2004.
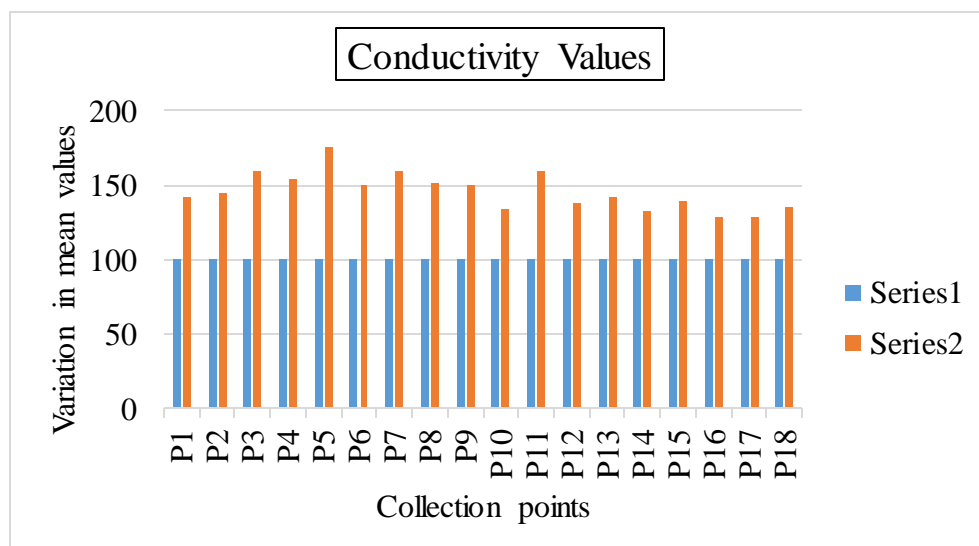
Graph 1: Demonstrating the variations of the electrical conductivity parameter, acceptedvalues (series 1) found values (series 2) in the domestic reservoirs.

According to Santos (2016) the presence of dissolved substances that dissociate it in cations and anions determine the electrical conductivity in the water, by developing the capacity of the water of transmitting electric current. The values indicated to determine the electrical conductivity are above 100 uS / cm, allowed limit, however, according to Sardinha (2008) from the conductivity we obtain information about decomposition (increases the conductivity) and about the primary production (reduces the conductivity), by showing a greater accentuation in points 3, 5, 7 and 11, by emphasizing once again how concrete tanks have a negative influence on water quality.
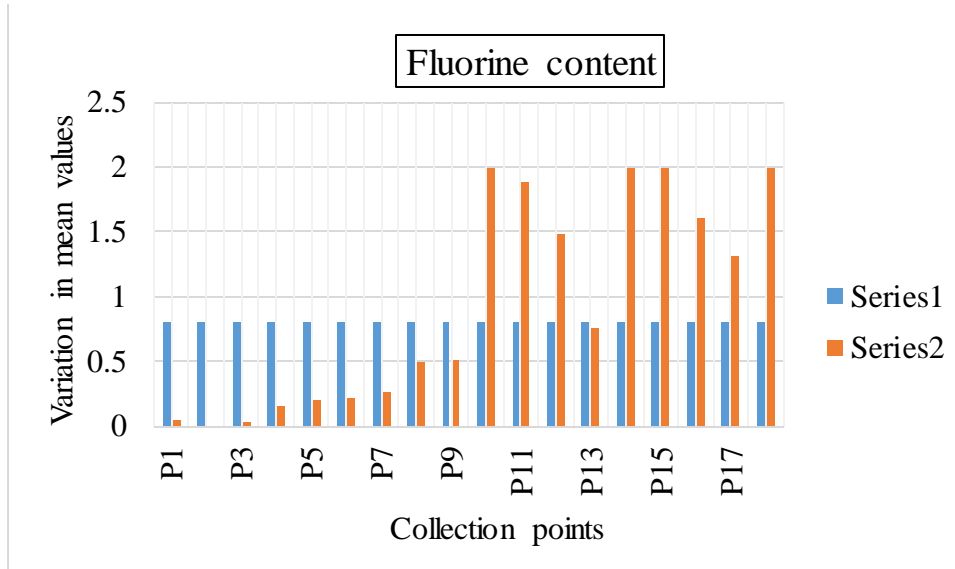
Graph 2: Demonstrating variations in fluorine content, ideal values (Series 1), values found values (series 2) of the home reservoirs.

Fluorine has efficiency in the decline of dental caries, which justifies the importance of additioning it in public water supply, by being employed in Brazil for more than 50 years (Brito et al., 2016). Therefore, considering the climatic characteristics, fluorine concentrations should be appliedin order to ensure the maximum benefit of caries prevention and the minimum risk of doserelated toxicity this onemay trigger offserious health problems such as dental and skeletal fluorosis, reversible gastric disorders and temporary reduction of urinary capacity (Funasa, 2012).
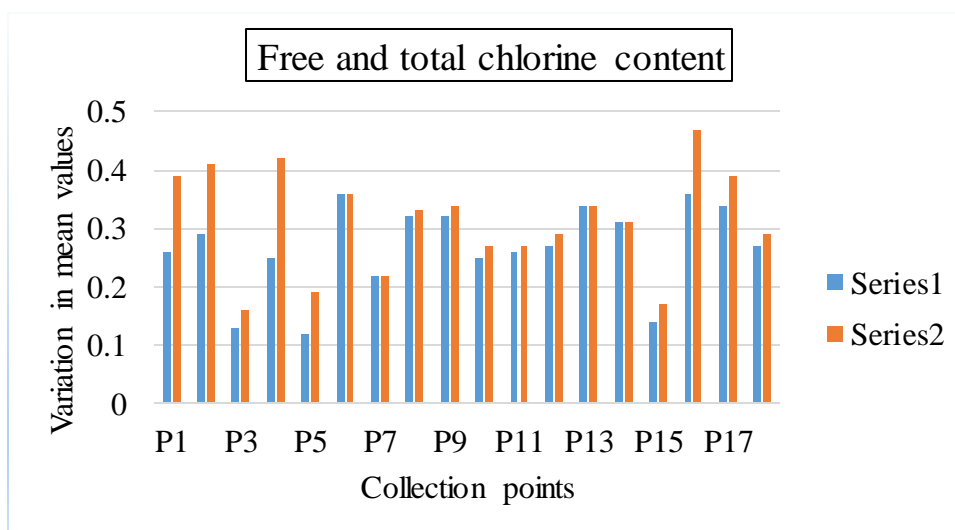
However, it is emphasized that the minimum and maximum allowed values set outin Ordinance MS Nº 2,914 / 11, related to fluorine, are 0.5 to 1.5 mg / L, and the ideal for the average daily maximum temperature of city from 21.5 to 26.3 is 0.8. Proving this way that most of the collection points are outside of the established limits, where the high zone is characterized by very low values and may present dental caries outbreaks, and the lower zone presentsmostly values above 1.5, which can lead to severe health problems severe as there is a significant difference between the points suggests that this may be due to the interference in the turbing and the type of water distribution system (fish scale), that characterizes changes in the concentrations of the extremities of the water distribution systems.

Still on the parameters it should be noted that the content of free and total chlorine was mostlywithin quality standards that stablish 0.2 mg / L as the minimum concentration, since it placesdata that put on 83.3% of the water samples from the reservoirs within the proposed minimum limit, as shown in figure.

The chlorination technique is very efficient for the microbiological control, because it is based on eliminationing of the bacterial cells through the oxidation of the free sulfhydrylgroups. Thus, the inadequacy of chlorine levels observed in 16.7% of the samples of group A, thus representing a potential risk for consumer health. In the case of the samples of group B all fit on the potability standard.

Table 3: Distribution of chlorine parameter of the water samples collected from the taps connected to the domestic reservoirs (A) and directly to the water distribution system (B).

Sample				
Chlorine	AbsoluteFrequency (n)		RelativeFrequency (%)	
	A	B	A	B
Down	3	0	16,7	0
Standard	15	18	83,3	100
Total	18	18	100	100

Source: Own research (2018/2019)

In Table 3, there is a demonstration of the absolute and relative frequency arrangement of the samples of groups (A, B) which are in accordance with the established microbiological quality standard and those ones that are out of standard (Brasil, 2004 Apha, 1998). It is noticeable that 33.3% of the samples of the domestic

reservoirs are not within the microbiological standard, that is, it contains total coliforms, noting that 27.8% represents the highzone of the city, in contrast to the samples from the group B, it was not observed presence of total coliforms, by presenting significative dissimilarity that indicates microbiological contamination of the water stored in the domestic reservoirs.

Table 4: Distribution of the total coliform frequency of the water samples collected from the taps connected to the domestic reservoirs (A) and directly in the public watersystem (B).

Sample				
Total coliforms	AbsoluteFrequency (n)		RelativeFrequency (%)	
	A	B	A	B
Standard	12	18	66,7	100
Out of	6	0	33,3	0
Total	18	18	100	100

Source: Own research (2018/2019)

However, the found results agree with Campos, J.A.D.B et.al; Genthe et.al that through the research have verified the absence of bacterium in the water distribution system, and the samples of the domestic reservoir with a significant deterioration, by presenting values higher than those ones allowed by the potability standard.

Ministry of Health Ordinance 2,914 / 11 determinesthat heterotrophic bacterium counts should be

performed for measuring the integrity of the water distribution system (reservoir and system), and therefore it was indispensable its analysis in which the presence of heterotrophic bacterium were found in 50% of the reservoirs, thus demonstrating that it has its compromised integrity.

However, it knows that the water intended for human consumption has a significant number of coliforms

and heterotrophic bacterium by indicating that the treatment has not been effective or that there is contamination in the water distribution system and storage. (Mcdaniels, A. E. et al.) In this case, byanalyzing the results it was verified that in the control group (B) there is no imminence of contamination, so it is notorious that the storage is the deteriorating agent of water quality.

IV. CONCLUSION

Targeting an ideal scenario, cities that offer a water distribution system should provide for the population a good water quality and that one is in accordance with the legislation. It is known that physical and chemical and microbiological parameters are a great ally in waterquality warranty, so it is necessary that they are in accordance with the potability standards recommended by Ministry of Health Ordinance N°. 2,914 / 11, after all whenever that involves the health of the population in general, it demands responsibilities by responsible organs.

Therefore, the results obtained show that the physical and chemical parameters analyzed are within the minimum and maximum values allowed by Ministry of Health Ordinance No. 2,914 / 11, by indicating that the water collected, treated and offered by the municipal water distribution system of the city of Barra do Choça – BA is of good quality based on the portrayed analyzes, not causing health risk but in the domestic reservoirs is a deteriorating factor of the quality of the water stored in it as can be verified by observing the contents of chlorine, fluorine and electrical conductivity, besides the presence of total coliforms in some points collected and the contamination in 50% of the reservoirs by heterotrophic bacterium.

It was also observed faults in the water distribution system because it is characterized as a fishbone system and it was observed a decrease in the values of the parameters used at the extremities of the system (high zone), a factor that justifies the formation of groupings in the dendogram, besides demonstrating a greaterburden of bacterial infection at the higher zone of the city in whichfrom 33.3% of the contaminated reservoirs only 5.5% is at the low zone.

In view of this, corrective measures are necessary in order to ensure the health of the population. However, in order to warranty that the water maintains its properties, it is important to explain that they do not depend only on the treatment phases offered by EMBASA, but as how the way the wateris collected and if the reservoirs receive the due care as hygiene semiannually. Therefore, it is explained that it is indispensable to alert the population about the function of the reservoir and the importance of hygiene and its utility in maintaining the quality of water intended for human consumption to the health promotion.

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