Physico-Environmental Characterization of the Micro Basin Contributing to Fazenda Nova's (Goiás) Public Water Supply[1]

Fernando Ernesto Ucker[2], Nádia Liley Rodrigues[3]

[2]Environmental Engineer, PhD in Agronomy, Professor of Faculdade Araguaia, Goiânia, Goiás.
[3]Studentofthe Environmental EngineeringCourseof Faculdade Araguaia, Goiânia, Brazil.

[1]Course Conclusion Paperpresented for the Environmental EngineeringCourseof Faculdade Araguaia, Goiânia, Brazil.

Abstract— A study of the physical and environmental characteristics of a river basin is crucial for advances in environmental management and plans aimed at managing and guaranteeing quality adequate to its use in the public water supply system. Hence, this study set out to undertake a physico-environmental characterization of the drainage basin of the Grande river, which contributes to supplying water to the municipality of Fazenda Nova, Goiás. The result could help monitor the availability and quality of the water and action for the recovery and preservation of areas at risk or degraded. The drainage area extended over 8.64 km² with a 14 km perimeter. The predominant soils in the hydrographic basin are Red Argisol and Quartzarenic Neosol. Morphometric characteristics, soil type, land use and cover and altimetry all indicate warning signals for physical and environmental quality. They also indicate that mitigating measures be undertaken, involving revegetation of land cover and the adoption of plans for land use and soil cover in the area under study.
Keywords— Morphometry; environmental quality; hydrographic basin.

Caracterização Físico-Ambiental Da Microbacia De Contribuição Ao Abastecimento Público De Fazenda Nova – Go

Resumo— O estudo das características físicas e ambientais de uma bacia hidrográfica é importante para o desenvolvimento da gestão ambiental e planos que visem o manejo e garantem a qualidade adequada para a sua utilização no sistema de abastecimento público de água. O objetivo deste trabalho foi a caracterização físico-ambiental da bacia hidrográfica do córrego Grande, que exerce contribuição ao abastecimento do município de Fazenda Nova, GO. O resultado será auxiliar na monitoração da disponibilidade e qualidade da água e açõe s de recuperação e preservação de áreas que apresentam riscos ou degradação. A área de drenagem encontrada foi de 8,67 Km² e 14 km de perímetro. O solo predominante na bacia hidrográfica é o Argissolo vermelho e o Neossolo Quartzarênico. As características morfométricas, tipo de solo, uso e cobertura da terra e altimetria indicam uma situação de alerta à qualidade físico- ambiental e para a adoção de medidas mitigadoras, reflorestamento da cobertura florestal e de adoção de planos de uso e cobertura do solo no local estudado.
Palavras-chave— Morfometria; qualidade ambiental; bacia hidrográfica.

I. INTRODUCTION

Water directly interferes with the life cycle of living beings and with the way of life of humans, in particular. Inadequate use of this hydro-resource has resulted in a gradual loss of water quality in sources, due to increased sedimentation and more specially to changes in potability parameters for human supply. Anthropic activity on the biota and soil, with different uses and occupation has accelerated the process of water quality degradation, with economic and social consequences.

According to Coutinho *et al.* (2013), dynamic hydrological processes in basins could suffer considerable modification as a result of anthropic activities, such as changes in land occupation, deforestation, agricultural expansion and intensive urbanization. Therefore, alterations in the components of the river basin could interfere with the hydrological cycle and affect water flow, both qualitatively and quantitatively.

In Brazil, concern for the management and quality of water resources, and recognition of the need to preserve such a precious and vital asset, was highlighted for the first time in 1934, with the so-called Water Code, in Decree 24.543/34 (PIZELLA, 2015). With this, new policies emerged, such as the National Water Resources Policy (PNRH), the 1997 Law 9.433 (BRASIL, 1997). One of its principles establishes that the river basin is the territorial unit for implementation of the PNRH and for the action of the National System of Water Resource Management (SNGRH).

For Souza *et al.* (2014), it is crucial to identify water quality and verify its vulnerability to human activity, when one considers the need to conserve water resources. This contributes to its management without losing the perspective of analysis of the hydrographic basin. Therefore, monitoring the water resource is highly relevant, as the physico-environmental characterization of a basin can be used as a starting point for designing projects for a water supply system for human consumption and for monitoring and managing the quality and quantity of drinking water.

Coutinho (2013), Calil*et al.* (2012) and Santos (2015) emphasize that characterization of the physical environment of the river basin, with a view to drawing attention to all critical areas from the point of view of water maintenance, is a basic condition for planning water conservation and the production of water, as are also land use and cover. For Pompermayer*et al.* (2016) and Santos (2015), therefore, spending on monitoring and planning for preserving the environmental quality of a river basin contributing to supply, generates beneficial economic returns, and maintains the availability and quality of drinking water.

With all of the above as a background, the aim of this study was the characterization and physico-environmental mapping of the Grande river micro basin, located in the municipality of Fazenda Nova, Goiás, with a view to qualifying it in terms of vulnerability, on the basis of the quality and availability of water for public supply of the municipality.

II. MATERIALS AND METHODS

The Grande river basin is a micro basin of the Araguaia river basin, which covers the midwestern region of the State of Goiás, located between the 50º47'10,34"W - 16º9'58,24"S and 50º47'38,84"W - 16º13'23.20"S coordinates (Google Earth Pro, 2017). The predominant climate in the region is tropical (Aw), according to the Köppen (1948) classification. The basin covers an area of 8.64 km² and presents a perimeter of 14 km. Red Argisol and Quartzarenic Neosol soils predominate in the region, according to data collected from the LAPIG geographical information site.

The Fazenda Nova micro basin was chosen for survey in this study because of its extension and also because it is a basin contributing to the municipality's public supply, as interference could affect the water needs of the population of the region.

According to Valle Junior *et al.* (2010), data of various types must be obtained through the supervised classification of images to survey the environmental quality in the basin, and the interference of physiographic characteristics, plant density and land use and cover in water quality and availability for supplying the region.

A Geographic Information System was used to organize and process the information obtained. Other instruments, such as Google Earth Pro and the TerraClassCerrado project collection were also used. The latter provides a series of geographic data about the Cerrado (Savannah), processed and organized into thematic maps from which shapefiles of the area can be downloaded and data for further analysis extracted. Therefore, the use of geographic information instruments was vitally important for the drafting of this project.

For the cartographic base, data collected in the virtual environments of geoinformation, such as the Laboratory of Image Processing and Geoprocessing (Lapig), State System of Geoinformation of Goiás (SIEG) and TerraClassCerrado. The data obtained, in shape format, were the drainage network of the Grande river basin, land use and cover, local geology, altimetry and hypsometry of the river basin and other characteristics which interfere with water quality and availability. These data were then processed, digitized and used in designing the maps using the Geographic Information Systems (GIS), Quantun Gis (Qgis) and Spring.

Following Bosquita *et al.* (2016), the quality of drainage of the micro basin was studied on the basis of density (Dd). This is a parameter for knowing the development of the drainage system, and it is obtained

by the ratio between the total length of the drainage network, including perennial and intermittent channels, and its total area (A). From this result, data which indicate the susceptibility of the micro basin to erosion can be obtained, by relating it to the results obtained from parameters, such as the surface runoff ramp length (RL) and the ruggedness index (RI), presented in Table 1.

Table 1. Description of morphometric parameters and their formulas. Adapted from Pinto et al. (2014).

Parameter	Formula	Description
Drainagedensity (Dd)	$Dd = \Sigma TL/A$	TL is the total length of all channels (km); A is the total drainage area (km²).
Surface runoff ramp length (RL)	$RL = 1/4Dd$	Dd is the drainage density (km.km^{-2}).
Ruggedness Index (RI)	$RI = W*Dd$	W is the altimetric width of the basin (km); Dd is the drainage density (km.km^{-2})

According to Pinto *et. al.* (2014), the calculation of these parameters, with drainage density, results in the vulnerability of the micro basin to the surface erosion, presented in Table 2. Thus, with adaptations for the study of the micro basin, the calculation was made with the sum of weights which range from 5 (very high) to 1 (very low).

Table 2. Intervals for vulnerability analysis. Adapted from Pinto et al. (2014).

Interval – Resultof addition	Degree of vulnerability to surface erosion	Vulnerabilityscale
From 3 to 5.4	Verylow	1
>5.4 to 7.8	Low	2
>7.8 to 10.2	Average	3
>10.2 to 12.6	High	4
>12.6	Very high	5

After the review and analysis of satellite images, field observations were made in order to verify the critical degradation points in the delimited area of the basin. The main focus of the on-site visit was an analysis of the main sources virtually located through Google Earth Pro. The sources confirmed were georeferenced and their coordinates are presented in Table 3. Evaluation of the sources (A, B, C, D, E and P) was conducted using studies by Belizário (2015) and Gomes *et al.* (2005) which present an analysis based on perception, observing characteristics such as vegetation, color and odor of the water, presence of residues and animals, and anthropic use.

Table 3. Coordinates of the location of the sources visited in the drainage basin of the Grande river, Fazenda Nova, Goiás. Google Earth, 2017.

Sources	Coordinates	
	Latitude	Longitude
Source A	-16.187299°	-50.782840°
Source B	-16.188053°	-50.783327°
Source C	-16.188669°	-50.784102°
Source D	-16.193747°	-50.781238°
Source E	-16.188592°	-50.786559°
Source F	-16.187830º	-50.789455º
Source G	-16.180925º	-50.791405º
Source H	-16.179129º	-50.791202º
Source I	-16.176589º	-50.793643º
Source J	-16.179311°	-50.802968°
Source K	-16.180037°	-50.804109°
Source L	-16.188073°	-50.799003°
Source M	-16.202059°	-50.797965°
Source N	-16.201019°	-50.792314°
Source O	-16.198799°	-50.785547°
Source P	-16.191417º	-50.778797º

The studies by Belizário (2015) and Gomes *et al.* (2005) on the quality of sources, use macroscopic parameters to obtain results which determine if the source falls within the quality categories ranging from "excellent" to "very bad", as presented in Tables 4 and 5. The evaluation parameters received weights ranging from 1 to 3, which were added, and the result then served as a parameter for the qualitativeclassification of the source. The other sources were visually evaluated by means of processing and vectorization of the CNES/Airbus satellite images. However, in this case a maximum of possible parameters, such as proximity to homes, location and presence of preservation areas, was observed. This analysis could yield data on critical points in the micro basin.

Table 4. Classification of the quality of sources in terms of preservation. Adapted from Gomes et al. (2005).

Qualitylevel	Score
Excellent	37 to 39 points
Good	34 to 36 points
Reasonable	31 to 33 points
Poor	28 to30 points
Bad	Lessthan28 points

Table 5. Weight and description of macroscopic parameters. Adapted from Gomes et al. (2005).

Parameters	Weight		
Color ofwater	1) Dark	2) Clear	3) Transparent
Odor	1) Strong	2) Weak	3) None
Refuse in thevicinity	1) Much	2) Some	3) None
Floating materials	1) Many	2) Some	3) None
Scum	1) Much	2) Some	3) None
Oil	1) Much	2) Some	3) None
Sewage	1) Present	2) Some	3) Absent
Vegetation	1) Seriousdegradation	2) Lowdegradation	3) Preserved
Usedbyanimals	1) Presence	2) Only traces	3) Absent
Anthropic use	1) Presence	2)Only traces	3) Absent
PresenceofPPA	1) Withoutprotection	2) Withprotection (withaccess)	3) Withprotection (withoutaccess)
Proximityto homes	1) <50 meters	2) 50 to 100 meters	3) >50 meters
Type of ownership of the area	1) Absent	2) Private property	3) Parks orprotectedareas

Evaluation of the interference of land use and cover in the environmental vulnerability of the hydrographic basin was obtained by applying the study method proposed by Mota (2013) and Pinto *et al*. (2014). Their methodology consists of adopting weights for each type of land cover (Table 6). These were then multiplied by the area of occupation and the result divided by the area of the micro basin.

Table 6. Degree of vulnerability attributed to land use and cover units. Adapted fromPinto et al. (2014).

Land use/cover	Forest	Silviculture	Agroforestry	Pasture	Urbanarea
Weightattributed	1	2	3	4	5

III. RESULTS AND DISCUSSION

The Grande river micro basin presents a drainage extension of 13,436 km, and was classified as fourth order. Drainage density (Dd) in the area studied was 1.55 km.km², and characterized as a basin with good drainage, according to Bosquila's (2016) classification, even though Calil*et al*. (2012) and Périco (2011) considered a density below 5 km.km² as low drainage.

If a river basin presents high density, this means that the soil is not very permeable. This could influence the occurrence of flooding and the transportation of soil particles to water bodies, according to Rocha and Kutz (2001). Thus, low drainage density means that the basin is less susceptible to erosion. The micro basin studied presents good density, which indicates that the soil has reasonable rain water infiltration capacity. But it should be noted that this parameter alone cannot be used as an indication of an area of low vulnerability. Périco *et al*. (2011) define drainage density as a parameter indicating the degree of development of the water system.

Ramp length (RL) is the slope of the terrain down to the river, in other words, the greater the slope the greater the transportation of soil particles and rainwater to the river. When compared to the 0.1751RL found by Pinto *et al*. (2014), who state that this value could influence soil loss, it could thus be affirmed that the slope of the micro basin of the Grande river, in relation to the main water body (0.771), could lead to the transportation of soil particles.

Ruggedness index (RI) yielded a value of 186. Higher and lower RI values represent higher and lower potential for erosion, respectively. This parameter is used to verify the suitability of the soil for certain uses and occupation. A study by Oliveira (2013) in the same region and biome as that studied here, produced a ruggedness index of between 17.7 and 27.2 for the Meia Ponte river basin, classifying it as having capacity for forestation only. This result is lower than that of 186 RI found in the Grande river micro basin. This shows the need for greater focus on the management and stewardship of the area. The same occurs in the physico-conservationist analysis of the subbasin of the Ibicuí river, Rio Grande do Sul (Sampaio *et al*., 2010), which has an RI ranging from 0.565 to 4.428, which shows capacity for forestation in the sites with higher values.

The interaction of these three morphometric parameters gives the micro basin's degree of susceptibility to soil erosion.when compared with studies by Pinto *et al*. (2014) and Bueno *et al*. (2011), the result

of this interaction showed an average degree of vulnerability to surface erosion. In the pedological description of the micro basin, presented in Table 7, two soil profiles were described,Dystrophic Red Argisol, corresponding to approximately 88% of the area of the micro basin and Dystrophic RegolithicNeosol covering 12% of the area, represented in Figure 2. In the micro basin area, Red Argisol (PVd) predominates in an area presenting undulated relief with gravel and stones which, according to Calil*et al.*(2013), are factors which accelerate surface runoff.

According to Araujo *et al*. (2004) and Santos (2013), the PVd unit presents low fertility (dystrophic) soils, characterized as being more susceptible to erosion,and also with low rates of water infiltration. As the Argisol is porous there is greater percolation and leaching of elements and low retention of pollutants, as is represented in Figure 1. Such factors contribute to and alert for areas subject to degradation and susceptibility to erosion, which suggests the need of conservation practices to prevent the transportation of sediments to the water body used for the region's public supply.
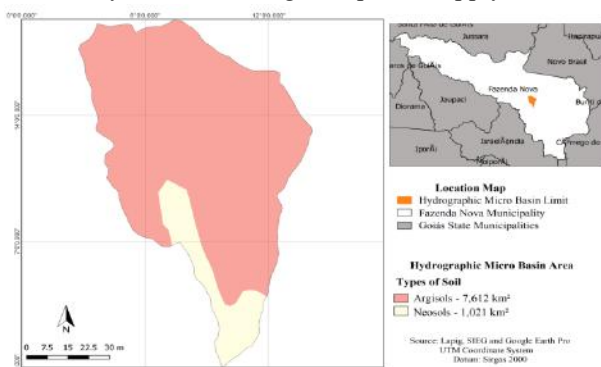

Fig,1. Map of the predominant soil profiles in the area studied.

Table 7. Survey of characteristics of soil types found (SIEG, 2013).

Class	Area	Characteristic	Relief	Vulnerability	Texture
Argisol	7,612 km²	Gravelandstone	Undulating	2.2	Average/clay
Neosol	1,021 km²	Sand	Undulating	2.8	Average

The altimetry of the region is 560 meters at its highest point and 400 meters at its lowest. Thus, its altimetric width yielded 160 meters, as presented in Figure 2. In comparison with studies by Reckziegel and Robaina (2006), the area of the micro basin can be

characterized from a slope between 14% and 27%, altimetric width greater than 100 meters and predominant altitude greater than 160 meters, with relief varying from undulating to steep. It can thus present hills and hillocks, which results in a process of surface dynamics of erosion to mass movements.
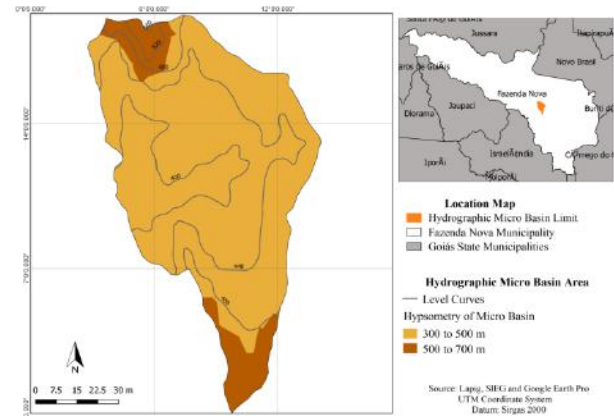

Fig.2. Map of the representation of level curves and hypsometry of the hydrographic micro basin.

In the micro basin, eighteen sources were mapped, as shown in Figure 4. From the field research, it was seen that of these, thirteen are perennial, and five (B, F, O, G, L) intermittent. During the temporal evaluation of the satellite images, some changes in location were observed. These are now more downstream, the result of deforestation in the region to make way for pasture. As a result of the mapping, representation of a drainage network was also extracted which was more complex (Figure 3) than those available in the SIEG and LAPIG sources. This difference is due to the use of a smaller scale to interpret the image features. Therefore, division of the hydrographic basin into a smaller scale (micro basin) helped obtain a better drainage network, covering all runoff stretches, whether perennial or intermittent.
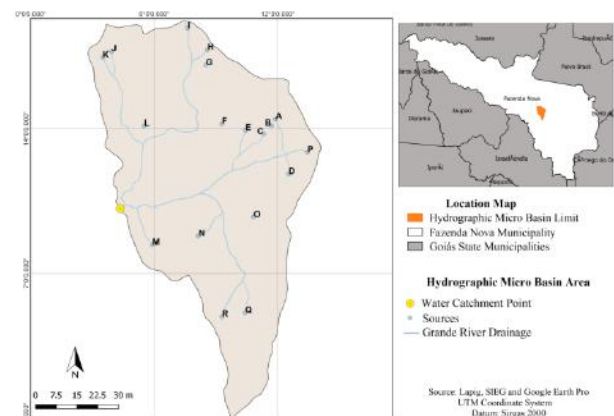

Fig.3. Map of source locations and drainage network in the micro basin of the Grande river ona scale of 1:10,000.

The field study helped with the location and evaluation of the environmental impacts of the sources. The macrocosmic parameters of the six main sources (A, B, C, D, E and P), presented in Figure 4, were evaluated according to Gomes's (2005) previously presented method. Only one of the six sources was evaluated as "good", while the others ranged from "very bad" to "bad", as presented in Table 8. The other sources were not visited or analyzed as they showed a deficit in preservation area, where only five (J, M, K, Q and P) have a 50-meterradius of protective vegetation, as demanded by the Forestry Code (2012, Law 12651).

Carvalho (2000) emphasizes that riparian forests are of utmost importance for the protection of water resources, as the surrounding forest protects them against erosion, and consequently against silting. It also protects them against the arrival of agrochemicals and sediment and improves the physico-chemical and microbiological quality of the water. In this way, it is possible to evaluate how the lack of vegetation affects some of the sources visited, because without vegetation they are susceptible to pollution and external contamination.

Table 8. Environmental quality of sources – Macroscopic results.

Parameters	Sources					
	A	B	C	D	E	P
Water color	1	2	1	1	1	3
Odor	3	3	2	3	3	3
Refuse in vicinity	2	3	1	2	1	3
Floating materials	3	3	3	3	2	3
Scum	3	3	3	3	3	3
Oil	3	3	3	3	3	3
Sewage	3	3	3	3	3	3
Vegetation	1	1	1	1	1	2
Usedbyanimals	1	1	1	1	2	3
Anthropic use	3	1	1	1	2	3
PresenceofPPA	1	1	1	1	1	2
Proximityto homes	3	3	3	2	3	2
Typeofowners hiparea	1	2	1	2	1	3
Total score	28	29	24	26	26	36
Classification	Bad	Bad	Very Bad	Very Bad	Very Bad	Good

In the area under study, according to the Forestry Code, there should be a 30-meter stretch of PPA, along the total length of the Grande river, as it is less than 10 meters wide. And sources should have a 50-meterradius of PPA. It should have a total preservation area of 0.858 km² but has only 0.430 km². Therefore, public policies should be drawn up to control the use and cover of the micro basin, as a means towards preserving the availability of water at the source which supplies the town and preventing problems, such as water crises or a lack of drinking water.

Agriculture and cattle raising are predominant in the micro basin with an extensive area of pasture. However, as the soil is fragile and susceptible to erosion, most pasture land is very degraded. On analyzing the data on land use and cover in the micro basin, shown in Figure 4, it was seen that combined agriculture and cattle raising represents about 5,109 km², which corresponds to 59.13% of the total Grande river micro basin area. Native vegetation corresponds to 3,121 km², or about 36.12% of the total area while the urban area occupies 0.18 km², or 2.10% of the area.

The results of soil vulnerability in relation to land use and cover are presented in Table 9. According to Pinto *et al.* (2014), the result of the weighted area, divided by the total basin area of 2.95 could be considered level 3 or average in the scale of vulnerability to surface erosion, because in their analysis the values obtained from this same type of evaluation of the basin of the Espírito Santo river in Minas Gerais ranged from 2.89 to 2.84, which is medium vulnerability while from 3.44 to 3.97 represents high vulnerability.

Table 9. Determination of vulnerability in relation to land use and cover.

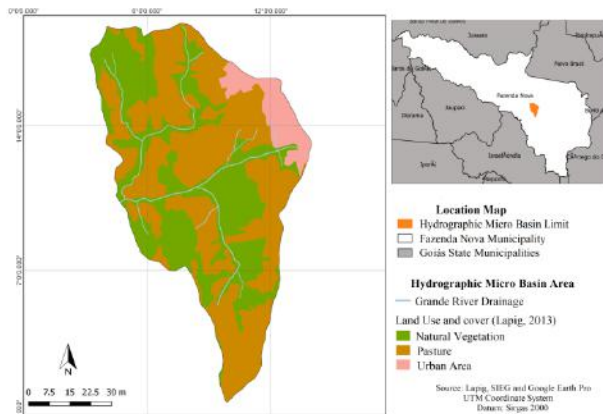| Unit of use/cover	Weight	Area of use/cover (km²)	Weightedarea (km²)
Forest	1	3,121	3,121
Pasture	4	5.37	21.48
Urbanarea	5	0.18	0.9
Total weightedarea (km²)			25,501
Total hydrographic basin area (km²)			8,671
Vulnerability			2.95

Fig.4. Map of land use and cover in the Grande river micro basin.

The land use situation in the micro basin is a result of deforestation of the Cerradowith a view to intensifying cattle raising, which is the basis of the economy in the region. Therefore, areas which should be destined for permanent preservation (PPA), such as river margins and land surrounding sources and springs, were transformed to accommodate the expansion incattle raising. Hence, the calculation of areas destined for preserving river margins and sources in the basin yielded a deficit of 0.428 km² (Figure 5).

The deficit in forest area related to PPAs was detected in studies of drainage basins located in rural areas by Umetsu*et al*. (2012) in Mato Grosso, Pompermayer*et al.* (2016) in the Federal District, Oliveira *et al.* (2013) in Goiás and Sampaio *et al.* (2010) in Rio Grande do Sul, by means of a study of physico-conservationist deterioration. However, the issues surrounding forest conservation in rural areas whether forest reserves or PPAs have not yet yielded the results expected with the promulgation of the July 18, 2000, Law 9985, National System of Conservation Units (BRASIL, 2000).
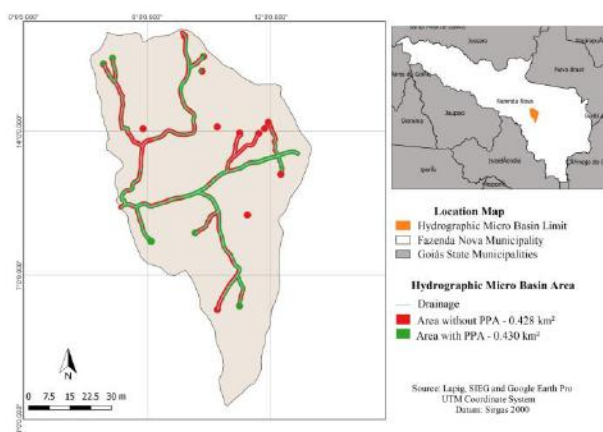

Fig.5. Representative map of the PPAdeficit in the micro basin.

IV. CONCLUSION

In general, the Grande river micro basin presented medium vulnerability to erosion and critical environmental quality, influenced by the fact that a large part of the land is covered by pasture. The steep slope, soil type and the morphometric characteristic of the drainage area create an environment susceptible to degradation, thereby compromising the water supply to Fazenda Nova. Although drainage density was classified as good, the morphometric and land use and cover parameters were mainly responsible for the alarming result of the physico-environmental quality of the region.

Analysis of the physico-environmental characteristics in a GIS environment proved adequate for evaluating morphometric, topographic, land use and cover and quantitative parameters of the preservation areas of the Grande river micro basin. However, the study showed critical quality levels and an environment susceptible to erosion processes, thereby subjecting water bodies to silting, leaching and loss of drinking water quality.

The predominance of cover involving pasture and PPAs at a level of almost half of what there really should be in the riparian margins, and especially the very bad classification of the sources, where the majority do not have a preservation area of 50 meters, suggest the need to adopt mitigatory measures involving revegetation and the implementation of a stewardship plan for land use and cover and for water, in order to guarantee the qualitative and quantitative conservation of the water bodies supplying the region and control the growth of the agricultural and cattle raising activities.

REFERENCES

[1] ARAUJO, M. A.; TORMENA, C. A.; SILVA, A. P. Propriedades físicas de um Latossolo Vermelho distrófico cultivado e sob mata nativa. **Revista Brasileira de Ciência do Solo**, Viçosa, v. 28, p. 337-345, 2004.

[2] BELIZÁRIO, W. da S. **Análise Geoquímica e Ambiental das Bacias Hidrográficas dos Córregos Almeida e Santa Rita em Aparecida de Goiânia, GO.** 2015. 95 f. Dissertação (Pós-Graduação em Geografia) – Instituto de Estudos Socioambientais, Universidade Federal de Goiás, Goiânia. 2015.

[3] BOLLMANN, H. A.; MARQUES, D. M. L. da M. Gestão Ambiental Integrada de Bacias Hidrográficas: Bacia do Rio Cachoeiras - São Mateus do Sul – PR. **Revista Brasileira de Recursos Hídricos,** Porto Alegre, v. 6, n. 3, p. 45-65, 2001.

[4] BOSQUILIA, R. W. D.; FIORO, P. R.; DUARTE, N.; BARROS, P. P. da S. Diferentes imagens de satélite no mapeamento visual de drenagens e nascentes em

amostras circulares. **Revista Interciência,** Caracas**,** vol. 41, n.5, pg. 25-259, 2016.

[5] BRASIL. Ministério do Meio Ambiente. Lei nº 4.771, de 15 de setembro de 1965. Institui o Código Florestal Brasileiro. **Diário Oficial da República Federativa do Brasil**, Brasília, DF. 1965.

[6] BRASIL. Ministério do Meio Ambiente. Resolução nº 303, de 20 de março de 2002. Dispõe sobre parâmetros, definições e limites de Áreas de Preservação Permanente. **Diário Oficial da República Federativa do Brasil**, Brasília, DF. 2002.

[7] BUENO, C. R. P.; ARRAES, C. L.; PEREIRA, G. T.; CORA, J. E.; CAMPOS, S. Análise multivariada na determinação do risco de erosão em solos sob irrigação. **Revista Irriga,** Botucatu, v. 15, n. 1, p. 23-35, 2010.

[8] BUZELLI, M. G.; CUNHA-SATINO, M. B. Análise e diagnóstico da qualidade da água e estado trófico do reservatório de Barra Bonita, SP. **Revista Ambiente & Água,** Taubaté,v.8, n.1, p. 186-205, 2013.

[9] CALIL, P. M.; OLIVEIRA, L. F. C. de; KLEIMANN, H. J.; OLIVEIRA, V. A. de. Caracterização Geomorfométrica e do Uso do Solo da Bacia Hidrográfica do Alto Meia Ponte, Goiás. **Revista Brasileira de Engenharia Agrícola e Ambiental,** Campina Grande, v.16, n.4, p.433-442, 2012.

[10] CARVALHO, P. E. R. **Técnicas de recuperação e manejo de áreas degradadas**. In: GALVÃO, A. P. M. Reflorestamento de propriedades rurais para fins produtivos e ambientais: um guia para ações municipais e regionais. Colombo: EMBRAPA-CNPF, 2, p.19-55, 2000.

[11] COUTINHO, L. M.; ZANETTI, S. S.; CECÍLIO, R. A.; GARCIA, G. de O.; XAVIER A. C. Usos da Terra e Áreas de Preservação Permanente (APP) na Bacia do Rio da Prata, Castelo - ES. **Revista Floresta e Ambiente,** Nova Iguaçu, v. 20, p. 425-435, 2013.

[12] FIDALGO, E. C. C.; PRADO, R. B.; PEDREIRA, B. da C. C. G.; ARAÚJO, R. S. de. Caracterização e mapeamento do uso e cobertura da terra no COMPERJ, Estado do Rio de Janeiro, Brasil. **Embrapa Solos.** Boletim de Pesquisa e Desenvolvimento. Rio de Janeiro, 2011.

[13] GOMES, P. M.; MELO, C.; VALE, V. S. Avaliação dos impactos ambientais em nascentes na cidade de Uberlândia – MG: Análise Macroscópica. Sociedade & Natureza, Uberlândia, v. 17, p. 103-120, 2005.

[14] GUERRA, S. M. S.; SILVA, A. M. R. B. da; ARAÚJO, S. P.; CORRÊA, M. M.; SILVA, V. L. da; SANTOS, B. R. T. Caracterização Morfométrica e Avaliação da Qualidade da Água da Bacia Hidrográfica de Bita, Ipojuca – PE. **Revista Brasileira de Geografia Física,** Pernambuco, v.8, n3, p.759-775. 2015.

[15] JÚNIOE, R. F. do V.; PISSARA, T. C. T.; PASSOS, A. de O.; RAMOS, T. G.; ABDALA, V. L. Diagnóstico das áreas de preservação permanente na bacia hidrográfica do Rio Tijuco, Ituiutaba - MG, utilizando tecnologia SIG. **Revista Agrícola,** São Paulo, v.30, n3, p. 495-503. 2010.

[16] KOPPEN, W. **Climatologia: con um estúdio de los climas de latierra**. México: Fondo de Cultura Economica, p.400. 1948.

[17] MOTA, L. H. da S.; VALLADARES, G. S.; COELHO, R. M.; CRISCUOLO, C. Vulnerabilidade à Degradação dos Solos do município de Campinas, SP. **Revista Geografia,** Londrina, v.22, n.3, p. 65-79, 2013.

[18] OLIVEIRA, L. F. C. de; CALIL, P. M.; RODRIGUES, C.; KLIEMANN, H. J.; OLIVEIRA, V. A. de. Potencial do Uso dos Solos da Bacia Hidrográfica do Alto rio Meia Ponte, Goiás. **Revista Ambiente & Água,** Taubaté, v.8, n.1, p. 222-238,2013.

[19] OLIVEIRA, P. T. S. de; SOBRINHO, T. A.; STEFFEN, J. L.; RODRIGUES, D. B. B. Caracterização Morfométrica de Bacias Hidrográficas Através de Dados SRMT. **Revista Brasileira de Engenharia Agrícola e Ambiental,** Campina Grande,v. 14, n. 8, p. 819-825, 2010.

[20] PÉRICO, E.; Cemin, G.; Arend, U.; Rempel, C.; Eckhardt, R. R. Análise fisiográfica da bacia hidrográfica do rio Forqueta, RS. In: Simpósio Brasileiro de Sensoriamento Remoto, 15, 2011, Curitiba, **Anais...** São José dos Campos: INPE, p.1200-1207, 2011.

[21] PINTO, L. V. A.; ROMA, T. N. de; BALIEIRO, K. R. de C. Avaliação Qualitativa da àgua com Diferentes Usos do Solo em seu entorno. **Revista Cerne,** Lavras, v. 18, n. 3, p. 495-505, 2012.

[22] PINTO, V. G.; LIMA, R. N.; RIBEIRO, C. B. de M.; MACHADO, P. J. de O. Diagnóstico físico-ambiental como subsídio a identificação de áreas vulneráveis à erosão na bacia hidrográfica do Ribeirão do Espírito Santo, Juiz de Fora (MG), Brasil. **Revista Ambiente & Água,** Taubaté,v. 9, n. 4, p. 632-646, 2014.

[23] PIZELLA, G. D. A Relação entre Planos Diretores Municipais e Planos de Bacias Hidrográficas na Gestão Hídrica. **Revista Ambiente & Água,** Taubaté, v.10, n.3, p. 535-645, 2015.

[24] POMPERMAYER, R.; ANGELO, H.; ALMEIDA, A. N. de. Custo Social da Degradação da Qualidade Hídrica para o Abastecimento Público. **Revista Floresta e Ambiente,** Nova Iguaçu, v. 23, n. 3, p. 320-329, 2016.

[25] RECKZIEGEL, E. W.; ROBAINA, L. E. de S. Estudo de parâmetros morfométricos do relevo e da rede de drenagem da área situada entre os rios Jaguari e Ibicuí no município de São Vicente do sul – RS. In: VI SIMPÓSIO DE GEOMORFOLOGIA. 2006. Goiânia.

[26] ROCHA, J. S. M. KURTZ, S. M. J. M. **Manual de Manejo Integrado de bacias Hidrográficas**. Santa Maria: Editora da UFSM. 282 p. 2001.

[27] SAMPAIO, M. V.; SANTOS, M. da S.; ROCHA, J. S. M. da; PAULA, M. D. de; MENDES, A. V. Deterioração Físico – Conservacionista da Sub-bacia Hidrográfica do Rio Ibicuí – Mirim – RS. **Revista Ciência e Agrotecnologia,** Lavras, v.34, n. 2, p. 300-306, 2010.

[28] SANTOS, E. H. M. dos; GRIEBELER, N. P.; OLIVEIRA, L. F. C. de. Relação entre uso do solo e comportamento hidrológico na Bacia Hidrográfica do

Ribeirão João Leite. **Revista Brasileira de Engenharia Agrícola e Ambiental,** Campina Grande,v. 14, n. 8, p. 826-834, 2010.

[29] SANTOS, H.G. dos; JACOMINE, P.K.T.; ANJOS, L.H.C. dos; OLIVEIRA, V.A. de; LUMBRERAS, J.F.; COELHO, M.R.; ALMEIDA, J.A. de; CUNHA, T.J.F.; OLIVEIRA, J.B. de**. Sistema brasileiro de classificação de solos.** 3.ed. Brasília: Embrapa, p. 353, 2013.

[30] SOUZA, M. M de; & GASTALDINI, M. do C.. Avaliação da qualidade da água em bacias hidrográficas com diferentes impactos antrópicos. **Revista Engenharia Sanitária e Ambiental**, Rio de Janeiro, v. 19, n. 3, p. 263-274, 2014.

[31] UMETSU, R. K.; PEREIRA, N.; CAMPOS, E. F. de P. de; UMETSU, C. A.; MENDONÇA, R. A. M. de; BERNASCONI, P.; CAMARGO, M. F. Análise morfométrica e socioambiental de uma bacia hidrográfica Amazônica, Carlinda, MT. **Revista Árvore,** Viçosa, v. 36, n. 1, p.83-92, 2012.

[32] ZUCCO, E.; PINHEIRO, A.; SOARES, P. A. Influência do Uso do Solo no Transporte de Cargas Anuais de Poluentes em Uma Bacia Agrícola. **Revista Brasileira de Recursos Hídricos**, Porto Alegre, v. 19, n. 2, p. 19-28, 2014.