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Research Paper

Groundwater Quality of Capim Grosso Region, Bahia , Brazil

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ABSTRACT: *The region Capim Grosso has semiarid climate and scarce surface drainage. This article presents the results of hydrochemistry of groundwater these Bahia State area taking up the potability of groundwater for human and agriculture use. To achieve these objective water samples were collected from wells and conducted in situ measurements the physico-chemical parameters such as pH, eH, electrical conductivity, total dissolved solids, temperature, turbidity, dissolved oxygen and analysis measures in laboratories of the following components* HCO_{3-} , SO_4^{2-}, NO_{3-}, F^-, PO_4^{3-}, Cl^-, Mg_2^+, Na^+, Ca_2^+, K^+, Ba_2^+, Pb_2^+, Zn_2^+, Fe_2^+, Mn_2^+, Al_3^+, Cu^+, *using of fluorimetric techniques, titrimetric and espectrofométricos. The results indicate that groundwater is classified generally as magnesian and calcic chlorinated, highly salinated, with high hardness and exceptionally high risk of salinization of soils. From the point of view for potability, only the elements iron, zinc, copper and fluoride showed no impediment to domestic supply, all other elements exceeded the limits established by Brazilian law, so they are considered unfit for human consumption. Before all the results it is apparent that from a qualitative point of view, groundwater Capim Grosso has not appropriate hydrochemical characteristics for human consumption and agriculture, suggesting the state agencies of the State of Bahia management study from other sources catchment water to this region of the Brazilian semi-arid region.*
Keywords: *Hydrogeochemical; groundwater; potability; Capim Grosso region.*

I. INTRODUCTION

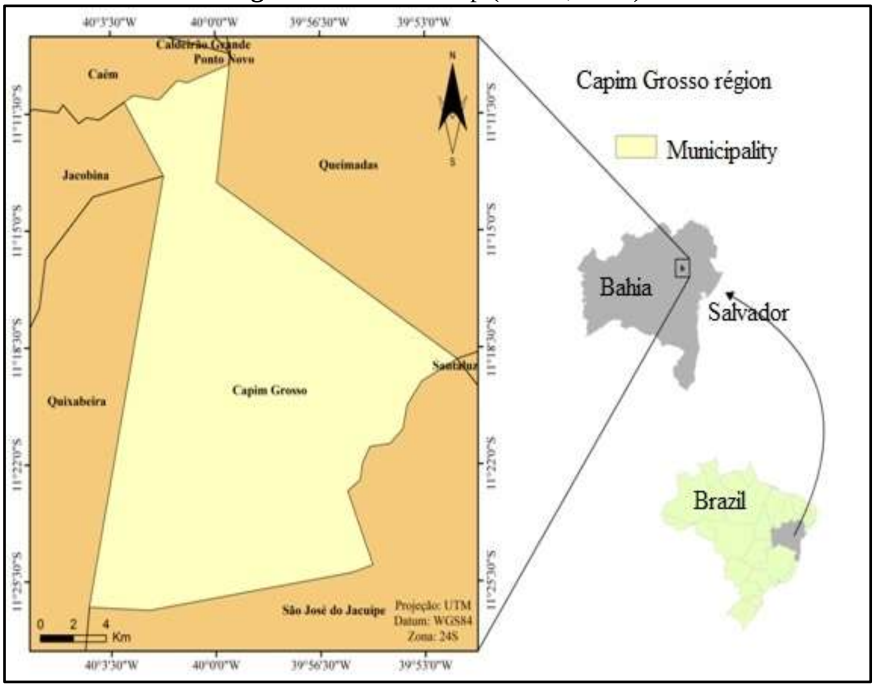
The use of groundwater date from ancient times, the Egyptians and Persians built tunnels to capture these waters. Similarly , the attempt to understand the origin , occurrence and movement of groundwater began to be speculated by the older philosophers , who raised hypotheses and tried to theorize on this topic. This knowledge has been enhanced slowly for hundreds of years until the arrival of the eighteenth century, where he laid the foundations of Geology and allowed the foundation for understanding the dynamics of groundwater (Todd , 1959) .

In the semi-arid region of northeastern state of Bahia, Brazil, the aquifer is predominantly installed in high-grade metamorphic rocks, granulites-migmatites, generically called crystalline rocks. These groundwater reservoirs have virtually zero primary porosity and interconnected inter-crystalline gaps are minimal, and the hydraulic conductivity is extremely small. The water accumulation within these fractures and are in this way then developing a secondary porosity. In the latter case, the hydraulic conductivity depends on the size and intensity of the fracture, but in general it is considered low. The infiltrated and percolated water in this aquifer has predominantly meteoric rise, it is accumulated in their small openings and zones of weakness. Thus, the main characteristics of fissure aquifers, in very general way, are: random reservoirs, discrete and of small extent; small flows and brackish waters. These characteristics can vary from one region to another, since these attributes are dependent on other factors, such as climate; intensity and type of rock fracture.

The fissure and granular nature of the aquifer system of the municipality of Capim Grosso, Bahia, Brazil, have brackish and salt water and low flow. But there are improved and current studies on the physicochemical characteristics of the aquifer. It is noted that this reservoir are highly relevant to urban and rural areas, since the region Capim Grosso has little surface drainage and the system is low rainfall, where rainfall is scarce and irregular. This municipality is fully inserted in the Brazilian Drought Polygon, area driven into the northeastern backlands and legally recognized as a region subject to critical periods of drought. In this area dominates the deficits in the water balance and different levels of aridity (RIOS, 2015).

The municipal polygon Capim Grosso, Bahia, Brazil, comprises an area of about 336 km², located within the limits of geographic coordinates 11º 23'00" south latitude and 40 ° 01'00" west longitude, lying 268 km from the capital State of Bahia, Salvador city (Figure 1). This article presents the results of evaluative research on the quality of groundwater in the area of the municipality of Capim Grosso related to hydrochemical aspects and measuring the potability of the water of these Brasilian semi-arid sites.

Figure 1: Location map (RIOS, 2015).



II. GENERAL CHARACTERISTICS

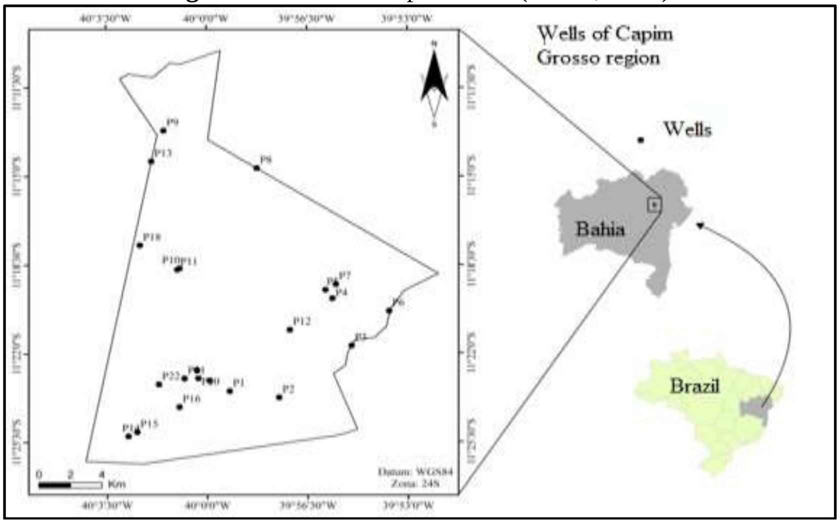
The climate domains Capim Grosso is situated in semi-arid climate range (SEI,1999), characterized by high temperatures, low rainfall , with two stations i) summer, with a concentration of rainfall and ii) Winter , dry and average the annual rainfall of 400 to 800 mm range. The soils were classified as Red-Yellow Dystrophic Latosol, Planosol Eutrophic and restrictively Udorthent Dystrophic CPRM (2005). They are considered slightly acidic due to their genetic relationship and saline due to intense evaporation and reduced rainfall . The geomorphology of the municipality of Capim Grosso is made up trays provincials SEI (2015).

The local vegetation dominates the Caatinga arborous with palm trees and Contact Caatinga- Seasonal Forest (SEI, 2015). This primary vegetation has been practically removed for agriculture and livestock activities. The region is still practicing archaic and uninformed farm, using rudimentary techniques and the production is for the domestic market and for subsistence. The local geology consists of crystalline rocks of high metamorphic grade of Proterozoic age belonging to the complex Caraíba and Tanque Novo Ipirá in addition to the suite São José do Jacuípe , recovers by lateritic detritus sediments, made of sand with clay levels and gravel old and recent and quaternary colluvial deposits CPRM (2005) . The hydrography of the region is fully inserted inserted into the Rio Itapicuru basin , specifically in the region called Alto Itapicuru (INEMA, 2015). Surface drainages are scarce, with limited and intermittent watercourses example the stream of Father Thomas, the river fish and Itapicuru Mirim. This together form watercourses form a dendriform dendritic drainage regulated by brittle geological structures.

III. MATERIALS AND METHODS

To achieve the results presented in this publication were used the following methodological steps: i) detailed search theoretical basis research and allow survey and selection of wells through SIAGAS system (CPRM), where the data 18 registered wells were found and the registration of CERB , which store data in 29 wells drilled. The Agriculture Secretariat of Municipal Capim Grosso Hall was also consulted, stating the location of drilled private wells in the city. At the end of this process, they were registered and visited and sampled 22 wells (Figure 2).

Figure 2: Location map of wells (RIOS, 2015).



During the water sampling and in situ analysis of physicochemical parameters we used a multiparameter probe Horiba U-50 Multiparameter Water Quality Checker to obtain the physico-chemical parameters such as hydrogen potential (pH) , redox potential (EH), Dissolved Oxygen (DO), Electrical Conductivity (EC), Total Dissolved Solids (TDS), temperature, turbidity and salinity. Water samples were stored in bottles in plastic polyethylene containers previously decontaminated by aqueous solution containing 5% HCl or HNO_3 and reseal , field records, gloves,GPS, ; deionized water and ice to keep samples in cold temperatures.

Prior to sample collection the wells were purged by pumping for a period of 10 to 20 minutes , time required to remove the water pipe and to obtain a sample directly from the aquifer. The water was collected in nature , using the containers for storage. In some of the sampled wells there was no electric pump equipment, if necessary, so use Disposable Samplers Groundwater - Bailer. The samples for nitrate analysis (NO_3) were acidified with 1mg/L of H_2SO_4 and chilled in order to preserve its characteristics to the analysis. Samples dedicated to the analysis of metals were filtered in the laboratory, they were subsequently acidified and refrigerated until the time of analysis . The sample preservation techniques followed the technical guidelines Analysis Practical Handbook of Water (FUNASA, 2006) and the Standard Methods for the Examination of Water and Wastewater (APHA,1995). The order of analysis followed the parameters of established methods, carried out in the Plasma Laboratory of Geosciences Institute of Federal University of Bahia, where the results of HCO_3 content, titration with sulfuric acid and Cl (titration with silver nitrate) by tritrimetrie , SO_4^{2-} and NO_{3-} were dosed by spectrophotometry and F^- by fluorimetry (SPADNS method). The second part of the samples was vacuum filtered with cellulose membrane (0.45 μm) taken at a rate of 200 mg/L for each sample, and acidified with 5mg/L of HNO_3 , subjected to digestion processes stored in becker to concentration disposing on the plate heater at an average temperature of 60 ° C , to Ca metal analyzes, Mg, Na , K, Fe, Cu , Zn , Mn , Ba , Pb and Al using ICP-OES device 700 series from Agilent Technologies. The analytical results obtained are shown in Table 3.

IV. RESULTS AND DISCUSSIONS

There is no pure water in nature (RIOS,2015). This material is able to dissolve solids, gases and dilute liquids. By precipitating in the form of rain, it carries substances from the atmosphere. Percolate to the ground , it dissolves the materials present . Upon reaching the aquifer , it incorporates the chemical characteristics of the rocks that compose it , based on the analytical results were constructed graphs and charts through systematic data in Excel (Tables 1,2,3) , and were made maps with the spatial distribution of each variable in the underground waters of the municipality. The Total Dissolved Solids (TDS) have an average of 4.600mg/L, ranging from a minimum of 720mg/L and a maximum of 14,000 mg/L. Overall, the analyzes show numbers are above the Maximum Amount Allowed (VMP) for STD 1000mg/L for drinking water established by Ordinance N^o. 2914/2011 of the Ministry of Health of Brazil . The values of electrical conductivity (EC) have average 7603.18μS/cm, and which has the highest conductivity with 22500μS/cm , and less with 1.130μS / cm. The electrical conductivity is not a parameter legislated by Ordinance N^o. 2914/2011 of the Ministry of Health of Brazil, but the technical literature recommends a lower EC to 750μS/cm to a good drinking water (MENDES and OLIVEIRA, 2004).

The average hydrogenionic potential (pH) found in the waters of the region was 6,63mg/L , the lowest of 4,03mg/L and the highest of 7,40mg /L. The means indicate that all the wells are in the ranges established as normal and expected for a groundwater (CUSTÓDIO and LLAMAS, 1983) . The hydrogenionic potential is not a legislated parameter by Ordinance No. 2914/2011 of the Ministry of Health of Brazil. Urge point out that the average values do not imply consumption problems , but very low or high values may result in the dissolution of minerals, algae growth , corrosion or fouling of pipes (MENDES and OLIVEIRA, 2004). The average of chlorides values found in the study was 1.962,05mg/L, with the lowest value of 181,77mg/L and the highest value of 6.996,18mg/L. The anion Cl^- combined with the alkali metal form of the salts most abundant in nature, being found in all natural waters. In groundwater , chloride originates from the leaching of soil and aquifer rocks and also contamination of sewage, industrial effluents and intrusion of saline wedge in coastal regions. The Ordinance N^o. 2914/2011 of the Ministry of Health of Brazil down to drinking water to a maximum of 250mg/L chloride, most of the measurements taken showed better results than the set number.

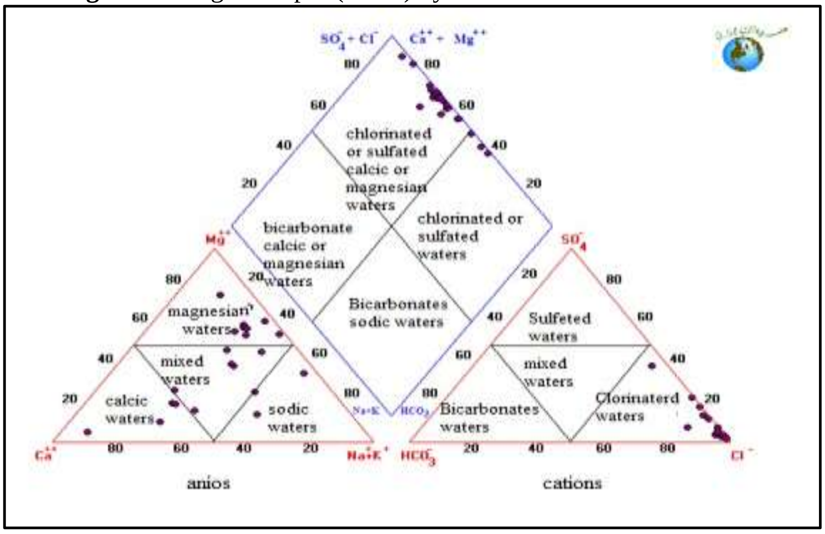
Sulfate salts are ionic compounds containing the anion and SO_4^{2-} are formed when sulfuric acid (H_2SO_4-) is reacted with base (OH-), promoting the neutralization process. It gave the average value of 122,42mg/L sulphate in groundwater. The highest value was found 481,75mg/L and the lowest of 5,47mg/L . Excess sulphate in industrial supply can cause fouling in boilers and heat exchangers and human consumption , their intake causes laxative effect (CETESB , 2009) and unpleasant taste (MENDES and OLIVEIRA, 2004) . The value of 250mg/L is established Ordinance N^o. 2914/2011 of the Ministry of Health of Brazil.

Calcium and magnesium present average values are 338,04mg /L calcium, the highest value found in the order of 2.811,25mg L and the lowest of 15,40mg /L. High concentrations of this element in the water contributes to increased salinity, electrical conductivity and hardness. Calcium is not a legislated parameter by Ordinance N^o. 2914/2011 of the Ministry of Health of Brazil. It is noteworthy that for the human body is an important element , especially in the skeletal system and in combination with other minerals (sodium, potassium, etc.) develops enzymatic functions so essential to the growth of young people (MENDES and OLIVEIRA, 2004) , however, high levels of calcium can cause kidney problems. The sodium and potassium the highest value of 814,99mg/L the minimum value 159.06 mg/L and 404,80mg/L and lower than 2.10 mg/L, respectively. The Ordinance N^o. 2914/2011 of the Ministry of Health of Brazil establishes the maximum value of 200 mg/L sodium, establishes no number for potassium in drinking water , since this element is always found in small quantities. However it is urgent to point out that this element in normal amounts involved in the enzymatic system and the nervous influxes and its deficiency causes muscle weakness and loss of brain power (MENDES and OLIVEIRA, 2004) .

The Dissolved Oxygen (DO) have an average of 4,71mg/L, with higher values obtained from 7,31mg/L less than 2,89mg / L. In these wells were found higher Fe values. The alkalinity of the water is 2.0 mg/L and most 41,01mg/L, average values are 11,38mg/L. This parameter is not legislated by Ordinance N^o. 2914/2011 of the Ministry of Health of Brazil, though out the World Health Organization indicates a minimum value of 5 mg/L. The alkalinity of the water with respect to its quantitative ability to neutralize acids (H+) and therefore the greater the number of ions hydroxyl (OH-) , the more water is alkaline . The natural source of alkalinity comes from the rocks, the atmosphere, organic matter and photosynthesis, and anthropogenic origin are domestic and industrial waste. The higher alkalinity values are north , north-eastern region , it found out that the lowest value found was below the LQM to bicarbonate which is 2.0mg / L , so we used the LQM itself as the reference value , having noticed greater numbers of the order of 41,01mg / L and average 11,38mg/L. The Ordinance N^o. 2914/2011 of the Ministry of Health of Brazil does not establish a VMP (maximum allowed) for alkalinity as it has no toxicity problems.

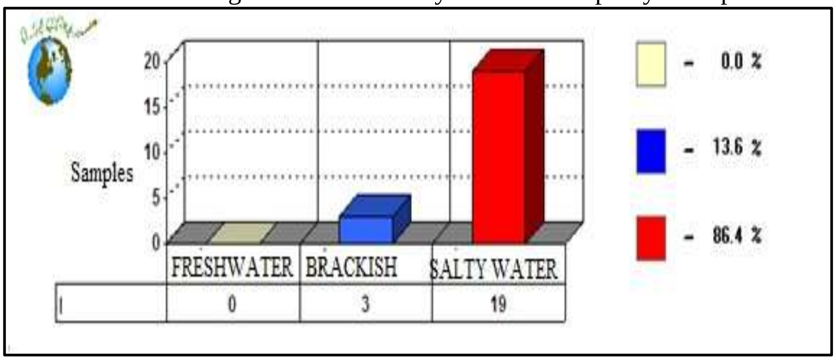
For total hardness the lowest value found was 97,07mg/L and the highest value 2.893,22mg/L, average 688,67mg/L. Using the criteria of Custodio and Llamas (1983) the waters of the region are classified as hard to very hard. The mean values obtained for phosphate was 0.07 mg/L, the lowest result of the order of 0,002mg/L and the highest of 0.42mg/L. For the lowest nitrate was 0.05mg/L , and most of 387,25mg/L mean values were 55,68mg/L. The fluoride values and are uniform throughout the area with an average of 0,52mg/L. The highest concentration was 0,97mg/L and less than 0,26mg/L. The pointed fluoride in all wells at an average of 0.52 mg/L. The highest concentration was 0,97mg/L and less than 0,26mg/L, values within the limits allowed Ordinance N^o. 2914/2011 of the Ministry of Health of Brazil . It is noted that fluoride values are very uniform throughout area study, but the greatest focus on the northeast and southeast of the city. This fluoride comes from apatite $Ca_5(PO_4)_3$(F,OH,Cl) widely found throughout the territory. The values for iron, respectively 0.10 mg/L and 0,16mg/L, with an average of 0.01mg/L, often absent in its waters. In relation to the manganese values are of the order of 0.01 mg / L and 1,98mg / L medium are 0,40mg/L. Elements such as Ba, Al,Zn and Cu have no significant values in the waters of the region. The Ordinance N^o. 2914/2011 of the Ministry of Health of Brazil, does not make a VMP for phosphate, 10mg/L for nitrate, 0.3mg/L for iron, 0.1mg/L for manganese, 0.2mg/L for aluminum, 5,0mg/L of zinc and 2.0mg/L copper. These chemical components (Table 1,2,3 and 4) only the nitrate is completely above the maximum allowed by VPM such Ordinance. Urge noted that the nitrate contamination in water can cause damage to health, especially for babies, known as the Blue Baby Syndrome, where the nitrate induce methemoglobinemian. Not enough, nitrate intestine can be reduced to nitrite and reacted with secondary amines to form nitrosamides, which are carcinogens (Oliveira Mendes, 2004). For the classification hydrochemistry was used Qualigraf software (Möbus, 2003), where the main values of the cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anions (CO_{3-}, HCO_{3-}, Cl^{-} and SO_4^{2-}) were plotted in triangular diagram Piper (1944). The result diagram allowed to classify these waters as being generically sulfated water / chlorinated and calcic/magnesian (86.4%) and secondarily sulfated water / chlorinated sodic (13.6%) (Figure 3).

Figure 3: Diagram Piper (1944) hydrochemical characterization.



With regard to water salinity showed no well freshwater, brackish water showed only three and all other presented brine. (Figure 4) .

Figure 4: Classification in relation to groundwater salinity in the municipality of Capim Grosso (RIOS, 2015) .



Comparing the analytical results received with the maximum permissible values (VMP) established by Ordinance N°. 2914/2011 of the Ministry of Health of Brazil, it turns out that almost all sampling sites and analyzed have values higher than those established for the potability expressed by quoted above ordinance, and thus not suitable for human consumption.

Considered the use of water for irrigation, the main parameters to be observed are salinity, sodicity the toxicities (FEITOSO *et a*l, 2008). The RAS parameter - Adsorption ratio of sodium, plotted in the SAR diagram and adopted by the U.S. Salinity Laboratory, RAS is an index which indicates the relative proportion of Na^{+} over Ca^{2+} and Mg^{2+}, that content is important especially when high sodium rates, as they tend to replace calcium and magnesium, compromising the soil. The results of water classification for irrigation by the US Salinity Laboratory (USSL, 1954) for the municipality of Capim Grosso, indicates the predominance of C5 S2 classes (31.8%) demonstrated an exceptionally high risk of salinity and medium risk sodium ; followed C5-S3 (27.3%), further evidencing an exceptionally high salinity risk and high risk sodium; C4-class S2 (18.2%) indicating very high salinity risk and medium risk sodium; C3-S1 (13.6%) indicates a high risk of salinity and low risk sodium, and finally, the class C4-S1 (9.1) indicates that a risk of very high salinity and low risk sodium.

V. CONCLUSIONS

The water can be used for human consumption is the drinking water, that free of substances that offer health risk. For agriculture uses exist criteria for irrigation is no different, as the water with inadequate properties may compromise the crop, the soil and the irrigation tube system. The physical and chemical parameters evaluated for Capim Grosso, iron, zinc, nickel, copper and fluoride did not show values above those permitted by law. The other parameters showed higher values than legislated by the Ministry of Health, therefore cannot be consumed by the population. The use of groundwater, obtained through the use of collection wells should not be a recommended technique for this semi-arid region of Bahia. The results the light of scientific rigor indicate that other means of capture and water storage should be prioritized by government agencies to reduce the serious problem of supply and use of this poor region in water resources.

REFERENCES

[1]. American public health association (apha). **Standard methods for the examination of water and wastewater.** 20 th ed. Washington: APHA/AWWA, 1998.

[2]. CETESB. **Significado ambiental e sanitário das variáveis de qualidade das águas e dos sedimentos e metodologias analíticas e de amostragem**. Relatório técnico CETESB. São Paulo: 2009.

[3]. CPRM – Serviço Geológico do Brasil. **Projeto cadastro de fontes de abastecimento por água subterrânea**: Diagnóstico do município de Capim Grosso – Bahia. Salvador: CPRM/PRODEEM, 2005.

[4]. **Sistema de Informações de Águas Subterrâneas** - SIAGAS. Rio de Janeiro, 2015. Disponível em: http://siagasweb.cprm.gov.br/layout/ . Acesso em: 10 de Junho de 2015.

[5]. CUSTÓDIO, E.G.; LLAMAS, M.R. **Hidrologia Subterrânea**. Barcelona: Ediciones Omega S.A., 1983. 2 v.

[6]. FEITOSA, F.; MANOEL FILHO, J. **Hidrogeologia:** conceitos e aplicações. Fortaleza: CPRM, LABHID-UFPE, 2008, 812p.

[7]. FUNDAÇÃO NACIONAL DE SAÚDE (FUNASA). **Manual prático de análise de água.** Brasília: FUNASA, 2006, 2ª ed. ver.

[8]. GOVERNO DO ESTADO DA BAHIA. SEPLANTEC/SEI – **Análise dos Atributos Climáticos do Estado da Bahia.** SEI, Salvador, 1998.

[9]. INEMA - Instituto do Meio Ambiente e Recursos Hídricos. **Relatório de informações hidrológicas e meteorológicas.** Disponível em: http://monitoramento.inema.ba.gov.br/planilhas/plu/.

[10]. LOGAN, J. **Interpretação de análises químicas de água**. Recife: [U.S. Agency for International Development], 1965. 67 p.

[11]. MENDES, B., OLIVEIRA, J.F.S. **Qualidade da Água para Consumo Humano**. Lisboa: Lidel, Edições Técnicas Ltda., 2004.

[12]. MINISTÉRIO DA SAÚDE DO BRASIL**. Portaria Nº 2914/2011 de 12 de dezembro de 2011. Brasília** – DF: Republicado no Diário Oficial da União de 14/12/2011.

[13]. MOBUS, G. **Qualifraf.** Programa para análise da qualidade de água. FUNCEME. Disponivel em: HTTP: http://www3.funceme.br/qualigraf/mi/midia/show/3. PIPER, A. M. **A graphic procedure in the geochemical interpretation of water anallysis**. Transactions American Geophysical Union: Washington, 1944, v. 25, p. 911-923.

[14]. RIOS,D.C. **Hidrogeoquímica Das Águas Subterrâneas Do Município De Capim Grosso, Bahia.** 2015. 111 f. Dissertação (Mestrado em Geologia) – Instituto de Geociências – Universidade Federal da Bahia – UFBA. Salvador, 2015.

[15]. SANTOS, A. C. Noções de hidroquímica. In: Feitosa A. C.; Manoel Filho, J. (Eds.). **Hidrogeologia**: conceitos e aplicações. Fortaleza: CPRM, LABHID-UFPE, 2008.

[16]. SUPERINTENDÊNCIA de Estudos Econômicos e Sociais da Bahia - SEI**. Balanço hídrico do estado da Bahia. Salvador**: SEI, 1999. 250 p. (Série Estudos e Pesquisas, 45).

[17]. **Sistema de informações municipais.** Bahia, 2015. Disponível em: http://sim.sei.ba.gov.br/sim/informacoes_municipais.wsp. TODD, David K. **Hidrologia de águas subterrâneas.** São Paulo: Edgard Blücher Ltda, 1959.

[18]. UNITED STATES SALINITY LABORATORY (USSL). **Diagnosis and Improvement of Saline and Alkali soils**. U.S.D.A. Handbook. Nº 60 -. 1954.

Estimators	Minimum Maximum Median Arithmetic Mean Standard Deviation Standard Error Coefficient of variation SW normality test (p value)	Minimum Maximum Median Arithmetic Mean Standard Deviation Standard Error Coefficient of variation SW normality test (p value)	Minimum Maximum Median Arithmetic Mean Standard Deviation Standard Error Coefficient of variation SW normality test (p value)	Minimum Maximum Median Arithmetic Mean Standard Deviation Standard Error Coefficient of variation SW normality test (p value)	Minimum Maximum Median Arithmetic Mean Standard Deviation Standard Error Coefficient of variation SW normality test (p value)	Minimum Maximum Median Arithmetic Mean Standard Deviation Standard Error Coefficient of variation SW normality test (p value)	Minimum Maximum Median Arithmetic Mean Standard Deviation Standard Error Coefficient of variation SW normality test (p value)	Minimum Maximum Median Arithmetic Mean Standard Deviation Standard Error Coefficient of variation SW normality test (p value)
STD	720	14000	3660	4758.1818	3529.0585	752.3978	74.17%	0.0154
Turbidity	0	84.4	0	10.1409	24.2339	5.1667	238.97%	0.0054
pH	4.03	7.4	6.79	6.6377	0.6958	0.1483	10.48%	0.0085
E_H	-37	163	-1	8.0455	41.4045	8.8275	514.63%	0.0085
°C	25.22	29.66	27.125	27.3086	1.2541	0.2674	4.59%	**0.701***
O.D	1.89	7.31	4.745	4.7105	1.3784	0.2939	29.26%	**0.9753**
CE	1130	22500	5805	7603.1818	5721.9164	1219.9167	75.26%	0.0133
Dureza	97.08	2893.22	509.205	688.6732	608.5569	129.7448	88.37%	0.0084
SO_4^{2-}	5.47	481.75	72.45	122.4223	122.7772	26.1762	100.29%	0.0094
F^-	0.26	0.97	0.455	0.5282	0.2066	0.0441	39.12%	**0.07**
PO_4^{3-}	0	0.42	0.03	0.07	0.1001	0.0213	142.99%	0.0076
Cl^-	181.77	6996.18	1367.525	1962.0505	1796.3132	382.9753	91.55%	0.0095
NO_3^-	0.05	387.25	25.5	55.68	84.8103	18.0816	152.32%	0.007
HCO_3	0	41.01	8.4	11.3823	10.6454	2.2696	93.53%	0.009
Mg^{2+}	19.98	1203.99	242.24	335.69	319.2633	68.0672	95.11%	0.0096
Na^+	159.06	815	370.75	404.8055	198.3192	42.2818	48.99%	**0.0792**
Ca^+	15.41	2811.25	206.75	338.0432	590.2046	125.832	174.59%	0.0056
K^+	2.1	31.2	12.5	13.0595	7.6015	1.6207	58.21%	**0.4335**
Ba^+	0	14.21	0.25	1.2023	3.0217	0.6442	251.33%	0.0046
Pb^{+2}	0	0.05	0	0.0027	0.0108	0.0023	394.94%	0.0032
Zn^{+2}	0	1.92	0.02	0.1323	0.4096	0.0873	309.66%	0.004

Table 1 : Descriptive Statistics and Normality Test Shapiro- Wilks .* Numbers in bold represent the values that reached the normal range (> 0.05) in the Shapiro- Wilks test

	STD	Tur	pH	E_H	°C	O.D	CE	Dur	SO_4^{2-}	F^-	PO_4^{3-}	Cl^-	NO_3^-	HCO_3	Mg^{2+}	Na^+	Ca^+	K^+	Ba^+	Pb^{+2}	Zn^{+2}	Fe^{+2}	Mn^{+2}	Ni^{+2}	Al^{+3}	Cu^+
STD	**1.00***	0.10	-0.12	0.13	0.22	-0.02	**1.00**	0.62	0.30	0.30	-0.50	**0.99**	-0.16	-0.06	**0.98**	**0.84**	-0.27	**0.77**	0.27	-0.19	0.03	0.35	0.37	0.30	-0.14	-0.34
Tur	0.10	**1.00**	0.22	-0.24	-0.11	-0.30	0.10	-0.01	-0.14	0.14	0.02	0.12	-0.27	-0.09	0.03	0.27	-0.21	0.02	0.32	-0.23	0.31	0.09	-0.18	0.07	-0.19	-0.08
pH	-0.12	0.22	**1.00**	**-1.00**	0.37	-0.03	-0.12	-0.16	0.30	0.36	0.47	-0.12	-0.36	0.35	-0.06	-0.12	0.08	-0.44	-0.38	0.14	-0.19	0.10	0.30	-0.45	-0.11	-0.23
E_H	0.13	-0.24	**-1.00**	**1.00**	-0.35	0.04	0.13	0.15	-0.30	-0.36	-0.47	0.12	0.36	-0.35	0.07	0.12	-0.09	0.44	0.36	-0.14	0.18	-0.11	-0.30	0.45	0.12	0.23
°C	0.22	-0.11	0.37	-0.35	**1.00**	0.19	0.22	0.04	0.45	0.25	0.07	0.17	-0.11	0.00	0.27	0.07	-0.14	-0.02	-0.38	-0.13	-0.10	-0.13	0.36	-0.07	0.03	-0.03
O.D	-0.02	-0.30	-0.03	0.04	0.19	**1.00**	-0.02	0.17	-0.11	-0.04	0.04	0.03	-0.03	-0.20	-0.04	0.01	0.21	0.11	-0.12	0.25	-0.31	-0.50	-0.14	0.12	-0.21	-0.01
CE	**1.00**	0.10	-0.12	0.13	0.22	-0.02	**1.00**	0.62	0.30	0.30	-0.50	**0.99**	-0.16	-0.06	**0.98**	**0.84**	-0.27	**0.77**	0.27	-0.19	0.03	0.35	0.37	0.30	-0.14	-0.34
Dur	0.62	-0.01	-0.16	0.15	0.04	0.17	0.62	**1.00**	0.18	0.16	-0.18	0.66	-0.56	0.18	0.63	0.63	0.40	0.48	0.03	-0.11	-0.19	0.25	-0.03	-0.05	-0.35	-0.50
SO_4^{2-}	0.30	-0.14	0.30	-0.30	0.45	-0.11	0.30	0.18	**1.00**	0.59	0.02	0.24	-0.35	0.39	0.37	0.12	0.03	-0.06	-0.59	-0.14	-0.31	0.21	0.35	-0.38	0.21	-0.33
F^-	0.30	0.14	0.36	-0.36	0.25	-0.04	0.30	0.16	0.59	**1.00**	0.13	0.27	-0.29	0.41	0.31	0.27	-0.11	0.06	-0.23	0.05	-0.12	0.16	0.38	-0.14	0.10	-0.37
PO_4^{3-}	-0.50	0.02	0.47	-0.47	0.07	0.04	-0.50	-0.18	0.02	0.13	**1.00**	-0.52	-0.26	0.53	-0.49	-0.46	0.26	-0.54	-0.22	0.05	0.02	-0.01	-0.09	-0.28	-0.05	0.01
Cl^-	**0.99**	0.12	-0.12	0.12	0.17	0.03	**0.99**	0.66	0.24	0.27	-0.52	**1.00**	-0.18	-0.08	**0.97**	**0.84**	-0.22	**0.77**	0.32	-0.12	0.02	0.33	0.35	0.30	-0.22	-0.33
NO_3^-	-0.16	-0.27	-0.36	0.36	-0.11	-0.03	-0.16	-0.56	-0.35	-0.29	-0.26	-0.18	**1.00**	-0.39	-0.20	-0.22	-0.37	-0.10	0.29	-0.26	0.24	-0.19	-0.08	0.31	0.44	0.24
HCO_3	-0.06	-0.09	0.35	-0.35	0.00	-0.20	-0.06	0.18	0.39	0.41	0.53	-0.08	-0.39	**1.00**	-0.01	-0.13	0.23	-0.39	-0.22	-0.02	-0.34	0.24	0.12	-0.59	-0.10	-0.36
Mg^{2+}	**0.98**	0.03	-0.06	0.07	0.27	-0.04	**0.98**	0.63	0.37	0.31	-0.49	**0.97**	-0.20	-0.01	**1.00**	**0.77**	-0.28	**0.72**	0.22	-0.12	-0.03	0.35	0.45	0.26	-0.15	-0.29
Na^+	**0.84**	0.27	-0.12	0.12	0.07	0.01	**0.84**	0.63	0.12	0.27	-0.46	**0.84**	-0.22	-0.13	**0.77**	**1.00**	-0.15	**0.70**	0.19	-0.18	0.03	0.29	0.04	0.27	-0.16	-0.35
Ca^+	-0.27	-0.21	0.08	-0.09	-0.14	0.21	-0.27	0.40	0.03	-0.11	0.26	-0.22	-0.37	0.23	-0.28	-0.15	**1.00**	-0.27	-0.31	0.04	-0.10	0.08	-0.41	-0.34	-0.18	-0.40
K^+	**0.77**	0.02	-0.44	0.44	-0.02	0.11	**0.77**	0.48	-0.06	0.06	-0.54	**0.77**	-0.10	-0.39	**0.72**	**0.70**	-0.27	**1.00**	0.46	0.08	0.23	0.21	0.29	0.55	-0.21	0.03
Ba^+	0.27	0.32	-0.38	0.36	-0.38	-0.12	0.27	0.03	-0.59	-0.23	-0.22	0.32	0.29	-0.22	0.22	0.19	-0.31	0.46	**1.00**	-0.03	0.57	0.25	0.11	0.46	-0.22	0.21
Pb^{+2}	-0.19	-0.23	0.14	-0.14	-0.13	0.25	-0.19	-0.11	-0.14	0.05	0.05	-0.12	-0.26	-0.02	-0.12	-0.18	0.04	0.08	-0.03	**1.00**	-0.15	-0.10	0.31	0.11	-0.21	0.40
Zn^{+2}	0.03	0.31	-0.19	0.18	-0.10	-0.31	0.03	-0.19	-0.31	-0.12	0.02	0.02	0.24	-0.34	-0.03	0.03	-0.10	0.23	0.57	-0.15	**1.00**	0.52	0.03	0.53	0.03	0.34
Fe^{+2}	0.35	0.09	0.10	-0.11	-0.13	-0.50	0.35	0.25	0.21	0.16	-0.01	0.33	-0.19	0.24	0.35	0.29	0.08	0.21	0.25	-0.10	0.52	**1.00**	0.39	-0.07	0.05	-0.13
Mn^{+2}	0.37	-0.18	0.30	-0.30	0.36	-0.14	0.37	-0.03	0.35	0.38	-0.09	0.35	-0.08	0.12	0.45	0.04	-0.41	0.29	0.11	0.31	0.03	0.39	**1.00**	-0.08	0.01	0.10
Ni^{+2}	0.30	0.07	-0.45	0.45	-0.07	0.12	0.30	-0.05	-0.38	-0.14	-0.28	0.30	0.31	-0.59	0.26	0.27	-0.34	0.55	0.46	0.11	0.53	-0.07	-0.08	**1.00**	0.03	0.47
Al^{+3}	-0.14	-0.19	-0.11	0.12	0.03	-0.21	-0.14	-0.35	0.21	0.10	-0.05	-0.22	0.44	-0.10	-0.15	-0.16	-0.18	-0.21	-0.22	-0.21	0.03	0.05	0.01	0.03	**1.00**	0.06
Cu^+	-0.34	-0.08	-0.23	0.23	-0.03	-0.01	-0.34	-0.50	-0.33	-0.37	0.01	-0.33	0.24	-0.36	-0.29	-0.35	-0.40	0.03	0.21	0.40	0.34	-0.13	0.10	0.47	0.06	**1.00**

Tabela 2: Spearman correlation . * stars in red indicate the best correlations between parameters .

Table 3: Results of chemical analysis of the wells in the Capim Grosso region.

Poço	Altitude	UTM X	UTM Y	STD (mg/L)	Tur (UTN)	pH	E_h (mV)	°C	Salin (PPM)	OD mg/L	CE (µS/cm)	Dur (mg/L)	SO_4^{2-} (mg/L)	F (mg/L)	PO_4^{3-} (mg/L)	Cl (mg/L)	NO_3^- (mg/L)	Alc tot (mg/L)
P-01	360	0392525	8740536	440	1.2	6.47	18	25.85	0.30	4.60	700	374.00	14.34	0.26	0.04	1607.51	28.57	0.02
P-02	365	0389461	8740086	320	0	6.79	-1	25.22	0.26	4.07	480	310.09	16.40	0.41	0.03	850.00	13.65	12.42
P-03	385	0400056	8740872	520	37.3	6.95	-11	27.09	0.46	1.86	870	598.16	268.73	0.66	0.11	1088.46	5.47	41.00
P-04	387	0398030	8747312	200	0	7.16	-25	27.01	0.16	4.85	320	527.00	132.71	0.37	1.42	738.60	0.65	16.65
P-05	395	0398095	8745952	72	2.6	6.79	-1	20.19	0.08	3.5	1130	87.00	29.71	0.40	0.13	118.77	39.90	0.00
P-06	378	0402007	8745690	730	8.4*	7.4	-37	20.33	0.72	4.1	1260	536.94	76.02	0.44	0.02	350.39	4.67	2.16
P-07	385	0398040	8748044	1300	0	7.25	-28	29.5	0.06	7.31	1850	346.78	32.60	0.39	0.26	325.50	108.15	6.12
P-08	372	0394085	8757872	282	0	7.21	-36	20.76	0.21	4.10	490	244.20	213.36	0.36	0.05	77.82	41.52	31.52
P-09	372	0388034	8758010	370	0	7.05	-36	20.46	0.33	3.16	600	460.45	102.71	0.66	0.07	139.42	16.93	20.32
P-10	395	0388138	8744400	680	0	6.98	-11	27.77	0.64	3.74	1300	884.52	206.53	0.64	0.02	2007.24	53.16	7.36
P-11	372	0388087	8748920	1070	0	6.80	-6	20.73	1.02	2.86	1700	1174.75	40.89	0.47	0.02	3084.71	23.04	0.00
P-12	395	0398131	8745018	240	80*	7.05	-17	25.62	0.21	3.58	380	602.71	38.58	0.46	0.07	872.11	11.69	12.22
P-13	378	0398670	8757274	340	0	6.72	3	20.86	0.29	8.31	540	358.72	20.07	0.31	0.01	1380.65	25.39	3.42
P-14	465	0385905	8757256	1400	0	6.42	20	28.62	1.35	5.31	2250	1477.60	102.55	0.42	0.05	6986.10	14.30	5.51
P-15	459	0388457	8757542	470	0	6.68	6	29.86	0.45	3.16	780	1260.02	186.52	0.30	0.02	1082.28	13.75	0.00
P-16	440	0388135	8758080	360	26.3*	7.01	-34	27.38	0.31	4.34	570	475.62	40.75	0.71	0.02	1247.85	3.29	6.60
P-17	452	0388025	8740365	367	5	6.47	18	26.31	0.31	6.66	520	367.87	18.38	0.69	0.02	1467.20	120.25	5.30
P-18	465	0388656	8751160	100	0	6.27	30	25.31	0.34	6.85	200	289.21	26.08	0.39	0.16	580.14	4.42	15.82
P-19	422	0388257	8740358	930	4.1*	6.28	31	27.16	0.86	3.74	1400	838.09	5.47	0.34	0.01	4088.65	69.55	5.85
P-20	406	0390320	8744471	80	0	6.12	39	26.6	0.07	3.12	150	352.82	64.48	0.26	0.01	257.57	7.38	1.58
P-21	407	0388455	8744650	220	0	4.05	165	26.94	0.21	4.35	390	1412.12	37.65	0.57	0.04	772.94	387.25	0.00
P-22	409	0387355	8740530	960	0	6.06	43	27.31	0.93	5.37	1550	940.5	215.34	0.71	0.01	4485.60	25.62	9.32

Poço	Mg^{2+} (mg/L)	Na^+ (mg/L)	Ca^+ (mg/L)	K^+ (mg/L)	Ba^+ (mg/L)	Pb^{+2} (mg/L)	Zn^{+2} (mg/L)	Fe^{+2} (mg/L)	Mn^{+2} (mg/L)	Ni^{+2} (mg/L)	Al^{+3} (mg/L)	Cu^+ (mg/L)
P-01	254.74	430.31	302.04	14.20	2.96	<LQM	0.02	<LQM	<LQM	0.04	<LQM	<LQM
P-02	155.24	259.56	355.56	7.63	0.29	<LQM	<LQM	<LQM	0.13	<LQM	<LQM	<LQM
P-03	415.24	377.25	178.81	11.02	0.41	<LQM	0.41	0.11	1.65	<LQM	0.11	<LQM
P-04	82.49	364.25	433.63	10.60	<LQM	0.01	<LQM	<LQM	0.28	<LQM	<LQM	<LQM
P-05	19.98	166.00	74.51	2.30	0.25	<LQM	0.18	<LQM	0.05	0.02	<LQM	0.02
P-06	504.49	722.37	15.41	16.00	0.21	<LQM	<LQM	<LQM	0.03	<LQM	<LQM	<LQM
P-07	60.52	159.06	179.44	3.32	0.25	<LQM	0.06	<LQM	0.21	<LQM	<LQM	<LQM
P-08	108.99	167.59	50.28	2.60	0.19	<LQM	<LQM	<LQM	1.98	<LQM	0.16	<LQM
P-09	271.62	322.81	206.75	12.48	0.14	<LQM	<LQM	<LQM	0.31	<LQM	0.11	<LQM
P-10	537.43	647.00	206.75	9.93	<LQM	<LQM	<LQM	<LQM	0.01	0.03	0.17	<LQM
P-11	880.68	815.00	242.88	27.52	0.75	<LQM	1.92	0.17	0.03	0.01	<LQM	<LQM
P-12	110.40	315.31	515.80	5.61	0.80	<LQM	0.02	<LQM	0.01	<LQM	<LQM	<LQM
P-13	265.24	253.37	73.15	17.32	1.67	0.05	0.02	<LQM	1.36	0.05	<LQM	0.06
P-14	1265.99	361.12	241.38	31.20	0.26	<LQM	0.03	<LQM	0.48	0.06	<LQM	<LQM
P-15	301.57	531.31	945.69	13.65	0.17	<LQM	<LQM	<LQM	0.34	<LQM	<LQM	<LQM
P-16	229.74	400.06	233.31	12.52	<LQM	<LQM	0.03	<LQM	0.01	0.01	<LQM	<LQM
P-17	135.71	508.00	226.00	15.07	2.82	<LQM	0.08	<LQM	0.04	0.04	0.11	<LQM
P-18	71.32	284.37	2811.25	10.46	0.20	<LQM	<LQM	<LQM	<LQM	<LQM	<LQM	<LQM
P-19	754.18	785.69	41.28	20.98	14.21	<LQM	0.05	<LQM	0.18	0.05	<LQM	<LQM
P-20	27.90	165.94	319.44	4.37	0.17	<LQM	0.02	<LQM	0.01	<LQM	0.22	<LQM
P-21	1055.17	335.25	18.42	17.91	0.36	<LQM	0.08	<LQM	0.18	0.05	1.95	0.01
P-22	764.74	527.00	63.09	20.32	0.39	<LQM	<LQM	<LQM	0.31	<LQM	<LQM	<LQM