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HIDROCHEMISTRY CHARACTERIZATION OF ALLUVIUM AQUIFER FOR AGRICULTURAL USE

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Abstract

Due to strong climate irregularity of the Brazilian semiarid, the alluvium aquifers have been allowed irrigation of valleys, promoting socioeconomic importance for semiarid Brazilian stats. However, hydrochemistry studies are essential for integrated and sustainable management that decrease salinity risk of the irrigated soil. The present study aimed to characterize the hydrochemistry of an alluvium aquifer stretch on Curu River – State of Ceará, to identify limitations for irrigation. We collected samples in situ to physiochemistry analysis of groundwater in two field camping. The sampling occurred in 10 wells during august 2017 (final of the rainy period) and November 2017 (dry period). The description and analysis of data was realized by Piper's diagram and Richard's diagram for toxicity risk. The results showed a varied water classes on rainy and dry period, in this last there was predominance of mixed and chlorinated water classes. About the toxicity risk, water presented high salinity contend with salinization risk of soils, however it is possible utilized this water applying best managing practices in irrigation, controlling the infiltration and drainage factors. The study contributed to a better hydrochemistry knowledge of alluvium aquifers and agriculture use of this resource in semiarid regions.

Keywords: Irrigation; Toxicity risk; Semiarid.

HIDROCHEMISTRY CHARACTERIZATION OF ALLUVIUM AQUIFER FOR AGRICULTURAL USE

Resumo

Devido à marcante irregularidade climática do semiárido brasileiro, os aquíferos aluvionares tem permitido a irrigação de vales, exercendo sua importância socioeconômica para estados do semiárido brasileiro. Contudo, estudos hidroquímicos são essenciais para diminuir os riscos de salinidade dos solos irrigados. O presente trabalho buscou caracterizar a hidroquímica de um trecho do Aquífero Aluvionar do rio Curu – Ceará, e identificar suas limitações para irrigação. Para isso foram coletadas, em duas campanhas de campo, amostras para parametrização fisicoquímica da água subterrânea. A amostragem se deu em 10 poços durante o período chuvoso, agosto de 2017, e no período seco, novembro de 2017 e foram descritas por meio de diagrama de Piper e diagrama de risco de sodicidade de Richards. Os resultados mostraram que as águas possuem classes variadas, no período chuvoso e no seco, houve uma predominância de águas de classe mista e cloretadas. Quanto ao risco de sodicidade, as águas apresentaram alto teor salino, que oferecem risco à salinização dos solos, no entanto, com um bom manejo da irrigação é possível utilizar a água, controlando os fatores de infiltração e drenagem. O estudo contribuiu para um melhor conhecimento hidroquímico das aluviões, e uso agrícola desse reservatório estratégico para as regiões semiáridas.

Palavras-chave: Irrigação; Risco de sodicidade; Semiárido.

CARACTERIZACIÓN HIDROQUÍMICA DE ACUÍFEROS ALUVIARES PARA USO AGRÍCOLA

Resumen

Debido a la marcada irregularidad climática del semiárido brasileño, los acuíferos aluviales han permitido el riego de los valles, ejerciendo su importancia socioeconómica para los estados de la región semiárida brasileña. Sin embargo, los estudios Los hidroquímicos son fundamentales para reducir el riesgo de salinidad en suelos de regadío. El presente trabajo buscó caracterizar la hidroquímica de un tramo del Acuífero Aluvial del Río Curú - Ceará, e identificar sus limitaciones para irrigación. Para ello, se recolectaron muestras en dos campañas de campo para la parametrización fisicoquímica del agua subterránea. El muestreo se realizó en 10 pozos durante la época de lluvias, agosto de 2017, y en la época seca, noviembre de 2017 y se describieron mediante un diagrama de Piper y un diagrama de riesgo de sodicidad de Richards. los resultados mostraron que las aguas tienen diferentes clases, en los períodos lluvioso y seco, hubo un predominio de aguas de clase mixtas y cloradas. En cuanto al riesgo de sodicidad, las aguas tenían un alto contenido en sal, lo que ofrecen riesgo de salinización del suelo, sin embargo, con un buen manejo del riego es posible utilizar agua, controlando los factores de infiltración y drenaje. El estudio contribuyó a un mejor conocimiento hidroquímico de la aluviones y uso agrícola de este embalse estratégico para regiones semiáridas.

Palabras-clave: Irrigación; Riesgo de sodicidad; Semiárido.

1. INTRODUCTION

The salt in water has big variability, according of the spring and watershed physiographic characteristics, hydrogeochemistry dynamic in rock-water interaction, land use management and other environmental factors. The evaluation of the water quality for irrigation occur in dependence of possible sols damage, plant and irrigation system, whom salinity and toxicity aspects are mean indicators (AYRES & WESTCOT, 1991).

In Brazilian Northeast, water and soils salinity is regular, due to crystalline rocks predominance, irregular rainfall distribution associate to high evapotranspiration potential. Furthermore, the low bioclimatic activity on rock's weathering and deficient soil drainage, accelerating salt precipitation on soil (HOLANDA et al., 2007; ARAÚJO et al., 2011; PEDROTTI et al, 2015). The soluble salt excess cause reduction in osmotic potential of the soil solution, making difficult at water absorption an nutritional no balanced for plant (GHEYI et al., 2010; DUTRA et al., 2015).

In this context, strategic alluvium groundwater uses for irrigation on semiarid need to compatibilizer water quality with soils type and tilths. Silveira et al. (2018) consider that irrigations perimeters (IP) in northwest semiarid are installed at areas with bigger water availability than the surroundings, more associate to dam systems and alluviums such the Irrigation Perimeter Curu-Pentecoste (IPCP), affirming that "Alluviums are related strategic groundwater reservoir in semiarid northeast environmental. However, the incipient knowledge about their quali-quantitative characteristics, has been difficulted water management of these waters, then the biggest use occur in interannual dry period, many times without grant and through irregular wells, offering risks to water reservoir.

Since 2014 the available waters for PICP are from, almost totality, alluvium aquifer, that receive part of his waters of the dams upwind, when these overflow through main canal of the Curu river, and other part from rainwater directly. The inclination of the aquifer in direction to estuary of the river, naturally, cause similar direction of groundwater SW – NE. At Curu river margin, there are shallow wells studied, they have maximum depth of 9 m and static level varied in according to recharge and water exploitation in moment of measurement.

Em litotipos sedimentares, a maior facilidade de dimensionamento de reservas e a maior vocação aquífera associada aos aquíferos intersticiais, de um modo geral, representam melhor acesso e disponibilidade hídrica, em comparação com os aquíferos fissurais. Particularmente, quando se trata de regiões com escassez hídrica superficial, essas áreas sedimentares são de grande importância estratégica para garantia e sustentabilidade hídrica para irrigação. Na Bacia do Rio Curu, Peixoto et al. (2017) destacaram a importância da água subterrânea na agricultura que consome 57% da vazão outorgada. No entanto, também é necessário que esta atenda padrões de qualidade compatíveis com as condições edáficas e sistema de irrigação das culturas (GOMES et al., 2017).

The sedimentary lithotypes have better measure of the available groundwater and highest aquifer vocation associates to porous aquifers, that generally, representing better access and hydric availability, in relation to fractures aquifers. In semiarid regions, sedimentary rocks are valuable from the point of view of hydrogeological for irrigation hydric sustainable. In Curu watershed, Peixoto et al., (2017) highlight the groundwater significance in agriculture, that consume 57% of the award flow. However, Its necessary to analyze water quality in relation to quality standard for edaphic conditions and crop irrigation system (GOMES et al., 2017).

This way, the current study aims characterize groundwater chemistry of a part of alluvium aquifer of Curu River and identify to potential and limitation for irrigation use. The results contributes for a better alluvium hydrochemistry knowledge, considering regional seasonal and hydroclimatic conditions, producing data and information to subsidize crop utilization of the waters, observing the quality limitations, risk of soil salinization and types of crops adapted to soil conditions.

2. METHODOLOGY

The study was realized in part of the alluvium at IPCP, originated in 1974 for National Department of Works Against Drought – DNOCS, nevertheless the effective implantation happened in 1979.

We chose 10 sampling points, in related to following criteria: wells with static level bigger than 1,5 m; Wells more accessible with proprietary permission. In the figure 1 is showed the sampling points.

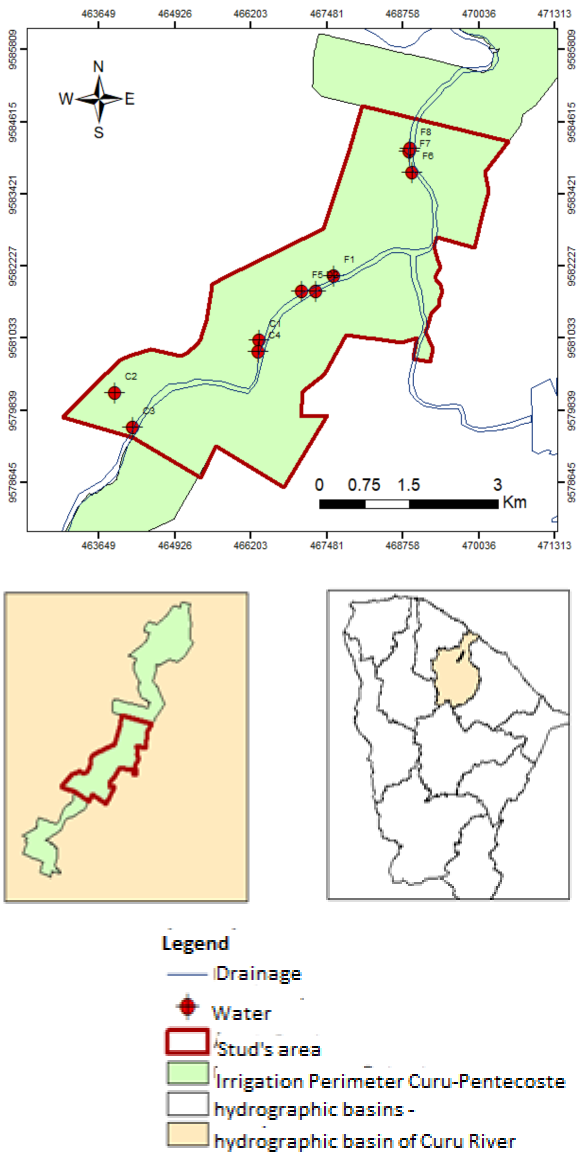

Figura 1 – study area and sampling points localization, IPCP – Ceará. Source: authors (2019).

We realized 4 sampling campaign, 2 for pre-analyze (November – 2016 and Abril - 2017), when we analyzed pH, electric conductivity (EC) and total dissolved solids (TDS) in 8 and 12 sampling points, respectively. 3rd and 4th sampling campaign were realized in 10 shallow wells at Jule 2017 and November 2017, representing end of the rainy season and dry season, respectively. We measure 18 physical-chemical attributes were determined in each of them: pH, electrical conductivity (EC), bicarbonate (HCO_3^-), alkalinity, chloride (Cl^-), calcium (Ca^{+2}), magnesium (Mg^{+2}), hardness, sulfate (SO_4^{-2}), sodium (Na^+), potassium (K^+), nitrate ($N\text{-}NO_3^-$), nitrite (NO_2^-), total ammoniacal nitrogen ($N\text{-}NH_3^+$), total iron (Fe^{+2} and Fe^{+3}), fluoride (F^-), turbidity and total dissolved solids (TDS).

The physical-chemical analyzes of the groundwater samples were measure at the Marine and Applied Geology Laboratory/ Universidade Federal do Ceará – LGMA/UFC. The methods employed followed the analytical procedures described in Standard Methods for the Examination of Water and Wastewater (APHA, 2012).

PH an electrical conductivity and water salinity were measured using a multiparameter probe, Thermo Scientific Orion and model Star A329 Portable. Total Nitrogen and Total Phosphorus were determined using the Cadmium Reducing Column and Ascorbic Acid method, respectively, after persulfate digestion. For the pre-analysis of the water, samples were collected in 50 mL bottles and the parameters of CE, STD, pH, salinity and temperature were measured with a portable conductivity meter brand Extech.

In the period of the 3rd sampling campaign, 90% of the wells were inactive, being necessary to operate a motor pump to extract the water sample, with pumping approximately 5 to 10 minutes before the collection of the samples. The motor pump used was a self-priming gasoline engine with 6.5 hp, with a maximum flow of 35 m^3 h^{-1}. Before pumping, the static level and depth of the well was measured to obtain the water column available in the well.

The samples were collected in sterile 0,5 L plastic bottles, and for ammonia analysis, 20mL of water was collected in a dark glass (amber) containing stabilizing reagents (phenol and citrate) for, shortly after, the samples refrigerated and protected from light in a cooler with ice until they arrive at the laboratory.

Water classification for irrigation purposes was carried out using the methodology adopted by the United States Salinity Laboratory, proposed by Richards (1954), which presents a classification diagram combining the sodium adsorption ratio (RAS) and the total concentration of salts, which makes it possible to form 16 classes of water, ranging from C1 to C4 and S1 to S4 in all possible combinations, with a C1 water presenting low salinity, electrical conductivity (EC) less than 250 µS cm-1 (0 , 25 dS m-1) and C4 represents water of very high salinity, electrical conductivity ranging between 2250 and 5000 µS.cm-1 (2.25 dS m-1). As for the classification from S1 to S4, it is related to the risk of toxicity which, like the risk of salinity, can be low, medium, high or very high, being expressed by the RAS index (Equation 01) based essentially on the effect of sodium in the conditions soil physics, causing infiltration problems by reducing permeability (SILVA et al., 2011 and CORDEIRO, 2001).

$$RAS = \frac{rNa^+}{\sqrt{\frac{rCa^{++} + rMg^{++}}{2}}} \quad \text{(Eq. 01)}$$

Where “r” means milliequivalent for liter of solution.

RAS was originated by United States Soil Salinity Laboratory (RICHARDS, 1954) has often been criticized for underestimating the risk of sodium toxicity and for not taking into account other ions (anions like HCO_3^- and CO_3^{-2}) suggesting alternative calculation methods, such as adjusted RAS (RASaj) and corrected RAS (RAScor). The values of RAScor are placed intermediates between RAS and RASaj, which suggests caution when making decisions regarding the classification of water for irrigation purposes (OLIVEIRA and MAIA, 1998).

Table 1 presents an approximation of potential problems, but should not be used to provide definitive criteria, when considering the characteristics of the region and the financial conditions of the irrigate to correct these waters

Table 1- Guidelines for interpreting irrigation water quality. Source: Adapted by Nakayama (1982) e Ayers e Westcot (1994). Legend: EC- electrical conductivity; TDS – total dissolved solids.

Potential Problem	**Restriction level**		
	Neither	**Leve a moderado**	**Neither**
Salinity	-	**Salinity**	-
EC (dS/m)	< 0,7	EC (dS/m)	< 0,7
TDS (mg/L)	< 450	TDS (mg/L)	< 450
Obstruction*	-	**Obstruction**	-
pH	<7,0	pH	<7,0
TDS	<500	TDS	<500
Toxicity		Toxicity	
Fe^{+2} (mg/l)	<0,1	Fe^{+2} (mg/l)	<0,1
HCO_3^- (mg/l)	<91,5	HCO_3^- (mg/l)	<91,5
Cl^- (mg/l)	<142	Cl^- (mg/l)	<142

*Obstruction risks of the irrigation system

Water use for irrigation classification is an instrument to prediction, with reasonable confidence, the general effect on soil-plant and system irrigation.

For the ionic classification of groundwater, Piper Diagram was used, frequently used to classify the chemical type of the water according to the dominant ionic content. The representation in this diagram is made in three fields where the percentage values of the concentrations of the main ionic constituents for the cations and anions are plotted, making it possible to identify the hydrochemical facies. The crossing of the extension of the points in the rhombus area shows its position and classifies the sample according to the facies. The software used was Qualigraf (MOBUS, 2003), which has a simple and optimized interface for water classification.

3. RESULTS AND DISCUSSION

Generally, water quality is influenced to various natural process, highlight: lithology; electric conductivity, quality of the recharge, hydrogeochemistry soil – rocks. Therefore, anthropogenic process related to land use, and activities potentially generated of residues that influencing on water quality of aquifer recharge.

In the dry season, waters have had higher salts concentration, how can be observed in the table 2. Its possible check that only wells C3 and F5 had higher concentration of salts in the rainy season. The well C3 is in crop area, that can be cause increasing TDS by means of agricultural inputs, as fertilizers. During the rainy season, nitrate value in well C3 was higher than 15.3 mg/L, evidencing the contamination to agricultural inputs. According to Pedrotti et al. (2015), the excess of soluble salts in the soil solution is the result of a combination of climatic, edaphic factors and soil management.

Table 2 - Descriptive statistics of the physic-chemistry parameters to 20 samples. Source: authors (2019)..

Parameters	**Descriptive statistics – rainy period**					**Descriptive statistics – dry period**				
	Min	**Max**	**Aver.**	**Stan. Dev.**	**V. C.**	**Min**	**Max**	**Aver.**	**Stan. Dev.**	**V. C.**
pH	4.04	7.47	6.78	1.01	0.15	4.72	7.23	6.68	0.72	0.11
EC(µS/cm)	484.00	1195.00	839.60	247.68	0.29	603.50	1585.00	905.09	290.88	0.32
Bicarbonate (mg CaCO3/L)	4.90	313.00	156.73	82.87	0.53	7.40	342.60	197.89	87.96	0.44
Total alkalinity (mg CaCO3/L)	4.00	256.50	128.46	67.92	0.53	6.10	280.80	162.21	72.08	0.44
Clorete (mg Cl-/L)	82.30	220.10	143.37	54.30	0.38	95.70	317.80	154.52	71.76	0.46
Calcium (mg Ca2+/L)	24.00	67.20	39.92	14.50	0.36	11.20	58.40	37.52	17.38	0.46
Magnesium (mg Mg2+/L)	19.70	48.00	27.66	9.27	0.34	32.20	62.40	44.39	10.29	0.23
Total hardness (mg CaCO3/L)	142.00	358.00	215.00	72.58	0.34	190.00	392.00	278.80	59.80	0.21

Sulfate (mg SO42- /L)	11.40	375.20	105.75	107.63	1.02	21.60	213.00	100.99	69.82	0.69
Sodium (mg Na+/L)	37.60	196.60	96.46	46.92	0.49	68.20	263.90	116.92	65.91	0.56
Potássio (mg K+/L)	2.30	20.30	10.96	6.95	0.63	4.00	7.00	5.23	1.00	0.19
Nitrate (mg N-NO3- /L)	0.30	15.30	2.27	4.61	2.03	0.20	6.00	1.52	2.53	1.66
Nitrite (mg N-NO2-/L)	0.01	0.03	0.01	0.01	0.72	0.00	0.04	0.01	0.01	1.34
Nitrogen (mg NH3/L)	0.00	0.28	0.05	0.09	1.77	0.19	2.50	0.75	0.90	1.20
Iron (mg Fe/L)	0.50	4.50	2.45	1.40	0.57	0.80	4.60	3.04	1.16	0.38
Fluorete (mg F-/L)	0.20	1.00	0.36	0.24	0.66	0.50	0.80	0.64	0.13	0.20
Turbidity (UNT)	15.00	643.00	138.70	194.46	1.40	33.00	290.00	137.50	85.97	0.63
Total dissolved solids (mg/L)	335.00	773.00	580.90	153.38	0.26	433.00	1161.00	657.80	213.76	0.32

Legend: V.C. = variation coefficient.

It is common to have a high concentration of nitrogen in groundwater in agricultural areas due to the application of inorganic and organic fertilizers (manure), nitrogen is easily lost through volatilization or leaching, contaminating the groundwater (HAMILTON; HELSEL, 1995; SANGOI et al., 2003).

It is also noticed the high EC value, greater than 1000 µS / cm in wells F6 and F7, which are located downstream of the study area, located almost on the Curu River bed, which is also an area where irrigation is intensive, where irrigation has not ceased even in the most critical period of scarcity, as they continued to irrigate by pumping water from the alluvium. According to Fernandes et al. (2010), incipient irrigation by farmers in Neosols Fluvic soils (Alluvium) can contribute to the increase of sodium in these soils making them vulnerable and susceptible to their contribution to groundwater. Moura (2014) found higher EC values in the waters of wells inserted in a shallow, explaining that these values may be related to the leachate salts and transported from higher areas to areas close to the regional base level.

We can be seen in Figure 2 that during the dry period the concentrations of the physical and chemical elements analyzed show higher values in the dry period than in the rainy season where there is a dilution of these ions; with the exception of only nitrate, ammoniacal nitrogen and nitrite followed the general behavior, with more expressive values in the rainy season, which can be explained by the use of nitrogen fertilizers in the soil leached during the rainy season. Nitrate leaching is considered the main loss of N available to plants, and excess N in the soil can easily be leached into groundwater (ERREBHI et al., 1998). Sangoi et al. (2003) state that factors such as the soil tillage system, soil type and the application of nitrogen fertilizers can influence both the water flow and the nitrate concentration in the soil solution. Iron and fluoride also had higher concentrations in the dry period.

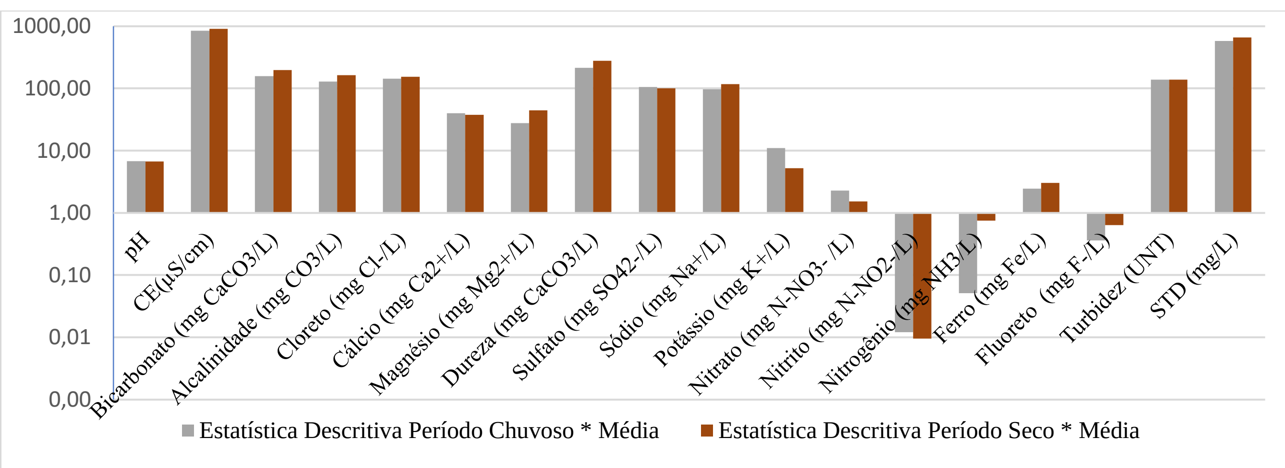

Figure 2 - Average values of the physical-chemical parameters of the well water analyzed in PICP-CE. Source: authors (2019).

3.1. Ionic classification of the waters

According Piper diagram (Figure 3), there are variation of ionic classification of water. In rainy seasonal, 50% of the samples was mixes, 40% chlorinated and 10% sulphated. Regarding cations, 60% was classified as mixes and 40% sodic.

These variations can be caused by exploitation regime of groundwater, use land and localization of wells in relation to crop areas and river channel. We divided he wells in colors for agricultural regions, that are divisions generated to administration of IPCP. Wells in red are inside C region, black are inside in D region, and green in F region.

The ionic abundance during rainy season is following: 40% as chlorinated, 40% mixes, 10% bicarbonate and 10% sulphated, in relation to cations, 60% mixes, 30% sodic and 10% magnesian.

Moura (2014) consider similar hydrochemistry to samples of groundwater at alluvium aquifer in Quixerambim river and affirm that highest chloride concentrations has been cause to lithology, rainfall scarcity and evapotranspiration.

There were not many seasonal changes in the ionic classifications of the 20 samples analyzed. Except for sample 9 represented by well F7, which in the rainy season was classified as sodium chloride and in the dry as Magnesian, this may have occurred because this well is located in a shallow (riverbed) already in a more downstream position in the area of study, and receiving influence from the river waters in the rainy season.

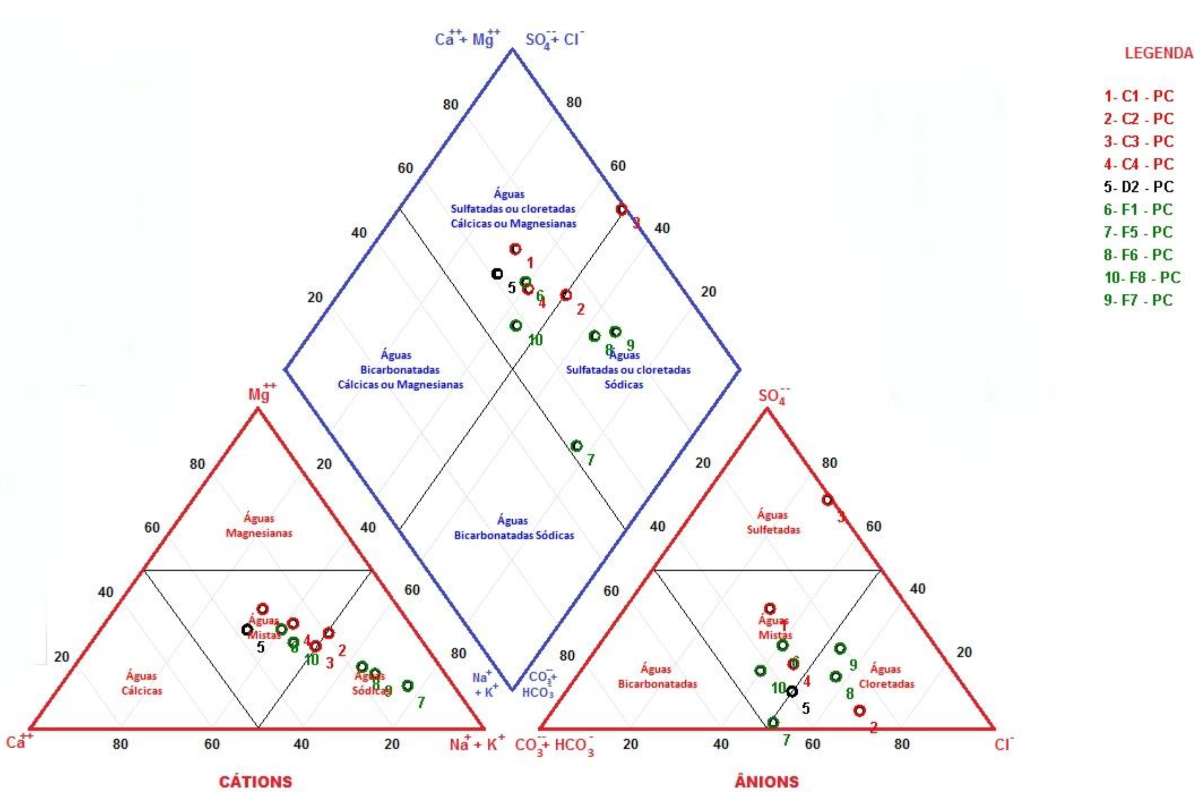

Figure 3 - Ionic classification of water in according Piper diagram (Rainy period). Source: authors (2019).

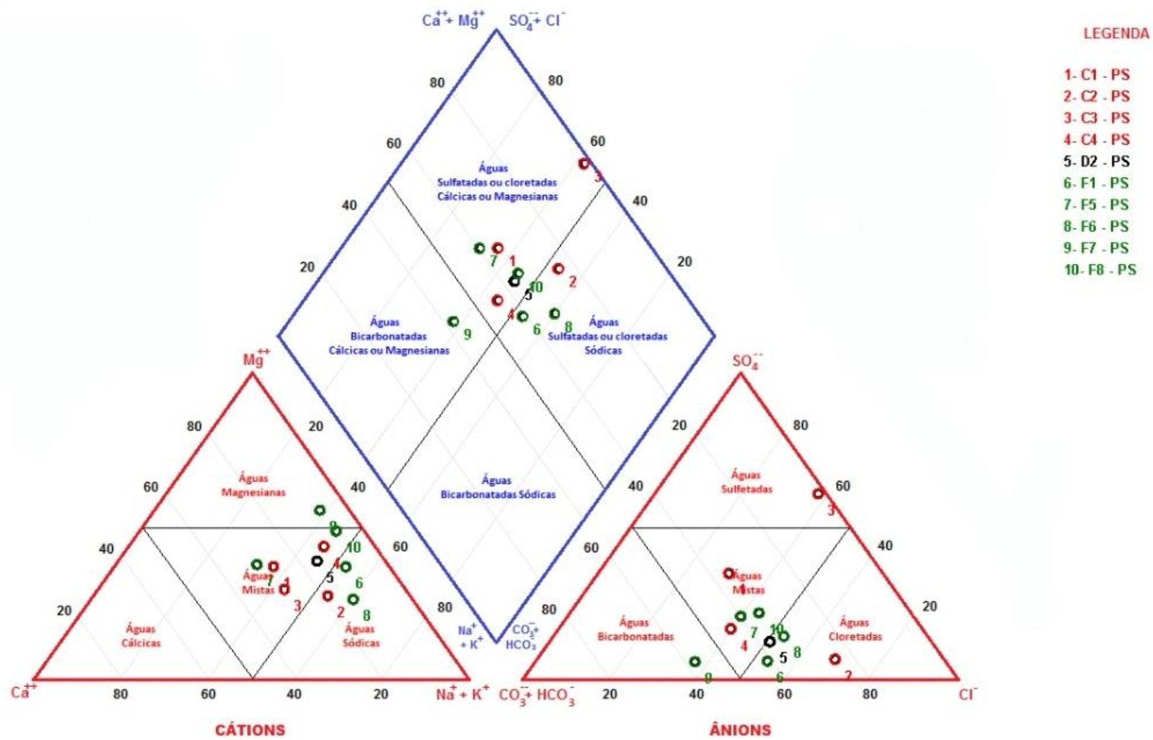

Figure 4 - Ionic classification of water in according Piper diagram (dry period).

3.2. Water qualiy for irrigation

The hydrochemistry of groundwater depends of the composition of the recharge water (pluviometry, surface water) and, subsequently, on its chemical evolution directly influenced by the water-rock interaction represented by the water percolation through the pores and/or fractures in lithotypes (GOMES, 2017). In Sedimentary aquifers, infiltration occurs more generally and in greater quantities, depending on the type of soil and type of sediment, or sedimentary rock in the unsaturated layer. Thus, the aquifer may be more vulnerable to contamination, due the effects of land use and occupation

The parameters treated in this topic are usually the first to be investigated when it comes to the use of water for irrigation. High values can cause damage to plants and soil, and it is common to characterize the quality of water for irrigation by salinity, expressed by the concentration of salts or TDS, as well as by the electrical conductivity (CE), considering that the salts dissolved in water conduct electricity. Table 3 describes the statistical values of the parameters related to salinity, where it is possible to observe the increase in values in the dry period.

Table 3 - Descriptive statistics of the parameters in relate to water salinity.

Parameters	Min	Average	Max	Standard deviation
EC (µS/cm) P.C.	484	839.6	1195	247.7
CE (µS/cm) P.S.	603.5	897.9	1585	276.9
Na^+ (mg Na^+/L) P.C.	37.6	96.46	196.6	46.9
Na^+ (mg Na^+/L) P.S.	68.20	115.39	263.9	62.73
STD (mg/L) P.C.	335	580.9	773	153.4
STD (mg/L) P. S.	433	653.9	1161	203.2

Legend: EC – Electrical conductivity; TDS - Total Dissolved Solids. R. S. – rainy season; D. S. – Dry season.

Water salinity represents the total amount of elements dissolved in a given volume of water that can be precipitated as salts, and is directly linked to the electrical conductivity (EC), sodium (Na +) and total dissolved solids (STD) and the higher the value of these parameters found in the analyzed waters, the greater the salinity. The electrical conductivity, which is the measure of how easy the water to conduct the electric current, is also linked to dissolved salts in the form of ions (SANTOS, 2008).

In table n. 4 are showed results of the iron total, this parameter presents high potential to damage microsplinker and dripping irrigation systems. Ayres & Westcot (1991) pustules that the maximum value of the permissible iron concentration should be 0,5 mg/l, however, this would result in an increase in the costs of filtering the irrigation system and, therefore, according to authors, waters with values higher to 2.0 mg/l of total iron are admissible for use in irrigation, and up to 5.0 mg/l is not toxic to plants in aerated soils, but may contribute to acidification of soil and loss of availability of essential phosphorus and molybdenum, in addition to forming unpleasant layers on plants and equipment through sprinkler irrigation. In IPCP the soils are fluvial neossolos with plots with a high clay content, drainage is poor, which restricts the use of ferruginous waters in this region.

Table 4 – Iron concentrations and water classification of alluvium aquifer of PICP- Ceará.

Sample	**Total iron (mg Fe^{+} L^{-1})***	**Damages potential**
C1	2,2	High
C2	4,2	High
C3	1,3	Medium
C4	3,2	High
D2	0,5	Medium
F1	0,6	Medium
F5	2,8	High
F6	1,9	High
F7	3,3	High
F8	4,5	High

*Low (< 0,2 mg.L-1); Medium (0,2-1,5 mg.L-1); High (> 1,5 mg.L-1). Source: Nackayama and Bucks (1986).

The concentration of Fe^{+2} in the groundwater indicates a redox condition. In the ferrous state (Fe^{2} +) it forms soluble compounds, and in oxidizing environments, Fe^{2} + becomes Fe^{3} + giving rise to ferric hydroxide, which is insoluble and precipitates causing a reddish color to the water, commonly called “pink cap”. Thus, waters with a high concentration of iron when they come in contact with the oxygen in the air become yellow (GOMES, 2013). According to Ayres & Westcot (1991), this coloring also occurs in the leaves of vegetables, which reduces the acceptance and the commercial value of these crops.

Iron is one of the main problems in irrigation water due to the ability to physically obstruct the pipes and emitters of the localized irrigation systems (NACKAYAMA and BUCKS, 1986). The distribution of water in terms of iron content in the study area shows that the highest concentrations are in the North and Southeast, more precisely, where wells C2 and F8 are located.

Due to the high concentrations of total iron found in alluvial waters, to use this water in irrigation it is necessary to use filtration systems, mainly in localized irrigation systems, to avoid clogging of pipes and drippers and, also, the loss of service pressure of the systems (BARBOZA et al., 2009)

The Richard’s (1954) classification, 60% of the samples for the rainy season were classified as C3 S1 (water with high salinity and low toxicity), 10% as C2S1 (water with medium salinity and low toxicity) and 30% as C3S2 (water with high salinity and moderately sodium). As for the salinity of these waters, for their use it is necessary to make the correct management of irrigation and the soil so that it does not come to salinize (Figure 5).

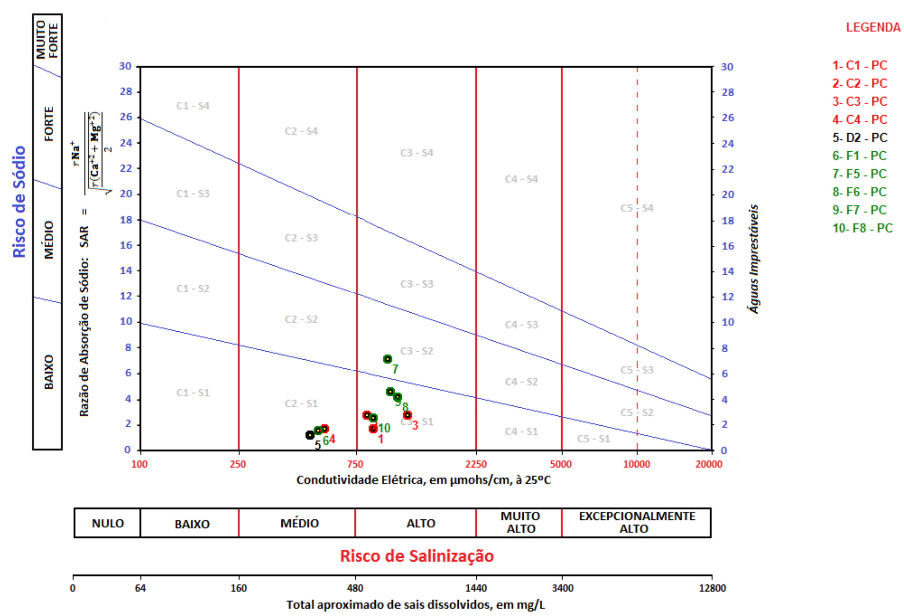

Figure 5 - Groundwater classes for agriculture able in rainy season (July 2017).

During the dry period, 50% of the samples were classified as C3S1, 10% C3S2 and 40% C2S1 (Table 6, Figure 5). Change occurred only points 3 and 9 represented by well C3 and F7, respectively. In these wells, reduced their risk of salinity, an unexpected fact since in the dry period the waters that suffered evaporation are with their most concentrated salts, however, the phenomenon can be explained by the use and occupation of the soil. The wells C3 and F7, during the rainy season, there were agricultural crops on soil, that had been prepared and fertilized, increasing the risk of alteration in groundwater, due to the application of agricultural inputs and changes their natural structure.

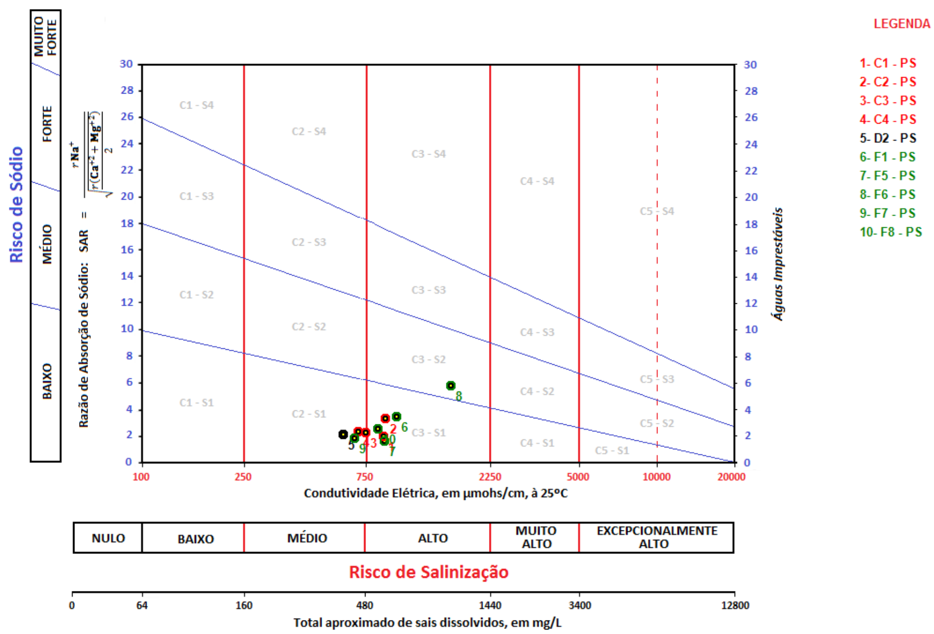

Figure 6 - Groundwater classes for agriculture able in dry season (September 2017).

Analyzing only EC values of alluvium aquifer waters, all samples are appropriate for irrigation of the numerous cultures (Table 5). However, the soil of the region varies between sandy and clayey facies, the clayey matrix difficult the drainage, could have salinization impacts when there is not a manage adequate.

Table 5 – Salinity tolerance for some cultures common in semiarid and arid regions. Source: Adapted de Ayers e Westcot (1994).

Crop	EC es(dS m^{-1})	Crop	EC es(dS m^{-1})
Avocado	1,3	Fava beans	1,6
Zucchini	3,2	Orange	1,7
Lettuce	1,3	Lemon	1,7
Cotton	7,7	Melon	2,2
Peanut	3,2	Corn	1,7
Rice	3,0	Strawberry	1,0
Potato	1,7	Turnip	0,9
Sweet potato	1,5	Bell pepper	1,5
Beet	4,0	Radish	1,2
Broccoli	2,8	Cabbage	1,8
Sugar cane	1,7	Soy	5,0
Onion	1,2	Sorghum	4,0
Carrot	1,0	Tomato	2,5
Cauliflower	2,5	Cucumber	2,5
Spinach	2,0	Pod	1,5
Bean	1,0	Grape	1,5

In the northeast of Brazil is common to plant annual crops in rainfed (when there is no irrigation complement), as examples in table 5: zucchini, broadleaf in general, beans, melons, corn and peppers, these present good edaphic adaptation, considering the type of soil and the quality of the available water. In addition to the annual crops, in the IPCP the largest area is occupied by planting the coconut tree, which is very tolerant of water and soil with high salt content.

4. FINAL CONSIDERATIONS

The groundwater of the Alluvial Aquifer has quality adequate for use in the irrigation of most of the crops already implanted, in condition of adequate irrigation management, given the restrictions in related to high content of iron and dissolved salts. Both periods seasonal, there was a predominance of classified waters as chlorinated and mixed.

The waters analyzed have medium to high risk of salinity and low risk of toxicity to sodium, showed the need to follow the appropriate management of irrigation, and choice of a culture of greater resistance to the quality of water available, using sustainability this resources. Seasonal monitoring of alluvial water quality is important to use properly, minimizing climatic and anthropic problems in high hydric scarcity region.

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