PERMEABILITY INDEX IN IRRIGATION WATER OF CHAPADA DO APODI - RN

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ABSTRACT: The ionic composition of water is fundamental to calculate the risk of salinization or soil sodicity, which can contribute negatively to the growth and development of the plants. The aim of this work was to evaluate the irrigation water quality of the Chapada do Apodi region using the permeability index. The data used in this work came from 320 water samples, 247 of which were well, 51 were from the river and 22 from the dam of the Chapada do Apodi region in the western part of the State of Rio Grande do Norte. In the water samples, the following physical and chemical characteristics were determined: pH, electrical conductivity (EC), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}) and potassium (K^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^{-}) and carbonate (CO_3^{2-}). The permeability index (PI) and the sodium adsorption ratio (SAR) were calculated. The number of samples per class according to the PI index was I > II > III for well, river and dam water, indicating that most of the samples are classified as of good quality for irrigation.

KEYWORDS: Water quality for irrigation, water infiltration, clay dispersion

ÍNDICE DE PERMEABILIDADE EM ÁGUAS PARA IRRIGAÇÃO DA CHAPADA DO APODI-RN

RESUMO: A composição iônica da água é fundamental para se calcular o risco de salinização ou sodicidade do solo, que pode contribuir negativamente para o crescimento e desenvolvimento das plantas. Objetivou-se com este trabalho avaliar a qualidade da água de irrigação da região da Chapada do Apodi usando o índice de permeabilidade. Os dados utilizados neste trabalho foram provenientes de 320 amostras de água, sendo 247 de poço, 51 de rio e 22 de açude da região da Chapada do Apodi no oeste do Estado do Rio Grande do

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Norte. Nas amostras de água foram determinadas as seguintes características físico-químicas: pH, condutividade elétrica (CE), cálcio (Ca^{2+}), magnésio (Mg^{2+}), sódio (Na^{+}) e potássio (K^{+}), cloreto (Cl^{-}), bicarbonato (HCO_3^{-}) e carbonato (CO_3^{2-}), sendo calculado índice de permeabilidade (IP) e a razão de adsorção de sódio (RAS). A quantidade de amostras por classe de acordo com o índice IP foi I > II > III paras águas de poço, rio e açude, indicando que a maioria das águas são classificadas de boa qualidade para irrigação.
PALAVRAS-CHAVES: Qualidade de água para irrigação, infiltração de água, dispersão de argila

INTRODUCTION

The ionic composition of the water is fundamental to calculate the risk of salinization or soil sodicity, which can contribute negatively to the growth and development of the plants, with the increase of salinity decreasing the water potential in the soil and sodicity causing degradation in the physical of the soil, mainly by the process of clays dispersion.

However, sodium concentration is involved not only in the process of water permeability in the soil, as shown by Doneen (1975), which is a function of the total concentration of salts, sodium and bicarbonate (HCO_3^{-}), proposing a permeability index that is a function of the chemical equilibrium of irrigation water composition and it was empirically developed from a series of experiments carried out in laboratories and in lysimeters and later under field conditions.

The aim of this work was to evaluate the irrigation water quality of the Chapada do Apodi region using the permeability index.

MATERIAL E METHODS

The data used in this study came from 320 water samples, 247 from well, 51 from river and 22 from dam of the Chapada do Apodi region in the west of the State of Rio Grande do Norte, located in the extreme Northwest of the state of Rio Grande of the North, in the geographical grid between Parallels 4°48 'to 5°41' and the meridians 37°30' to 38°5' WGr. Due to the thermal and pluviometric regime, the region has a climate, according to Koppen, BSwh 'type, with very hot and semi-arid climate, where the rainy season is late for fall, and the highest rainfall from summer to fall. The rainfall has a very irregular distribution in time and space, increasing the climatic risk, the average annual precipitation and temperature is approximately 697 mm and 27.5°C, respectively (Carmo Filho et al, 1991).

In the water samples the following physical and chemical characteristics were determined: pH, electrical conductivity (EC), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}) and potassium (K^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^{-}) and carbonate (CO_3^{2-}), using the methodology proposed by Richards (1954).

Sodium Adsorption Ratio (SAR), equation 1, and permeability index (PI), equation 2, were calculated with Na, HCO_3, Ca and Mg in $mmol_c\ L^{-1}$, classifying the water in classes I, II and III according to Doneen (1975).

$$SAR = \sqrt{\frac{2Na^2}{Ca+Mg}} \qquad (1)$$

$$PI = 100\frac{Na+\sqrt{HCO_3}}{Ca+Mg+Na} \qquad (2)$$

RESULTS E DISCUSSION

The mean values of permeability index (PI), standard deviation, coefficient of variation (CV), maximum and minimum value per water source are shown in table 1. In relation to the mean of PI, river > dam > well, already for the variability measured by standard deviation, well > river > dam. For well water, it presented the highest and lowest PI value, with 123.64 and 20.90, respectively.

Table 1. Mean values, standard deviation, coefficient of variation (CV), maximum and minimum value of the permeability index (PI) for well, river and dam water of the Chapada do Apodi Region.

	Well (n = 247)	River(n = 51)	Dam (n = 22)
Mean	53.12	62.76	56.87
Deviation	18.86	16.47	14.80
CV (%)	35.51	26.25	26.03
Maximum	123.64	105.31	104.73
Minimum	20.90	36.01	34.48

The percentage of samples per class of PI is shown in table 2, where it is verified that the majority of samples presented class I, with 84.21%, 72.55% and 95.47% for water of well, river and dam , respectively. For class II, 9.31%, 21.57% for well and river water, respectively, with no sample for dam. With respect to class III, well> river> dam, with 6.48%, 5.88% and 4.55%, respectively. The PI variations were 20.9-123.64, 36.01-105.31 and 34.48-

104.73 for well, river and dam water, respectively. Patel and Vadodaria (2015) verified a percentage of 77%, 15% and 8% for well water for class I, II and III, respectively, with PI values varying from 21.46 to 88.09. Prasanth et al. (2012) observed that 90.09% of the samples belonged to class III and only 9.1% to class 2. Abadom and Nwankwoala (2018) verified that 100% of the samples presented classification II.

Table 2. Samples percentage per permeability index class per source

Class	Well (n = 247)	River (n = 51)	Dam (n = 22)
	------------------------------	% ------------------------------	
I	84.21	72.55	95.45
II	9.31	21.57	0.00
III	6.48	5.88	4.55

The physical-chemical characteristics of the water according to the source and the class of the PI are shown in table 3, verifying that the water of class III, for well, river and dam water, have concentrations of Ca, Mg, Na , Cl, HCO_3 and of the EC lower than classes I and II, implying that the samples with the highest PI have a lower concentration of these ions, indicating that the samples with the highest risk of causing a decrease in permeability occur with the use of water with low salt concentration .

In class III, regardless of source, the HCO_3/Cl ratio was greater than 1, different from that in classes I and II, which were lower. According to Maia et al. (2012), when higher concentration of HCO_3 in relation to Cl occurs in the water for irrigation purposes, it contributes negatively to the soil structure, due to the HCO_3 precipitating he Ca, increasing the relative concentration of Na, causing the dispersion of clay.

Table 3. Mean values of some physico-chemical characteristics of water per class of permeability index and per source

Class	Ca	Mg	K	Na	Cl	HCO_3	CO_3	pH	EC	PI
	------------------------- mmol$_c$ L^{-1} -------------------------								dS m^{-1}	
	--- well ---									
I	7.47	4.40	0.23	5.75	11.58	5.41	0.20	7.19	1.70	46.55
II	1.49	1.04	0.35	2.93	3.19	2.29	0.19	7.20	0.52	78.90
III	0.88	0.36	0.24	2.62	1.63	2.14	0.31	7.65	0.37	101.41
	--- river ---									
I	5.41	4.29	0.41	6.95	12.86	3.93	0.39	6.89	1.53	56.14
II	1.44	0.88	0.14	2.34	3.07	1.83	0.09	7.00	0.45	74.71
III	0.73	0.33	0.14	0.86	1.07	1.20	0.00	6.33	0.19	100.59
	--- dam ---									
I	4.79	4.75	0.24	7.89	12.80	3.96	0.40	7.49	1.78	54.59
II	-	-	-	-	-	-	-	-	-	-
III	0.90	0.20	0.52	0.66	1.20	1.40	0.00	6.40	0.17	104.73

In relation to PI correction with some physical-chemical characteristics of the water, it is observed in table 4, that there was a significant negative correlation of PI with Ca, Mg, K, Cl, HCO_3, pH and EC for well water, for river water with Ca, Mg, Na, Cl, HCO_3 and EC, and for dam water with only Ca and HCO_3. The correlation between PI and K for well water was low with r = 0.13, but was significant at p <0.05 due to the number of samples was 247. Chaabane et al. (2016) verified a negative correlation between PI with pH, Ca, Mg and Cl.

Table 4. Correlation coefficient between permeability index (PI) with some physical-chemical characteristics of irrigation water per source

	Well (n = 247)	River (n = 51)	Dam (n = 22)
Ca	-0.60^{*}	-0.70^{*}	-0.45^{*}
Mg	-0.43^{*}	-0.69^{*}	-0.24^{ns}
K	0.13^{*}	-0.27^{ns}	0.64^{ns}
Na	-0.07^{ns}	-0.31^{*}	0.25^{ns}
Cl	-0.26^{*}	-0.51^{*}	0.08^{ns}
HCO_3	-0.56^{*}	-0.53^{*}	-0.48^{*}
CO_3	-0.01^{ns}	-0.25^{ns}	0.11^{ns}
pH	0.24^{*}	0.07^{ns}	-0.06^{ns}
CE	-0.31^{*}	-0.65^{*}	0.05^{ns}

^{ns}, * - not significant and significant at p < 0,05, respectively

There are several methods to classify irrigation water, and PI is one of the three indexes that compose the water quality classification proposed by Donnen (1975), which is based on the risk of salinity, permeability and ion toxicity. The salinity potential of water includes all salts of Cl and Na and $MgSO_4$, being estimated by $PS = Cl + \frac{1}{2}SO_4$. As for permeability, this is influenced by the concentration of salts in water, as well as Na and HCO_3, from which the permeability index mentioned by the author appeared. The toxicity of ions refers to some excess ions in irrigation water that affect plant growth / development, such as Cl, Na and B. For B, Maia and Rodrigues (2012) proposed an index that, using as reference water with EC < 0.75 $dS.m^{-1}$, estimates index based on deviation, how far this is in relation to standard, and may cause toxicity to plants .

Considering that sodium causes soil dispersion of the clay and the amount of salts causes flocculation, observed the classes proposed by Doneen (1975) that the higher the salinity of the water, the lower the risk of clay dispersion. Thus, water with sum of cations and anions greater than 10 $mmol_c$ L^{-1} and PI < 80, are classified in class I, that is, good for irrigation, reducing a maximum of 25% of maximum permeability. The problem with soil permeability begins to appear when the sum of cations and anions of irrigation water is less than 10 $mmol_c$ L^{-1} and PI > 80.

Comparing two indexes that evaluate the water risk can cause soil clay dispersion, the SAR and PI, it is verified that there is a positive relationship between these indices and is given by $PI = f_a.SAR$, with $f_a = \frac{100}{\sqrt{2}}\left(1 + \frac{\sqrt{HCO_3}}{Na}\right)\left(\frac{\sqrt{Ca+Mg}}{Ca+Mg+Na}\right)$ or by $PI = \frac{100.SAR^2\left(Na+\sqrt{HCO_3}\right)}{2Na^2+Na.SAR^2}$. The ratio PI/SAR is verified in figure 1, being this potential relation decreasing in relation to EC and sum of cations and anions.

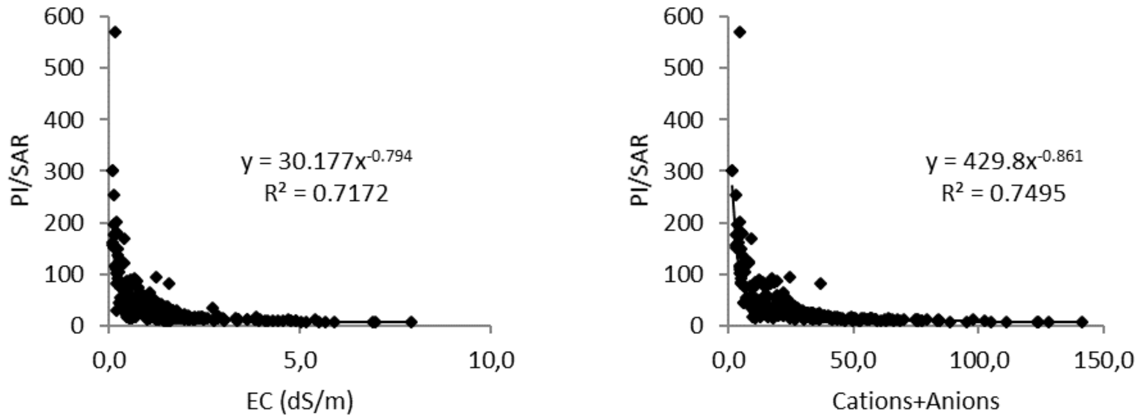

Figure 1. Ratio of PI/SAR to EC and the sum of cations and anions

CONCLUSION

The number of samples per class according to PI index was I > II > III for well, river and dam water, indicating that most water are classified as good quality for irrigation.

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