

IRRIGATION WATER QUALITY USING CATION RATIO AND SODIUM ADSORPTION RATIO IN THE BAIXO AÇU REGION.

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ABSTRACT: The irrigation water quality is assessed primarily by its risk of salinity and sodicity to the soil. The aim of this work was to compare the method of relationship between cations and Sodium Adsorption Ratio (SAR) in the evaluation of the risk of soil dispersion of water for irrigation in the Baixo Açu region. The data used in this work came from 50 samples of water collected in this region, that is located in western of the State of Rio Grande do Norte, being 20 samples of well, 18 of river and 12 of dam. In the water samples the following physical and chemical characteristics were determined: pH, electrical conductivity (EC), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), chloride (Cl^-), bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}). The values of sodium adsorption ratio (SAR), monovalent cation adsorption ratio (MCAR) and cations ratio of soil structural stability (CROSSo) were calculated. The risk of soil dispersion was $\text{CROSSo} > \text{MCAR} > \text{SAR}$ for well, river and dam water.

KEYWORDS: soil dispersion, physical soil properties, modeling

QUALIDADE DA ÁGUA DE IRRIGAÇÃO USANDO A RELAÇÃO DE CÁTIONS E RAZÃO DE ADSORÇÃO DE SÓDIO NA REGIÃO DO BAIXO AÇU

RESUMO: A qualidade da água irrigação é avaliada principalmente pelo seu risco de salinidade e sodicidade para o solo. Objetivou-se com este trabalho comparar o método da relação entre cátions com a Razão de Adsorção de Sódio (RAS) na avaliação do risco de dispersão de solo das águas para irrigação da região do Baixo Açu. Os dados utilizados neste

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trabalho foram provenientes de 50 amostras de água coletadas na região do Baixo Açu, região Oeste do Estado do Rio Grande do Norte, sendo 20 de poço, 18 de rio e 12 de açude. Nas amostras de água foram determinadas as seguintes características físico-químicas: pH, condutividade elétrica (CE), cálcio (Ca^{2+}), magnésio (Mg^{2+}), sódio (Na^+), potássio (K^+), cloreto (Cl^-), bicarbonato (HCO_3^-) e carbonato (CO_3^{2-}). Foi calculado os valores da razão de adsorção de sódio (RAS), razão de adsorção de cátions monovalente (RACM) e da cations ratio of soil structural stability (CROSSo). O risco de dispersão do solo foi $\text{CROSSo} > \text{RACM} > \text{RAS}$ para as águas de poço, rio e açude.

PALAVRAS-CHAVES: dispersão do solo, propriedade física do solo, modelagem.

INTRODUCTION

Irrigated agriculture in Northeast of Brazil is responsible for exporting fruits to various markets around the world, mainly in Rio Grande do Norte, the country's largest melon exporter.

The quality of irrigation water is evaluated mainly by its risk of salinity and sodicity to the soil, measured by the electrical conductivity (EC) and the sodium adsorption ratio (SAR), respectively. Water with high EC decreases the osmotic potential of the soil, reducing the availability of water to the plants, while high sodicity can compromise the soil structure by the clays dispersion.

Although the risk of sodicity has been evaluated for many years due only to the effect of sodium in relation to calcium and magnesium, Robbins (1984) found that soils with high potassium concentration could also contribute to soil dispersion, $\text{Na}/\text{K} < 4$. In 2004, Smiles and Smith (2004) proposed the monovalent cation adsorption ratio (MCAR), including K^+ in the calculation of soil dispersion risk, $\text{MCAR} = (\text{Na} + \text{K}) / \sqrt{(\text{Ca} + \text{Mg})/2}$. Rengasamy and Marchuka (2011) proposed a more detailed indicator to evaluate the risk of soil dispersion to cations ratio of soil structural stability (CROSS), correcting the values of K and Mg with coefficients, $\text{CROSS} = (\text{Na} + 0.56\text{K}) / [(\text{Ca} + 0.6\text{Mg})/2]^{1/2}$. In order to improve water quality assessment for irrigation in relation to the risk of soil dispersal, Smith, Oster and Sposito (2015) proposed other coefficients for K and Mg, different from those proposed by Rengasamy and Marchuka (2011), and named Cations Ratio of Soil Structural Stability Optimizing (CROSSo), $\text{CROSS}_o = (\text{Na} + 0.335\text{K}) / [(\text{Ca} + 0.0758\text{Mg})/2]^{1/2}$.

Therefore, the aim of this work was to compare the method of cations ratio and Sodium Adsorption Ratio (SAR) in the evaluation of the risk of soil dispersion of water for irrigation in the Baixo Açu region.

MATERIAL E METHODS

The data used in this work came from 50 samples of water collected in the region of Baixo Açu, western region of the State of Rio Grande do Norte, being 20 samples of well, 18 of river and 12 of dam. The region shows, according to the Koppen classification, climate type BSw'h', a very warm and semiarid climate, where the rainy season is late for fall, with the highest rain season from summer to fall. The rain is quite irregular in time and space, increasing the climatic risk, with an annual precipitation and temperature average of approximately 697 mm and 27.5 °C, respectively (Carmo Filho and Oliveira, 1995).

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

The interpretation of the water quality was given by the Cations Ratio of Soil Structural Stability Optimizing (CROSSo), proposed by Smith et al. (2015), according to Eq. 1, with Na, K, Ca and Mg in $\text{mmol}_c \text{L}^{-1}$. Monovalent Cation Adsorption Ratio (MCAR) proposed by Smiles and Smith (2004), according to Eq. 2 and the Sodium Adsorption Ratio (SAR) proposed by Richards (1954), by Eq. 3 were also calculated.

$$\text{CROSS}_o = \frac{\text{Na} + 0.335\text{K}}{\sqrt{\frac{\text{Ca} + 0.0758\text{Mg}}{2}}} \quad (1)$$

$$\text{MCAR} = \frac{\text{Na} + \text{K}}{\sqrt{\frac{\text{Ca} + \text{Mg}}{2}}} \quad (2)$$

$$\text{SAR} = \frac{\text{Na}}{\sqrt{\frac{\text{Ca} + \text{Mg}}{2}}} \quad (3)$$

RESULTS AND DISCUSSION

The mean values, standard deviation and coefficient of variation (CV) of CROSS_o, SAR, MCAR and CROSS_o/SAR and MCAR/SAR ratios for the evaluated sources are observed in table 1. Comparing the mean values of CROSS_o, SAR and MCAR, for all evaluated sources, the sequence of CROSS_o > MCAR > SAR was observed. Regarding to SAR, the values of CROSS_o and MCAR were higher, approximately 1.36 and 1.18 times, respectively. As for the variability, in general, river > well > dam.

Table 1. Mean values, standard deviation and coefficient of variation (CV) of CROSS_o, SAR, MCAR and, CROSS_o/SAR and MCAR/SAR ratio for the evaluated sources

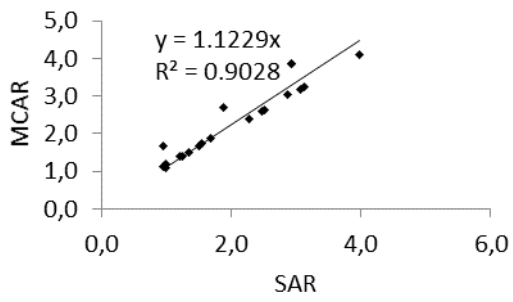
	CROSS _o	SAR	MCAR	CROSS _o /SAR	MCAR/SAR
----- Well -----					
Mean	2.82	2.02	2.31	1.39	1.17
Deviation	1.38	0.91	0.98	0.20	0.18
CV (%)	48.95	45.01	42.44	14.13	15.31
----- River -----					
Mean	2.98	2.29	2.49	1.32	1.19
Deviation	1.73	1.41	1.35	0.08	0.27
CV (%)	58.21	61.71	54.42	5.82	23.12
----- Dam -----					
Mean	1.47	1.07	1.25	1.38	1.18
Deviation	0.48	0.39	0.39	0.07	0.05
CV (%)	32.75	36.43	30.79	5.31	4.38

Evaluating the relationship of MCAR and CROSS_o with SAR, it is observed that both MCAR and CROSS_o overestimated the risk of soil dispersion, however CROSS_o > MCAR, figure 1. Despite the relationship between the evaluated indexes, these can be estimated from the SAR, as demonstrated by Maia and Braga (2017) proposing the relations

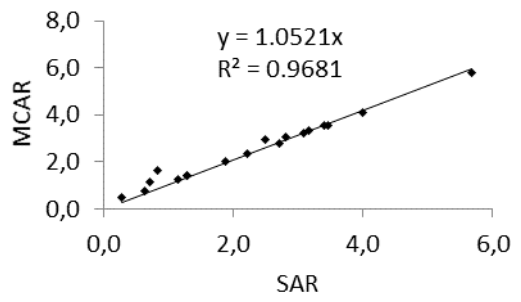
$$\frac{CROSS_o}{SAR} = \left(1 + \frac{0.335K}{Na}\right) \sqrt{\frac{Ca+Mg}{Ca+0.0758Mg}} \quad \text{and} \quad \frac{MCAR}{SAR} = \left(1 + \frac{K}{Na}\right), \quad \text{therefore,}$$

$f_1 = \left(1 + \frac{0.335K}{Na}\right) \sqrt{\frac{Ca+Mg}{Ca+0.0758Mg}}$ and $f_2 = 1 + \frac{K}{Na}$, it follows that $CROSS_o = f_1 \cdot SAR$ and $MCAR = f_2 \cdot SAR$. The mean values of f_1 were 1.39, 1.32 and 1.38 for well, river and dam water respectively and, for f_2 , 1.17, 1.19 and 1.18, also for well, river and dam water respectively (table 1). Maia and Braga (2017) also demonstrated that f_1 can be estimated by

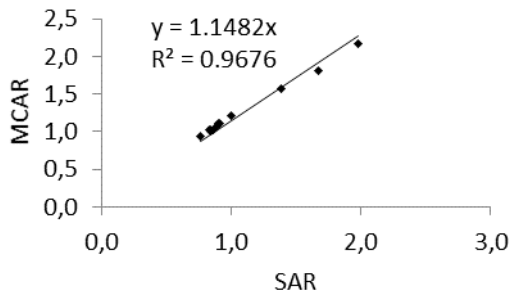
$$\text{the approximation involving the Ca/Mg ratio by } f_1 = \left(1 + \frac{0.335K}{Na}\right) \sqrt{\frac{1 + \frac{Ca}{Mg}}{0.0758 + \frac{Ca}{Mg}}}$$



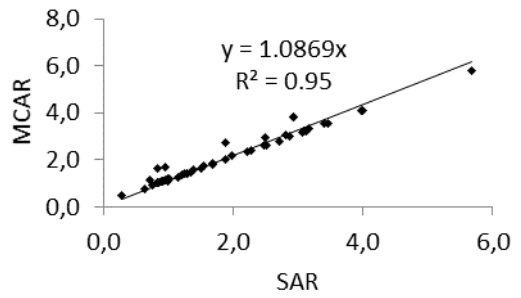
Well



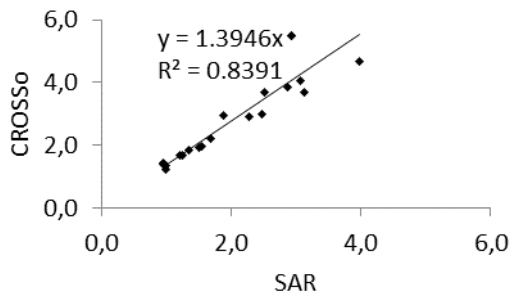
River



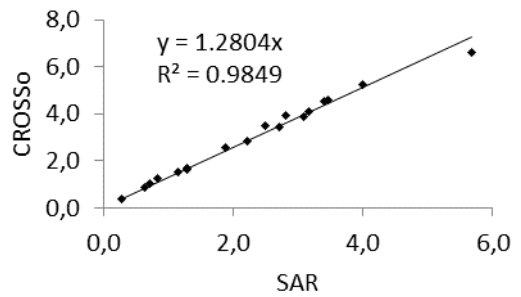
Dam



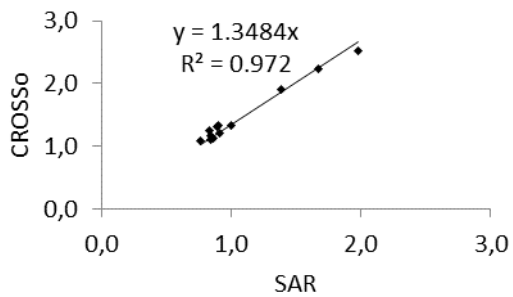
All



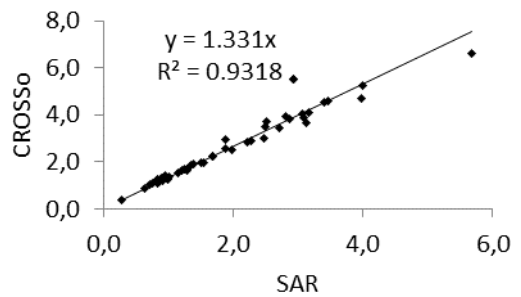
Well



River



Dam



All

Figure 1. Relation between MCAR and CROSSo with SAR

Both CROSSo and MCAR are the sum of sodium adsorption ratio (SAR) and potassium adsorption ratio (PAR), however, because potassium does not have the same soil dispersing power as sodium, and magnesium does not have the same flocculation power as Ca, a correction of K and Mg was made (Smith et al., 2015). This was done because Rengasamy and Marchuk (2011) observed that this correction fit better with soil dispersion, being better than the use of SAR as the index of soil clay dispersion.

For use of CROSSo in a practical way, instead of SAR, Oster et al. (2016) state that CROSSo is the only index that explains the effects of the four main cations of the irrigation water on the physical properties of the soil. Zhanga et al. (2018) evaluated the CROSSo and they obtained excellent result in a Solonetz. Laurenson and Houlbrooke (2012) evaluated CROSS to establish guidelines for the interpretation of wastewater in Australia. However, Marchuk et al. (2012) state that the use of SAR is recommended only when the cations predominance is Na, and CROSS is recommended for cases with varying ratios of cations. Kumar et al. (2014) state that because CROSSo is a new index, it has not yet been fully tested. It can be evaluated in soils containing various concentrations of Ca, Mg, K and Na, as well as the influence of mineralogy, organic matter and pH.

CONCLUSION

The risk of soil clay dispersion was $CROSSo > MCAR > SAR$ for well, river and dam water.

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