SOIL SALINITY MAPPING IN THE IRRIGATED PERIMETER JACARÉ-CURITUBA, LOW SÃO FRANCISCO WATERSHED, SERGIPE, BRAZIL

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ABSTRACT: Irrigation development has played a vital function in raising agricultural production worldwide, but the negative side-effects of intensive irrigated farming on soil and water have also been substantial. On-farm, salinization and waterlogging are the main problems. This study was therefore conducted to evaluate salinity of Jacaré-Curituba irrigation scheme, as part of a large Project with the objective to recover a salinity area. An area of 10,000 m^2 was delineated, and regularly spaced grid (cell size: 20 m) of sampling points were geo-referenced using GPS. A total of 26 composite soil samples were collected from each sampling points at a depth of 20 cm. Soil samples were analyzed for pH, electrical conductivity (EC), and exchangeable sodium percentage (ESP) following the standard Richards (1954) procedure. Descriptive statistics technique was used to analyze the data. The result showed that pH ranged 6.8 to 8.83, electrical conductivity ranged from 0.44 to 65.36 $mScm^{-1}$ and the exchangeable sodium percentage ranged from 0.53% to 25.53%. This indicated that soils of the irrigation scheme are characterized by saline and sodic soils with different degree of salinity.

KEYWORDS: Irrigated agricultural, Semi-arid region, Soil degradation

MAPEAMENTO DA SALINIDADE DO SOLO NO PERÍMETRO IRRIGADO JACARÉ-CURITUBA, BAIXA BACIA HIDROGRÁFICA DO SÃO FRANCISCO, SERGIPE, BRASIL

RESUMO: O desenvolvimento da irrigação tem desempenhado um papel vital no aumento da produção agrícola em todo o mundo, mas os efeitos colaterais negativos da agricultura irrigada intensiva sobre o solo e a água também são substanciais. Na exploração agrícola a

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salinização e o encharcamento são os principais problemas. Portanto, este estudo foi conduzido para avaliar a salinidade no perímetro irrigado Jacaré-Curituba, como parte de um grande projeto com o objetivo de recuperar uma área salinizada. Uma área de 10.000 m^2 foi delineada, e uma grade espaçada regularmente (tamanho da célula: 20 m) de pontos de amostragem foram georreferenciados usando GPS. Um total de 26 amostras de solo compostas foram coletadas de cada ponto de amostragem a uma profundidade de 20 cm. As amostras de solo foram analisadas quanto ao pH, condutividade elétrica (EC) e porcentagem de sódio trocável (ESP), seguindo o procedimento padrão descrito por Richards (1954). A estatística descritiva foi utilizada para analisar os dados. Os resultados mostraram que o pH variou de 6,8 a 8,83, a condutividade elétrica variou de 0,44 a 65,36 $mScm^{-1}$, o pH variou de 6.8 a 8.83 e a porcentagem de sódio trocável variou de 0,53% a 25,53%. Isto indicou que os solos do perímetro irrigado são caracterizados por solos salinos e sódicos com diferentes graus de salinidade.

PALAVRAS-CHAVE*:* Agricultura irrigada, Semiárido, Degradação do solo

INTRODUCTION

Few plants can tolerate much salt, as it prevents the uptake of moisture, with a consequent rapid decline in yields. Salinization may come about when irrigation releases salts already in the soil, or when irrigation water or mineral fertilization brings new salts to the land. Waterlogging is a related problem. It curtails plant growth by eliminating air from the soil, effectively stifling the plant. Waterlogging also often leads to salinization of soils. Worldwide, FAO estimates that 34 Mha (11 percent of the irrigated area) are affected by some level of salinity (FAO, 2011). Soil salinity by now is becoming an international problem in many of the irrigated lands, which have inadequate drainage and use too much amount of irrigation water (AREDEHEY et al, 2018).

Salinization has been identified as the main process of soil degradation in agricultural areas (FAO, 2015). Soil loss is estimated at around 1.5 million hectares of arable land each year due to salt accumulation, and in Brazil, although information on saline areas is not well defined, it is estimated that 20 to 25% of irrigated areas face salinization problems, and this problem is more imminent in the northeast region with 155 million hectares, of which 52% in the semiarid (OLIVEIRA; GOMES-FILHO; ENÉAS-SON, 2010).

The Jacaré–Curituba Settlement Project has 5,005 hectares, of which 3,156 ha would be irrigable through the capture, adduction and distribution of water from the São Francisco River. The irrigated perimeter is inserted in the territory of the Jacaré-Curituba Agrarian Reform Settlement. Jacaré–Curituba irrigation scheme is divided into five sectors that account for 133 irrigated lots, 700 irrigating in total. The area with irrigation system totals 1,826.72 hectares, being 102.62 ha for livestock and 1,724.10 ha for agriculture. The activities are from primary sector of the economy, such as polyculture and livestock agriculture, are developed in extensive pastures. The cultivated crops are diversified by vegetables, legumes, fruits and vegetables, being the main plantations of okra, cassava, maize, beans, sunflower, guava, passion fruit, lettuce, watermelon and pumpkin.

In the Sergipe semiarid, salinized areas were reported by Aguiar Netto et al. (2007) and Resende et al. (2014) at the California irrigated perimeter. The settlement of California is the geographical neighbor of the settlement in question and may suffer from the same problem. In the very beginning of the project activities Waters of São Francisco point to difficulties with the salinization of the soils. The evaluation process was started in 2013-2016, as a community demand, and details can be seen in Santos and Lucas (2015).

One of the problems that has been identified is the excessive use of water in this area, which causes salinity problems, since the salts present in the soil go through the process of excessive salt deposition by fertigation techniques, besides causing the percolation of these salts. causing soil and groundwater contamination. Therefore, the objective of the present study was to evaluate in a spatial way the conditions of the main determinants of soil salinity in the Jacaré-Curituba irrigated perimeter.

MATERIAS AND METHODS

Jacaré–Curituba irrigation scheme is located in northwestern of Sergipe State (Figure 1). It is found between 9º42' S latitude and 37º44' W longitude. Jacaré–Curituba irrigation scheme is part of the São Francisco watershed. The semiarid area has edaphoclimatic characteristics with irregular relief and rocky outcrops in some points.

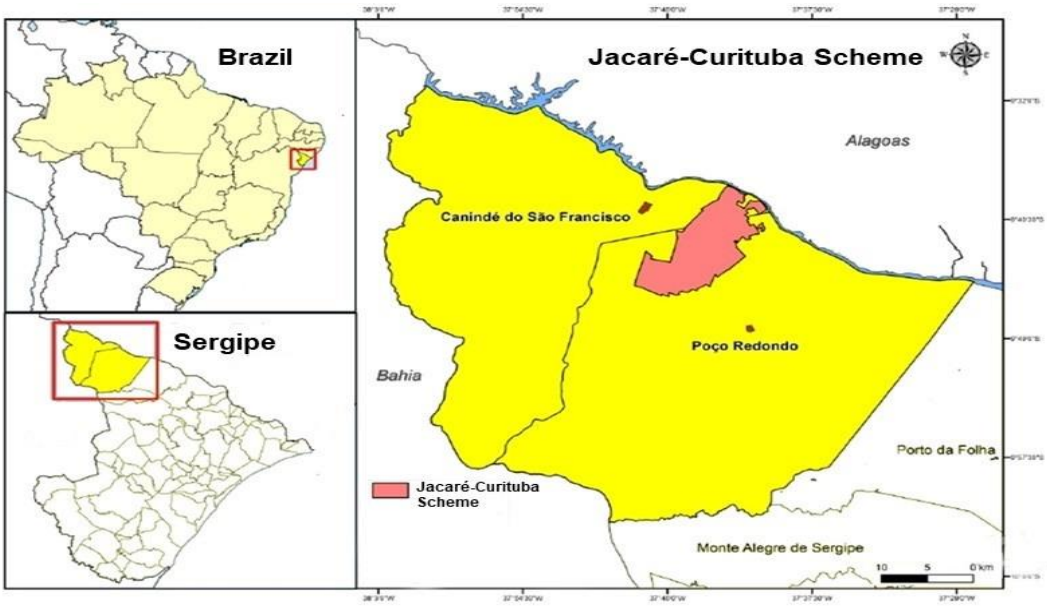

Figure 1. Jacaré-Curituba scheme localization.

An area of 1 hectare irrigation scheme was demarcated using compact receiver and integrated GNSS equipment (Figure 2). Grid sampling, one of the soil sampling strategies which deliver more in-depth information about soil salinity. The grid cell size was made to be 20 x 20 m, and a composite soil samples were collected from each grid node, coordinates of each composite soil sampling points were recorded using a global positioning system at an accuracy of ±3 m.

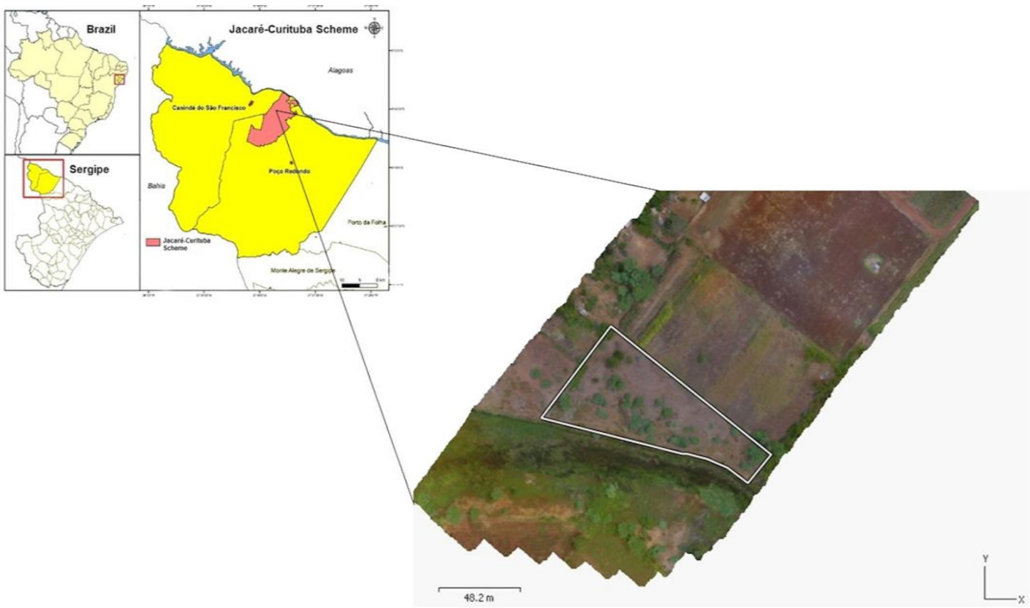

Figure 2. Sampling soil area

Samples were collected from the surface soil (0–20 cm) using a hand auger. The collected samples were put in a clean plastic tray, crushed, mixed thoroughly, and transferred to plastic sampling bag. A total of 26 soil samples were collected from the delineated irrigation scheme. Finally, all soil samples were transported to analytical laboratory for analysis.

Field soil samples were air-dried at a convenient laboratory temperature. Following the drying process, soil samples were grinded mechanically by using a proper equipment to be ready for laboratory analysis. pH of the soil was determined by preparing saturated paste method and extract the soil water solution as descript in Richards (1954). Soil pH was then measured by inserting the electrodes of the pH meter into the soil suspension. Soil water was used to measure the electrical conductivity (EC) using digital conductivity meter. The cation exchange capacity (CEC), the measure of the amount of readily exchangeable cations in the soil, was determined to the major exchangeable cations (Ca, Mg, Na, and K). The exchangeable sodium percentage (ESP), the widely used means of soil sodicity. Geostatistics was used to estimate and map soil properties between spaces. Ordinary kriging was performed to spatially predict the parameters studied in the study area.

Data were analyzed using descriptive statistics, calculating the mean, minimum value, maximum value, standard deviation, coefficient of variation, thus seeking to characterize them. The geostatistical analysis of the studied attributes was adjusted using the GS + computer program, version 9. Thematic maps were generated using the Qgis software, version 2.18.24.

RESULTS AND DISCUSSION

Soil pH of the study area ranged from 6.8 to 8.83 with a mean of 7.7 and CV of 20% (Table 1). The electrical conductivity (EC) of soil samples analyzed ranged from 0.44 to 65.36 $mScm^{-1}$ with an average value of 11.43 $mScm^{-1}$ and the vales of the ESP ranged from 0.53% to 25.53% with a mean of 6.69% (Table 1).

Table 1. Descriptive statistics of soil pH, EC, and ESP

Parameter	Min	Max	Mean	SD	CV (%)
pH	6.8	8.83	7.7	0.55	20
EC ($mScm^{-1}$)	0.44	65.36	11.43	18.88	21
ESP (%)	0.53	25.53	6.69	7.8	22

Minimum value (Min); Maximum value (Max); Mean (Mean); Standard deviation (SD); Coefficient of variation (CV).

Figure 3 shows the pH, EC, and ESP spatial distribution where the salinity is predominant at the lowest of the area. Santos (2015) found the same behavior of the salinity in his research in Jacaré-Curituba irrigation scheme.

This study pointed out that in soils of the irrigated fields of Jacaré-Curituba irrigation scheme, there is salinity hazard and is building up gradually as the irrigation practices are continuing. Increasing salinity hazards in the soils with this pace will cause toxicity and eventually will impair the growth of irrigated crops. Hence, reclamation measures should be introduced to soils of the irrigated fields considering series of options starting from leaching, fertilization, and selecting salinity-resistant crop varieties (AREDEHEY et al, 2018).

Environmental and agricultural damage caused by salinity, sodicity and waterlogging may imply very severe economic and social damage, therefore well-designed policies need to be developed for prevention and remediation (MATEO-SAGASTA AND BURKE, 2010) what should be avoid at the Jacaré-Curituba irrigation scheme or minimized.

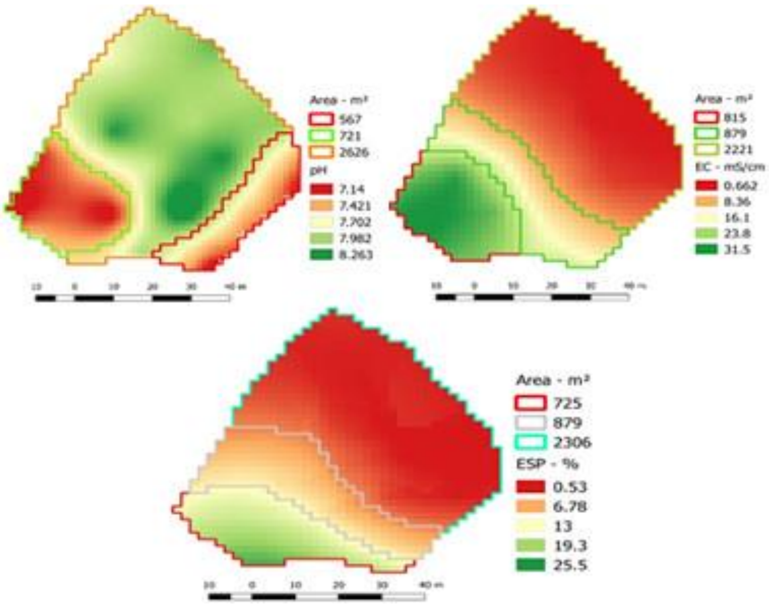

Figure 3. Spatial distribution of the parameters pH, EC and ESP.

CONCLUSION

The Jacaré-Curituba irrigation scheme is characterized by a series of salinity levels based on the chemical properties of the soil, having as parameters the pH, electrical conductivity (EC) and exchangeable sodium percentage (ESP). Therefore, it is essential to evaluate the short, medium and long term changes of these factors in areas that have the same conditions so that an information bank can be developed to support the management and recovery of these areas.

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