Salinity mapping of fields irrigated with winery effluents

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Abstract

Land application of food-processing effluent waters is a widely practiced treatment and disposal technique that allows for the beneficial reuse of nutrients and water. However, excessive application of these waters can lead to subsurface water degradation and increase in soil salinity. The objective of this research was to assess the spatial distribution of salinity in fields having received winery effluent waters and to evaluate the effectiveness of two forage grasses (Elephant grass and Sudan grass), in removing salts from the soil profile. Salinity mapping of the fields was conducted using the electromagnetic induction (EM) technique and soil sampling. The salinity maps indicated that both grasses were efficient in removing salt from the soils. However, the results suggested that the Elephant grass had a greater uptake capability. The study also showed that the use of the EM technique improved the knowledge of salinity variability across the fields and was a valuable tool for evaluating the beneficial effects of forage grasses in improving subsurface soil and water quality.

Introduction

Land application of food-processing effluent waters is a widely practiced treatment and disposal technique that allows for the beneficial reuse of nutrients and water. However, excessive application of these waters can lead to subsurface water degradation and increase in soil salinity. Such water contamination problems are encountered across the country, including in the Central Valley of California where intensive agriculture is practiced and numerous food-processing plants need to dispose of their excess waters. Researchers at the Center for Irrigation Technology (CIT) - California State University, Fresno have been working for several years with the City of Fresno's Public Utilities to monitor subsurface water quality at a disposal site that received winery effluents for thirty years. Such monitoring was mandated by the Regional Water Quality Control Board to determine the organic and nitrogen loadings that occurred on the site. In December 2003, the discharge of winery effluents to the site was ceased permanently. Since then, compliance with regulations requires the City of Fresno to plant and harvest forage grass on the site to uptake nitrogen and salts from the soil.

A research study is currently being conducted by CIT in one section of the site, where two forage grasses have been planted and lysimeters have been installed to determine the movement of nutrients and salts as the section is being irrigated with fresh water. The two grasses studied are Elephant grass and Sudan grass; each grass was planted in 2004 on 0.72 acre and 0.58 acre, respectively. Elephant grass is a perennial forage grass (*Pennisetum Sp*.) that grows throughout the tropical world and is one of the most widely used forage for animals. Elephant grass was introduced in California in 1994 and was patented by Morton Rothberg as "Promor A". This plant grows in clumps or stools with an upright growth habit and is very palatable to animals. Elephant grass is a fast growing C4 plant which can be harvested 3 times a year and can produce tremendous amount of high-nutrient animal feed. Past studies indicate this grass as capable of absorbing over 1000 lbs of total nitrogen per year (Goorahoo et al., 2004). Elephant grass can grow in soils with high salts and nitrogen content, and is the crop of choice for wastewater facilities and dairy farms because of its high nitrogen and salt removal capabilities. Details on the CIT study and results from the lysimeter data can be found in another paper presented at this Irrigation Show (Adhikari et al., 2005). In this paper, we present the spatial distribution of soil salinity in the areas planted with Elephant grass and Sudan grass, evaluate the changes in salinity that occurred over one year, and compare the efficiency of the two grasses.

Materials and Methods

The study was conducted at the stillage disposal site located at the Fresno/Clovis Regional Treatment Facility, CA. Soil salinity measurements were taken in the two fields planted with Elephant grass and Sudan grass. The electromagnetic instrument used in this study was the EM-38 dual dipole (Geonics Limited, Mississauga, ON, Canada) which provides measurement depths down to 6 feet without ground contact. The instrument includes a transmitter and a receiver spaced about 3.3 feet apart in a non conductive casing. Photograph of the EM38-DD meter is presented in Figure 1. The transmitter part of the instrument induces a primary magnetic field in the ground, which creates a current in the soil matrix and generates a secondary magnetic field recorded by the receiver. The electrical conductivity (EC) being measured is the ratio of these two magnetic fields. The EM technique has been used by several researchers for agricultural and environmental applications (McKenzie et al., 1989; Slavish, 1990).

Figure 1. EM-38 meter used in this study

In each field, the EM data were collected following a grid pattern of 15 feet X 18 feet. A total of 84 locations were surveyed in the Elephant grass field, and 90 locations for Sudan grass. The EM measurements were taken in July 2004 just before planting and then in April 2005 for both fields. After each survey, six locations were chosen in each field for ground truthing. This was required because the efficient use of the EM data required the conversion of apparent soil conductivity into soil salinity. The soil samples were collected down to 4 feet and were analyzed for EC, moisture content, and saturation percentage, following standard analytical methods (Klute, 1986; Miller et al., 1997). Then, the ESAP software was used to predict the soil salinity data based on the survey and sample information (Lesch and Rhoades, 1999). Contour maps showing the salinity distribution on both fields in 2004 and 2005 were generated with the Surfer software (Golden Software, 1999).

Results and Discussion

The electrical conductivity data of the soils collected after each survey are shown in Table 1. In 2004, the EC values were similar in both fields, ranging from 4.9 dS/m to 7.6 dS/m for Elephant grass, and from 4.9 dS/m to 9.6 dS/m for Sudan grass. Higher EC was found at 0-1 ft in the Sudan grass field and at 3-4 ft in the Elephant grass field. The EC values tended to decrease with depth for the Sudan grass field; no trend could be observed in the Elephant grass field. In 2005, the soil EC values considerably decreased in both fields, and particularly for the area planted with Elephant grass. The EC remained below 3.5 dS/m in the Elephant grass field with the lowest values found in the first two feet. In the Sudan grass field, the EC was not very variable across depth, ranging from 3.6 dS/m to 4.3 dS/m.

Table 1. Electrical conductivity of soil samples collected in both fields (average of 6 locations)

Depth	-------------------2004--------------------		-------------------2005--------------------	
	Elephant grass	Sudan grass	Elephant grass	Sudan grass
0 -1 ft	7.6	9.6	2.1	3.9
1 - 2 ft	5.9	5.3	2.3	4.3
2 – 3 ft	4.9	5.3	2.9	4.2
3 – 4 ft	7.0	4.9	3.5	3.6

Maps showing the spatial distribution of soil salinity in both fields are presented in Figures 2 and 3 for 2004 and 2005, respectively. The data represent the average soil salinity down to 4 ft. The 2004 maps represent the salinity levels just before planting and the 2005 maps show the salinity data about nine months after planting. Relatively high salt concentrations were observed for both fields in 2004. The average salinity levels ranged from about 4 to 8 dS/m in the Elephant grass field. The Sudan grass field exhibited a more heterogeneous spatial distribution with EC values ranging from 2 to 8 dS/m; the lowest EC was observed in the south-west part of the field. In 2005, the soil salinity levels decreased in both fields. The highest salinity values reached 4 dS/m and 5 dS/m in the Elephant grass and Sudan grass fields, respectively. However, in most parts of the Elephant grass field, the soil salinity levels remained below 3 dS/m. Soil salinity was higher in the Sudan grass field, ranging from about 4 to 5 dS/m. The study indicates that both grasses helped in removing salts from the soil profile. However, when comparing the two fields, the Elephant grass appeared more efficient in removing the salts from the soil profile.

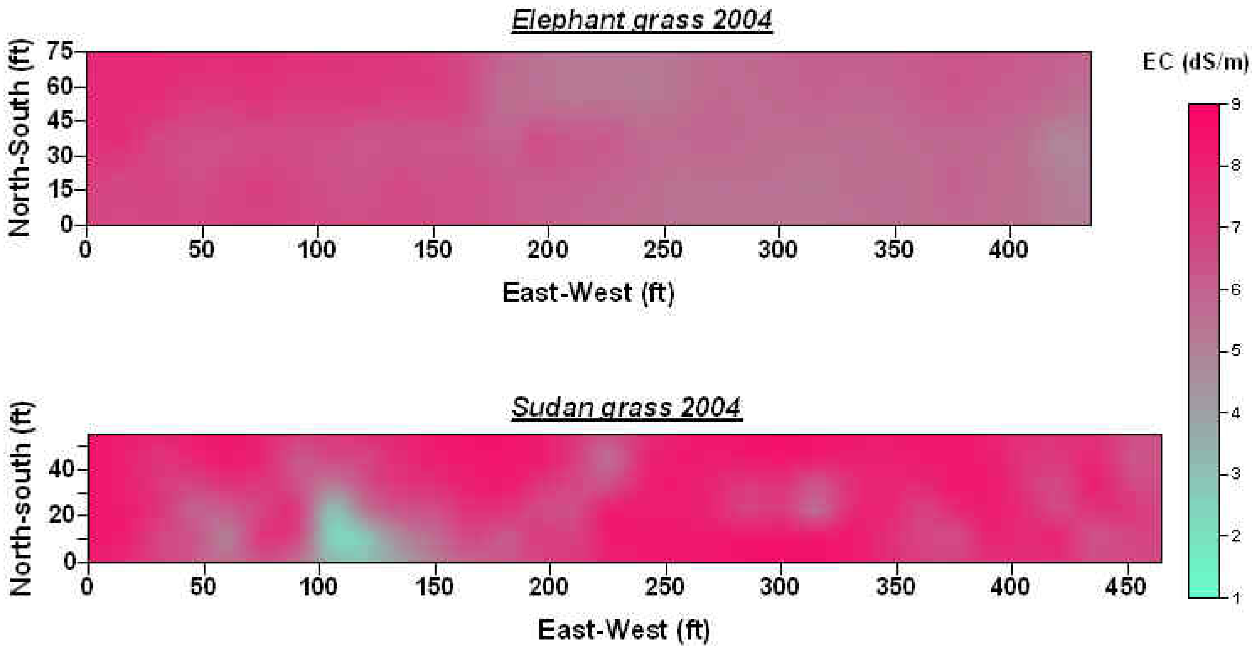

Figure 2. Soil salinity (dS/m) distribution observed in 2004 in both fields

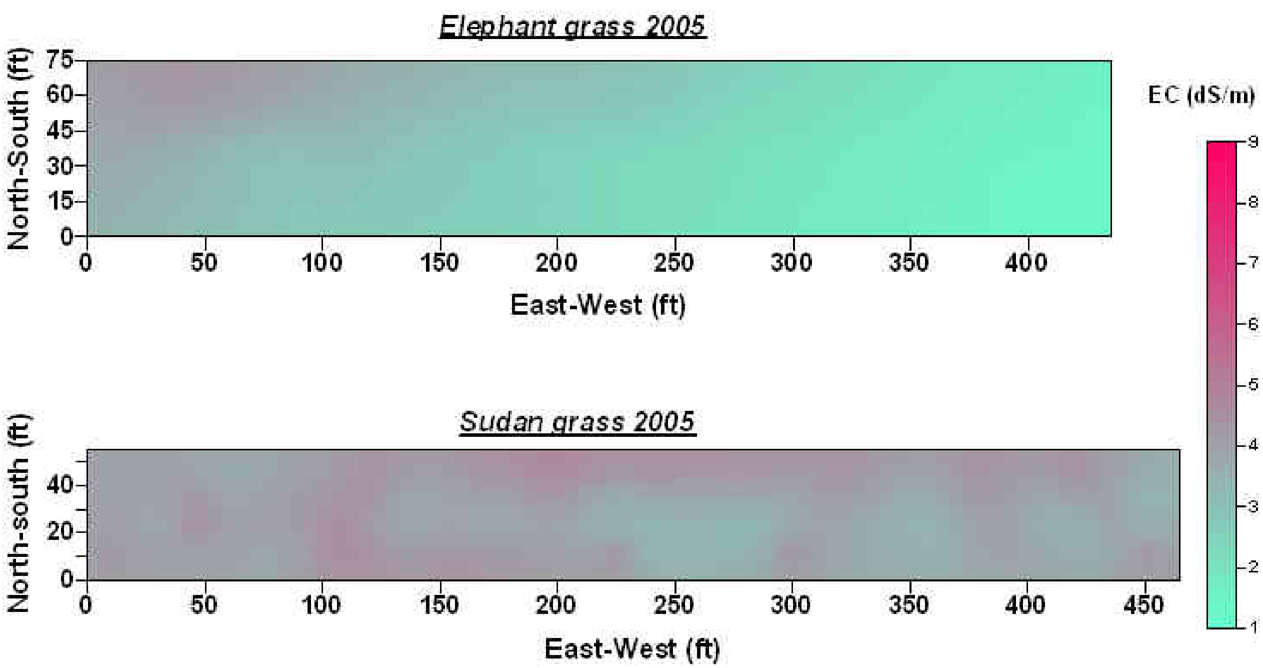

Figure 3. Soil salinity (dS/m) distribution observed in 2005 in both fields.

Conclusions

The purpose of the study was to assess the spatial distribution of salinity in fields having received winery effluent waters and to evaluate the effectiveness of two forage grasses, Elephant grass and Sudan grass, in removing salts from the soil profile. Results indicated that both grasses helped in salt removal; however, the Elephant grass appeared to have a better uptake capability. The study also showed that the use of the EM technique improved the knowledge of salinity variability across the fields and was a valuable tool for evaluating the benefits of using forage grasses for improving subsurface soil and water quality.

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