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SOIL SALINITY APPRAISAL IN LARGE-IRRIGATION AREAS BY USING EM38 TECHNIQUE

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ABSTRACT

In large irrigation areas, easy and quick soil salinity appraisal by conventional techniques is not possible due to the fact that field and laboratory studies on conventional soil salinity appraisal techniques are difficult and time consuming. Therefore, it has been lately witnessed that an instrument, dubbed as EM38, acting with electromagnetic induction technique has been commonly used for the purpose of easy assessment and quantification of soil salinity especially in large-scale agricultural areas. In this study, assessment of soil salinity by conventional method and EM38 technique was compared. The study is carried out in Serik Plain on the Southern coastal Mediterranean region near Antalya province, Turkey. Sampling points were randomly selected in the studied area. Soil samples as 6 layers on these selected sampling points were collected. These soil samples were analyzed for soil salinity by conventional methods (ECe, dS/m) in the laboratory. EM38 lectures (ECa, dS/m) as apparent soil salinities were done at the same sampling points. As a result of the study, a significant linear relationship was obtained between laboratory soil salinity measurements (ECe) and EM38 readings (ECa). It was concluded that the developed calibration equation can be used to precisely estimate soil salinity at any unsampled site in the study domain.

KEYWORDS:
ECe, ECa, electrical conductivity, salinity estimation

INTRODUCTION

Salinity is one the most important factors which plagues agricultural production by decreasing plant growth and yield in addition to impairing soil quality. It is mainly an arid-zone problem leading to land desertification. Soil salinity also poses major environmental hazard by degrading the quality of aquatic environment and decreasing wildlife diversity. Soil salinity can occur naturally in areas where the parent material is rich in salts. In addition, some factors such as geological structure, climate, distance to the sea, topographic features and natural drainage patterns can trigger off soil salinity formation [1]. In irrigated areas, salinity problems may arise in two ways [2]: (1) since all irrigation waters contains dissolved minerals salt even in lower concentrations, salt accumulation occurs in soil with time as a result of irrigation practices; (2) excess irrigation in order to prevent salt accumulation in soil may cause the rise of groundwater table especially in poorly drainage areas. The rise of groundwater table with high levels of dissolved salts may cause salinity problems [3]. Therefore, salt accumulation in plant root-zone may closely be associated with the quality of irrigation water and/or the irrigation method used [4]. Depending on the plant species and varieties, increased soil salinities may affect plant growth and decrease yield significantly.

Increases in soil salinity leads to reduction of land available for agricultural production. Of the world's agricultural areas, 37% are sodium, 23% are salt affected soils and the remaining 40% are only fertile agricultural areas. Throughout the world, about 4×10^4 ha of land becomes unavailable for agricultural production every year because of salinization [5]. Although figures regarding the amount of salt-affected areas have not been updated yet, salt affected soils in Turkey are nearly equal to 20% of the irrigable area [6].

In large areas, easy and quick soil salinity appraisal by conventional techniques is not possible. Because field and laboratory studies on conventional soil salinity appraisal techniques are difficult and time consuming. Therefore, an instrument called EM38 acting with electromagnetic induction technique is developed for the purpose of easy assessment and quantification of soil salinity especially in large-scale agricultural areas. EM38 instrument measures apparent electrical conductivity which is a relative indicator of soil salinity. Depending on the horizontal or vertical dipole positions use of the EM38 instrument, salinity of 100 and 200 cm of soil layers, respectively, can be determined. In this study, assessment of soil salinity development in a large scale irrigation area was compared by using conventional method and EM38 technique.

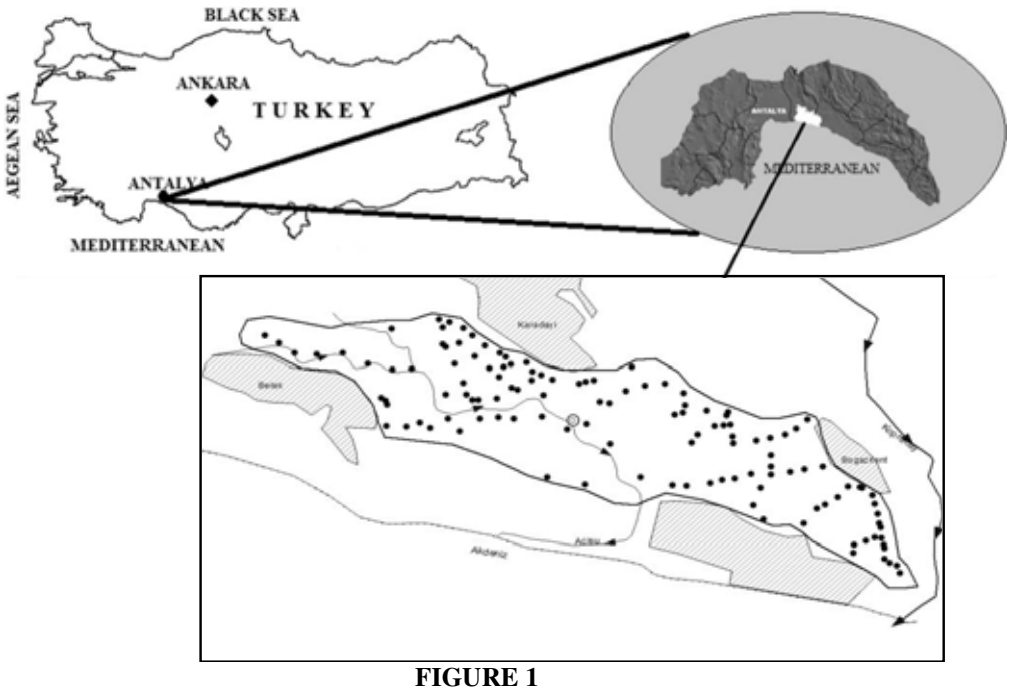


FIGURE 1
Location of the study area and EM38 lecturing sites (●)

MATERIALS AND METHODS

This study was carried out in the southern part of Antalya-Köprüçay irrigation district. It is located within 36º 49′ 75″ - 37º 01′ 97″ north latitudes and 30º 49′ 63″ - 31º 16′ 62″ east longitudes (Figure 1).

In the study area, 22 sampling points were selected randomly in order to determine soil salinity by conventional methods and EM38 readings. The EM38 readings were realized by placing the device on the ground first in horizontal- than in vertical-dipole orientations at these selected sampling points in the area. As a precaution, any metal objects that may influence the electromagnetic field of the EM38 were removed during the lecturing process. Soil samples were collected directly beneath the EM38 reading site at each selected sampling points as 6 layers including 0–30, 30–60, 60–100, 100–130, 130–160 and 160– 200 cm-depth of soil profile. Collected soil samples (n=132) were air-dried, grounded and sieved to pass through a 2-mm screen. Saturation soil pastes were prepared using 100 g sub-samples, kept in the laboratory for 12 hours of equilibrium time and the saturation extracts were taken to measure standard electrical conductivities (ECe) following the procedure described by USLS [7]. Calibration of EM38 instruments is done as explained by Diaz and Herrero [8]. Then, all the ECa readings were converted to the standard ECe values by using calibration equations. The contour maps of soil salinity were produced for the converted standard ECe values by using geographical information system, ArcView 3.0a GIS [9] and the procedure described by Cetin and Diker [10].

RESULTS AND DISCUSSION

Average soil salinity values for each layer of the profile from 22 selected sampling points were given in Figure 2. Electrical conductivity values of the saturated soil paste extracts, ECe, increased with increasing soil depth indicating that the vertical variability and level of salinity in the deeper horizons were high. This kind of salinity development in irrigated areas is an indication of normal profiles. Similar conclusions have been reported by Cetin et al. [11] and Kaman et al. [12] at different places. In a study realized in Spain by using EM technique and EASP software, Amezketa [1] found similar results and claimed that the main reasons of increased salinity with increasing depth were improper use of the farm land and limited water use or ineffective drainage conditions, i.e. inefficient leaching in the area.

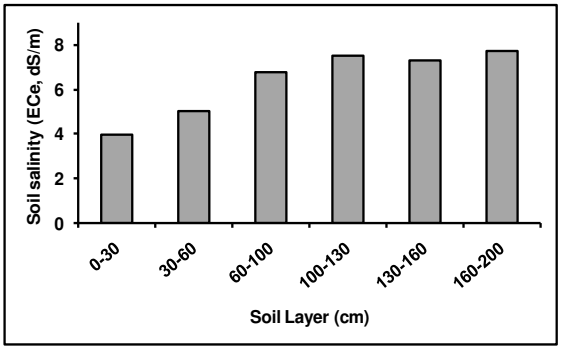


FIGURE 2
Average soil salinity values for each layer of the soil profile from 22 selected sampling points

Average soil salinity values obtained by conventional method were 4.86 and 6.36 dS/m for 0-100 (ECe1) and 0-200 cm (ECe2) soil profile, respectively. Similarly, average apparent electrical conductivity values obtained by EM38 reading were 1.64 and 2.36 dS/m for 0-100 (ECa1) and 0-200 cm (ECa2) soil profile, respectively.

The relationship between ECe and ECa was shown in Figure 3. This result indicates a strong linear relationship (R^2=0.95) between ECe and ECa for 0-100 cm soil profile. Similarly, point patterns on the graphs for EM38 horizontal (ECa1) and vertical-dipole position (ECa2) readings showed that the relationship between these variables were in the linear form with the determination coefficient of R^2=0.98 (Figure 4). This result indicates that calibration obtained for 0-100 cm soil depth can be used to estimate soil salinity of 0-200 cm depth, too. Similar conclusions were drawn Herrero et al. [13] and Amezketa [14]. Both of these researchers investigated soil salinity of 22 and 20 sampling points, respectively, in an irrigated area by using EM38 technique. They concluded that both ECa1 and ECa2 readings were similar (i.e. slopes close to 1 and intercepts close to 0).

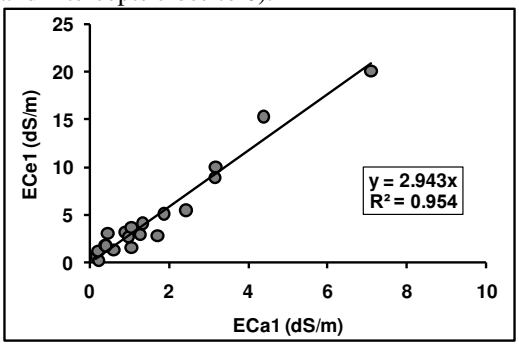


FIGURE 3
The linear association between ECa1 readings in the horizontal dipole position and ECe1 values in 0-100 cm soil depth (n=22)

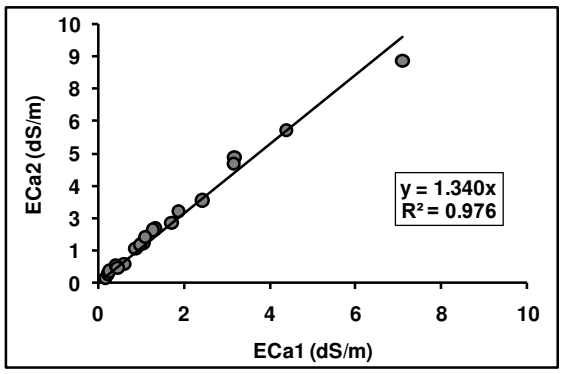


FIGURE 4
Linear regression equation between ECa1 and ECa2 lectures obtained at the 22 sampling points

The spatial distribution patterns of soil salinity of an area can be produced by using ECa reading obtained by EM38 instrument [14]. Also in this study, ECe values were calculated from ECa values by using calibration equation given in Figure 3. Then, the soil salinity contour maps of the study area were produced for the converted ECe values by using geographical information system, ArcView 3.0a GIS [9] and the procedure described by Cetin and Diker [10].

Mapping results were depicted in Figure 5. Patchy areas which are darker compared with the other parts on the map indicate high soil salinity levels. It is important to highlight that the nearer to the Mediterranean Sea, the higher the soil salinity development, revealing the negative impact of the sea water intrusion on the lowlands irrigation located in the very vicinity of the Mediterranean. Also, Kaman et al. [15] in a study related to seawater intrusion throughout the Acısu creek located in the map and Kurunc et al. [16] in a study related to spatial variation of some groundwater quality variables in the same irrigation district found some hot spots of soil salinity.

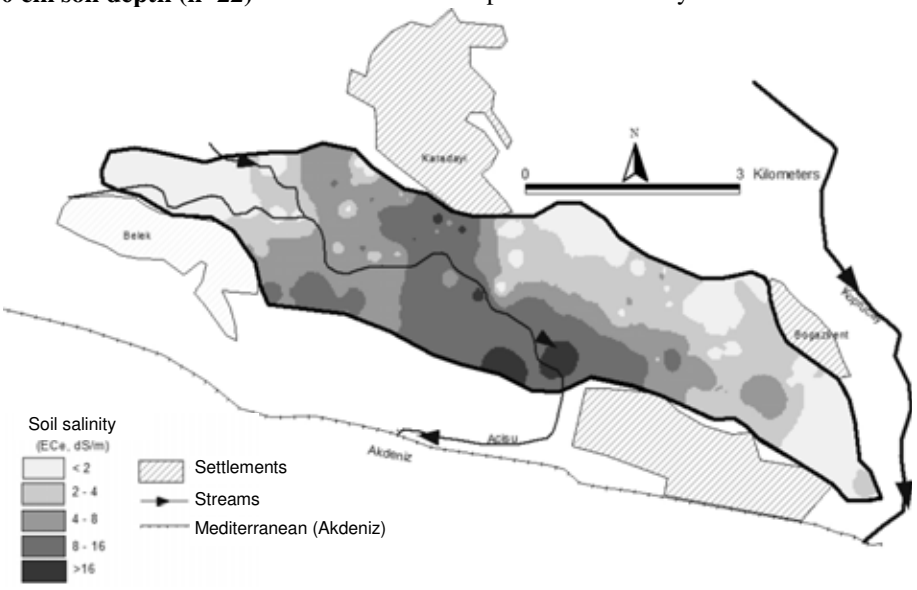


FIGURE 5
Spatial variability of the soil salinity for 0-100 cm depth

CONCLUSION

In this study, analyzed soil salinity values by conventional method and apparent electrical conductivity values by EM38 readings at horizontal- and vertical dipole positions from 22 sampling points were used as a material. The significant relationships between ECe and ECa1 and between ECa1 and ECa2 were obtained. Using calibration equation obtained for ECe and ECa1, EM38 readings were converted to obtain standard ECe values. As a result, it was concluded that since the correlations between EM data and ECe were high and the linear type association is statistically significant, electromagnetic induction technique, i.e. EM38 device, can facilitates field spatial variability of soil salinity with least effort. The electromagnetic induction technique require less soil sampling, because of that, handling of less soil samples, compared to conventional method.

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