Possibility of Using EM38 Device to Determine the Extent and Severity of Soil Salinity: A Case Study in the Lower Seyhan Plain, Turkey

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ABSTRACT

Salinity is an increasing problem in irrigated areas which causes important reductions in agricultural production. Distribution of soil salinity and its variability are required to set up measure-observation control in an irrigated area. The conventional methods to determine soil salinity in an irrigated area entail intensive land survey and laboratory analysis. However these take plenty of time and cost much. Instead of these conventional methods, lately, practical and simple techniques have become a current issue in salinity assessment. One of them is to use electromagnetic induction meter (Geonics-EM38) that measures apparent soil salinity, ECa. EM38 is a device which is designed to measure ECa horizontally and vertically, i.e., to a depth of 0-1 m and 0-2 m, respectively. In this research, we tried to investigate the effectiveness of EM38 device in identifying and mapping of soil salinity. The study was conducted in Yemişli Irrigation District (YID), covering an area of 7110 ha. YID is located in the Lower Seyhan Plain in the eastern part of the Mediterranean region, Adana, Turkey. The majority of farmers in YID use irrigation return flows of poor quality, diverted from main drainage canals. For this reason, the fields in YID are always under the risk of soil salinization. Therefore, soil salinity has to be monitored frequently in a quick and efficient way. Because of these characteristics, YID was chosen and 112 EM38 readings were done for salinity assessment. Concurrently, soil samples from 20 points, distributed randomly in the field, were taken from 1 m soil profile with 0.3 m intervals, summing up three totally. Extracts of soil saturation paste were obtained. Composite samples for 0-1 m depths were prepared by using extracts of each layer and salinities of composite samples were measured, ECe, to determine average ECe of 0-1 m depth. The relationship between ECe and ECa is determined. Then, ECe map was produced and salinity profile distribution was developed for the study area. The results showed that the electromagnetic induction meter (EM38) can be used very efficiently to determine soil salinity in areas prone to salinization like in YID. Additionally, spatial and temporal changes in soil salinity can be derived from EM38 readings, provided that the deterministic association between ECa and ECe is determined.

Keywords: Soil salinity, salinity map, electromagnetic induction meter (EM38), drainage water.

INTRODUCTION

Irrigation is essential in arid and semi-arid regions for agricultural production. However it should be noted that soil salinity may be an important risk for sustainable agricultural production owing to mismanagement of irrigation schemes and other inherent problems of irrigation methods. Salt accumulation which may occur in plant root-zone may closely be associated with the irrigation methods used (Tuzcu et al., 1988). Irrigation with inferior quality waters may also increase soil salinity (Cetin and Kirda, 2003). Salinity, which is among the most important factors limiting agricultural production, would adversely influence plant development and thus cause decreasing crop yields. Soil salinity is among the main cause for desertification in arid climates. Inferior water quality causing soil salinity limits biodiversity and harms environment. Increased soil salinity causes decrease of fertile agricultural lands. Of World's agricultural areas, 37% sodium and 23% are salt affected soils, and the remaining 40% is only fertile agricultural areas. There are more than 100 countries whose agriculture is severely affected by salinity (Szabolcs, 1989). Areas left annually out of agricultural production is 4×10^4 ha (Lamsal et al., 1999). Salt affected soils in Turkey are nearly equal to 20% of whole irrigated areas (Konak et al., 1999).

Soil salinity may some time be caused by saline main material. In such areas, soil salinity may occur with shallow groundwater and soil evaporation exceeding annual rains. Topographic features, natural drainage, climate, geological characteristics, soil forming main material and the distance to sea are among the factors influencing salt accumulation in agricultural areas (Amezketa, 2006). Salinity development in irrigated areas, however, may be attributed to using inferior quality of irrigation water. Mismanaged irrigation methods, low quality irrigation water, inadequate drainage and depressions in land topography are among the likely causes of salt accumulation in agricultural areas (Cetin and Kirda, 2003). Soil salinity in irrigated agriculture must be prevented to sustain soil fertility. To this effect, an easy assessment and quantification of soil salinity is essential.

High number of sampling is needed to assess salinity in large areas. Additionally, handling of high number of soil samples for standard soil analyzes for salinity is difficult, although it can be done. However, classical and conventional soil analyses methods for salinity assessment are difficult and time consuming. Therefore, new methodologies have been developed in recent years for easy and quick assessment of soil salinity in agricultural areas (Amezketa 2007). Electromagnetic salinity assessment is among recently developed techniques used for measuring soil salinity. The equipment called electromagnetic induction salinity meter (EM) is portable and designed for convenient salinity assessment in agricultural areas (Amezketa, 2006). Data collected with the EM technique are essentially so called apparent salinity (EC_a) which can be converted to standard soil extract salinity (EC_e) with proper calibration. Depending on how it is used, one can measure average soil salinity either over a depth of 0-1 m or 0-2 m. Field data collection is very easy and fast.

We had investigated assessment and distribution of soil salinity over a large area (7110 ha) within 0-1 m soil depth with EM38. The objectives of the work were (1) to study functional dependence between ECa and ECe and (2) to construct salinity map of the irrigated fields with EM38 data.

MATERIALS and METHODS

The work was undertaken on Yemisli irrigation district area in Karatas, Adana (Figure 1), Turkey, within the Fourth Development phase of the Lower Seyhan Irrigation Project. The study area of 7110 ha was within the service boundaries of the drainage scheme P2D1. Irrigation water source used in the area is diverted largely from drainage channels carrying low quality irrigation return waters from the upstream areas.

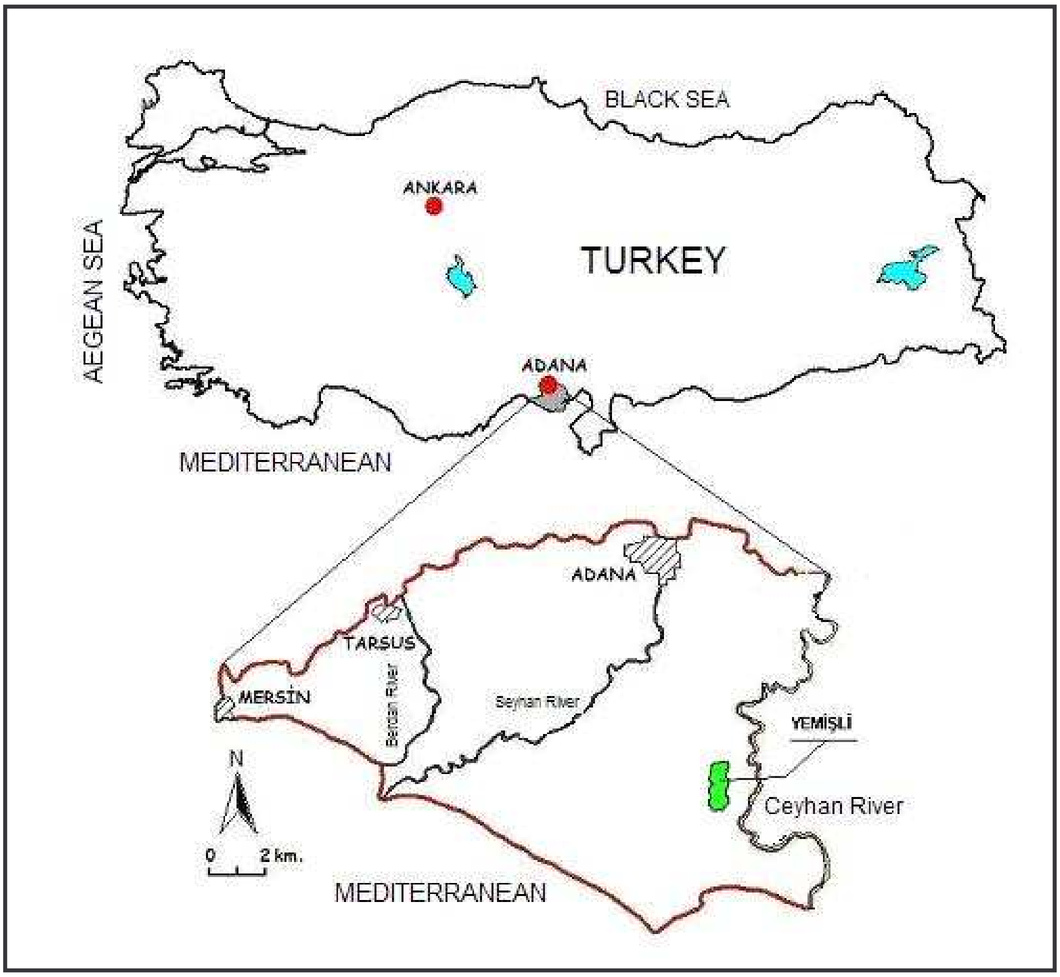

Figure 1. Location of the study area

Soils of the area belong to Helvaci series consisting of mainly alluvial deposits of delta plain. Soil pH changes within the range of 7.1 -7.4 and exchangeable Na is rather high. Although soil lime content of 20% should be considered rather high, the low soil permeability is the main limitation to problem-free irrigation practice.

Soil samples were collected from 3 layers of 0–30, 30–60 and 60–100 cm from 20 sampling sites with wide range of salinity. The samples were analyzed for standard ECe measurements. Additionally, EM38 measurements (ECa) were done at 112 different sites characterizing the study area. Soil temperature measurements which were needed for temperature corrections of the ECa data were also made at 2 depths, 50 and 100 cm. The measuring sites were selected in irrigated cropped fields.

The EM38 sensor can measure apparent soil salinity as an average either over a depth 0-1 m or 0-2 m depending on how it is positioned over the soil surface. If it is laid horizontally over the soil surface, the data collected represents average salinity over 0-1 m soil depth. Alternatively if it is placed over the soil surface vertically, the measurement represents the average salinity over proportionally deeper zone of 0-2 m depth. In the study undertaken here, only the measurement over shallow depth of 0-1 m was considered and therefore the equipment was placed over the surface horizontally (Figure 2).

Figure 2. The EM38 placed horizontally to assess soil salinity over 0-1 m soil depth

Soil samples collected from the study area were first air dried, then sieved to 2 mm size. Saturation pastes were prepared from 100 g sub samples, and the extracts obtained after 12 hours of equilibrium time were analyzed for standard electrical conductivity measurements (ECe).

The apparent salinity measurements (EC_a) made with EM38, close to soil sampling sites, were calibrated against classical EC_e measurements. The ECa data collected in the complete study area were later converted to ECe by using calibration equation and used conveniently for constructing the salinity map of the study area.

RESULTS and DISCUSSION

Soil salinity distribution profile constructed using samples from 20 sites is given in Figure 3 which showed that salinity increased from 2.9 dS m^{-1} in surface layer of 0-30 cm depth to 7.7 dS m^{-1} in 60–100 cm depth. Amezketa (2006) used EM38 data with ESAP program for mapping field soil salinity distribution in Spain. His data also showed that the soil salinity increased with soil depth owing to usage of low quality irrigation water and inadequate drainage. It appeared that the similar situation existed in our study area where irrigation water salinity may be as high as 5 dS m^{-1} and the drainage systems are generally blocked by farmers to facilitate easy diversion of drainage water for irrigation purposes.

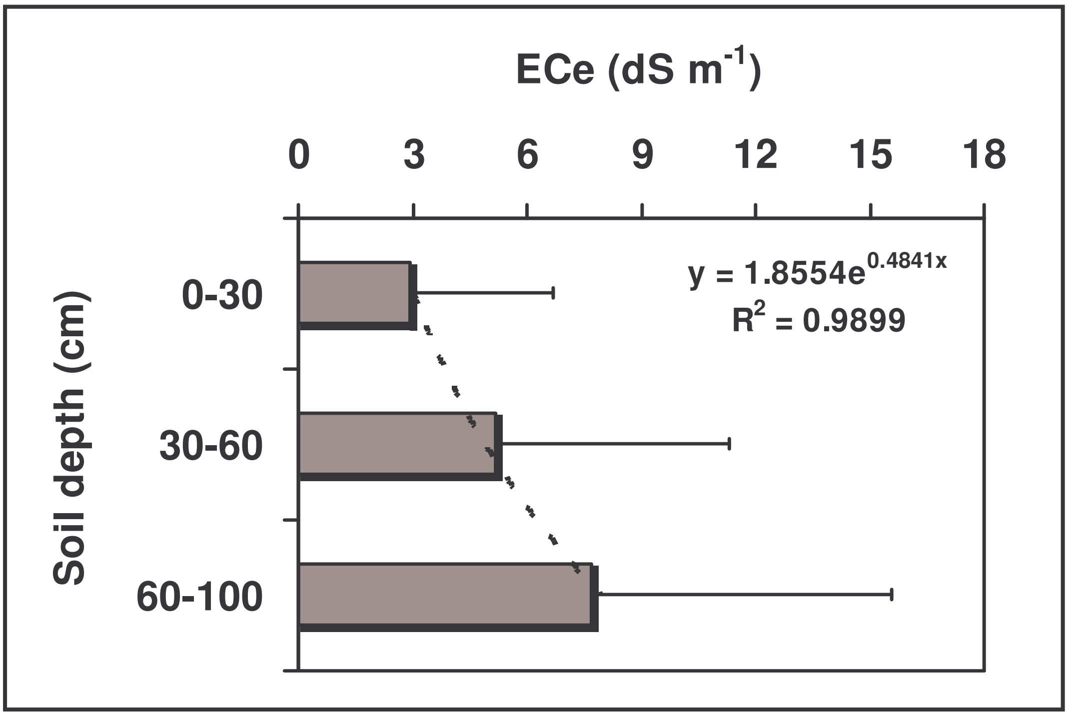

Figure 3. Soil salinity profile. Histograms show average soil salinities (n =20) with bars of standard deviations

The calibration relation EC_a on EC_e was linear with r^2 = 0.85 (Figure 4). The slope of the linear relation was nearly unity as earlier reported by Herrero et al. (2003) who used 22 data points. The calibration equation reported by Amezketa (2007) -who used 20 data points- also showed that the linear relation of EC_a on EC_e was nearly 1:1 as confirmed in our study.

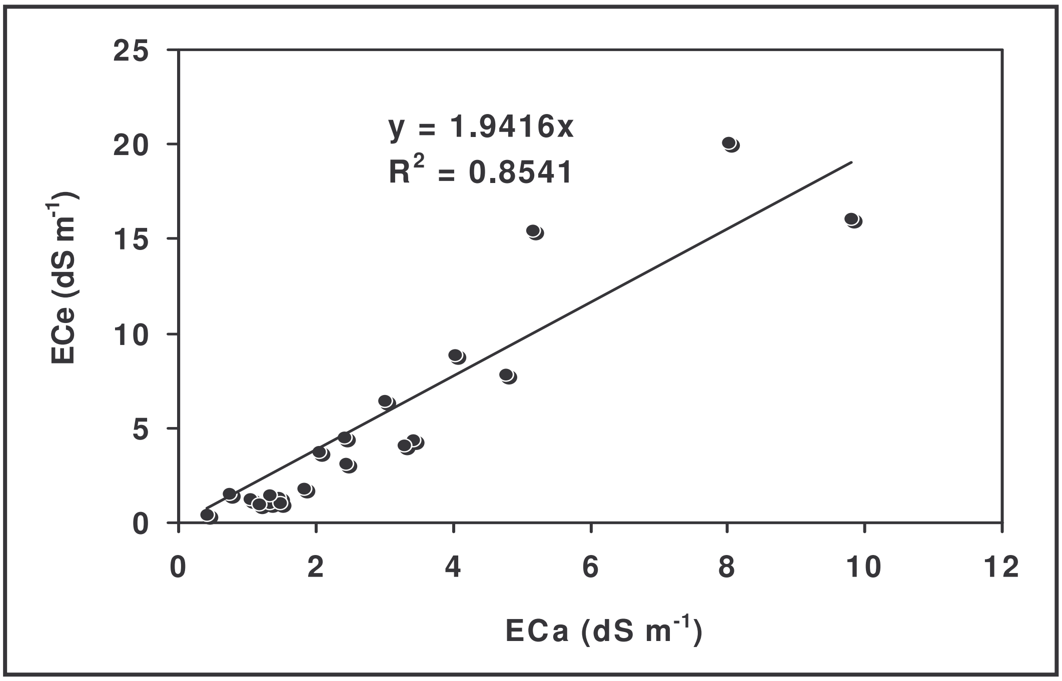

Figure 4. Calibration of EC_a described by a linear regression equation with EC_a on EC_e using 20 measurements.

The EC_a data collected with EM38 allowed conveniently mapping of spatial distribution of field soil salinity (Amezketa, 2007). Figure 5 shows spatial distribution of EC_e measurements assessed with using EC_a data collected with EM38. The average soil salinity calculated based on using actual EC_e data of the 20 composite soil samples was ~ 5.27 dS m^{-1} (Figure 3). Because the areal average soil salinity estimated from the salinity map (Figure 5) produced by using EM38 data were nearly the same (5.30 dS m^{-1}) with the mean of composite samples, the results lead us to conclude that calibrations with limited number of samples were adequate for describing salinity in large areas with EM38 device.

The results of this work showed that a good association existed between EM38 and ECe data. The calibration equation developed facilitated convenient assessment of soil salinity within the whole area of over 7000 ha. The equipment EM38 may therefore be a good device for monitoring the extent and severity of soil salinity in irrigation schemes.

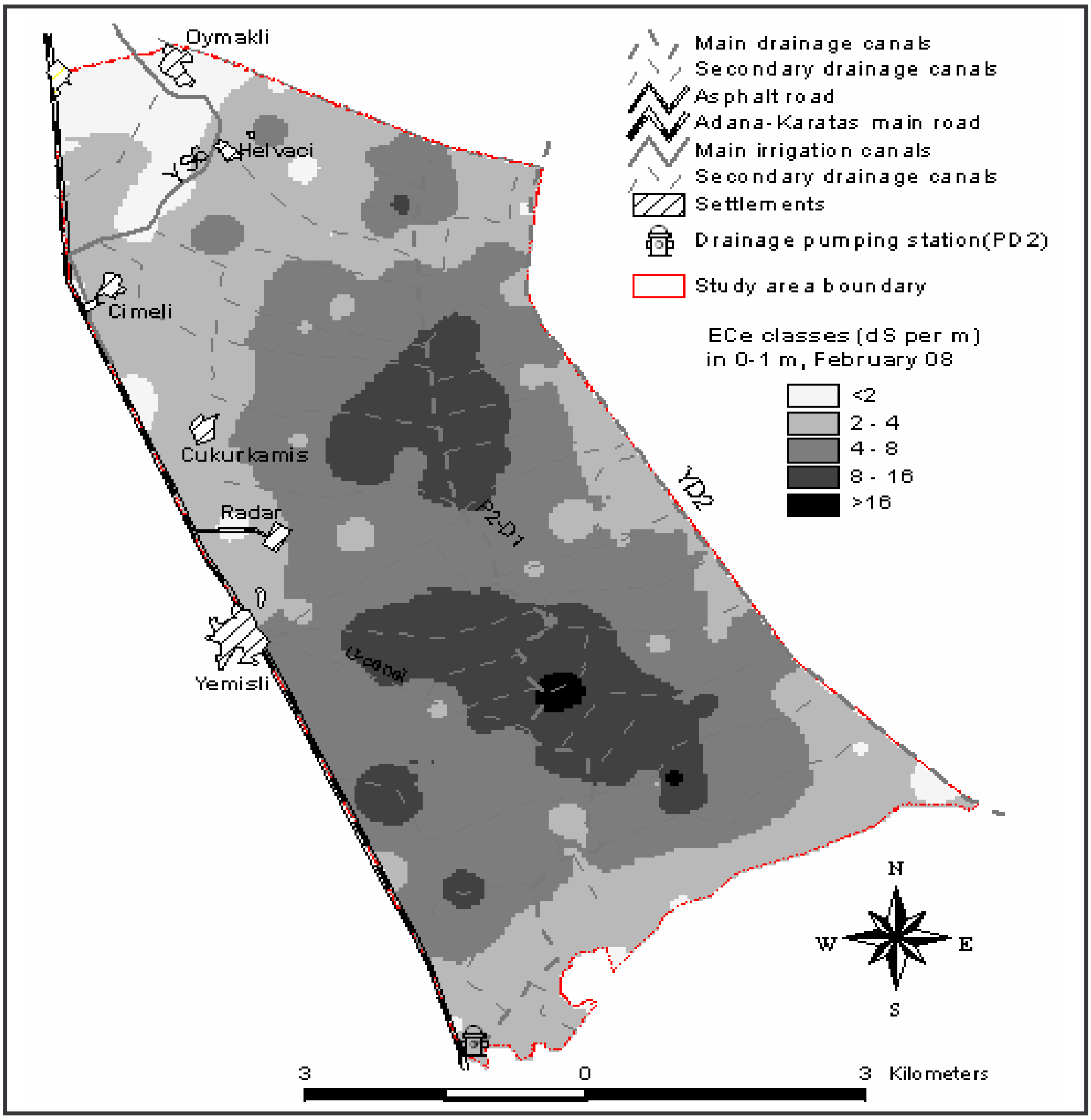

Figure 5. Salinity map constructed with EM38 data

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