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New Approach for Localization, Prediction, and Management of Saline-Infected Soils

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New Approach for Localization, Prediction, and Management of Saline-Infected Soils

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Preface

Soil salinity is one of the most common soil degradation processes, found particularly in arid and semi-arid areas (Rhoades, 1990). Under such climatic conditions, precipitation is insufficient to enable regular water percolation in the soil, resulting in the accumulation of salt along the soil profile. Moreover, the use of effluent water for irrigation purposes, mostly in clayey soil texture, leads to increased precipitation of evaporate minerals (Ghabour and Dales, 1993). This is critical where the water table is high and the evaporation processes are significant.

The degradation of soils in the "Jeze'el" Valley, one of Israel's most important agricultural areas, is a good example of this phenomenon. In this clayey area (Alluvial Vertisol) increasing salinity problems are caused by irrigation with domestic effluent water (Ravikovich et al., 1992). An increase in the soil salinity is followed by an increase in the soil SAR, a common parameter used to categorize soil deterioration (Rhoades 1990). The main reason for soil salinization near local water reservoirs is the changes in the quality of the water, i.e. the transition from seasonal winter flood water to domestic effluents. As a result, an increase in the field's water table in the vicinity of the water reservoir is evident, manifested by capillarity water uplift to the soil surface. This complicated phenomenon emphasizes the importance of testing and mapping the changes in the soil properties caused by irrigation with low-water quality and its relative location to the feeding water reservoir. Since the salinization problem is quite local and may change from one season to another, the monitoring tool may improve the soil and water management in an effort to prevent adverse effects to the environment. Traditional methods used for examining soil properties include ground-based geophysics and laboratory analysis (Robbins, and Wiegand, 1990), which are time-consuming methodologies. In recent years quantitative spectral techniques for measuring soil properties, such as salinity, organic matter or moisture content, were developed and reported (Nanni M.R., Alexander J., and Demotte M., 2006). These

techniques enable the determination of several soil properties rapidly and accurately; this information can then be used as a data source for spatially mapping the property in question over large areas almost in a real-time manner (Ben Dor et al., 2003). Moreover, the recent possibility of acquiring high spectral resolution data from air and space domains using hyperspectral sensors (with spectral resolution ranging from ~ 1 to 30nm) put the acquisition of ground spectral information in an advanced position for innovative mapping purposes (Dehaan and Taylor 2001). In this regard, Ben-Dor et al. (2004) showed that it is possible to map EC on a pixel-by-pixel basis over Vertisol soils from Israel using the DAIS-7915 airborne hyperspectrometer. The Ground Penetrating Radar (GPR) uses electromagnetic waves to form images of the subsurface, by transmitting radar pulses into the ground and receiving returned pulses from interfaces below. Radar waves that are returned are gathered to form an image, which can be analyzed for its derived electrical properties, and subsurface characteristics. The subsurface range resolution is mainly dependent on the dielectric constant and the frequency of the GPR waves. This can vary from several cm to several tenths of a cm in the relevant range (Davis and Annan, 1989). The purpose of this research was to apply both spectral and GPR measurements over saline-infected soils across the "Jeze'el" valley and to find complementary issues between the two methods to facilitate a new multidisciplinary ground-based remote sensing methodology to monitor and map soil salinity.

Materials and Methods

Two field areas were selected in this study: the irrigated fields of Mizra and Genigar (Figure 1). In each of these research sites chemical data such as EC and SAR were determined in the laboratory using the traditional wet chemistry methods. In the field, remote sensing data were acquired using Ground Penetrating Radar (GPR), which was operated at different frequencies ranging from 100 MHz to 1 GHz (Davis and Annan, 1986, 1989). The reflectance spectra were measured using an ASD field spectrometer and were done both in the field (using sun radiation) and in the laboratory (using the contact probe device with artificial illumination).

Results

The average EC values measured in each of the fields ranged from 2 to 16dc/m. This high values indicate that the selected areas are indeed adequate for studying salinity.

soil -infected problems.

In the Mizra field experiment, two different salt (white and green) crusts were found and measured for their in situ reflectance

The spectral information of both crusts were compared to the JPL and USGS spectral libraries and showed significant similarity to Gypsum (CaSO_4). Whereas the spectral feature of Gypsum in the green crust was quite weak relative to the white crust, chemical analysis of the white crust confirmed that this is indeed a Gypsum (CaSO_4) crust and the green crust is a combination of Gypsum, Halite (NaCl) and Organic matter. For this purpose, several crust samples were evaluated; their chemical analysis revealed a positive correlation between Gypsum and Halite on the surface (Figure 2). Furthermore, the laboratory results also showed a positive correlation ($R^2 = 95\%$) between the surface concentration of Gypsum and the EC values measured at a depth of 60 cm.

Results of samples taken from most of the "Mizra" field showed that a positive correlation exists between the spectroscopic data and the soil moisture. The more moisture found on the surface, the more intensive is the evaporation process. This water brings salt to the soil surface and as a result, gypsum and halite are precipitated. At a close distance to the reservoir, the spectral measurements showed large amounts of Gypsum, whereas south and away from the reservoir the Gypsum salts decreased significantly (Figure 3)

In the "Mizra" irrigated field, close to the reservoir's embankment, the ground water levels were found to be 0.2-1 m below the soil surface (in two piezometers located 10 m from the reservoir).

In the central part of the "Genigar" field, differences between groundwater levels were found along a short strip characterized by abnormally (high) hydrostatic pressure. The existence of this area served as evidence for the presence of a small buried riverbed within the soil profile. This high water table causes a local saline problem away from the reservoir.

The GPR results used over this area confirmed the existence of this buried riverbed. Figure 4 shows an example of the results of the GPR profile findings. It can be seen that a lateral change from the surface down to a depth of 7 meters has occurred. As discussed, this lateral change was observed in the vicinity of Point 3 on the East line of "Genigar" field (Figure 3). Using the ASD over this area and the gypsum as an

indicator for salinity revealed a positive agreement within the GPR results. This shows that combining reflectance and GPR methods can be an effective tool to locate potential saline-infected areas along the selected fields.

Finally, all of the collected information (GPR, spectroscopy, chemical analysis) were projected on a GIS domain and a soil salinity potential map was generated. This geo rectify information serves as a powerful tool for salinity soil management of the area. Collecting more data into this system on a temporal basis may also serve as a tool for saline monitoring and predicting, which in turn can serve as a vehicle to preserve the soil degradation processes.

Conclusion

1. Spectroscopy can be a sensitive field method to locate saline-infected areas.
2. Halite and gypsum correlations can help in assessing salinity down to a 60-cm depth using the soil surface information.
3. The GPR system can point out irregularity problems along the area that might serve as a indicator to search for saline problems.
4. More tools such as EM (electromagnetic) may be further applied to this multi-sensor approach to precisely detect and map soil salinity within similar areas.

Acknowledgment

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Figures

Figure1 :The tested area



Figure 2: lab results of surface Gypsum and Halite concentrations

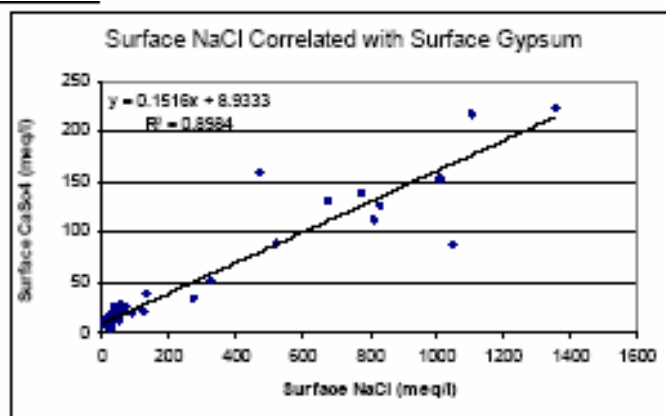


Figure 3: "Mizra" field spectroscopic scan line shows a decrease in the presence of Gypsum minerals as the scan progresses south and away from the reservoir. A correlated decrease in EC values was evident as well.

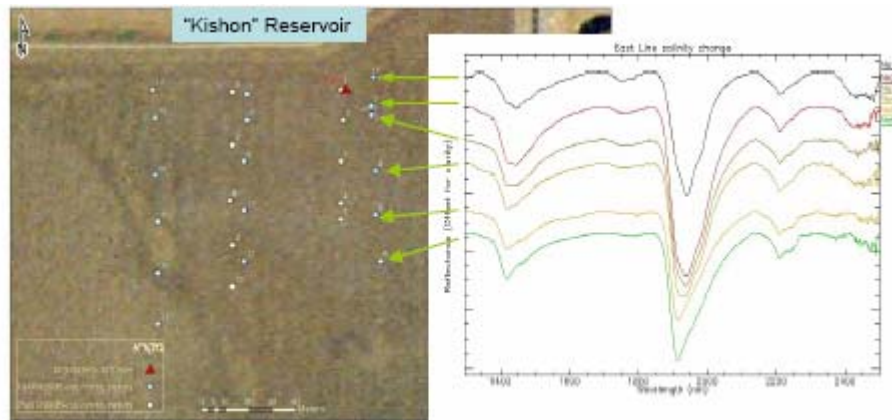
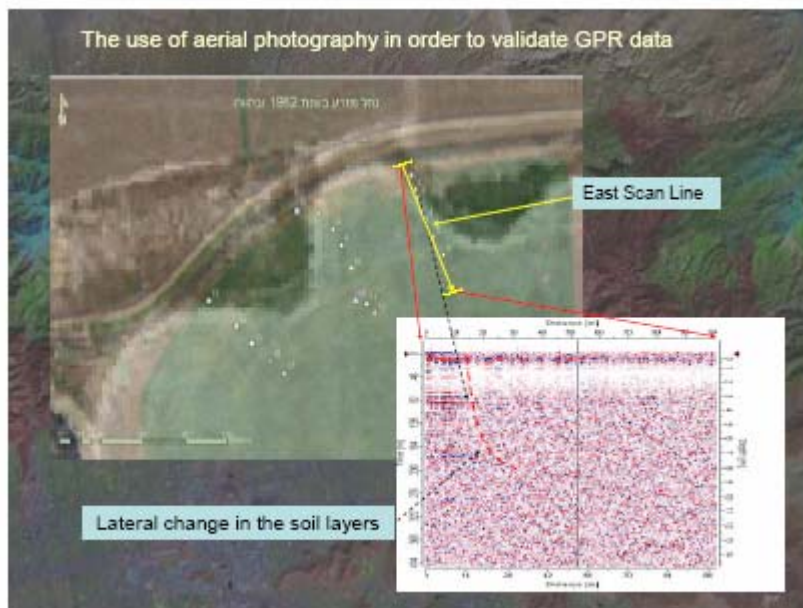


Figure 4: Old and new "Mizra" river paths, as observed by the GPR analysis.



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