Using of ASD Spectral Reflectance and GIS Techniques for Mapping and Analyzing of some Salt Soils Distributed in the Northern Al-Jazirah Irrigation Project

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ABSTRACT

Saline soil problems are one of the most common land processes and reflects severe environmental hazard. In order to study the spectral reflectance characteristics of the soil salinity levels, an area located in the Northern Al-Jazirah Irrigation Project was selected. The main objective of this study is to investigate the potential of identifying and predicting salt content in soils at various irrigated areas according to the spectral reflectance characteristics of the soils Analytical Spectral Devices (ASD) spectroradiometer (in contact probe mode) with spectral range from 350 nm to 2500 nm was used to measure the spectral reflectance characteristics of the collected soil samples.

Laboratory measurements have indicated that saline soils have higher reflectance characteristics than do nonsaline soils. The near and middle infrared bands were superior to the visible bands in detecting different soil salinity levels. The supervised classification of the available ETM+ image demonstrated that spectral separation of different soil salinity levels and various land cover types is an efficient, reliable and dependable tool of using remote sensing to map soil salinity.

Keywords: Remote sensing, Reflectance, Spectroradiometer, Soil salinity, GIS.

استخدام انعكاسية التحليل الطيفي وتقنيات نظم المعلومات الجغرافية في رسم خرائط وتحليل بعض الترب الملحية وتوزيعها في مشروع ري الجزيرة الشمالي

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الملخص

تعد مشكلة ملوحة التربة واحدة من أكثر المشاكل شيوعا في الأراضي والتي يمكن أن تعكس خطرا" بيئيا". تهدف الدراسة الحالية إلى معرفة خصائص الانعكاسية الطيفية للتربة بالاعتماد على نسب محتوى الملوحة في التربة للمناطق المروية. ولغرض تحقيق أهداف الدراسة في قياس الانعكاسية فقد تم اختيار منطقة مشروع ري الجزيرة الشمالي لكونها تحتوي على مستويات مختلفة من ملوحة التربة . تم استخدام جهاز التحليل الطيفي (ASD Spectroradiometer) وبطريقة المجس التلامسي في قياس خواص الانعكاسية الطيفية لنماذج الترب وضمن المدى الطيفي (350nm-2500nm).

أظهرت نتائج البحث المختبرية إن الانعكاسية الطيفية لنماذج التربة الملحية تكون أعلى من الترب ذات الملوحة القليلة أو غير المالحة وان الحزمة الطيفية التي تقع ضمن الأشعة تحت الحمراء القريبة والمتوسطة تكون الأفضل في تحديد خصائص الانعكاسية الطيفية لمستويات ملوحة التربة. أظهرت النتائج أيضا أن طريقة التصنيف الموجة لبيانات راسم الخرائط الموضوعي (ETM+) لها كفاءة وقدرة عالية في فصل أصناف الغطاء الأرضي ومستويات التملح لإعداد خرائط تملح التربة.

الكلمات الدالة: استشعار عن بعد، انعكاسية، مقياس الطيف، ملوحة التربة، نظم المعلومات الجغرافية.

INTRODUTION

Soil salinization is a process in which dissolved salts concentrate on the soil surface and in the upper soil layers. It influences soil properties and leads to a reduction in crop yields and land productivity (Jensen, 2007). In irrigated areas, where the water table approaches the ground surface in arid and semi-arid regions salt accumulation occurs in areas known as discharge zones. Capillary rise of saline groundwater causes the direct precipitation of evaporate minerals at the surface in these zones (Dehaan, and Taylor, 2002). Salinization may also occur when salts are concentrated in soils by the evaporation of irregular irrigation water (Daood, 2006).

The salinization problem can be managed by the early recognition of salinized soils, the implementation of effective methods to combat the salinization phenomenon such as improved irrigation, drainage, and farming practices, and the monitoring and mapping of salinized land on a regular basis (Yongling, *et al.,* 2008).

In order to investigate the soil salinity level, the ASD spectroradiometer and landsat multispectral remote sensing image were employed according to the following steps;

1- Study the reflectance characteristics of the non-saline and saline soil samples collected from Northern Al-Jazirah Irrigation Project by incorporating remote sensing data into a GIS environment, this region was selected because it provides a good illustration of a salinity- affected area.

2- Interpolate the resulted dataset through computer-aided digital analysis and processing,.

3- Develop a spectral classification of the non-saline and saline soil in the study area. An ASD spectroradiometer covering the spectrum from 350 nm to 2500 nm was used to measured the reflectance characteristics of soil samples at Remote Sensing Center/University of Mosul.

The final results will be provided vital information to growers by identifying salt-affected areas and can be used to implement precision farming practices for variable seeding, fertilizer, or amendment described.

STUDY AREA

The study area is about (484 km^2) is located in the northwestern of Mosul city between 36^0:47':1.23" to 36^0:36':28.19" N and 42^0:05':49.08" to 42^0:22':18.98" E within the Northern Jazirah Irrigation Project (Rabe'ea) (Fig. 1). The area is relatively semi-arid with an average annual rainfall of 321.3 mm computed from meteorological data of a 15-year period (1994 - 2009). Eighty percent of the rainfall occurs from January to April, with the highest rainfall of 63.7 mm in the month of March. In the other side, the average monthly of the higher temp. occurs from June to Sept. with a range of 38.5 - 42.50^0c (Iraqi Meteorological Authority, 2009).

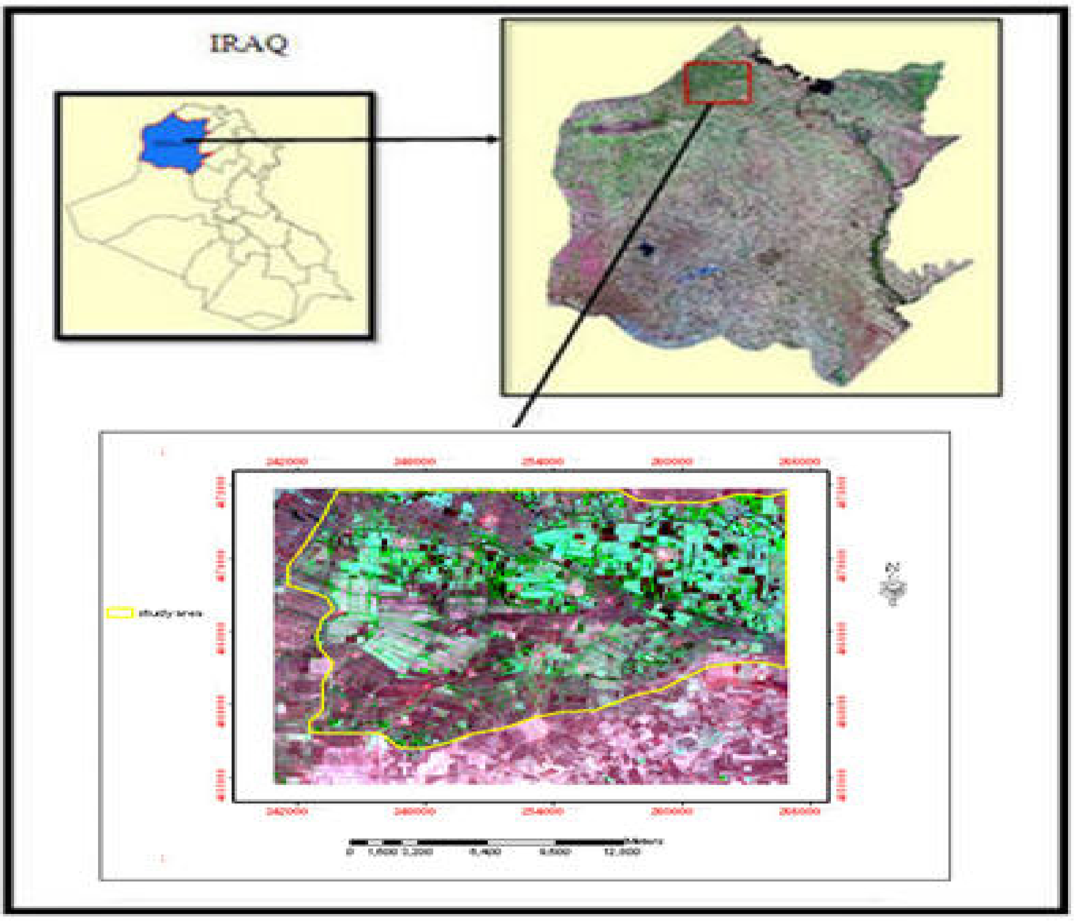

Fig. 1: Location of the Study Area.

MATERIALS AND METHODS

A satellite image of Enhanced Thematic Mapper Plus (ETM+) acquired in 13 July 2009 and covers the study area was used. For the study described in this paper, soil cover type was used. Five samples of soil taken at 31October 2011 with different salt concentrations have been collected from the study area and used in the research. The in-situ coordinates for each sample was measured by using Global Positioning System (GPS) type Garmin:GPSMAP76CSx. The GPS dataset were projected to geodetic system of UTM_WGS84_38N and saved into a text file. This file was imported into ArcGIS9.3 desktop and converted to shapefile layer to be overlaps with the ETM+ as shown in (Fig. 2).

Soil samples were collected from five observation sites. Then the soil samples were grinding with a sieve of 2mm diameter and their spectral reflectance were measured and analyzed in the laboratory by using Field Spec 3 Analytical Spectral Devices (ASD) spectroradiometer in contact probe mode was used as shown in (Fig. 3). It was specifically designed for laboratory and field measurements to acquire visible near infrared (VNIR) and short-wave infrared (SWIR) spectra with a spectral range of 350 nm to 2500 nm. The used reference panel (which is also called a white reference standard) is a pressed poly-tetrafluoroethylene

(PTFE) which is available commercially as Spectralon (Labspere, 1998). This type of panel offers ideal Lambertian properties and high reflectance value (95-99% for white surface) over the used spectral range (350-2500nm). RS3 and View Spec Pro ASD application software have been used for storing the incident illumination from the white reference panel, which is called the white reference (WR) and for spectral measuring of the soil samples. The output results have been then interpolated to produce salinity map with different classes by using GIS packages.

ERDAS imagine 9.1 and Arc GIS9.3 were used for implementation of the research methodology which includes extraction the tonal anomalies and specify the changes in spectral content that are consider as surface indicators of salinity.

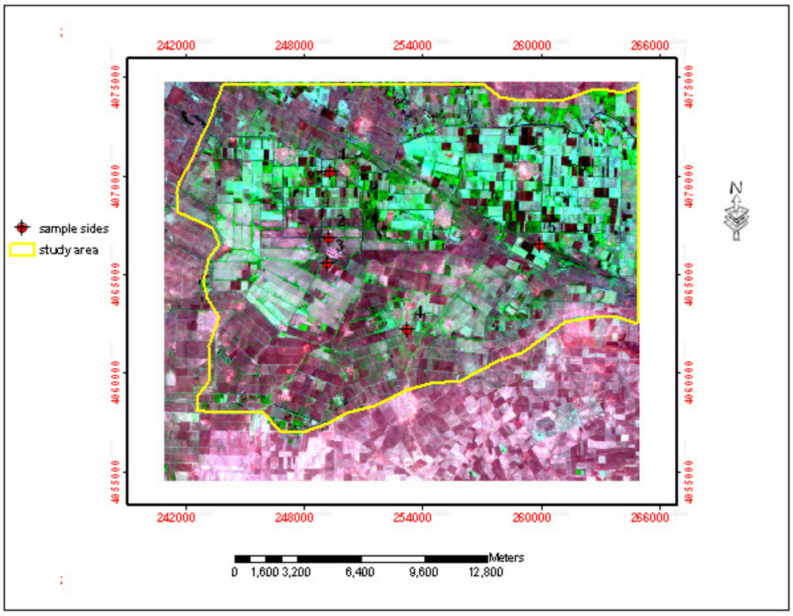

Fig. 2: Locations of the Soil Samples Plotted on ETM+ Image.

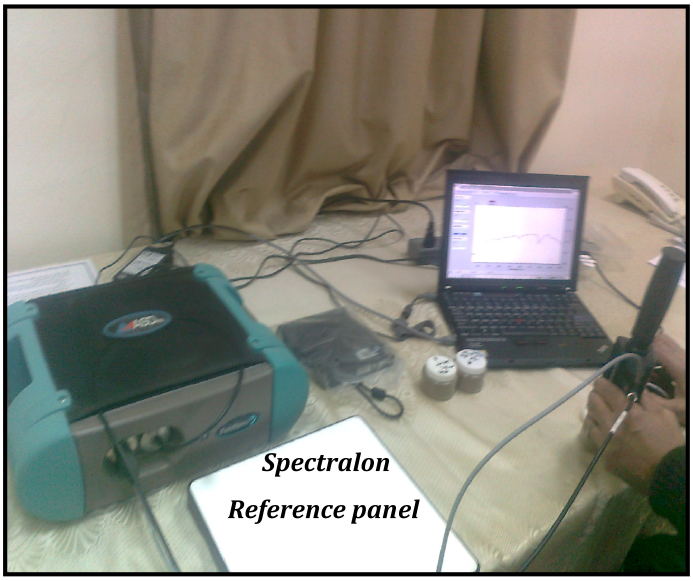

Fig. 3: The ASD Spectroradiometer laboratory Measurements.

RESULTS AND DISCUSSION

Soluble salts are most commonly detected by measuring the soil solution's ability to conduct an electrical current, referred to as electrical conductivity (EC). There are several detection methods for assessing soluble salt content of a soil. In the present study, the electrical conductivity values of the selected soil samples were obtained by using HANNA (HI8633) conductivity meter according to the saturated soil extract method (1:1 soil-to-water method) as described by (El-Hamid, *et al.,* 1992). (Table 1) lists the measured electrical conductivity values with respect to the locations of selected soil samples shown in (Fig. 2).

Table 1: The Electrical Conductivity Values of the Soil Samples.

Sample No.	Irrigation. unit	Easting (m)	Northing (m)	Elevation (m)	EC (ds/m)	EC level [11]	Land cover
١	G4	249309	٤٠٧٠١٦٤	٣٦٦	٦١.١	Very strongly saline	Bare land
٢	G17	٢٤٩٢٦٩	٤٠٦٦٧٩٨	٣٦٠	١.٢	Non-saline	wheat
٣	N16	٢٤٩١٨٨	٤٠٦٥٥١٥	٣٦٣	٣١.٧	Very strongly saline	Barley
٤	O2	٢٥٣٢٣٠	٤٠٦٢١٩٩	٣٧٠	٠.٤	Non-saline	Wheat
٥	D20	٢٥٩٩٢٢	٤٠٦٦٤٩٣	٣٥٠	٢٩.٨	Very strongly saline	Bare land

The spectral reflectance data were measured by using an ASD Field Spec 3, for five soil samples with different salt concentration. (Fig. 4) shows the resulted spectral reflectance of the samples as measured by the ASD spectroradiometer. The figure also shows that, all the soil samples gives the same spectral signature with a two water absorption band of (1443nm) and (1935nm). Based on the EC data given in (Table 1), (Fig. 4) also shows the spectroradiometer reflectance measurement of soil at varying salt concentrations. The figure shows that, due to the crystal structure of the salts, the reflectance generally increases with increasing surface soil salt concentrations (i.e., increasing EC) (Mahmoud, *et al.*, 2009) except the behavior of sample 4 which referred to the existence of gypsum in this site (O2) .(Fig. 4) also illustrates that, the greater the amount of salt content in a soil, the lower the absorption of incident energy and the greater the spectral reflectance. It's also indicates that, the near and middle infrared bands were superior compared with the visible bands in detecting different soil salinity levels.

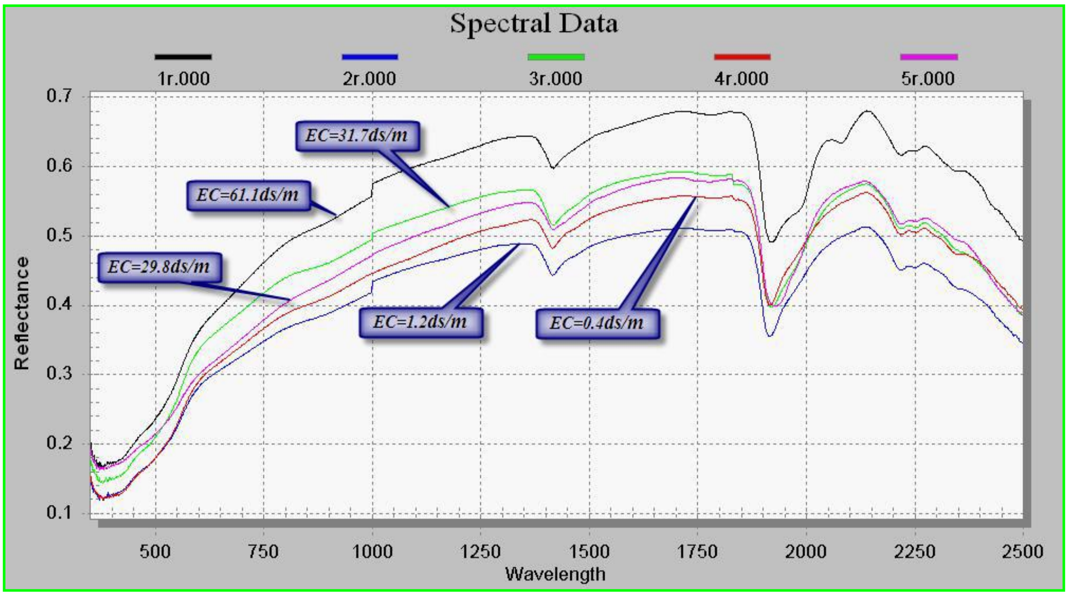

Fig. 4: The Spectral Reflectance Curve of the Soil Samples at Varying EC Levels.

In order to display the better discrimination of salinity concentration in the soil samples, a combination of the spectral bands of the ETM+ images with the spectral charactristics (which measured in the present study) of soil salinity applied as shown in (Fig. 5). The fulse color composite image consists of bands 7, 4 and 2 represented by red, green and blue shown in (Fig. 6) are choosed to be the best bands combination image in the present study because these channels have less correlation and a high Optimum Index Factor (OIF) (Al-Daghastani, 2004). The false color composite image helps to select the training area of the salt soil in the supervised classification method and to identify the salt soil in the classification processing stage.

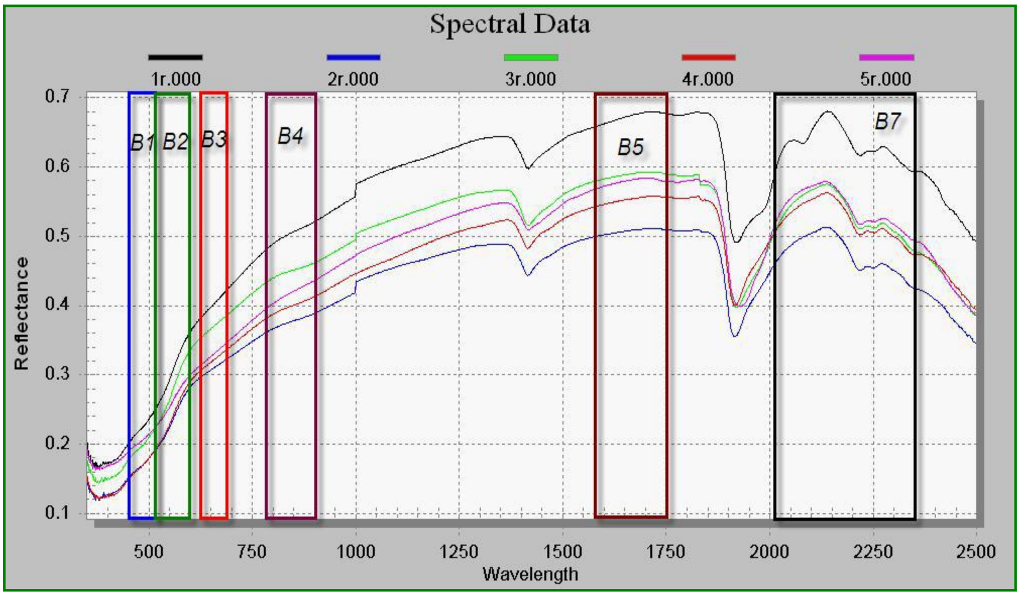

Fig. 5: The ETM+ Bands with the Spectral Reflectance of the Soil Samples.

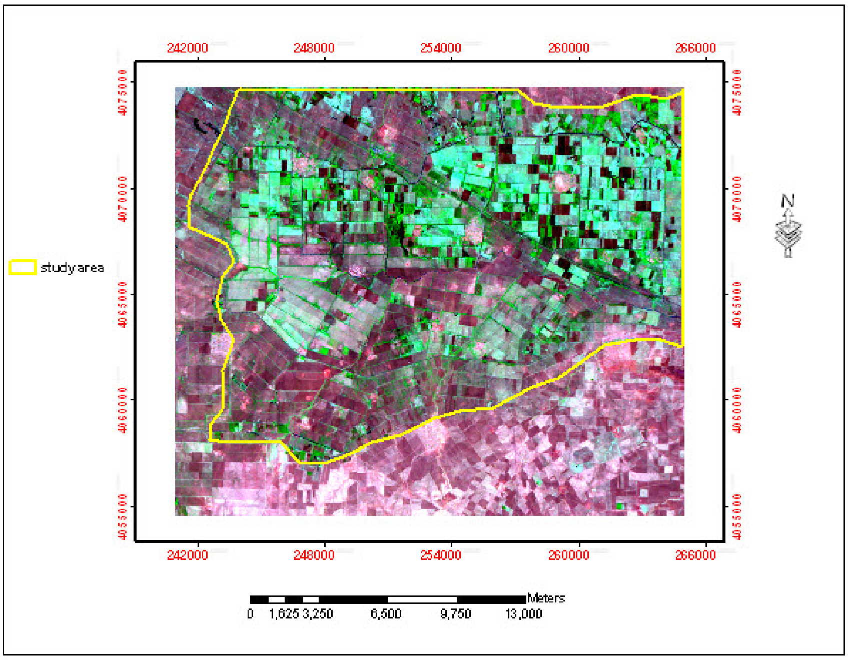

Fig. 6: False Color Composite Images (7R,4G, and 2B).

The collected spectral data acquired from a spectroradiometer was used in the image classification process. The image classification have been carried out using ERDAS9.1. Supervised classification was completed using a selective training areas that described the avialble land cover features in the study area. Extraction of the seven classes images was assisted by adopted image classification process as shown in (Fig. 7).

This Figuer illustrates that the salt effected soil emerged in the form of patches scattered in different places in the study area. from (Fig. 7) and the field observations, it can be pointed out that, salinity distribution in the study area is clearly related to the non-regulated irrigation operations, which in turn led to a high level of ground water, in addition to the prevailing climatic conditions of a high temperature that increase evaporation of water especially in the summer seasons.

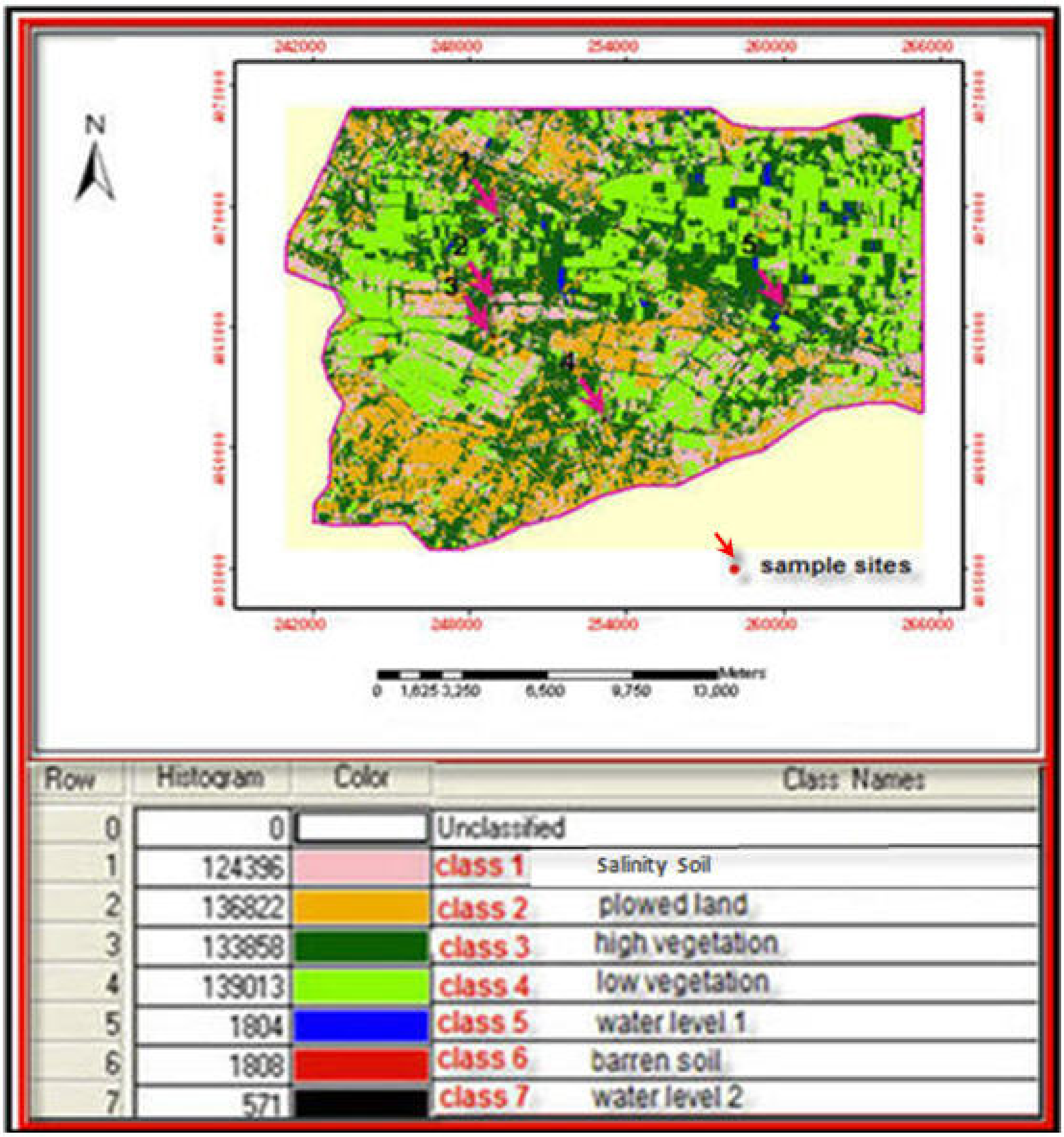

Fig. 7: Classified Image and Data as Given by ERDAS9.1.

CONCLUSIONS

This paper have introduced an ASD contact spectroscopy and GIS techniques for identifying and mapping the soil salinity in the study area located to the northwest of Mosul (Rabe'ea). From the results, it is concluded that the use of remote sensing data followed by site observations is a powerful tool in detecting saline areas. The results also indicate that salt effected soil emerged in the form of patches scattered in different places in the study area because of the erroneous administration of the agricultural operations such as unregulated irrigation. The results show the feasibility of using GIS and remote sensing technique to predict locations of soil salinity.

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