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Management of Saline Soils Using Remote Sensing

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ABSTRACT

Salinity constitutes one of significant problems in soils of arid and semiarid regions. In general, more than one-third of the world earth and large part of areas in Iran located in arid and semiarid regions. Thus, it is essential to identify and classify the saline soils in order to tackle such arduous conditions and to manage properly. The present research took place in southern part of West Azarbaijan province and north of city of Mahabad. It made preparation of salinity map of soil and sampling in form of a systematic networking of 1000*1000 m with 0-15 cm deep. The electric conductivity of saturated soil carried out in the measurement lab, image processing by using PCI software and data analysis by geographic information system (GIS) and statistical software SPSS. The results suggested that electric conductivity variations in the soils of study region is between 0.31-26.19 dS m^{-1} and salinity map of the soils categorized between 3 saline areas of 0-8, 8-16 and more than 16 dS m^{-1}. The reasons of the salinity in this region include shallow underground water supply and their utilization for irrigating farmlands, vicinity to Urmia Lake and rocks of surrounding mountains. Therefore, underground water discharge by deep drainages and washing farms with the Urmia dam water reservoir recommended for preventing continuous trend of the soil salinity. This research is aiming to map the salinity of the soil for providing a specific managerial plan to improve and rehabilitate earth in the study region.
KEYWORDS: *Salinity map; Saline soils; Electric conductivity; Saline areas; Underground water.*

I. INTRODUCTION

Saline and sodium content of soil is the most destructive process of earth particularly in arid and semiarid regions where potential vaporization and sweating are exceeding precipitation. For this, the solvable salts are concentrated in soil and increasing salinity and eliminating its fertility. Additionally, excusive sodium content causes soil particles propagation that leads to severe soil destruction and erosion (Farifteh et al., 2005). There are vast saline lands all over the continents, in which the details and locational spreads have not been wholly identified (FAO, 1988). Many researchers reported different values relative to the soils spreads and intermittently implying that around one billion hectares of lands or approximately seven percent of areas of the continents covered by this type of soil (Wannakomol, 2005). On the other hand, there are about 77 million hectares should be added that have been continuously salinized because of human actions of which 58 percent located in the Fariab region (Ghassemi et al., 1995). It notes that around 12 percent of Iran's lands (19 million hectares) are irrigable that near 50 percent of it are in various degrees involved in salinity, sodium content and submerging problems (Mir-Mohammadi and Gharayazi, 2002). The saline soils scattered in different small areas in the country by which most surrounding lands are seriously threatened and endangered. Thus, we should control the salinity and its consequential problems by proper scientific measures and management. Moreover, the alkalization is not almost possible considering climatology of the country where is dominated by arid and semiarid lands and water shortage. Therefore, in order to solve the salinity problem, we should take other approaches and measures into account. One approach may be to identify such lands and prepare the salinity map to manage the soil problem (Abdinam, 2004). In recent years, casual topography of soil has dramatically changed because of developments in geographic science and remote sensing. Today, updating soil studies for planning and control of the soil management in agriculture is very useful. So that, accessibility of information on characteristics and behavior of soils will help better decision-making on management and use of lands and environmental protection. Recognition of soil as a quality of ground results to assess value of lands for many applications, depending directly on the properties of soil. These are obtainable by preparing soil maps (Alijani et al., 2012). However, the first step is to identify the salinity regions and prepare the salinized soil maps in the country. Many researchers (like, Dadrasi Sabzevari et al., 2007; Sekouei Oskouei et al., 2007; Tajgardoun et al., 2009) feel it necessary to identify and classify the salinized soils in order to combat and manage scientifically these

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situations. Examining salinity variation of soil, particularly in the vast areas of the region, is expensive and time-consuming. Anyway, it needs to take procedural steps could simply pave such enormous grounds and assess the salinity variation trend (Daempanah et al., 2011). At present, by increasing development of remote-sensing techniques, it is easily possible to use them; such technological capabilities enabling us to define the chemical and physical properties of soils through satellite imaging (Rangzanand Mokhtari, 2006). Since, spectral reflection of salinized soils is remarkably dependent on soil moisture. Therefore, more aridity of soil, more crystalized salts and sedimentation in soil particles that might increase surface reflection (Khan et al., 2001). At this time, concentrated salt becomes greater because of evaporation from ground surface, and then their differentiation from no salinized soils carried out with scrutiny (Alavipanah, 2003). Along with many researchers examined this method by using various satellite images, Harney et al., (2005) introduced a method for specialized management of soil salinity and attempted to draw up the map of 139 hectares of lands of southern California. On the other hand, Utest and Borotu (2001) tried and wrapped up the salinity map of southeastern lands of Cuba in an area of 200 m and 0-20 deep. All of them concluded that salinity is greater in the low lands. They understood that the excessive salinity of low lands depends on the shallow underground water proportional to the high lands. By designing a system of 100*100 m and conducting electric conductivity, James et al., (2003) obtained the salinity of a farmland in Britain which was 0.4-14.6, 14.7-27.2 and 17.3-48 mS m^{-1}. Lish et al., (2005) studied 13 hectares of agricultural lands of southwest USA and prepared the salinity maps of the farmlands before and after alkalization using the electric conductivity in depth of 0-60 cm.

II. MONITORING SANITIZED REGIONS

There are two types of salinity: one for arid lands and the other for irrigable lands. Salinity often occurred because of heightened underground water levels. This phenomenon either eradicates the greeneries and livings of soils or diminishes their birth. In some regions, salts exist naturally (salt mines in Semnan, Yazd, Qom and East/West Azarbaijan provinces, etc.) where plenty of lands contain salts, but though there are salts in the depth of the earth and do not hurt greenery. If salinity appeared on ground surface, causes damages. Origins of seawater salinity are main rocks and drains of salt-water drainage of the past time. Usually, the categorization of soils is drawn out through density of salt as shown in Table 1(Metternicht, 1998).

Table 1: Range of plant resistance to soil salinity

Salinity (dS/m^2)	Plant response
0 – 2	Most of plants
2 – 4	Likely to limit the growth of sensitive plants
4 – 8	Limiting the growth of plants
8 – 16	Only resistant plants
>16	Only a few plant growth that very resistant

Salinity effects on green growth is a concept of greenery. A given salinity may lead to reduced function of greenery crops, while it is not harmful to other plants because their toleration is variable (Kafi et al., 2009). However, plants categorized based on their toleration limit or threshold against salinity as indicated in Table 2.

Table 2: Resistance to salinity of some crop

Plant	Degree of resistance	Plant	Degree of resistance
Hordeum	T	Hodeum Volgareh	MT
Bean	S	Brumodagress (***Bromus)***	T
Beans	MS	Z	MS
Cotton	T	Wild Rye	MT
Corn	MT	Cucumber	MS
Rough Rice	MS	Lettuce	MS
Sorghum	MS	Pea	S
Soya	S	Tomatoes	MS
Sugar	T	Pumpkin	MS
Wheat	T	Spinach	MS
Alfalfa	MS	Clover (Trifoliumalexanderium)	MS
T: Resistant	**MT**: Moderately resistant	**S**: Sensitive	**MS**: Moderately Sensitive

In the past, farmers estimated salinity degree of soil by reducing produce, but it was not helpful because salinity had not similar definitions for people. Thus, there was no possibility to draw up maps of salinized or salinity affected regions. In recent years, a new method applied for investigating salinized lands, that is remote sensing. It is to collect information by plane, satellite and/or any device situated over land.

III. MATERIALS AND METHODS

This research carried out in the agricultural year of 2012 in the region situated on an area of around 15000 hectares in the 37º, 15', 25" to 37º, 34', 18" northern latitude and 45º, 6" to 45º, 20' eastern longitude in a 15 km distance of the northern regional city of Mahabad (Shahrobaran Plain) in the West Azarbaijan province. This region locates with a cold and humid climate. According to the 30-year statistics of Mahabad meteorological stations, the absolute minimum and maximum temperature degrees in the month of June-July were -21.5ºC in the months of December-January and 42ºC in the month of June-July of the years respectively. The annual average precipitations in these stations calculated around 356 mm and the monthly average was 29 mm. The average relative humidity is 64 percent, and the highest 100 percent and lowest 22 percent. The applied maps of lands show that 34 percent of the region allocated for agriculture of which 21 percent by irrigation, 13 percent by rain fed farms, 63 percent predominated by grasslands and 1 percent for residential. The main agricultural crops of the region are grains, sugar beet, alfalfa, farm fruits, beans, and apple and nucleate fruits orchards that cultivated by irrigation. In the meantime, the area of the irrigable farmlands in the study region is so much larger than the rain fed, and the most cultivation lands, at first instance, correspond to apple and nucleate fruits orchards, and next, to vegetables. Generally, in these regions, the underground water levels are high, draining is not favorable, and most irrigation and natural drainages ruined. The water requirements for irrigable lands supplied by channeled network of Mahabad dam, precipitation and numerous deep and shallow wells. Of course, the main salinity problem of soil in these regions rises from underground water supply.

To identify the region, at first, a preliminary observation made to recognize and test the salinity variations by GPS followed by taking samples from a few points. These points entered into the Arc GIS and defined by satellite imaging; then the study areas of salinized soils were presumably checked and cross-sectioned. It notes that in this research, we used of meteorological, geological, vegetation, water resources and IRS-P6 satellite imaging data. In this research, soil sampling was made in form of regular system 1000*1000 m and depth 0-15 cm. EC was carried out in lab and measured after drying and screening. Finally, image processing made by PCI software and data analysis performed by using GIS and statistical description of results by SPSS software. Figures1, 2 and 3 portray the study region in 3 areas of 0-8, 8-16 and>16ds m^{-1}, respectively.

Figure 1: Salinity ranges between 0-8 Figure 2: Salinity ranges between 8-16

Figure 3: Range of salinity greater than 16

IV. RESULTS AND DISCUSSION

According to the soil salinity mapping in the region carried out by PCI and Arc GIS software, and the data taken by EC on samples of the study region in light of proper management for cost and timing improvements, and considering resistance of plants against salinity as shown in Table 1, three (3) salinity areas defined for mapping of soil. The salinity areas include 0-8 dS m^{-1} (relative simple and saving improvement), 8-16 dS m^{-1} (arduous, costly and time-consuming improvement) and >16 dS m^{-1} (approximately not improving). The results showed that the study soils have a large local variation for salinity level. Table 3 reflects the descriptive statistical results for EC of soil samples in three regional areas for salinity.

Table 3: Descriptive statistics results for the electrical conductivity of soil samples			
Statistics	**Range dSm^{-1}**		
	0 - 8	**8 – 16**	**>16**
Number of observations	99	19	30
Average	2.38	11.09	19.89
Median	1.66	10.22	19.39
Mode	0.63	8.07	13.68
Standard error	1.87	2.47	3.23
Variance	3.51	6.11	10.43
Skewness	1.07	0.72	0.34
Elongation	0.28	-0.73	-0.59
Range	7.36	7.91	12.51
Minimum	0.31	8.07	13.68
Maximum	7.67	15.98	26.19
Total values	236.07	210.84	596.8

The results of a detailed and homogeneous mapping of base soil in Fig. 4, reveal differentiation capability of the specified areas for salinity to understand potentiality of the lands. It can provide the best and most profitable productivity and possibility for improving and combating salinity. Moreover, the frequency histogram of distribution for different soils already been available (Fig. 5).

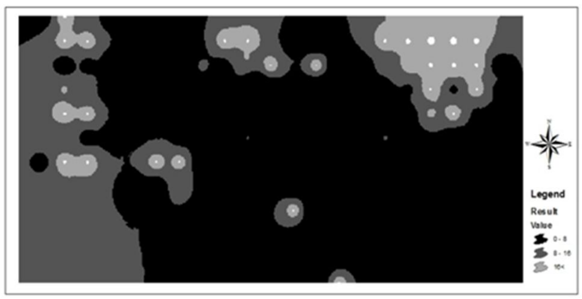

Figure 4: Map of the study area soil

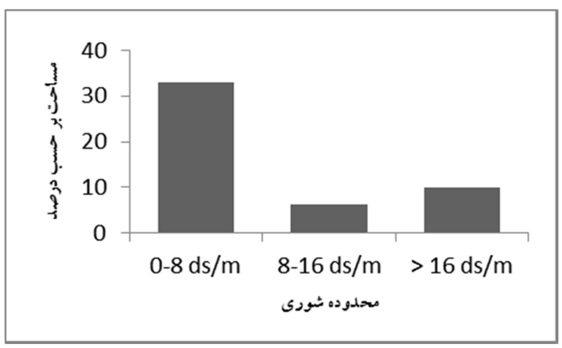

Figure 5: Histogram of the frequency distribution of soil salinity limits

According to the results of measured samples and frequency histogram of distribution obtained from the study region with salinity range of 0-8 ds m^{-1}, we found that a large area, something of 33 percent of the entire lands affected by salinity. Of course, in first instance, it may make us to be happy because it would be hopeful to improve and redevelop such lands largely rather than other salinized areas. In second instance, there is possibility to identify these types of areas based on the prepared salinity map (Fig. 4) and draw up the managerial mechanisms for improvements such as alkalization, and suitable draining, as already experimented and recommended by some researchers (Rahimi and Ahmadnejad, 2005; Pazira, 2006). To prevent and tackle expansion of the salinized lands, avoiding irrigation by these waters, even by lower degree of salt and/or mixed fresh water, not recommended. In a research by Rahimian et al., (2012), they examined the relationship between underground salt water and salinity profile of soil in Dasht-e-azadegan. It specified that the underground water effect on salinity of deep soil profile, particularly in depth of more than 90 cm to the ground surface, have been considerable and also the surface layers of soils being affected (even slightly) by the underground water. Therefore, remedy of draining system and/or constructing new drains in the study region are necessary to reduce and eliminate continuous salinity of these lands. They can not only be saved from a danger of increasing salinity by the farmers', authorities' supervisory efforts, using Mahabad dam water and shortening irrigation period, but also to make improvement and, at the same time, to farm those crops fully or partially stabilized against salinity, such as barley, sugar beet, wheat and forage barley as indicated in Table 2. Fortunately, another area with salinity level of 8-16 covers only a small plot, about 6.33 percent, of lands. Such rectification and improvement require particular management and salinity expertise supervision. These efforts may not afford alone realization of a solution and should accompany with application of rectifying materials. Thus, this job seeks the authorities' attentions of the Ministry of Agriculture and allocation of sufficient funding. Besides the alkalization and draining work, Emami et al., (2011) have proposed other mechanisms such as the materials for improving the salt and sodium content soils in the arid and semiarid regions. For the lands with such degree of salinity, only the resistant or highly resistant crops can grow but with not so good produces. Therefore, cultivating crops such as barley, sugar beet, wheat and Bermuda grass are fruitful. However, unfortunately, in those lands with salinity range >16, approximately 10 percent of the entire lands covered by salt soils, as shown in Fig.3, no crop is grown. For this, improvement and rectifying work is so difficult and costly and perhaps, even in some instances, it is impossible. By considering the locality, it is appropriate to think about change of application of these lands to establishing agriculture-related industrial and production plants.

V. CONCLUSIONS AND RECOMMENDATIONS

The results of the research show that soils of the study region involve great variability and the salinity category of improving lands is larger than other two salinized areas. Hence, it appears that providing salinity maps for identification, classification and utilization of these lands via draining of Mahabad water supply can be effective on promulgating managerial measures and actions for improving and rehabilitating the regional soils. Of course, it is apparent that efforts and paying attention by the authorities in the agricultural sector, and allocation of sufficient budget can pave the way for such actions.

Due to the significance of these farmlands and their climatic conditions of the province for cultivation, preparation of the soil salinity maps aiming to formulate appropriate managerial endeavors. Because of higher costs of improvement and rehabilitation works, the targeted attempts are to make the maps avail for better management along with diminishing economic costs. Finally, it is notable and recommended that farming crops like Frankia is useful since they are resistant against the salinity of the area between these lands and Uremia Lake and located in a rage of >16 dS m^{-1}, and also tolerating salt and dry soils, aridity, heat and coastal conditions and a thin layer of seawater salt.

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