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Vertical and horizontal in the soil salinity content for selected soil samples in Al-Rrefaee city, The-Qar, Iraq

*Hussein Khalefa Chlaib, *Riyadh Shaker Beedeh, *Nisreen Sameer Jabbar, and **Talib Saber Hurayjah,
*Soil Sci. and Water Res., Dept. Collage of Agric., Univ. of Sumer
**Dept. of lands, Agric. Directorate, Thi Qar, Iraq

Abstract: The soil salinity distribution maps were drawn for Al Refaae city for depths of 0-5 cm and 5-15 cm with a total area of 55 km^2 by taking 38 soil samples, 19 samples for each depth. EC (1:1) values for the 0-5 cm depth samples ranged between 6.5 dsm^{-1} (R14) and 77.6 dsm^{-1} (R8) and the EC values for the 5-15 cm depth samples ranged from 7.6 dsm^{-1} (R12) and 139.5 dsm^{-1} (R9). The contour maps of the depth of 0-5 cm show that the northern, western, and southern parts of the study dominated by high conductivity values (> 25 dsm^{-1}), while the eastern part is controlled by the low conductivity values. For the 5-15 cm depth samples, EC contour map showed that the northern part of the study area has low EC values (< 25 dsm^{-1}), while for the southern part, the EC values were higher than 25 dsm^{-1}. Maps of desertification degree in the 0-5 cm depth region is much more and wider than the desertification degree for the 5-15 cm depth sample areas which is obviously due to the used surface land and the dominated weather, which affect the soil surface much more than subsurface soil.

Keywords: Soil salinity, contour map, electrical conductivity.

التغييرات العمودية والافقية في المحتوى الملحي لنماذج ترب مختاره من مدينة الرفاعي / محافظة ذي قار- العراق

*د. حسين خليفه جليب و*رياض شاكر بديح و*نسرين سمير جبار و**طالب صبر حريجه
قسم علوم التربة والموارد المائية، كلية الزراعة، جامعة سومر*
**رئيس مهندسين اقدم، قسم الاراضي، مديرية زراعة ذي قار، ذي قار- العراق

المستخلص :

رسمت خرائط توزيع ملوحه التربه لمدينة الرفاعي ولعمقين 0-5 سم و 5-15 سم ولمساحة اجماليه بلغت 55 كم^2 وذلك بأخذ 38 نموذج تربه بواقع 19 نموذج لكل عمق. تراوحت قيم التوصيليه الكهربائيه لنماذج العمق 0-5 سم بين 6.5 ديسيمنز م$^{-1}$ (نموذج R14) و 77.6 ديسيمنزم$^{-1}$ (نموذج R8)، بينما تراوحت قيم التوصيليه لنماذج العمق 5-15 سم بين 7.6ديسيمنز/م (نموذج R12) و139.5ديسيمنز م$^{-1}$ (نموذج R9). اظهرت النتائج ان الاجزاء الشماليه والغربية والجنوبيه من المنطقة تهيمن عليها قيم التوصيلية العاليه (> 25 ديسيمنز م$^{-1}$) بينما الجزء الشرقي ذو قيم التوصيلية الواطئه. وقيم التوصيلية لنماذج العمق 5-15 سم، بينت خارطتها الكنتورية ان الاجزاء الشماليه تقل فيها قيمة التوصيله (< 25 ديسيمنز م$^{-1}$)، اما الاجزاء الجنوبيه فان قيم التوصيلية فيها تكون اكبر من 25 ديسيمنز م$^{-1}$. تم رسم خارطتين تمثلان تصنيف المنطقة حسب درجة تصحرها وللعمقين المدروسين. الخرائط اوضحت ان المناطق المتصحره للعمق 0-5 سم والقريبة من السطح هي أوسع من مناطق العمق5-15 سم وهذا قد يكون راجعا إلى طريقة ونوعية استخدام الأراضي وتأثيرات الطقس والتي تؤثر على السطح اكثر واسرع من تاثيرها على التربة العميقه.

Introduction

Salinity is one of the most serious problems facing irrigated soils in the dry and semi-dry areas of the world. This danger comes from the fact that it is associated with the most valuable agricultural lands in these areas, which is the main source of agricultural products. It also has a suitable ventilation system, and its water system can be easily controlled by irrigation. Since the sedimentary plain lies within a dry area, the salinity in its areas takes the attention when talking about the treatment of agricultural problems (Shrivastava and Kumar, 2015; Imadi and Ahmed, 2016).

Soil Salinity can be defined as a quantitative accumulation of soluble salts in the root propagation area at a specific concentration so high as to inhibit and impedes the ideal growth of the plant and transform the soil profile into an environment that is not suitable for root propagation (Shrivastava and Kumar, 2015; Imadi and Ahmed, 2016).

Salts are transferred to the surface of the soil by a natural poetic property and carried with saline water and then accumulate due to evaporation. Salt can also be dense in the soil due to human activity when the salinity rises the salinity negative effects raise too which can lead to soil and plant degradation (Hird and Bolton, 2016)

The salinity is one of the most important problems facing the soils in southern Iraq because it lies within the dry and semi-dry areas according to the world map of Koppen-Geiger climate classification (Kottek et. al., 2006), which is not a problem facing the Iraqi soil only, but the soils of the entire world. The salinity works to convert large areas of lands to unsuitable lands for agriculture or useless agriculturally, which result because of the natural conditions and human interfere which led to a difference in the balance between the salts that are formed in the soil and what consumed by the seeds during the process of germination. The previous result also occurs when the irrigation water increases more than the limits for each agricultural crop, and poor management and misuse of the land and agriculture. Salinity of the soil can be defined as an increasing in the salts concentration in the soil solution more than the necessary salts used for plant growth. In south Iraq, the main reason for salt accumulation in the soils is the irrigation by flooding and absence of the effective drainage net (Imadi and Ahmed, 2016).

70-80% of the central and southern Iraq lands is located within the middle and high-salty soil. The amount of salts stored in the Mesopotamia Delta is within a depth of 5 meters and with an area with 150000 km^2 is estimated to be about 1 billion tons. Due to the drought and the evaporation in the summer, the salts remain in the depths within the soil horizons and after that the salts appear at the surface of the soil as a result of the capillary property, the method of irrigation, the type of chemical fertilizers used as well as the type of crop, the last factor contributes to increase the percentage of salinity in the soil depending on the type of crop (Allawi and Hammadi, 1980)

The most important salts that increase soil salinity are Na, Ca, K, Mg, Cl, CO_3, HCO_3, SO_4, Solvent and NO_3 in soil solution. Salinity usually expressed by the EC which measured by dsm^{-1}, In general, the concentration of salts in the soil extract should not exceed 4 dsm^{-1}, which is about 2560 ppm, and the ratio of sodium should not exceed 15% (Oudah, 1990), in this case the soil is classified as a salty saline, but if the EC of its extract is 4 dsm^{-1} and its sodium exchange ratio exceed 15, it called non-sodium (Oudah, 1990). Table 1 shows the soil salinity classes depending on the EC values (Gartley, 2011).

Table (1). Soil salinity classes depending on the EC values (Gartley, 2011)

EC dsm^{-1}	Soil type
0 - 4	Not salty
4-8	Low salinity
8-16	Medium salinity
More than 16	Highly saline

The aims of this research are reaching the bellow objectives

Obtain soil salinity contour maps which will be used as base maps to show the pattern of the salinity values distribution for Al-Refaae soil at different depths of 0-5 cm and 5-15 cm. These maps can be used as references for agricultural, geological, and environmental studies and future research for this area. Also, these maps can be used in future to compare the soil salinity changes with time.

Classify the studied area according to the desertification degree and finally, draw the desertification classification maps.

The Study Area

The study area is located in Al Refaae district within Thi-Qar Governorate /southern Iraq and about 80km away north from the governorate center (Al-Nasseryah), the area located between the latitudes 31°40'52.43"N - 31°44'6.07"N and longitudes 46°05'39.37"E - 46°06'55.96"E, with a total area of 35 km^2 (Figure 1). From the sedimentary prospective, the area is within the sedimentary plain of the Mesopotamian basin, which consists of different sediments of sand, clay and silt which represented by the flood plain sediments. The studied soils belong to sub group *Typic Torrifluvents* according to (Soil Survey Staff, 2004). Table 2 shows the coordinates of the study area using the GPS system. Figure 2 shows the topographic (contour) map of the area which represents the samples' elevation above sea level of the studied area, this map was conducted using Surfer® software, version 7, Golden Software, Inc. (Golden Software, 1999).

Figure 3 shows a half bird's eye view "3D shape" for the studied area which represents the differences in the ground (surface) elevation (topography).

Table (2). Represents the soil's sample numbers, their coordinates obtained from the GPS system, and their elevations.

Sample's No.	Longitude	Latitude	Elevation (m) above sea level
R1	46° 6'51.62"E	31°41'39.69"N	10
R2	46° 6'51.81"E	31°41'24.28"N	11
R3	46° 6'54.19"E	31°41'46.77"N	11
R4	46° 6'54.06"E	31°41'38.35"N	11
R5	46° 6'52.48"E	31°40'52.43"N	12
R6	46° 6'51.63"E	31°43'2.61"N	11
R7	46° 6'17.36"E	31°41'50.14"N	8
R8	46° 6'53.71"E	31°41'5.28"N	9
R9	46° 6'52.66"E	31°41'38.76"N	14

R10	46° 6'55.96"E	31°44'6.07"N	15
R11	46° 6'18.12"E	31°43'44.44"N	12
R12	46° 6'39.81"E	31°42'37.36"N	11
R13	46° 6'40.70"E	31°43'52.89"N	11
R14	46° 6'55.28"E	31°43'31.15"N	15
R15	46° 5'39.37"E	31°42'50.52"N	13
R16	46° 5'59.42"E	31°43'36.44"N	11
R17	46° 5'39.77"E	31°42'46.24"N	13
R18	46° 5'54.42"E	31°42'55.32"N	11
R19	46° 6'5.22"E	31°43'15.74"N	13

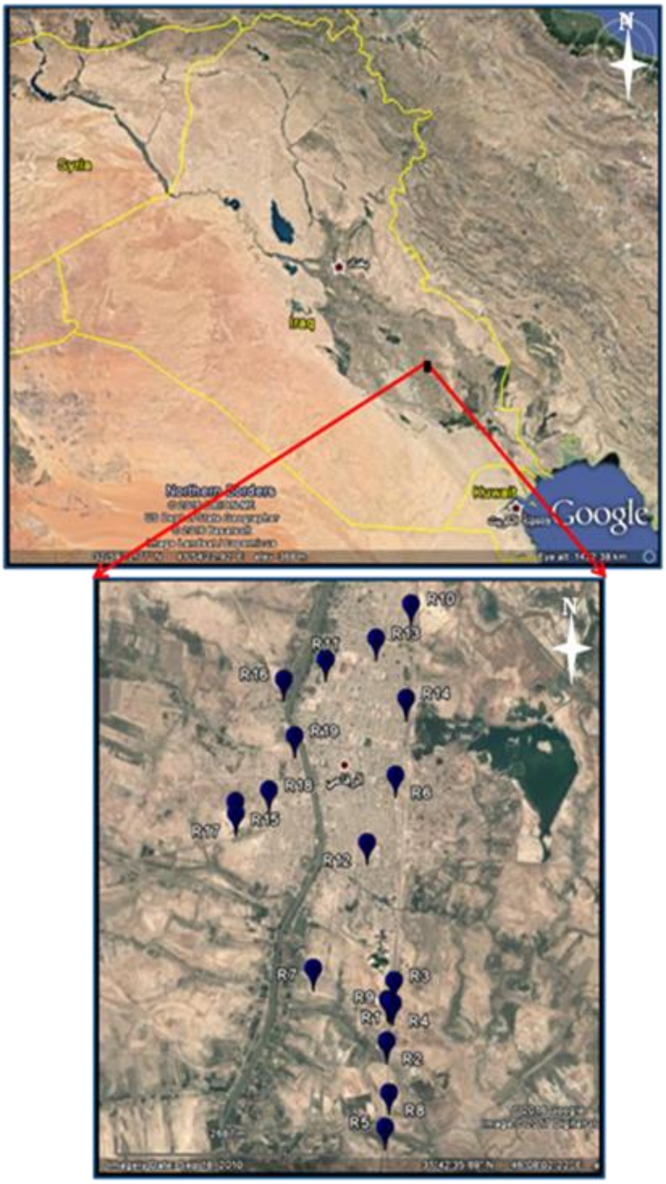

Figure (1). A Google Earth map represents the location of the study area on the map of Iraq; the blue empty balloons represent the sample locations.

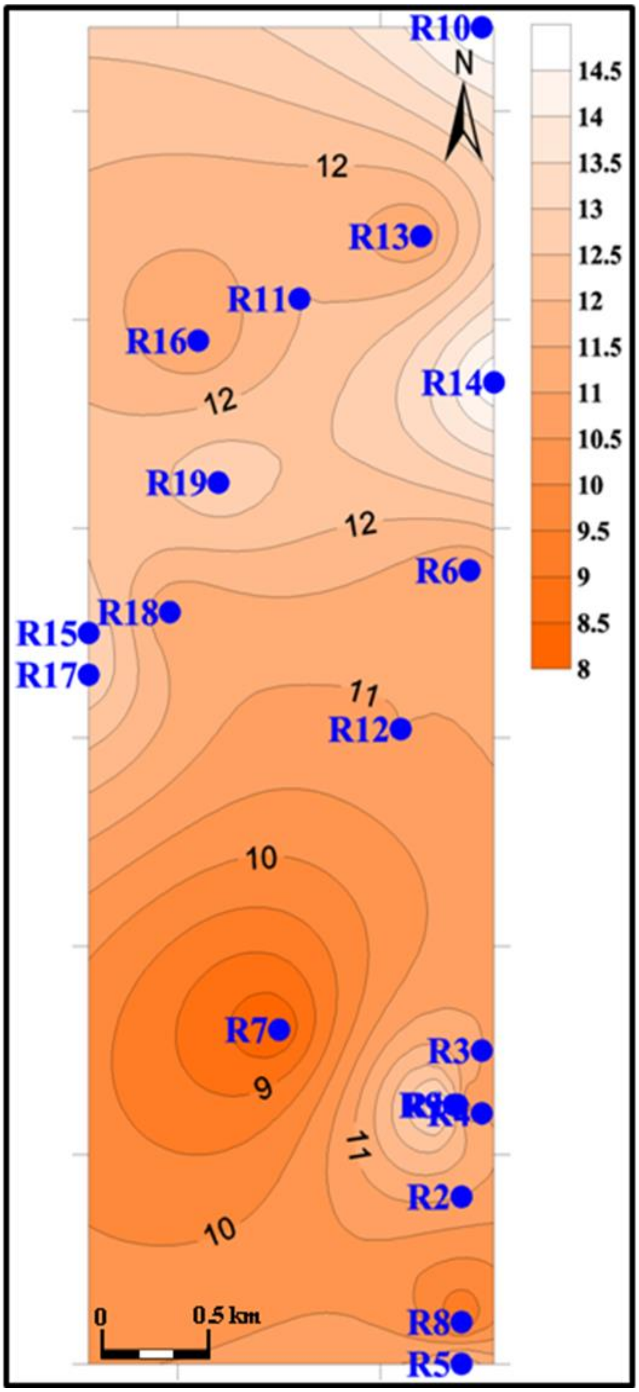

Figure (2). The contour (topographic) map of the studied area, the numbered blue filled circles represent the soil sample locations and numbers.

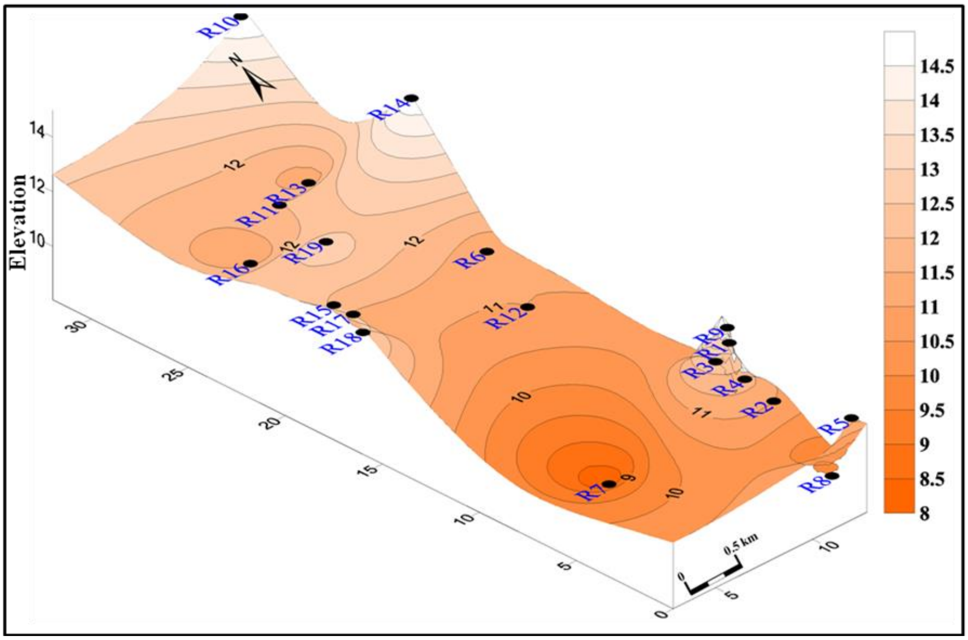

Figure (3). Half bird's eye view "3D shape" of the studied area elevation, the numbered black fill circles represents the soil sample locations and numbers.

Materials and Methods

Initially, the exploration area was explored as tentative and suitable for locating samples, the study area was divided into two sides located to the east and to the west of the city center. 19 sample locations were located to cover the study area, and at depths of 0-5 cm and 5-15 cm, these depths were chosen because they are the tillage and seed growth depths. The soil sample locations have variety in the land use and different natural plants. Some of them have natural plants and some of them from useless land. The ground water level was unknown.

Soil samples were collected from 27-28/12/2017. Soil surface layer impurities and salts were removed. Then, the Augur was used to extract the samples. Samples were placed in 1 kg plastic bags, all the important information of each sample was written on the plastic bags, the samples were stored in the laboratory at a suitable temperature.

The samples were air-dried in the laboratories of the Department of Soil Science and Water Resources - Faculty of Agriculture / Sumer University for a period of one week from 1/3/2017 to 7/3/2017. After complete drying, the samples were grinded using a glass mortar. The samples were sifted with a 2 mm diameter sieve to remove impurities and gravel. Samples were weighed and stored for measurement purposes. The used instruments were EC meter (smart combined meter SM801), Shaker **device and GPS.**

100 grams of air- dried and sifted soil was weighted. Then adding 100 ml of distilled water to the soil in a baker to make a leachate with a ratio of (1:1). After shaking the sample for a quarter of an hour and filter the sample and leave it for a quarter of an hour, then the sample ready for measurement.

The values of measured EC(1:1) are shown in Table (3).

To obtain an accurate measurement, the baker need to wash before and after putting the sample leachate, also, the EC electrodes must to have well washed before and after each measurement to remove all salts accumulated on the electrode. The electrodes of the device are immersed in the sample leachate, after many seconds, the device will read the sample EC(1:1) value.

Results and Discussion

The results of this study included the measurement of the EC(1:1) of the selected soil shown in Table (3).

Table (3). Shows the soil salinity which represented by the EC (1:1) values of the selected samples measured with dsm^{-1} and ppm units and the percentage of the salinity of the 0-5cm and 5-15 cm depths samples.

Samples No.	Soil salinity value					
	0-5 cm depth			5-15 cm depth		
	EC(1:1)	salinity		EC(1:1)	Salinity	
	(dSm^{-1})	ppm	%	(dSm^{-1})	ppm	%
R1	24.4	15616	1.5616	20	12800	1.2800
R2	35.5	22720	2.2720	46.2	29568	2.9568
R3	28.9	18496	1.8496	24.2	15488	1.5488

R4	7.2	4608	0.4608	10.8	6912	0.6912
R5	18.4	11776	1.1776	21.2	13568	1.3568
R6	10	6400	0.6400	9.9	6336	0.6336
R7	41.2	26368	2.6368	45	28800	2.8800
R8	77.6	49664	4.9664	71.4	45696	4.5696
R9	35.7	22848	2.2848	139.5	89280	8.9280
R10	61	39040	3.9040	22.6	14464	1.4464
R11	14.2	9088	0.9088	10.2	6528	0.6528
R12	7.4	4736	0.4736	7.8	4992	0.4992
R13	13.9	8896	0.8896	10.7	6848	0.6848
R14	6.5	4160	0.4160	8	5120	0.5120
R15	11.9	7616	0.7616	14	8960	0.8960
R16	16.2	10368	1.0368	8.8	5632	0.5632
R17	47.8	30592	3.0592	16.8	10752	1.0752
R18	15.2	9728	0.9728	12.1	7744	0.7744
R19	39.5	25280	2.5280	17.9	11456	1.1456

The EC(1:1) values for the 0-5 cm depth samples ranged between 6.5 (dsm^{-1}) (R14) and 77.6 (dsm^{-1}) (R8), while the EC(1:1) values for the 5-15 cm depth samples were ranged from (7.8 (dsm^{-1})) (R12) and (139.5 (dsm^{-1})) (R9).The contour maps were drawn using Surfer® software, it is observed from the contour map of the 0-5 cm depth EC(1:1) values that the northern, southern and western parts of the study area dominate the high conductivity values (> 25 (dsm^{-1})) while the eastern part of the study area are controlled by the low conductivity values, this distribution is normal due to the river location, northern, western and southern part are close to the river and the groundwater table will be close to the surface and this will add salts to the soil while the eastern part may has a deep ground water level. Figure 4 represents the contour maps for the EC(1:1) distribution of the soil samples with a depth of 0-5 cm with (dsm^{-1})and the ppm units.

As for the EC(1:1) values of the soil sample of depth 5-15 cm, the contour map showed that just the southern part of the study area increased the EC(1:1) value (> 25 dsm^{-1}) and closed to the value of 140 dsm^{-1}, while the rest of the study area was dominant with the low EC(1:1) values (< 25 dsm^{-1}). Figure 5 represents the contour maps for the distribution of the EC of the soil samples at a depth of 5-15 cm, in dsm^{-1} and in the ppm units.

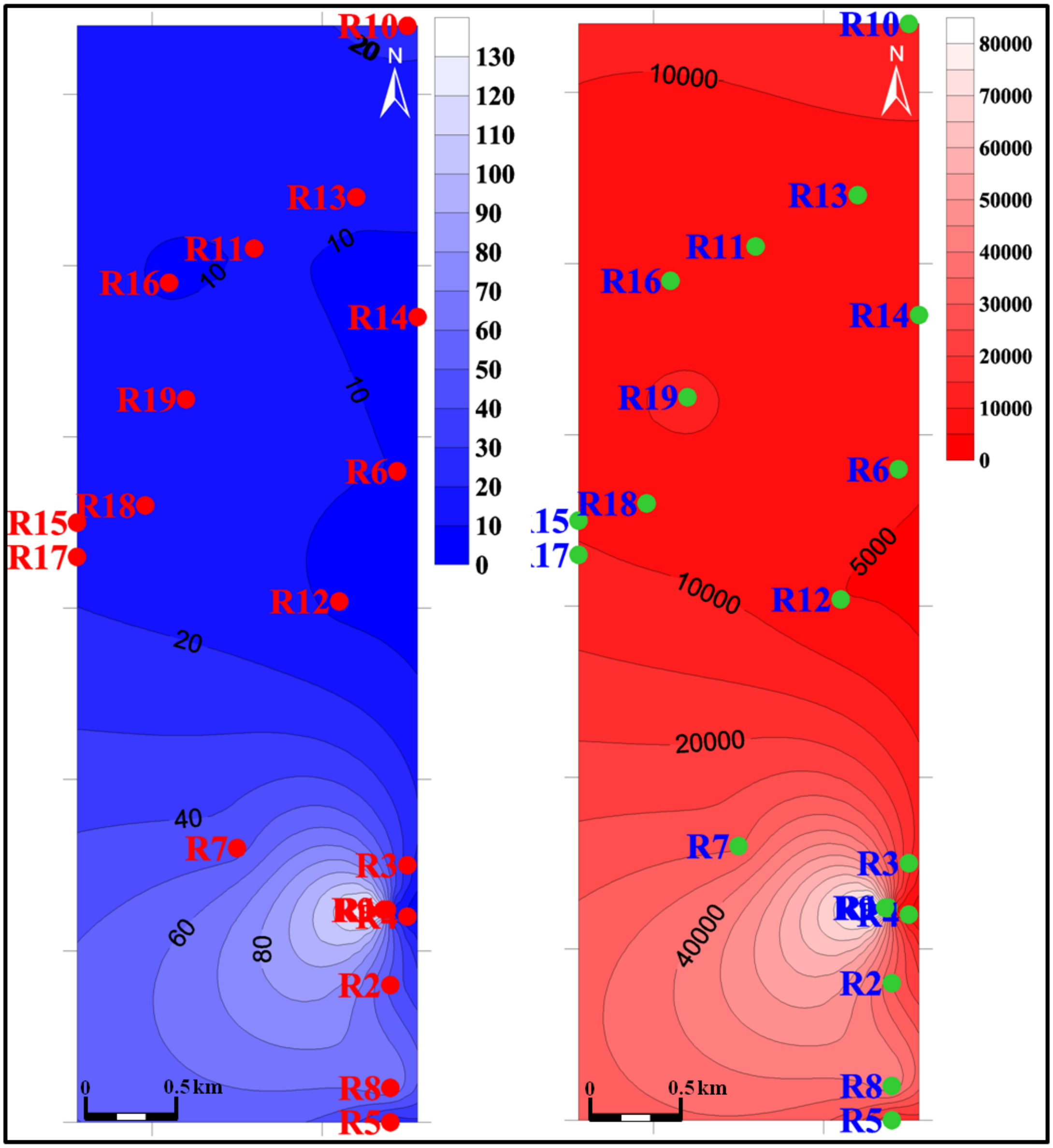

Figure (4). Contour map for the distribution of EC(1:1) values in (dsm^{-1}) units (left pan) and in ppm units (right pan) for soil sample of the study area at a depth of 0-5 cm, the red and numbered green filled circles represent the soil sample locations.

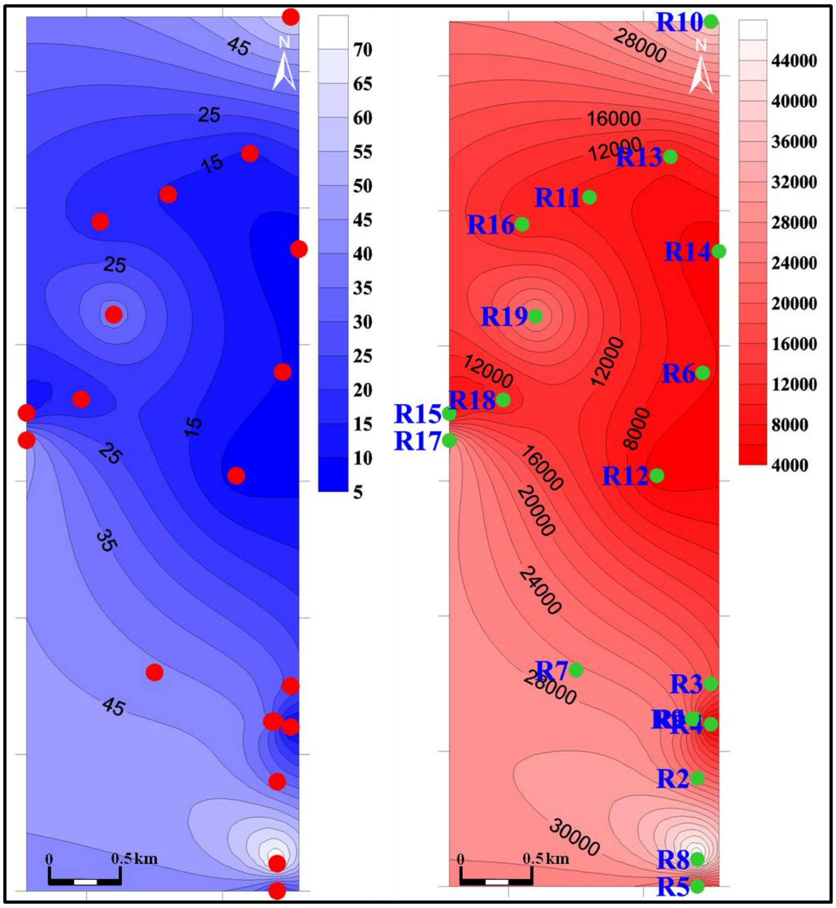

Figure (5). Contour map for the distribution of EC(1:1) values in ds/m units (left pan) and in ppm units (right pan) for soil samples of the study area at a depth of 5-15 cm, the numbered red and green filled circles represent the soil sample locations and numbers.

In general, it is noted that the EC(1:1) values of 0-5 cm depth samples are relatively higher than the EC(1:1) values of the 5-15 cm depth soil samples and may be the reason of this difference is near the ground water level from the level of the ground surface, which helps with the capillary property in salts deposition and accumulation near the surface and under shallow depths, as well as the increasing of the temperature and the evaporation, which results in salts deposition on the surface. And for both depths, the southern part has the highest EC(1:1) values.

By comparing the EC(1:1) contour maps for both depths, both maps approximately behave the same behavior in the EC distribution in the southern (high EC(1:1) values (> 25 dsm^{-1})) and eastern parts (low EC(1:1) values (<10 dsm^{-1})), while in the northern and western sides, the EC(1:1) values are different; in the 0-5 cm depth, the values are high , while they were low in the 5-15 cm depth samples.

To show the exact depth relative to the samples' locations and the EC(1:1) contribution map, a 3D combined figure (which is one of the Surfer 7 capability) of the sample's location post map, area elevation map, and (0-5 cm depth) EC(1:1) contour map with dsm^{-1} unite was done (Figure 6 upper pan). Also, a similar figure of the same depth samples with the ppm unit (Figure 6 lower pan) was done, too. One can see in some locations that the high elevation samples have the lower EC(1:1) values such as (R14, R15, R17, and R19), the reason for that might be due to the groundwater table location which be far from the soil samples locations. Also, some low elevation locations have the higher EC (1:1) values such as (R2, R7, and R19) which can be due to the close of the ground water table level.

Same procedure was done for the 5-15 cm depth samples (Figure 7), it was clear that is no any relation between the sample's elevation and the EC(1:1) values, that occurs because the EC(1:1) values are functions of many complex factors such as the ground water table, soil samples locations, the climate, the land use , agricultural process, ...etc. In general, no any relation between the EC (1:1) values for the both depths which is depended on many factors such as the climate and the land use as well as the surface elevation and groundwater depth.

Desertification Classification

The soil desertification classification for the 0-5cm and 5-15cm depth was done using the EC values (Sepehr et al., 2007; Armon, 2015). It can said that the areas of the studied samples of the soil of Al-Refaee suffer from a very severe desertification (EC > 15 dsm^{-1}), highly desertified areas (EC = 8-15 dsm^{-1}), areas with moderate desertification (EC = 4-8 dsm^{-1}), and no any presence of the non-desertification zones (EC <4 dsm^{-1}) .Figure 8 shows the soil desertification classification according to the 0-5cm (left pan) and the 5-15 cm (right pan) depth samples EC(1:1) values. The yellow colored area indicates the very severe desertified area, the red colored area illustrate the highly desertified areas, and the blue areas show the area with a moderate desertification while we could not see any non desertified area.

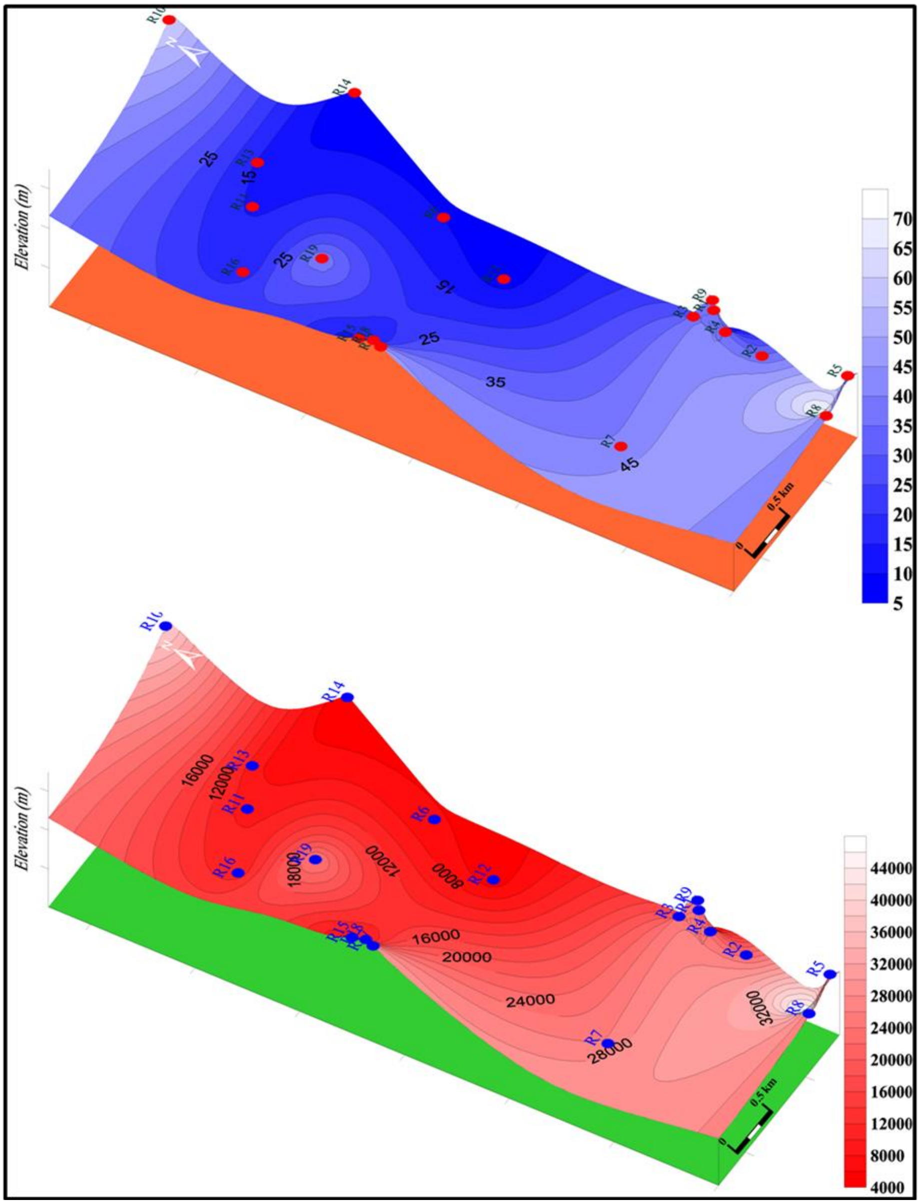

Figure (6). Three dimensions (3D) combined figure of the sample's location post map, area elevation map, and (0-5 cm depth) EC(1:1) contour map with dsm^{-1} (upper pan), while the lower pan shows the combined figure of the 0-5 cm depth samples with ppm unit. The red and blue stars are the sample locations, the left side Y-axis represents the sample elevation relative to the sea level, while the blue and red scales columns are the EC (1:1) values with dS/m and ppm units.

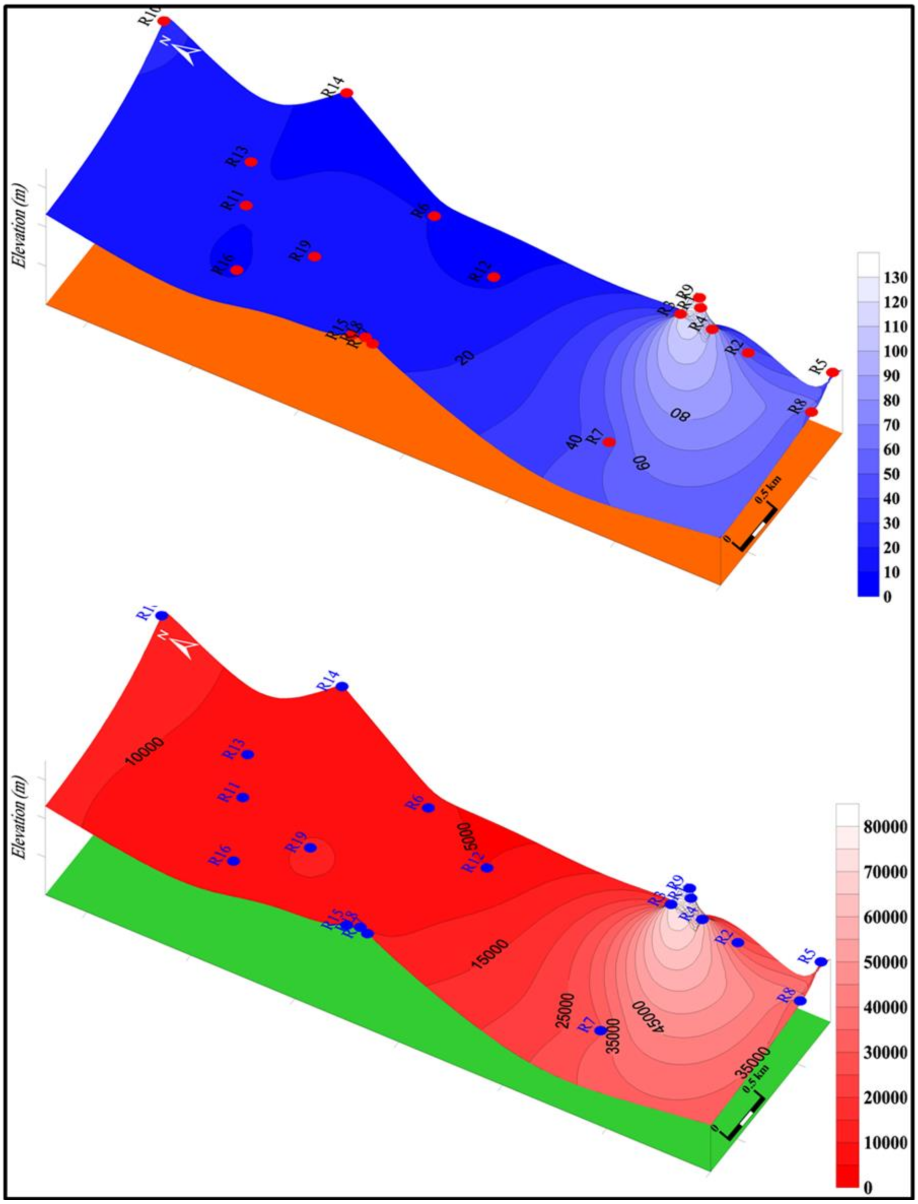

Figure (7). Three dimensions (3D) combined figure of the sample's location post map, area elevation map, and (5-15 cm depth) EC(1:1) contour map with dsm^{-1} (upper pan), while the lower pan shows the combined figure of the 5-15 cm depth samples with ppm unit. The red and blue stars are the sample locations, the left side Y-axis represents the sample elevation relative to the sea level, while the blue and red scales columns are the EC (1:1) values with dS/m and ppm units.

When comparing the two desertification maps in Figures 8, it is clear that the area with very severe desertification (yellow zone) in the 0-5cm depth is wider than the area of the 5-15 cm depth. Also the highly desertified areas (red zone) in the 0-5 cm depth map is narrower than in the 5-15 cm depth map, and the issue is the same with the with the moderate desertification (blue zone). The previous distribution of the desertified areas means that the surface soil desertified more than the subsurface soil, this is obviously due to the surface land use and the weather influence which affect the surface soil much more the subsurface soil.

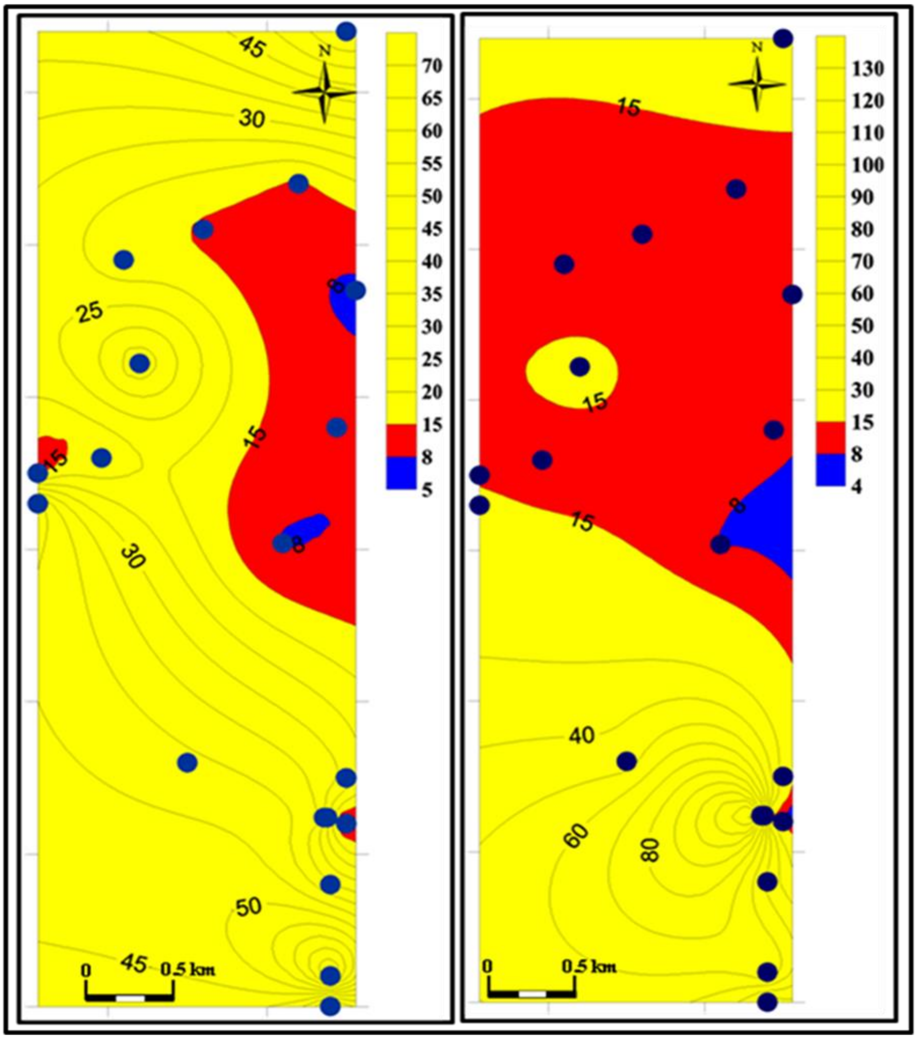

Figure (8). The soil desertification classification for the 0-5cm depth (left pan) and 5-15 cm depth (right pan) soil samples according to the EC(1:1) values, (yellow: very severe desertification, red: highly desertified areas, blue: moderate, and non-desertification zones were founded.

Conclusions

It is concluded from this study that the soil of Al-Refaee area has different levels of salts depending on the depth. This is what is known by the differences between the EC(1:1) values. For the sample depth 0-5 cm, the EC(1:1) values ranged between 6.5 dsm^{-1} (4160 ppm) (R14) and 77.6 dsm^{-1} (49664) (R8). As for the depth sample 5-15, the values were between 7.8 dsm^{-1} (4992 ppm) (R12) and 139.5 dsm^{-1} (89280 ppm) (R9). In general, no any relation between the EC(1:1) values for the both depths which is depended on many factors.

These differences in EC(1:1) values are due to the variations in land uses such as agricultural and urban uses or land abandonment without use. The level of the Earth's surface relative to neighboring areas also affects the value of electrical conductivity, where lowlands become a place for collecting water; high temperatures and evaporation becomes a compound of salts and also close to the level of ground water.

Depending on the values of the electrical conductivity, the studied area can be classified depending on the desertification degree; it can said that the studied areas in Al-Refaee city suffer from a very severe desertification (EC > 15 dsm^{-1}), highly desertified areas (EC = 15-8 dsm^{-1}) and areas with moderate desertification (EC = 4-8 dsm^{-1}) and no presence of the non-desertification zones (EC <4 dsm^{-1}). The desetified areas in the 0-5 cm depth region are wider than the 5-15 cm depth sample areas which are clear when observing the both maps which is obviously due to the surface land use and the weather influence which affect the surface soil much more the subsurface soil.

Recommendations:

The researchers recommend: Extend the study by taking a larger number of soil samples at different depths to get more accurate and comprehensive maps. Study the soil mineralogy analysis which is a major influence on the EC value

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