Soil Salinity Distribution Maps for Selected Soil Samples in Qalat Suker City, Thi-Qar/ Southern Iraq

Hussein Khalefa Chlaib, PhD[1]
Ali Saleem Khuraywit, B.Sc.(Agr.)[2]
Batool Hatif Kazim, B.Sc.(Agr.)[3]
Atarid Talib Kazim, B.Sc.(Agr.)[3]
[1] Assist. Prof., Department of Soil Sciences and Water Resources, Collage of Agriculture, University of Sumer, hkaldobayany@yahoo.com, hkchlaib@ualr.edu
[2]Agriculture Engineer
[3]Assist. Agriculture Engineer, Department of Soil Sciences and Water Resources, Collage of Agriculture, University of Sumer

Abstract

The soil salinity distribution maps were drawn for Qalar Suker city/ Thi-Qar governorate-southern Iraq for depths of 0-5 cm and 5-15 cm with a total area of 55 km^2 by taking 34 soil samples, 17 samples for each depth. The EC values for the 0-5 cm depth samples ranged between 2.2 dS/m (Q17) and 48.1 dS/m (Q6) and the EC values for the 5-15 cm depth samples ranged from 1.9 dS/m (Q7) and 39.0 dS/m (Q13). Contour maps of the study area were drawn using Surfer ® Software, version 7, The contour maps of the depth of 0-5 cm shows that the northern and western parts of the study dominate of the high conductivity values (> 20 dS/m) while the central, eastern and southern parts are controlled by the low conductivity values. For the 5-15 cm depth samples, EC contour map showed that the western parts of the study area have high EC values (> 20 dS/m), while for the northern, western, central and southern parts, the EC values were low. In general, the EC values for the 0-5 cm depth samples, are relatively higher than the 5-15 cm depth samples, the reason may be is the level of ground water is close from the ground surface which helps with the capillary rise

property to deposit the salts near the surface and under shallow depths as well as high temperature and increased the evaporation which deposit the salts near the surface.

Two desertification classification maps were drawn for the two depth. they showed that the desertified areas in the 0-5 cm depth region are wider than the 5-15 cm depth sample areas. Also, the desertification maps showed that the surface soil desertified more than the subsurface soil, this is may be due to the surface land use and the weather influence.

1-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.
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.

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.

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, 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.

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 1500000 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, Solvent and NO_3 in soil solution. Salinity usually expressed by the EC which measured by mmohs/cm, In general, the concentration of salts in the soil extract should not exceed 4 dS/m, which is about 2500 ppm, and the ratio of sodium should not exceed 15 (Mehdi Ibrahim, 1990), in this case the soil is classified as a salty saline, but if the EC of its extract is 4 dS/m and its sodium exchange ratio exceed 15, it called non-sodium (Oudah, 1990).

2- Total Dissolved Solids (TDS):

TDS is the total soluble salts in the solution (ionized and non-ionized) and does not include the suspended colloids, granular and dissolved gases. Also, TDS is the material that passes through a filter material and accumulative after evaporation ((Metcalf and Eddy, 2003). TDS consists of the negative and positive ions. The concentration of dissolved ions within natural water depends on the type of rock and soil that are in contact with and on the duration of the contact process (Hem, 1970).

There are many sources of salts as bellow:
1) the Salts that found in the soil resulting from melting and continuous erosion of the rock (parent soil).
2) the High level of ground water resulting from the absence of the good drainage after irrigation.
3) the Interference of the sea water with the groundwater, especially in the lands adjacent to the coastal areas.
4) Soluble salts that added through irrigation and fertilization.
The salinity occurs due to many reasons such as:
1) High levels of salt in the soil.
2) Land characteristics that allow the salt to move (the movement of groundwater).
3) Climate trends that allow salt to accumulate.
4) the bad human activities such as trees cutting because the trees absorb the salts from soil in the process of photosynthesis.

3- Salinity Affected Soil Classification in Iraq:

The problem of salinity is of great importance in most irrigation lands in Iraq, today very difficult to find an agricultural land free from the salt and starting from Samarra city on the Tigris and Hit city on the Euphrates till the Arabian Gulf southern Iraq. these hands has been abandoned by the owners due to the high salinity which exceed (50%) and as a result, the crop decreased (30-50%) (Al-Kinj, 1996).

Russel, 1954, was the first one who classified the soils affected by salinity in Iraq using the local names for these soils which are:
A) Shura Soil: a salty soils characterized by a dry white shell because of the accumulation of large quantities of chlorides CO_3 , sulfate SO_4, Na and Mg. this soil can be divided into three types depending on the salt composition:
1) Sodium chloride shura soils which are characterized by its solid saline shell.
2) Sodium Sulphate shura soils which are characterized as having a solid saline shell, too.
3) Magnesium sulphate shura soil which is characterized as having a

brittle shell without accumulative salts and white soil. B-Saback Soil: It is a salty soils containing a high percentage of the salts of calcium and magnesium chlorides and calcium and magnesium nitrates, which have the ability to hydrate as a result these soils are characterized by its moisture, viscosity and the dark color. Also, these soils contain a high ratio of dissolved organic matter as well as the soil horizons are saturated with moisture throughout the year.

The Shoura and Al-Sabakha soils are not very different in their texture, chemical properties, level of salinity, and the hydrological conditions. Al-Sabakha soil represents an advanced saline level of the ongoing salinization process in central and southern Iraq. Researchers have been able to diagnose salinization rates in Iraq as bellow:

1) light salinity lands: where the plants are affected to a certain extent and that the salinity problem is sufficient to classify them under the second category.

2) Intermediate salinity lands: where the crops are affected to some extent by their salinity and these lands are placed under the third category and are located at the bottom of Mesopotamia.

3) high salinity lands: where they affect the plants very seriously and these lands fall under the fourth category and as shown in Table (1) (Abdul-Aal and Al-Rawi, 1981)

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

Soil type	EC dS/m
Not salty	0 - 4
Low salinity	8 - 4
Medium salinity	16 - 8
Highly saline	More than 16

4- Measurement of the EC:

The salts' type and concentration in water varies depending on the source of water (rainfall, groundwater... etc.). Rainfall water is the lowest salt content water sources followed by river surface water and groundwater.

The importance of measuring EC is achieved through its use in many hydrogeological, hydrochemical and agricultural applications. Also, many of the standard specifications depend on EC values. Measurement of the conductivity is a quick way to estimate salinity through the mathematical relationships between them (Todd, 1980). The connection depends on the temperature of the water. Increasing the water temperature by 1 ° C causes an increase in EC by 2% and increasing the solubility by increasing dissolved salts (Detay, 1997).

5- The Study Area:

The study area is located in Qalat Suker district within Thi-Qar Governorate /southern Iraq, the area located between the latitudes 31°50'24.06"N - 31°53'37.53"N and longitudes 46°02'49.54"E - 46°06'01.36"E, with a total area of 55 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. 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).

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

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
Q1	46°5′77.2″E	31°52′18.0″N	10
Q2	46°5′19.51″E	31°52′99.51″N	11
Q3	46°4′62.20″E	31°52′40.35″N	11
Q4	46°4′93.19″E	31°52′89.49″N	11
Q5	46°3′97.54″E	31°53′38.14″N	12
Q6	46°4′69.20″E	31°53′73.27″N	11
Q7	46°5′22.31″E	31°51′51.35″N	8
Q8	46°5′23.19″E	31°51′27.20″N	9
Q9	46°4′31.20″E	31°50′46.56″N	14
Q10	46°4′22.30″E	31°51′20.22″N	15
Q11	46°3′75.50″E	31°51′34.27″N	12
Q12	46°3′54.33″E	31°51′68.18″N	11
Q13	46°3′52.25″E	31°51′59.44″N	11
Q14	46°4′05.40″E	31°51′79.13″N	15
Q15	46°4′20.25″E	31°51′96.2″N	13
Q16	46°4′07.49″E	31°50′68.44″N	11

Q17	46°4′17.35″E	31°50′86.43″N	13

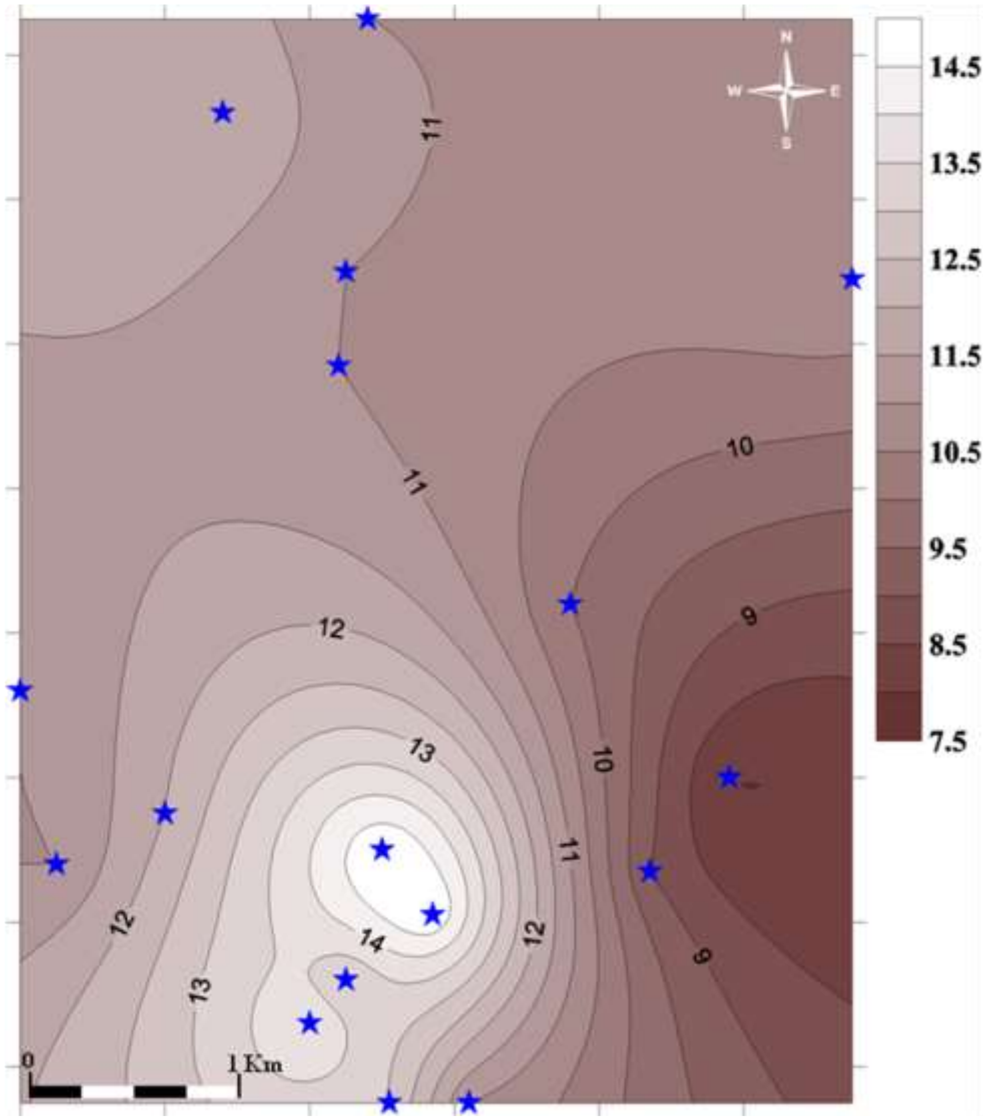

Figure (2): The contour (topographic) map of the studied area, the blue stars represent the soil sample locations.

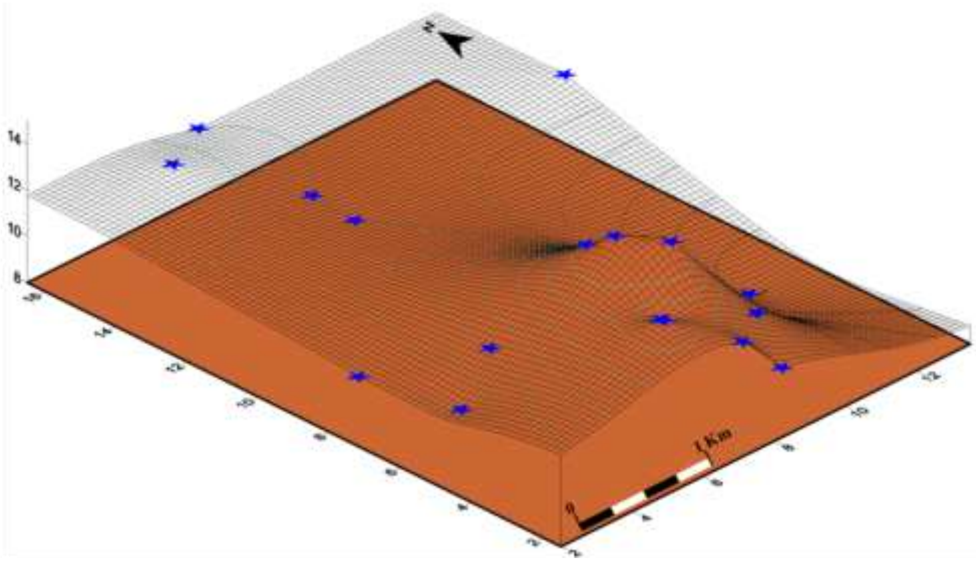

Figure (3): Half bird's eye view "3D shape" of the studied area elevation, the blue stars represent the soil sample locations.

6 - Objective of the Study:

The purpose of this research is to obtain EC contour maps which will be used as base maps to show the pattern of the EC values distribution for Qalat Suker 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, this research will classify the studied area according to the desertification degree and finally, draw the desertification classification maps.

7- Methodology:

7-1- Sampling method

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. Seventeen samples 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.

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.

7-2- Method of Samples Preparation

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 sample were grinded using a glass mortar. The sample were sifted with a 2 mm diameter sieve to remove impurities and gravel. Samples were weighed and stored for measurement purposes.

7-3- Materials

The materials that used in this study were air-dried and grinded soil, distilled water, test tubes, baker, sensitive balance, wash bottle, mortar, 2 mm diameter sieve, filter paper and plastic cones

7-4 Instrumentation

The used instruments were EC meter (smart combined meter SM801), Shaker device and GPS.

7-5- Work Method

1. Weight 100 grams of air- dried and sifted soil.
2. Adding 100 ml of distilled water to the soil in a baker to make a leachate with a ratio of (1:1).
3. Using the Shaker to shake the sample for a quarter of an hour.
4. Filter the sample by filter paper and leave it for a quarter of an hour as shown in Figure (4).
5. Measure the EC_e ,which is the EC of the leachate, by the EC meter after taking 10 ml of it.

The values of measured EC_e are shown in Table (3).

Figure (4): Shows the method of obtaining the soil leachate.

7-6- Measuring Method

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_e value.

8- Results and Discussion:

The results of this study included the measurement of the EC_e of the selected soil samples from Qalat Suker city at two different depths shown in Table (3).

Iraqi soil is rich in calcium salts, therefore the predominant salt in water is the calcium salts which gives Iraqi water the alkalinity (Russel, 1957).

Table (3): Shows the soil salinity which represented by the EC_e values of the selected samples measured with dS/m 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_e (dS/m)	ppm	% salinity	EC_e (dS/m)	ppm	% salinity
Q1	12.6	8064	0.8064	9.6	6144	0.6144
Q2	4.7	3008	0.3008	4.4	2816	0.2816
Q3	3.9	2496	0.2496	3.9	2496	0.2496
Q4	8.4	5376	0.5376	4.4	2816	0.2816
Q5	4.0	2540	0.2540	4.0	2560	0.2560
Q6	48.1	30784	3.0784	3.4	2176	0.2176
Q7	9.6	6144	0.6144	4.2	2688	0.2688
Q8	3.7	2368	0.2368	3.7	2368	0.2368
Q9	4.5	2880	0.2880	8.0	5120	0.5120
Q10	17.8	11392	1.1392	13.7	8768	0.8768
Q11	18.8	12032	1.2032	4.8	3072	0.3072
Q12	8.3	5312	0.5312	4.1	2624	0.2624
Q13	43.3	27712	2.7712	39.0	24960	2.4960
Q14	3.6	2304	0.2304	3.4	2176	0.2176
Q15	3.5	2240	0.2240	2.7	1728	0.1728
Q16	4.2	2688	0.2688	4.4	2816	0.2816
Q17	2.2	1408	0.1408	1.9	1216	0.1216

The EC_e values for the 5 cm depth samples ranged between 2.2 dS/m (Q17) and 48.1 dS/m (Q6), while the EC_e values for the 5-15 cm depth samples were ranged from (1.9 dS/m) (Q7) and (39.0 dS/m) (Q13). The contour maps were drawn using Surfer® software, It is observed from the contour map of the 0-5 cm depth EC_e values that the northern and western parts of the study area dominate the high conductivity values (> 20 dS/m) while the central, eastern and southern parts of the study area are controlled by the low conductivity values. Figures 5 and 6 represent the contour maps for the EC_e distribution of the soil samples with a depth of 0-5 cm with dS/m and the ppm units.

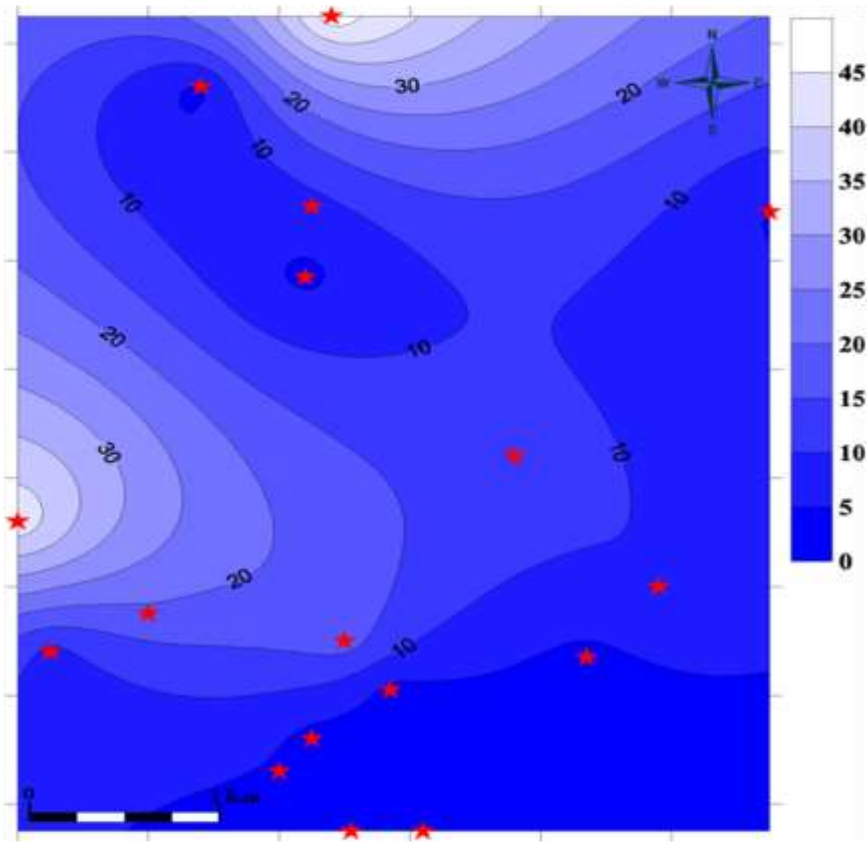

Figure (5): Contour map for the distribution of EC_e values in dS/m and for soil sample of the study area at a depth of 0-5 cm, the red stars represent the soil sample locations.

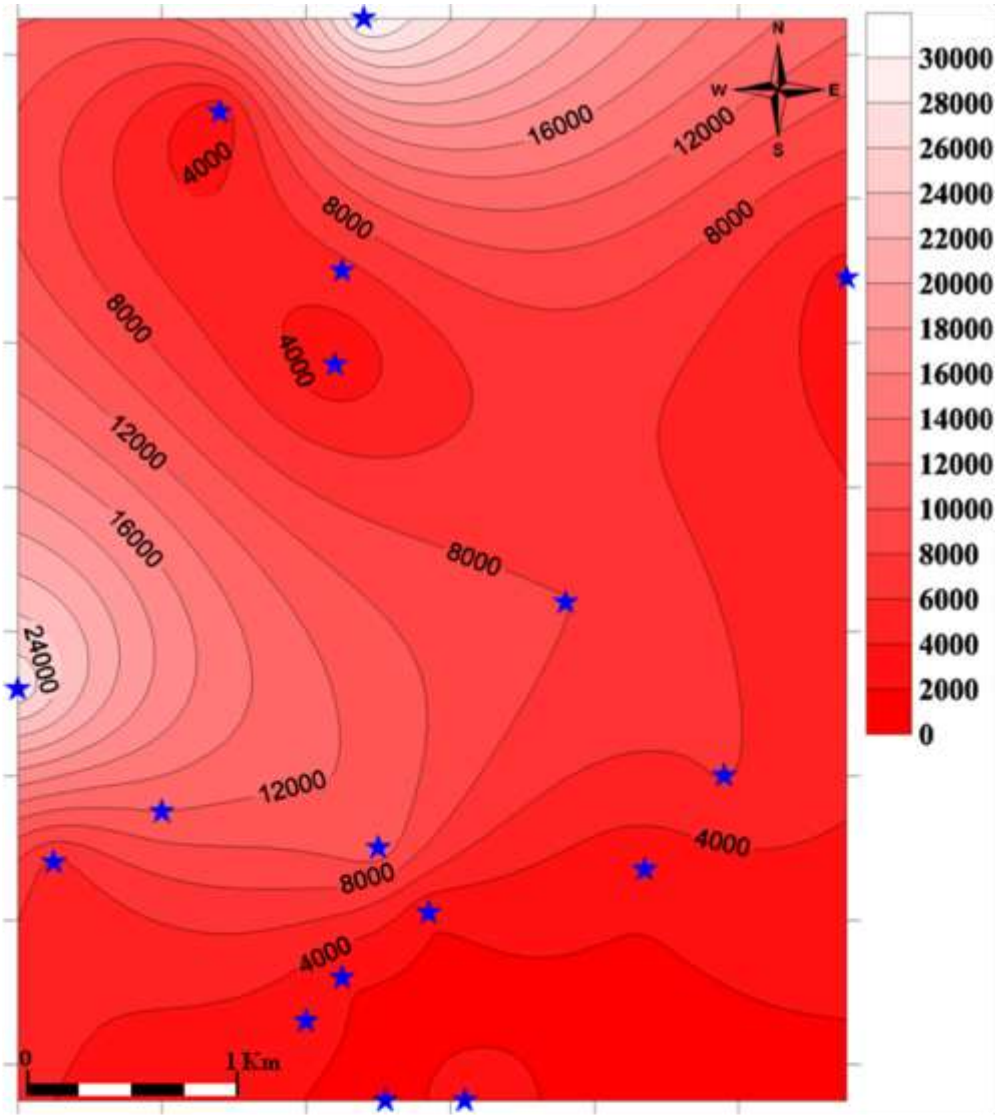

Figure (6): Contour map for the distribution of EC_e values in ppm units and for soil sample of the study area at a depth of 0-5 cm, the blue stars represent the soil sample locations.

As for the EC_e values of the soil sample of depth 5-15 cm, the contour map showed that the western parts of the study area increased the connection value (> 20 dS/m), while the northern, eastern, central and southern parts of the study area have low EC_e values. Figures 7 and 8 represent the contour maps for the distribution of the EC of the soil samples at a depth of 5-15 cm, in dS/m and in the ppm units.

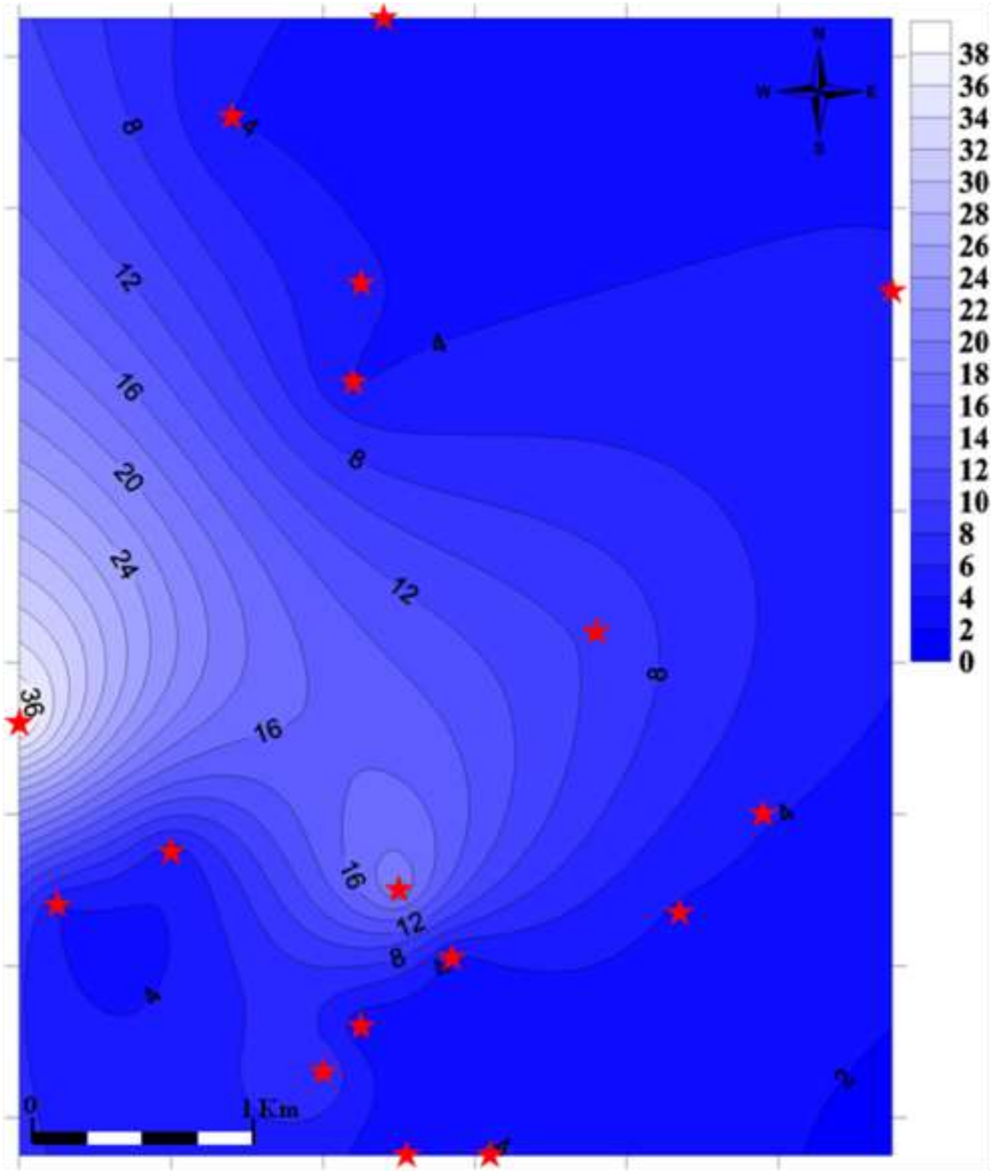

Figure (7): Contour map for the distribution of EC_e values in mmhose/cm for soil samples of the study area at a depth of 5-15 cm, the red stars represent the soil sample locations.

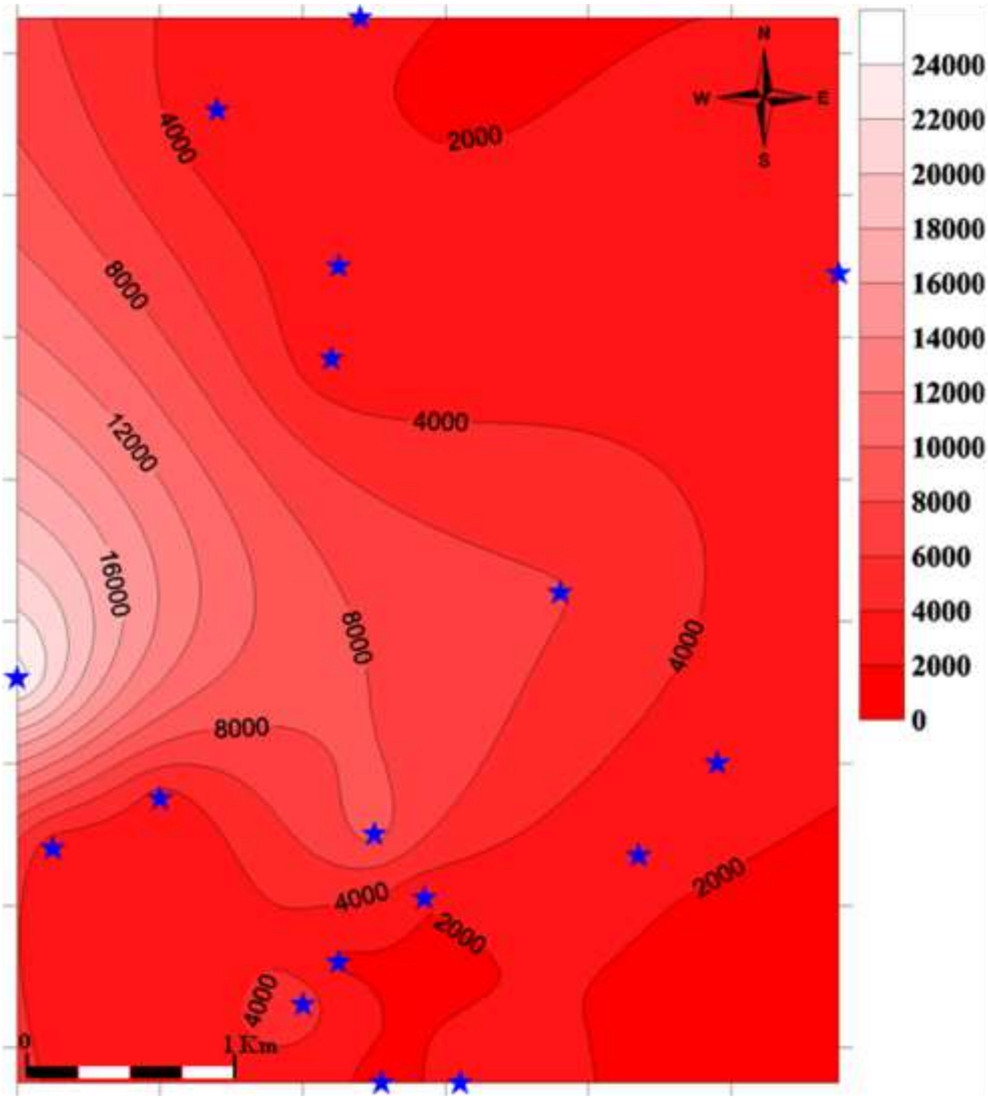

Figure (8): Contour map for the EC_e values distribution in ppm units and soil sample of the study area at a depth of 5-15 cm, the blue stars represent the soil sample locations.

In general, it is noted that the EC_e values of 0-5 cm depth samples are relatively higher than the EC_e 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.

By comparing the EC_e contour maps for both depths, both maps approximately behave the same behavior in the EC distribution; the western parts in both maps have high EC_e values (> 20 dS/m). The eastern and southern parts for both depths have low EC_e values (<10 dS/m). But the difference in the EC_e values appears in the northern parts at both depths; for the 0-5 cm depth, the northern side of the studied area has high EC_e values (> 20 dS/m) , while the same side of the 5-15 cm depth map has the lower EC_e values (< 4 dS/m).

To show the exact depth relative to the samples' locations and the EC_e 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 (5 cm depth) EC_e contour map with dS/m unite was done (Figure 9 upper pan). Also, a similar figure of the same depth samples with the ppm unit (Figure 9 lower pan) was done, too. One can see that the high elevation samples have the lower EC_e value such as (Q9, Q14, Q15, Q16, and Q17), the reason for that might be due to the groundwater table location which be far from the soil samples locations.

Same procedure was done for the 5-15 cm depth samples (Figure 10), also it was clear that the high elevation samples have the lower EC_e values which might be due to the far location of the ground water table relative to these soil samples locations.

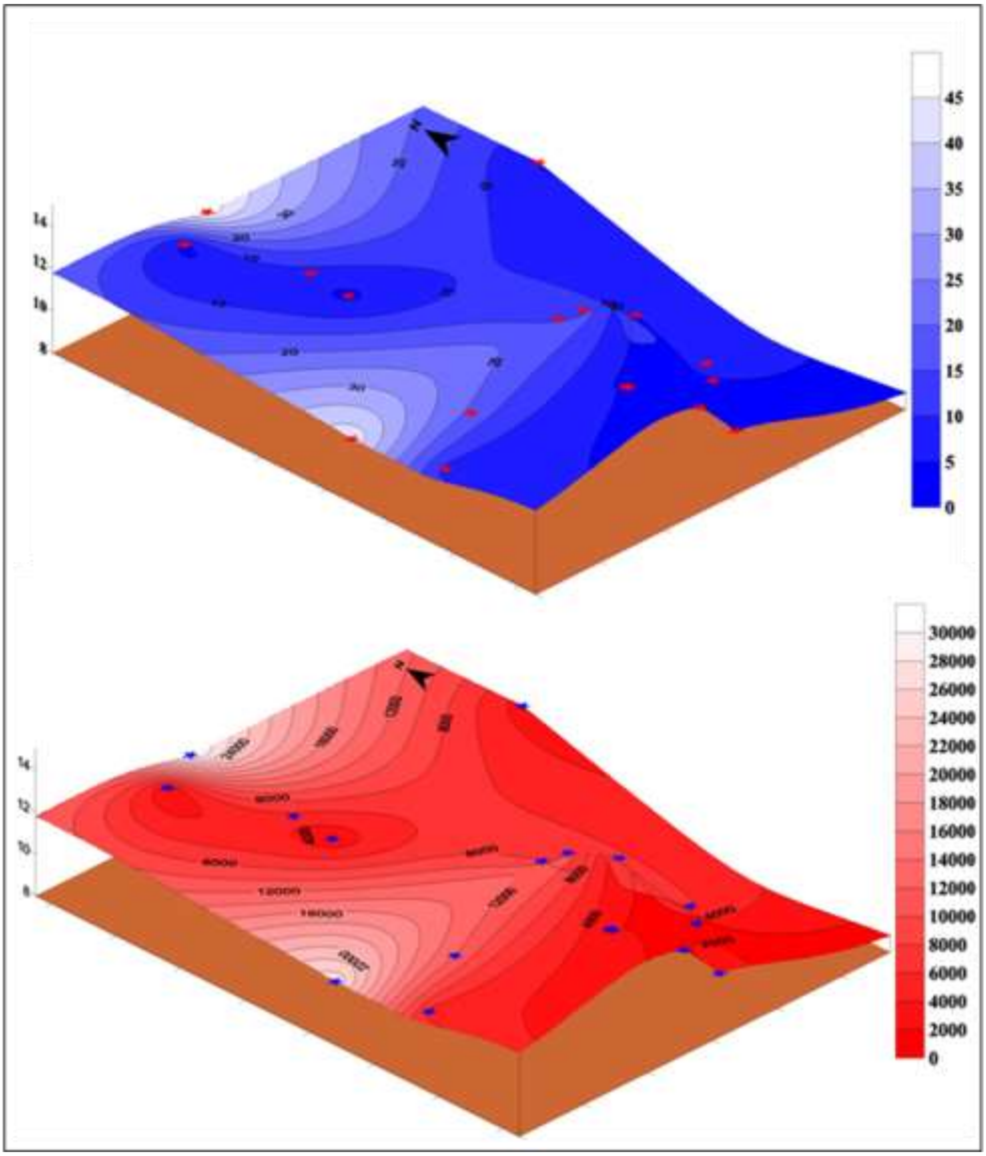

Figure (9): Three dimensions (3D) combined figure of the sample's location post map, area elevation map, and (0-5 cm depth) EC_e contour map with dS/m (upper pan), while the lower pan shows the combined figure of the 0-5 cm depth samples with ppm unit. The red and blue stars are the sample locations, the left side Y-axis represents the sample elevation relative to the sea level, while the blue and red scales columns are the EC_e values with dS/m and ppm units.

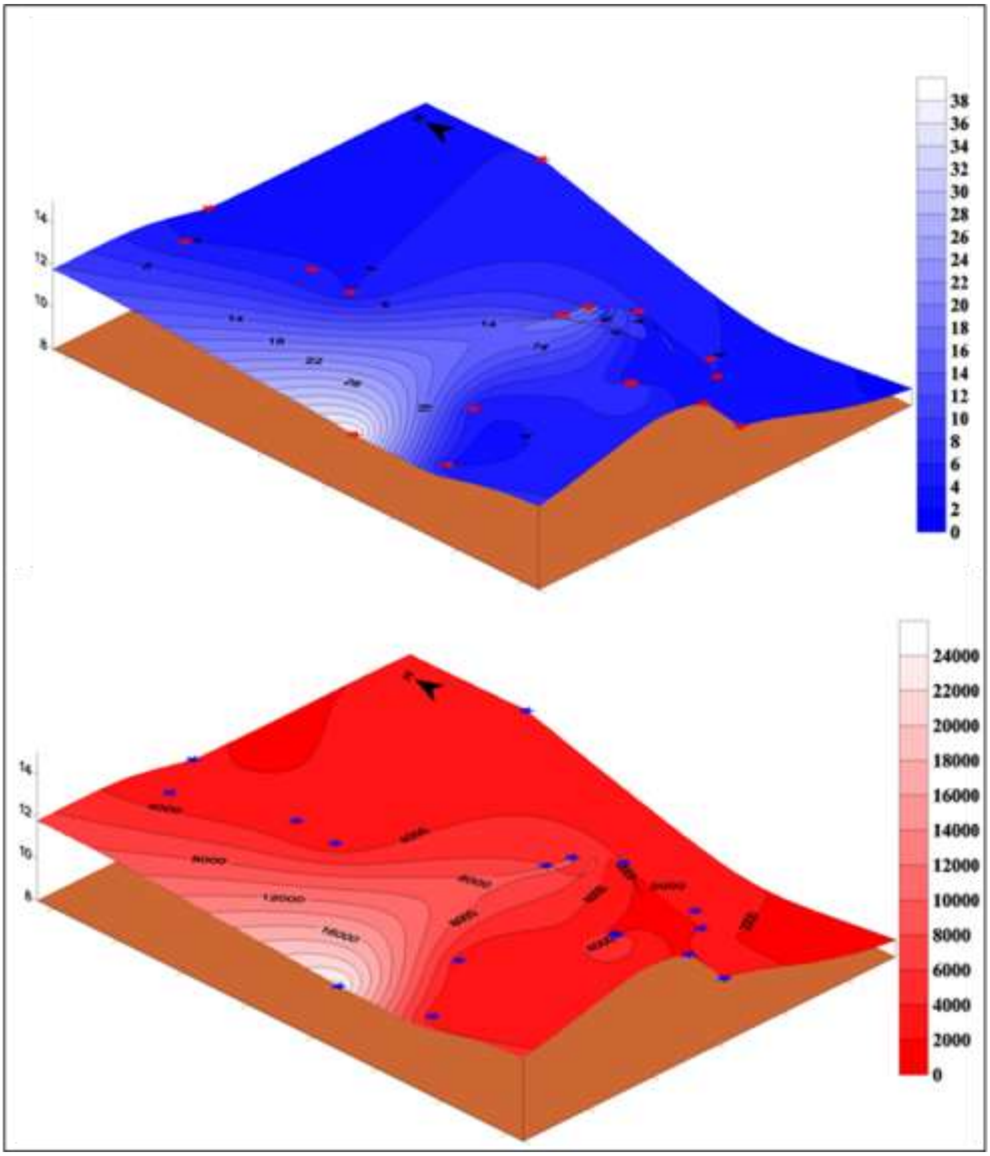

Figure (10): Three dimensions (3D) combined figure of the sample's location post map, area elevation map, and (5-15 cm depth) EC_e contour map with dS/m (upper pan), while the lower pan shows the combined figure of the 5-15 cm depth samples with ppm unit. The red and blue stars are the sample locations, the left side Y-axis represents the sample elevation relative to the sea level, while the blue and red scales columns are the EC_e values with dS/m and ppm units.

The soil desertification classification for the 0-5cm and 5-15cm depth was done using the EC_e values (Sepehr et al., 2007; Armon, 2015). It can said that the areas of the studied samples of the soil of Qalat Suker suffer from a very severe desertification (EC > 15 dS/m), highly desertified areas (EC = 15-8 dS/m), areas with moderate desertification (EC = 4-8 dS/m), and non-desertification zones (EC <4 dS/m) .Figure 11 shows the soil desertification classification according to the 5cm depth samples EC values. The red colored area indicate the very severe desertified area, the pink colored area illustrate the highly desertified areas, the blue areas show the area with a moderate desertification while the non desertified area colored with the green color. Figure 12 shows the soil desertification classification according to the 5-15cm depth samples EC_e values.

When comparing the Figures 11 and 12, it is clear that the areas with very severe desertification (red zone) and the highly desertified areas (pinky zone) in the 5 cm depth map is wider than in the 5-15 cm depth map. While the areas with the moderate desertification (blue zone), and non-desertification zone (green zone) in the 5-15 cm depth map is wider than in the 0-5 cm depth map. This means that the surface soil desertified more than the subsurface soil, this is may be due to the subsurface land use and the weather influence.

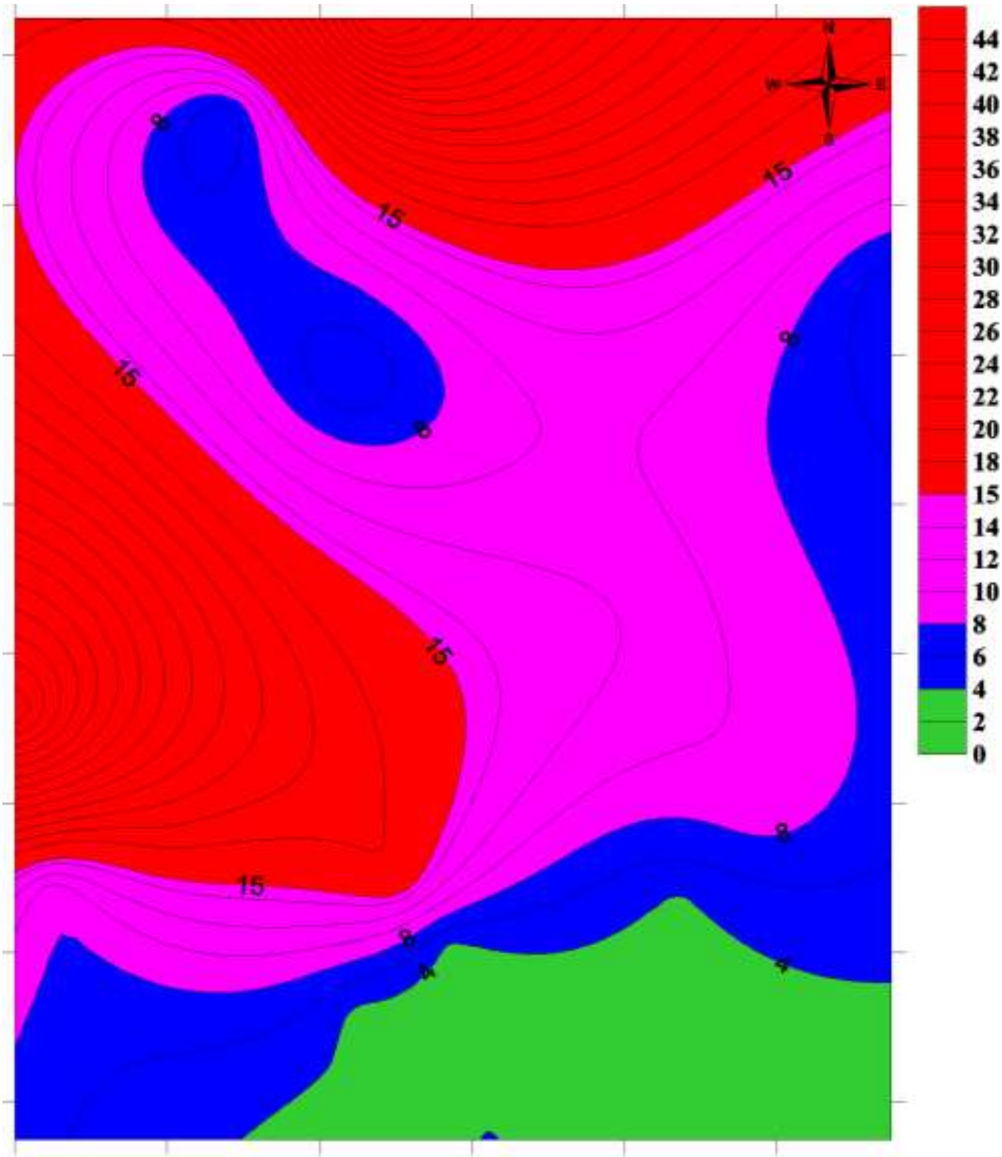

Figure (11): The soil desertification classification for the 0-5cm depth soil samples according the EC_e values, (red: very severe desertification, pink: highly desertified areas, blue: moderate, and green: non-desertification zones.

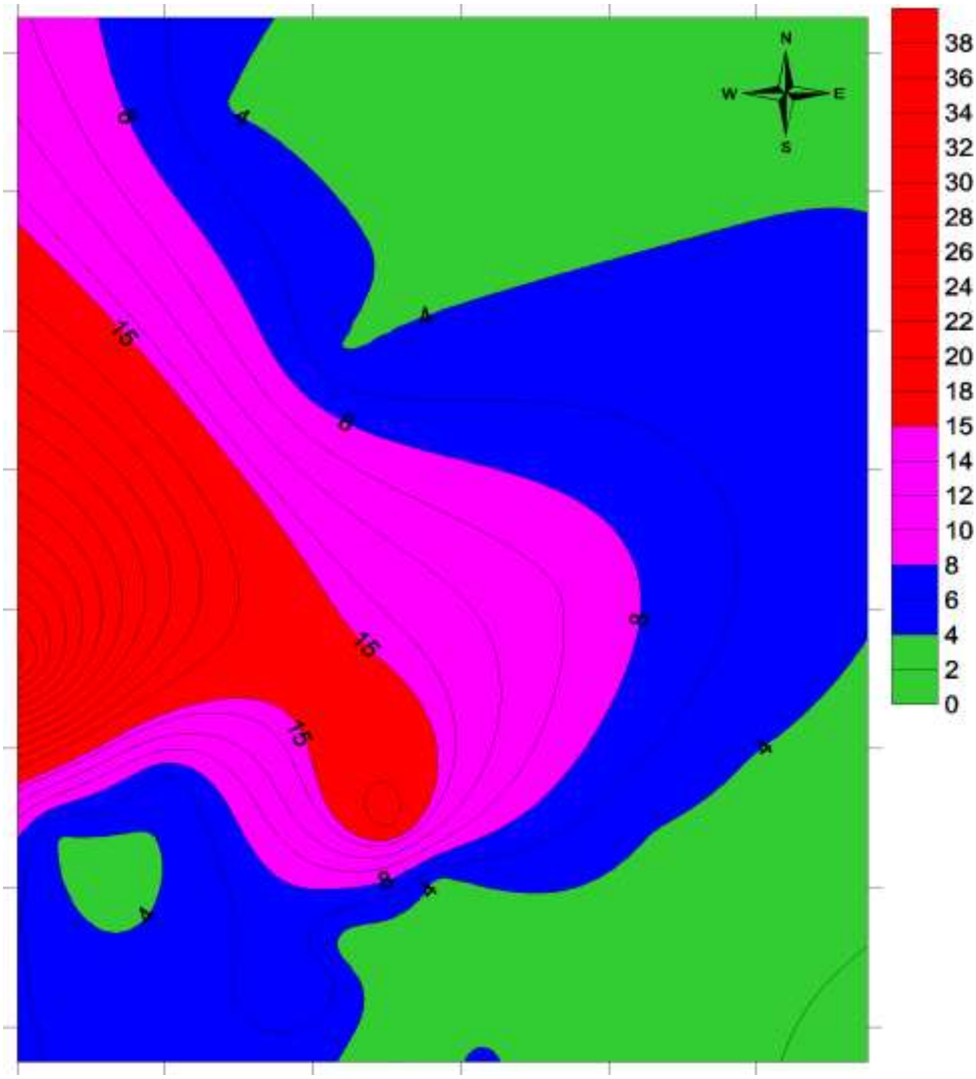

Figure (12): The soil desertification classification for the 5-15cm depth soil samples according the EC_e values, (red: very severe desertification, pink: highly desertified areas, blue: moderate, and green: non-desertification zones.

9- Conclusions

It is concluded from this study that the soil of the Qalat Suker area has different levels of salts depending on the depth. This is what is known by the differences between the EC_e values. For the sample depth 0-5 cm, the EC_e values ranged between 2.2 dS/m (1408 ppm) (Q17) and 48.1 dS/m (30784) (Q6). As for the depth sample 5-15, the values were between 1.9 dS/m (1216 ppm) (Q17) and 39.0 dS/m (24960 ppm) (Q13). In general, the 5 cm depth samples have higher EC_e values comparing with the 5-15 cm depth samples which a result of the evaporation processing on the soil surface.

These differences in EC_e 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 Qalat Suker city suffer from a very severe desertification (EC > 15 dS/m), highly desertified areas (EC = 15-8 dS/m) and areas with moderate desertification (EC = 4-8 dS/m) and non-desertification zones (EC <4 dS/m). The desetified areas in the 0-5 cm depth region are wider than the 5-15 cm depth sample areas which is clear when observing the both maps.

10- Recommendations:

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

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خرائط التوزيع الملحي لنماذج ترب مختاره من مدينة قلعة سكر / ذي قار-جنوبي العراق

د. حسين خليفه جليب[1]

علي سليم خريوت[2]

بتول هاتف كاظم[3]

عطارد طالب كاظم[3]

[1] استاذ مساعد، قسم علوم التربة والموارد المائية، كلية الزراعة، جامعة سومر، ذي قار- العراق

[2]مهندس زراعي

[3]معاون مهندس زراعي، قسم علوم التربة والموارد المائية، كلية الزراعة، جامعة سومر، ذي قار- العراق

المستخلص

رسمت خرائط التوزيع الملحي للتربه في مدينة قلعة سكر في محافظة ذي قار-جنوب العراق ولعمقين 0-5 سم و 5-15 سم ولمساحة اجماليه بلغت 55 كم^2 وذلك بأخذ 34 نموذج تربه بواقع 17 نموذج لكل عمق. تراوحت قيم التوصيليه لنماذج العمق 0-5 سم بين 2.2 ديسيمنز/م (نموذج Q17) و 48.1 ديسيمنز/م (نموذج Q6) بينما تراوحت قيم التوصيليه لنماذج العمق 5-15 سم بين 1.9ديسيمنز/م (نموذج Q7) و 19.7 ديسيمنز/م (نموذج Q13). رسمت خرائط التوزيع الملحي باستخدام برنامج ® Surfer، الاصدار السابع، يلاحظ من خارطة العمق 0-5 سم ان الجزء الشمالي والغربي من المنطقة يهيمنان على قيم التوصيلية العاليه (> 20 ديسيمنز/م) بينما الاجزاء الوسطية والشرقية والجنوبيه تسيطر عليها قيم التوصيلية الواطئه. اما بالنسبة لقيم التوصيلية لنماذج العمق 5-15 سم، فقد بينت خارطتها الكنتورية ان الاجزاء الغربيه تزداد فيها قيمة التوصيله (> 20 ديسيمنز/م)، اما الاجزاء الشمالية والغربيه والوسطى والجنوبيه فان قيم التوصيلية فيها تكون منخفضه.

بصورة عامه يلاحظ ان قيم التوزيع الملحي المتمثل بالتوصيلية الكهربائيه لنماذج العمق 0-5 سم تكون اعلى نسبيا في نماذج العمق 5-15 سم وقد يعزى ذلك الى قرب مستوى الماء الارضي من مستوى سطح الارض والذي يؤدي وبمساعدة الخاصية الشعريه الى ترسيب الاملاح قرب السطح وتحت اعماق ضحله وكذلك ارتفاع درجات الحرارة وازدياد التبخر والذي يؤدي الى ترسيب الاملاح قرب السطح. تم رسم خارطتين تمثلان تصنيف المنطقة حسب درجة

تصحرها وللعمقين المدروسين. الخرائط اوضحت ان المناطق المتصحره للعمق 5-0 سم والقريبة من السطح هي أوسع من مناطق العمق15-5 سم وهذا قد يكون راجعا إلى طريقة ونوعية استخدام الأراضي وتأثيرات الطقس.