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Spatial Analyzing of the Chemical Soil Properties for the Sanam Mountain- Al Zubair Region South of Basra Province and Diagnosis of its Effects on Soil Qualities Using Remote Sensing Technology and GIS

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Abstract. The article discusses the spatial analysis of the chemical soil properties that is a key component of the agriculture ecosystem based on satellite images. The main objective of the present study is to measure the chemical soil properties (total dissolved salts (TDS), Electrical conductivity (EC), PH, Cl^-, Ca^{+2}, K^+, Mg^{+2}, and Na^+) and the spatial variability. On 13 November 2020 (wet season), a total of 12 soil samples were collected in the field through random sampling in the Sanam mountain-Al Zubair region south of Basra province, to contain its soil samples components of minerals and precious elements such as silica and sulfur. From experimental results, the soil sample in the sixth position has the highest concentration of TDS values, reached (5798.4 mg/l), and the soil chemical parameters (EC, Cl^-, Ca^{+2}, K^+, Mg^{+2}, and Na^+, Sodium Adsorption Ratio (SAR), and the percentage of sodium dissolved in the soil (Na%)), which they exceeded the limit when compared with the Iraqi determinants and the World Health Organization determinants. Furthermore, the results showed spatial fitting and a high correlation between Salinity and Sodium Adsorption Ratio in the soil. Anomalies of the pH value (7.05) at the position_10 instead of position_11 (7.1) that has a very strongly saline soil, due to attributed to the presence of sulfur in this position. The article describes the spatial prediction for TDS values through the application of the curve fitting process using soil salinity index was done for the wet season years of (2000, 2005, 2010, 2015, 2018, 2020) and 2020_dry season for each position of the same field samples, to study the extent of the variation that occurred over these years. The highest concentration of TDS values was in positions (4, 6 & 8), as listed in table 5. The spatial analysis and data processing has been carried out using the Quantum Geographic Information System (QGIS 3.16) and Environment for Visualizing Images (ENVI 5.3).

Introduction

The sedimentary plain occupies the largest part of Basra province and a major settlement center for the population in the governorate, where most of the districts are concentrated such as; Al Zubair, Safwan, Al Faw, and Abu Al Khasib. The environmental conditions played a major role in highlighting the salinization process. Where the study region (Sanam mountain-Al Zubair) that chosen in this research suffers from an increase in salinity in some position as a result of due to the region's soil texture, which is characterized as sandy and loamy [1], the lack of water imports, whether from the back of the Qala'a Saleh dam, and the absence of underground basins in the sedimentary plain because this region is located within the territory of the sedimentary plain, which helps to collect water in it and thus dissolve the salts present in the saline formations, and this increases the local concentrations. The Sanam mountain is located in the southwestern part of Iraq, about (45 km) south of Basra, and about (5 km) southwest of Safwan, on the Iraqi-Kuwaiti border, geography. According to the physiographic divisions of Iraq, the composition of this mountain is located within the Dibddiba plain, which belongs to the unstable shelf area of the Mesopotamian Zone. According to the tectonic

divisions of Iraq., this composition is located within the basins area belonging to the area between the two rivers from the land of the introduction to the Arabian plate [2, 3, 4].
The importance of this study is determined and analyzed the deterioration of soil and its other effects as the increase in saline caused serious implications for the environment and social and economic sectors. [5]. Salinity is one of the main and important problems in the southern part of the sedimentary plain, and it is important determinants of irrigated agriculture spread in the central and southern regions of Iraq [6, 7], where a variation in salinity was observed from position to position in study region.
Soils affected by salts are classified according to two main classes; the total content of the dissolved salts (TDS), and the ratio of Na^{+} ions. Accordingly, soils affected by salts were placed into three classes, which are; saline, sodic, and saline-sodic. To study the soil of (Sanam mountain- Al Zubair) region, and determines the damage caused to it as a result of the high salt content in it, the soil samples are selected from separate positions distributed on this region, and its analysis in a laboratory to know its physical and chemical properties. Such as the values of total dissolved salts (TDS), electrical conductivity (EC), pH, and chemical parameters. The concentrations of TDS give the amount of soil salinity, quality, and suitability for agricultural and other uses. The EC reflects the ability of the soil solution to conduct electrical current and its direct relationship to the TDS [8, 9, 10]. By employing modern technologies represented by geographic information systems and remote sensing, the obtained soil samples positions from the fieldwork are projected on the satellite scene and prepare a map for their spatial distribution, using Quantum Geographic Information System (QGIS) program [11]. This program is used to determine the accuracy of spatial prediction for TDS values of the soil samples positions through the integration of the salinity index (SI) for the satellite images of the study region for the wet season of 2000, 2005, 2010, 2015, 2018, 2020, and 2020_dry season years, with TDS values by the curve fitting equation [12]. The curve fitting method was used as one of the most powerful and most widely used analysis tools in origin, to examine the relationship between independent variables (salinity index (SI)) from the satellite image and a response dependent variable (total dissolved salts (TDS)), which obtained laboratory from soil samples using MATLAB program.
Some studies that focus on studying the chemical soil properties occupied the extensive field of researches, such as; Hassan and Al-Shamma, 2019 [13] studied the environmental changes of the area surrounding the Ahdab oil field in Wasit province, using remote sensing techniques and geographic information systems, where the researcher used the vegetation cover index (NDVI) and the salinity index (SI). Satellite images of the sensor TM. They concluded that the area of vegetation cover decreased from 2007 to 2016, and the results of the detection of the salinity index show that the saline soil in 2016 is higher than that of 2007, and accordingly, the results of the detection of change indicate that the study area in the future will suffer from desertification and deterioration the soil. Al-Wali, 2018 [14] built an engineering scale to classify the chemical soil degradation of the soil of the study area, which is located in the south of Babil Governorate, by using geomatical techniques and calculating some salinity and soda indicators responsible for this phenomenon. He reached the prediction values using the multiple regression method with the spectral index (SI) where the numerical values for these spectral indices were extracted by the (Arc GIS) program, and the accuracy of their representation of the real values in the study area was tested with the formulas, linear and logarithmic by the (Microsoft Excel) program. The area of chemically degraded soils and its percentage from the total soil area of the study area were found.

Materials and Methods

The location of the study region: The study region (Sanam mountain-Al Zubair) is located in the southwestern part of Basra province in southern Iraq, within Al-Zubair district between latitude (30° 26′ 56.18" to 30° 7′ 15.40") N in the north, and longitudes (47°26′11.42" to 47°47′26.60") E in the east, and its area is (1127) km^2. The 12 soil samples for separate positions were determined using a GPS device in a UTM coordinate system. Figure 1 (a, b, c & d) shows the location of the study region with Iraq, the positions of the soil samples that projected spatially on the satellite scene (2020_wet season) and the corrected Basra map geometrically, and the pattern of their distribution on the clipped study region using the Quantum Geographic Information System (QGIS 3.16) program. Table 1 lists the available sources of Landsat satellite images for path 166 / row 039 with different times, and (30m) spatial resolution. The available remotely sensed data was downloaded from the website of the United States Geological Survey (USGS) Center for Earth recourses, observation, and science [15].

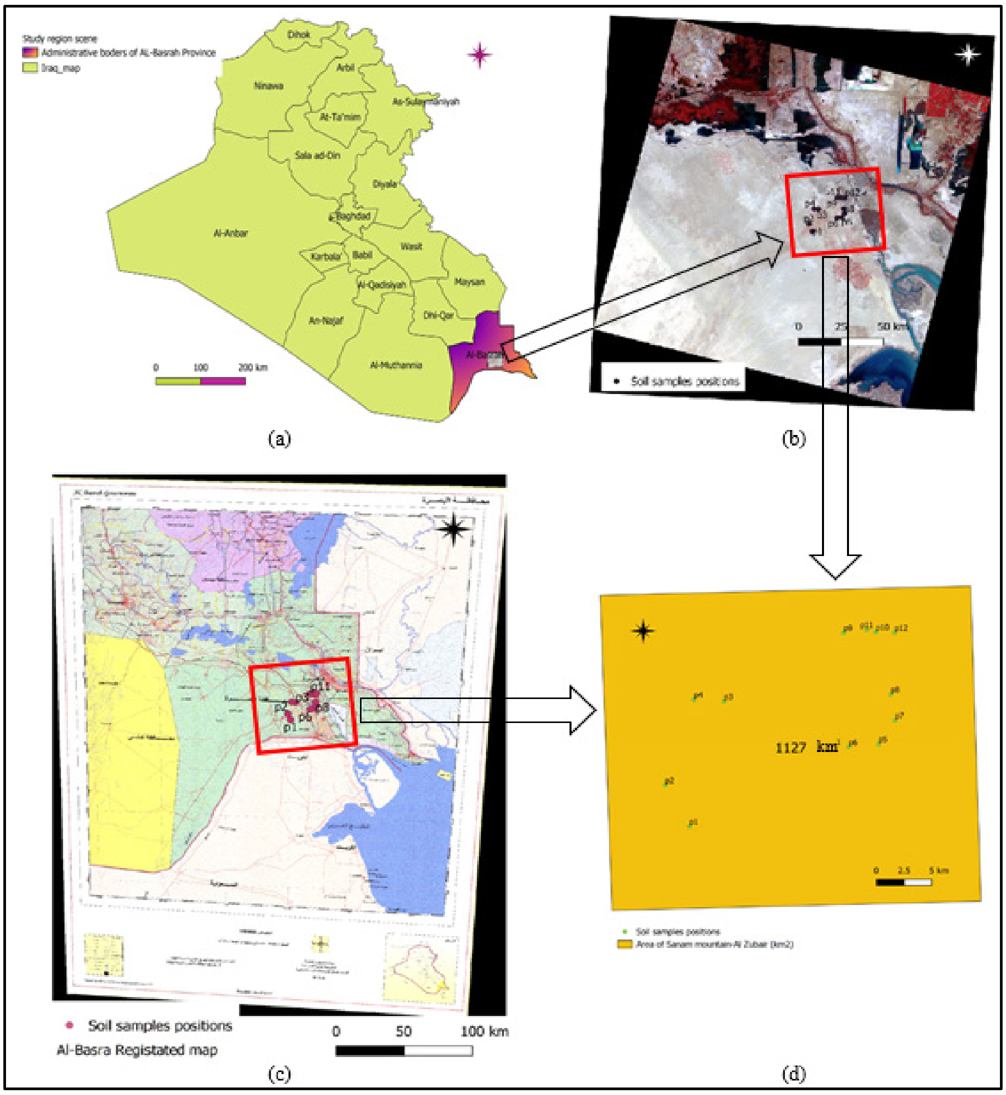


Figure 1. (a) Basra province location of the Iraq map, (b) soil samples positions on the pseudo band combination (NIR, RED &Green) of Landsat_8 OLI scene (2020_wet season), (c) soil samples positions on corrected Basra map, and (d) study region in km^2 with soil samples positions.

Table 1. Coverage region of Sanam mountain- Al Zubair by Landsat images during different years.

N0.	Date	Satellite
1	13 Nov.2000	Landsat_5 TM
2	19 Nov. 2005	Landsat_5 TM
3	16 Oct. 2010	Landsat_7 ETM+
4	20 Sept. 2015	Landsat_8 OLI
5	30 Oct. 2018	Landsat_8 OLI
6	19 Oct. 2020 (2020_wet season)	Landsat_8 OLI
7	31 July 2020 (2020_dry season)	Landsat_8 OLI

The 2020_wet season scene was the last obvious scene was adopted for the 2020 year. The scene date did not match with the collecting field data date, because of the bad weather during the satellite capture period in the wet season.

The real reason for studying this region is because the components of its soil samples contain minerals and precious elements such as silica and sulfur despite the high salinity of some sites and their non-use in agriculture

Fieldwork and laboratory: The 12 soil samples were chosen for separate positions indicated in figure 1c, with a depth of (35-50) cm. The mechanism of soil sample collection was L-shaped to calculate the average of these samples. Each position contains three samples were chosen. The distance between each of the two samples is 20 m, close to the spatial resolution of the Landsat satellite which is 30 m. The Ukr drilling machine was used to collect the samples running on diesel fuel for drilling to a depth of about one meter, where the arm length of the machine is one meter and in a spiral shape. Figure 2 shows position_1 which is located near the Sanam mountain, within the approaches to Sanam mountain in the Safwan region, and how the Ukr machine does the digging at this study position (fieldwork).

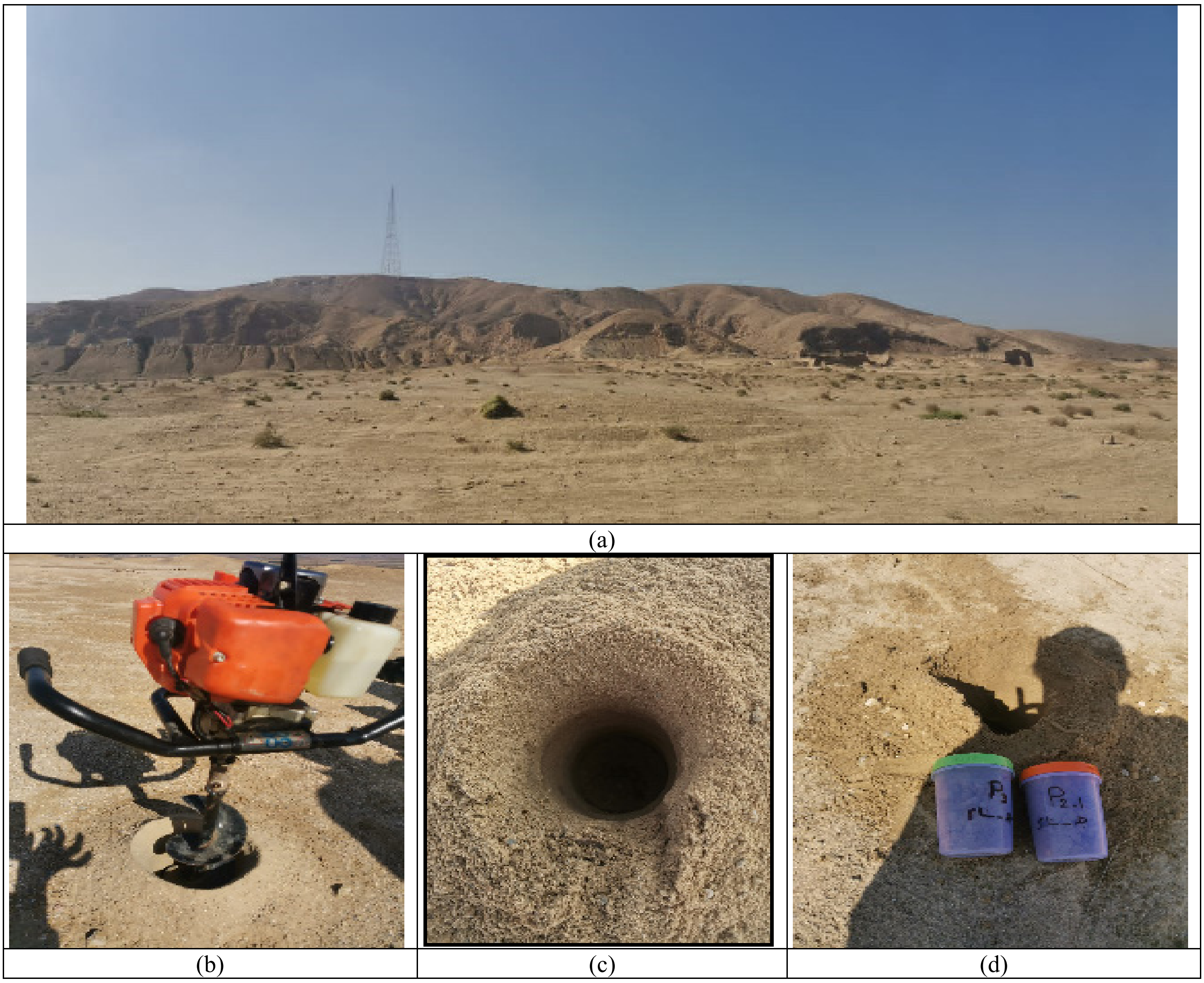


Figure 2. (a) Sanam mountain, (b) the Ukr machine that used in this study, (c) the pit depth of soil sample, and (d) the collecting of soil samples from the study position by special containers.

Soil samples were transferred to the laboratory of the National Center for Water Resources Management to measure its electrical conductivity (EC), pH, and soil chemical parameters (Cl^-, Ca^{+2}, K^+, Mg^{+2} & Na^+), by the following steps:

a) Soil samples were dried in a transparent greenhouse for several days, (see figure 3).
b) Samples were grinded separately with a very fine-toothed mill to obtain a powder for the soil.

c) The sample was sieved using a 2 mm hole sieve and the sample was stirred after sieving to ensure its homogeneity.
d) An aqueous or suspended soil extract was made by adding 1 mm of water per 1 g of dry ground and then the mixture was shaken by a mechanical vibration device (Shaker) for half an hour, and the solution was extracted by filtering this mixture by a filter paper and using a beaker and a glass funnel.


(a)

(b)

Figure 3. The greenhouse for drying soil samples, (a) the samples are inside the greenhouse, and (b) the greenhouse from the outside.

Research Procedures: The research procedures can be described as phases, follow:
Calculate the total dissolved salts (TDS) values using the relationship between its values, and the electrical conductivity (EC) values measured laboratory from soil samples for 2020_wet season, by applying the eq. (1) [16]:

$$TDS = EC \times a, \tag{1}$$

Where the factor a is (0.64), was determined depending on the range of electrical conductivity values presented by Phocaides.
Calculate the Sodium Adsorption Ratio (SAR), and the percentage of sodium dissolved in the soil (Na%)), to determine the extent of soil risk, and whether it could be considered safe for agricultural uses when the concentration of chemical elements in the soil exceeds the permissible limit, using the following eq. (2 & 3) [17, 8]:

$$SAR = \frac{Na^{+}}{\sqrt[2]{\frac{Ca^{+2}+Mg^{+2}}{2}}}, \tag{2}$$

$$Na\,\% = \frac{Na^{+}+K^{+}}{Ca^{+2}+Mg^{+2}+Na^{+}+K^{+}} \times 100, \tag{3}$$

Convert and calibrate the digital number (DNs) to reflectance values of all the adopted scenes on this study for the band combination (NIR, Red, and Green) as preprocessing step, using the eq.(4) printed in spectral math and Landsat calibration utilities tools for the Landsat_8 OLI, Landsat_7 ETM+, and Landsat_5 TM scenes by Environment for Visualizing Images (ENVI 5.3) software, respectively [18, 19].

$$\rho_{\lambda} = \frac{(M_{\rho} \times Q_{cal}) + A_{\rho}}{sin(\theta)}, \tag{4}$$

Where: ρ_{λ}= TOA planetary reflectance, M_{ρ}= Reflectance multiplicative of each band, Q_{cal}= Quantized calibrated pixel value (DN), A_{ρ}= Reflectance additive scaling for the bands, θ = Solar

elevation angle.The ρ_λ, M_ρ , Q_{cal}, A_ρ and θ factors are calculated from the metadata file (MTL file) of a scene.
Implement the salinity index (SI) of 2020_wet scene, given by eq. (5) [20, 21]:

$$SI = \sqrt[2]{Green^2 + Red^2 + NIR^2}, \tag{5}$$

Compare the TDS values for the wet and dry seasons of the 2020 year, using the curve fitting process between the salinity index (SI) values and the laboratory values of TDS calculated in phases 1 & 4, by the MATLAB program, for defining the best fit model of the relationship. Our experimental results showed that the best curve fitting equation is determined by the second-order of a polynomial function, can be defined using eq. (6):

$$TDS = -\,4438.014 \times SI^2 + 5807.005 \times SI + 726.016\ , \tag{6}$$

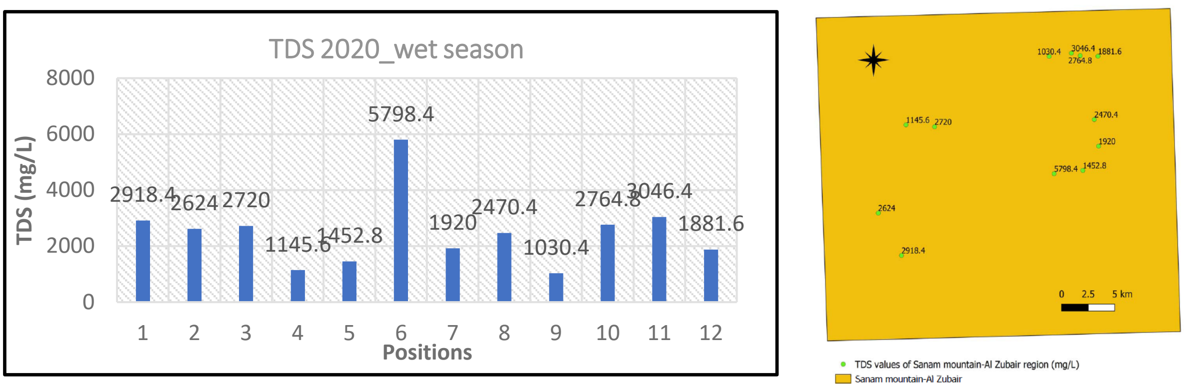
Spatial predict the TDS values for the previous wet season years of (2000, 2005, 2010, 2015, 2018) and 2020_dry season for each position of the same soil samples through the integration between the fieldwork values and the spectral values obtained from the remote sensing data, to study the variation within the period (2000-2020), using eq. (6).

Results and Discussion

Total Dissolved Salts (TDS): The values of the total dissolved salts for the soil samples of the study region in the 2020_wet season ranged between (1030.4-5798.4) mg/L, as shown in figure (4a), which was obtained from electrical conductivity (EC) laboratory values, by applying eq. (1). These values are not in accordance with the Iraqi specifications and the World Health Organization (WHO) specifications permitted [22, 23], which is (500-1500) mg / L. The distributed values of the study region were classified into two classes

- Strongly saline soil class represented a percentage (75%) of the total number of soil samples for (2, 3, 4, 5, 7, 8, 9, 10, and 12) positions, were ranged between (1030.4-2764.8) mg/L.
- Very strongly saline soil class represented a percentage (25%) of the total number of soil samples for (1, 6, and 11) positions, were ranged between (2918.4-5798.4) mg/L.

The TDS, EC, and pH results of the samples obtained from the laboratory results of analyzing the soil samples for the study region were dropped on the study area map, using the (QGIS) software, as shown in figures (4b, 6b & 8b).



(a) (b)

Figure 4. (a) TDS values for each position, and (b) its distribution on the Sanam mountain-Al Zubair region in 2020_wet season.

There is a disparity between TDS values of soil samples in the study region, as (2, 3, 4, 5, 7, 8, 9, 10, and 12) positions, which are located near the Sanam mountain within the approaches to Sanam mountain, near the border region of Safwan, near Al-Zubair desalination station, near the asphalt plant, adjacent to the Safwan highway leading to the border region, on the Safwan highway near the

Safwan gas station, near Al Najat school, adjacent to the highway linking Al Zubair and Safwan, and on the second side of the highway between Al Zubair and Safwan, respectively. These positions have the lowest salt concentration due to, the soil texture type for these positions is sandy, which does not retain salinity because of the washing operations. Therefore, the type of soil is suitable for irrigation and agricultural of plants whose roots are fibrous, pistachio, and tomato crops which tolerate the salinity within ranges, from (1030.4 to 2764.8) mg/L, provided the soil and good drainage are taken care of.

The (1, and 11) positions, which are located specifically near the Sanam mountain, within the approaches to Sanam mountain in the Safwan region, and near the highway Al Zubair-Safwan, which has the highest salty. Through the results, it appears that there are simple to very severe determinants, to grow some crops with care soil drains, as growing wheat, barley, yellow corn, and sunflower crops. This is due to the high salt content in the soils of the study region, for several factors, including; the soil of the region was originally formed because of rocks containing a high number of salts, the lack of rain, and the location of the region within the range of dry or semi-arid regions. The soil texture type of (1, 6 & 11) positions is loamy, its porosity is very low and retains its moisture for a longer time than other soil types, and the process of washing them is more difficult. The soil type of Sanam mountain region is rocky, most of the rocks suffered from mechanical and chemical erosion factors due to rain and wind, and the great discrepancy between day and night temperature, which has a noticeable effect on the mountain rocks and the surrounding regions. The soil texture of the selected soil samples positions are; sandy, sandy clay, loamy and some regions are calcareous.

Increase soil salinization is led to the disability to agriculture in those positions, therefore, they are not suitable for agricultural and other purposes. as illustrated in position_6. This position is located near the sports club on Al Zubair-Safwan road, where the percentage of salts are reached (5798.4) mg/l, listed in table 2, it is considered a very high percentage compared to positions (1 & 11). According to UNESCO classification, the TDS value is an acute problem in this position, and the land cannot be used to agriculture the crops even when well-drained soil is available. In addition to the high concentrations of chlorides (Cl^{-}), which is (2321) mg/l, more than (600) mg/l, calcium (Ca^{+2}) which is (740) mg/l, more than (200) mg/l, magnesium (Mg^{+2}) which is (192) mg/l, more than (120) mg/l, sodium (Na^{+}) which is (1012) mg/l, more than (200) mg/l, and potassium (K^{+}) which is (44) mg/l, more than (12) mg/l, which exceeded the permissible limit, when compared with the Iraqi determinants and the World Health Organization determinants. The reason is due to the geological nature of these positions. Where the increase in the salinity of the soil of this region is the result of the absence of underground basins in the sedimentary plain because this region is located within the territory of the sedimentary plain, which helps to collect water in it and thus dissolve the salts present in the saline formations, and this increases the local concentrations. As well as, there are no drains to wash the soil in these regions and drain the salt water, thus, the salts will accumulate and lead to soil degradation. This position is very far from the drain and the saltiest position.

All the mentioned positions and listed in table 2 were of different depths. The standard depth of Ukr device is 1 m. Due to the presence of sedimentary barrier formed of silica layer under the soil sample layer in these positions, and which impeded the drilling process, as a result, drilling was stopped at the mentioned depths in table 3. The silica layer appeared at different depths, as the positions (1, 2, 3, 6, 8, 10 & 11). So, some of these samples were closer to the surface land, such as (1, 6 & 11) positions, the depths of these positions were (1, 6, & 11) are 36 cm, as one of the reasons for an increase in the concentration TDS. The surface layer is more exposed to climatic factors, and because the sub-surface layer is silica layer in these positions, it does not allow the process of washing the soil by rain, in an ideal way, and water accumulates. When the temperature is rised and evaporated, the water evaporated a second time, and salts were deposited on the soil. This is also called the Sabkhah phenomenon is a white layer that formed on the surface of the soil in the form of spots. The presence of the sedimentary barrier of the silica layer, that was formed from the sediments of the elements, leads to a change in the structure of the soil and some physical properties, thus reducing the permeability of these soils, which leads to the retention of salts in them and the difficulty of washing operations. Figure 5. illustrates the silica substance (sedimentary barrier) under the soil sample layer for some positions of the study region near Sanam mountain.

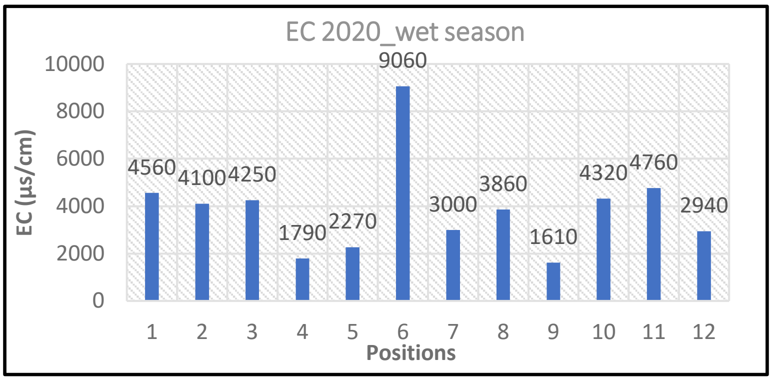
Table 2. Chemical parameters of soil samples in the study region.

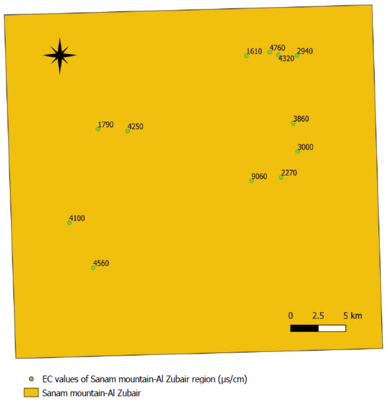
Soil samples positions	longtude (°)	latetude (°)	PH	Na%	SAR	EC	TDS	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Cl^{-}
					$(mg/l)^{0.5}$	µs/cm		mg/l				
1	47.51936111	30.20841667	7.05	29.128	14.223	4560	2918.4	680	84	278	36	596.4
2	47.49669444	30.24852778	7.16	25.573	11.217	4100	2624	600	81	207	27	426
3	47.55172222	30.33011111	7.4	28.215	13.601	4250	2720	620	72	253	19	5112
4	47.52366667	30.33194444	7.22	31.170	8.329	1790	1145.6	220	24	92	18.5	191.7
5	47.69622222	30.28883333	7.19	9.576	2.298	2270	1452.8	480	96	39	22	49.7
6	**47.66827778**	**30.28572222**	**7.05**	**53.118**	**46.879**	**9060**	**5798.4**	**740**	**192**	**1012**	**44**	**2321**
7	47.71166667	30.31180556	7.45	13.950	5.064	3000	1920	600	60	92	15	142
8	47.70755556	30.337	7.26	21.887	9.751	3860	2470.4	640	72	184	15.5	440
9	47.66336111	30.39669444	7.22	14.956	3.507	1610	1030.4	260	84	46	14.5	56.8
10	47.69366667	30.39741667	7.3	32.286	17.514	4320	2764.8	680	96	345	25	553.8
11	47.68519444	30.39977778	7.1	49.370	36.480	4760	3046.4	680	84	713	32	745.5
12	47.71111111	30.39686111	7.19	32.919	16.611	2940	1881.6	600	48	299	19	134.9

Figure 5. Silica layer.

Electrical Conductivity (EC): Figure (6a) shows that the electrical conductivity obtained values from a laboratory of soil samples for the study region in the 2020_wet season ranged between (1610-9060) µs/ cm. When compared with the Iraqi and international standards permissible (500-1500) µs/cm, it found that very high, attributed to the positive relationship between the total dissolved salts (TDS) and electrical conductivity (EC), as illustrated in figure 7. The EC of the soil samples in this region on 2020 wet season was divided into two classes:

- Soil class with high conductivity values represented (50%) percentage of the total soil samples for (2, 3, 4, 5, 7, 8, 9, 10, and 12) positions, were ranged between (1610-4320) µs/cm.
- Soil class with very high electrical conductivity values constituted (50%) a percentage of the total soil samples for (1, 6, and 11) positions, were ranged between (4560-9060) µs/cm.





(a) (b)

Figure 6. (a) EC values for each position, and (b) its distribution on the study region in 2020_ wet season.

The lowest values of the EC were in (2, 3, 4, 5, 7, 8, 9, 10, and 12) positions, and the greatest values for the EC were at the (1, 6, and 11) positions.

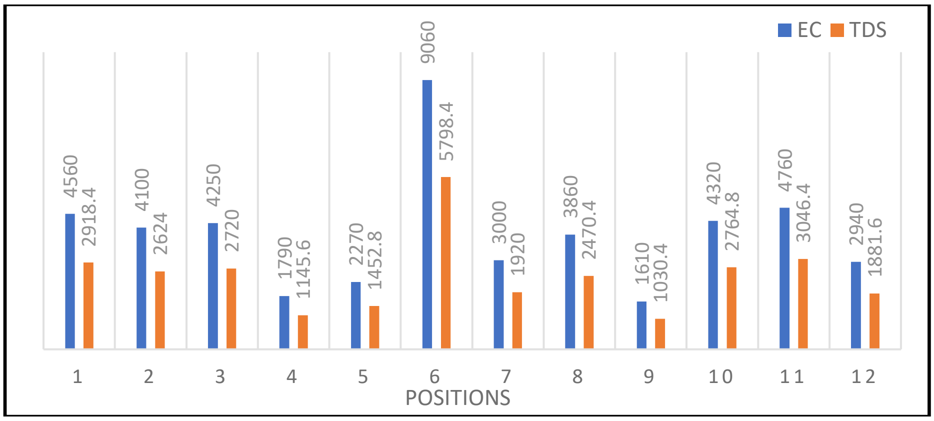
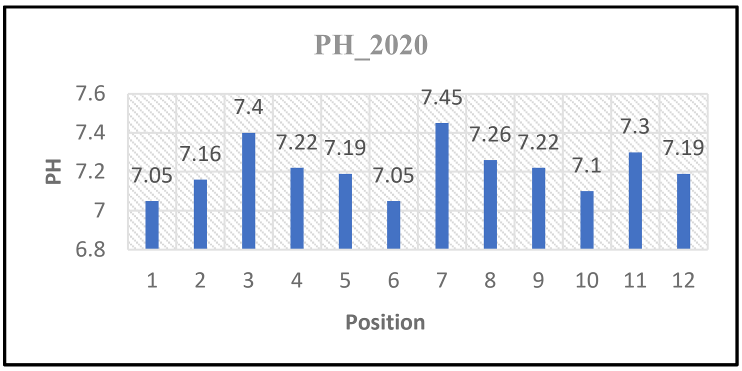
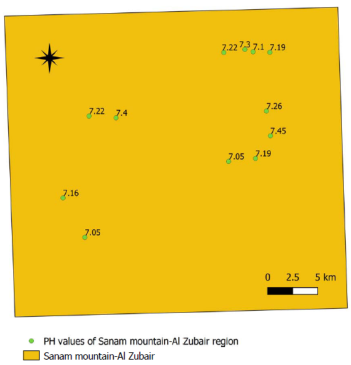


Figure 7. The relation between the TDS and EC values.

Soil reaction-PH: The degree of soil reaction (PH) is also an indicator of soil quality and it normally ranges from (6.5 to 8.5) for the Iraqi specifications and the World Health Organization specifications. The PH values obtained in a laboratory of soil samples from the fieldwork of the study region ranged between (7.05-7.45), within the permitted extent. The classification of soil samples based on the degree of their reaction (PH) into two classes:

- Mildly class values represented (83%) percentage of the total soil samples for (1, 6, and 10) positions, were ranged between (7.05-7.1).
- Mildly alkaline class values represented (17%) percentage of the total soil samples for (2, 3, 4, 5, 7, 8, 9, 11, and 12) positions, were ranged between (7.15-7.45).





(a) (b)

Figure 8. (a) PH values for each position, and (b) its distribution on the study region in 2020_ wet season

As shown in figure (8a), the pH values were at the lowest value in the (1, 6, and 10) positions, where the soil in the (1 & 6) positions suffer from salinization. In (2, 3, 4, 5, 7, 8, 9, 11, and 12) positions, the pH values were the highest value, the soil of these positions tended towards the alkaline, except (1, 6, and 10) positions. Some soil sample sites are affected by different levels of salinity and alkaline. The PH values have an inverse relationship with the values of total dissolved salts (TDS) which is one of the formulas of sodium chloride, and thus the presence of these salt will reduce the effect of other ions, and thus the pH value will decrease with the increase of the salinity, as shown in figure 9. The reason for the lower PH value at position_10 rather than at position_11, attributed to the presence of sulfur in some soils of these regions, which was distinguished by its pungent smell through the fieldwork, being it is aligned to oil fields or oil wells, lead to mitigation of the alkaline of the soil, especially since these regions have the long term exposure to this type of pollution. Generally, in wet and torrential rain regions, the soils are acidic. Because the water permeation successively through the layers of the earth, it dissolves and transfers various ground cations (positively charged ions), such as calcium, sodium, and others. Hydrogen replaces these cations on the soil surface, and the opposite occurs in the dry regions as it is in the study region. The values of the degree of soil reaction (PH) ranged between (7.05-7.45), without any determinants for agricultural use and growing crops.

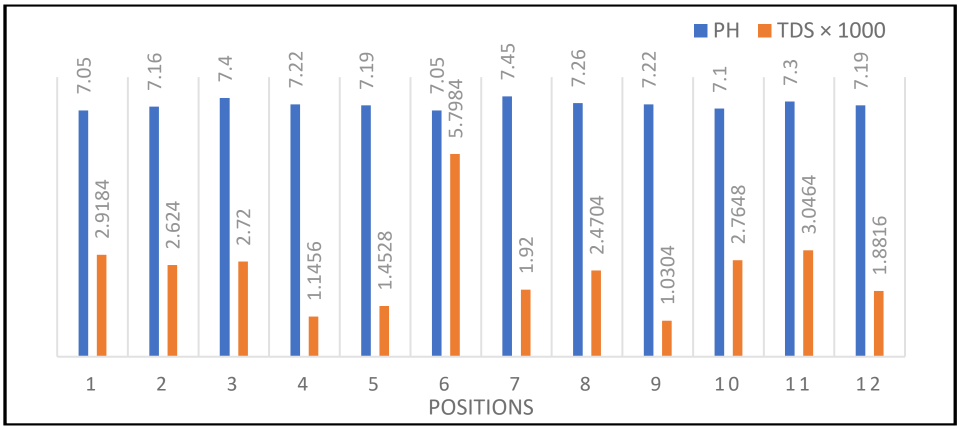


Figure 9. The relation between the TDS and PH values.

The spatial analysis of TDS, EC, and pH for the soil are influenced by structural factors, such as climate, parent material, topography, soil texture, and other natural factors.

The effect of SAR and Na% on the soil samples: One of the most important fieldwork and laboratory tests that have a direct effect on the salinity and sodic soils for the soil samples of the study region to be performed is mainly by measuring the chemical parameters (electrical conductivity (EC), sodium adsorption ratio (SAR), and the percentage of sodium dissolved in the soil (Na%)). The decrease in the values of these parameters will place the soil of the region within the suitable varieties for safe use. The values of SAR, and (Na%), were represented a percentage (50%) of the total number of soil samples for the study region is a soda saline soil within the range of chemically and morphologically degraded soils, it is considered a saline desert due to the high concentration of sodium, where ranged from (46.879 in position_6 to 2.298 in position_5), and (53.118 in position_6 to 29.576 in position_5), respectively. The high values of the SAR and Na% in the (1, 3, 6, 10, 11 & 12) positions indicate a high relation with the TDS values of soil samples. As the sodium ion is abundant between the soil solution and its colloids, which shows the soil morphology in a dark color which is known as the Shurah phenomenon. At position_6, the sodium ion concentrations increased to the extent that it displaces calcium and magnesium ions from the colloid exchange complex into the soil solution, transforming the soil into a bright morphological appearance (white), which is known as the Sabkhah phenomenon which represents the maximum state of chemical degradation in the soil. The high SAR contributes to increasing the (Na%) in the soil, which is negatively reflected in the poor water, air, and thermal conductivity of the soil, as well as the hardening of the soil and the difficulty of conducting agricultural operations in it with problems in the readiness of a significant number of nutrients due to raising the value of soil reaction to alkaline boundaries.

Variation of TDS values for 2020 wet and dry seasons: The TDS values of the 2020_wet season for soil samples (fieldwork output) illustrated in figure 4 are compared with the TDS values of the 2020_dry season were obtained from the curve fitting process (curve fitting output), using SI values of 2020_ dry season satellite scene, (see eq. (6)), to analyze the variation between two seasons (see figure 10). The concentrations of the total dissolved salts (TDS), were ranged (from 1030.4 mg/l in position_9 to 5798.4 mg/l in position_6, and (2444.259 mg/l in position_10 to 2614.389 mg/l in position_4) mg/l, for the 2020 wet and dry seasons.

These variations are due to several reasons, including:

1. As a result of washing the soil with rainwater, where the rainwater dissolves the salts in the subsurface layer. When the temperature increases, this water evaporates and leaves the salts visible on the surface of these soils.
2. With the nature of the geological area and the lack of permeability of the soil, salts are difficult to absorb.
3. A sedimentary barrier formed of silica under the soil sample layer.
4. The difference in the soil samples' depths is listed in table 3. The surface layer is more exposed to climatic factors, and because a sedimentary barrier formed of silica under the soil sample layer, it does not allow the process of washing the soil by rain, in an ideal way, and water accumulates. When the temperature is raised and the evaporation, the water evaporated a second time, and salts were deposited on the soil. This is also called the " Sabkhah " phenomenon (a white layer is formed on the surface of the soil in the form of spots), as the soil sample at position_6, which is the saltiest.
5. The soil texture of some samples positions is sandy (which does not retain salinity because of the washing operations) and loamy (Its porosity is very low and retains its moisture for a longer time than other soil types, and the process of washing them is more difficult).
6. The difference in the quantities of discharges from the Qalaat Saleh dam, which reached in the dry season 81 m3/s, and in the wet season 101 m3/s, as their height or decrease plays a large role in the rise and fall of salinity values.
7. 6.In addition to the influence of climatic factors on the study region (rain and humidity), where the relative humidity of the dry season reached (20%) at a temperature of (48) c°, and for the wet season, the humidity was (60%) at a temperature of (35°). The average rainfall for the dry and wet seasons was reached 0.0001 mm and 33 mm, respectively [24, 25].

Table 3. The depths of soil samples for Sanam mountain- Al Zubair region

Positions	**Soil samples depth (cm)**
1	35
2	40
3	40
4	50
5	50
6	35
7	50
8	40
9	50
10	40
11	35
12	50

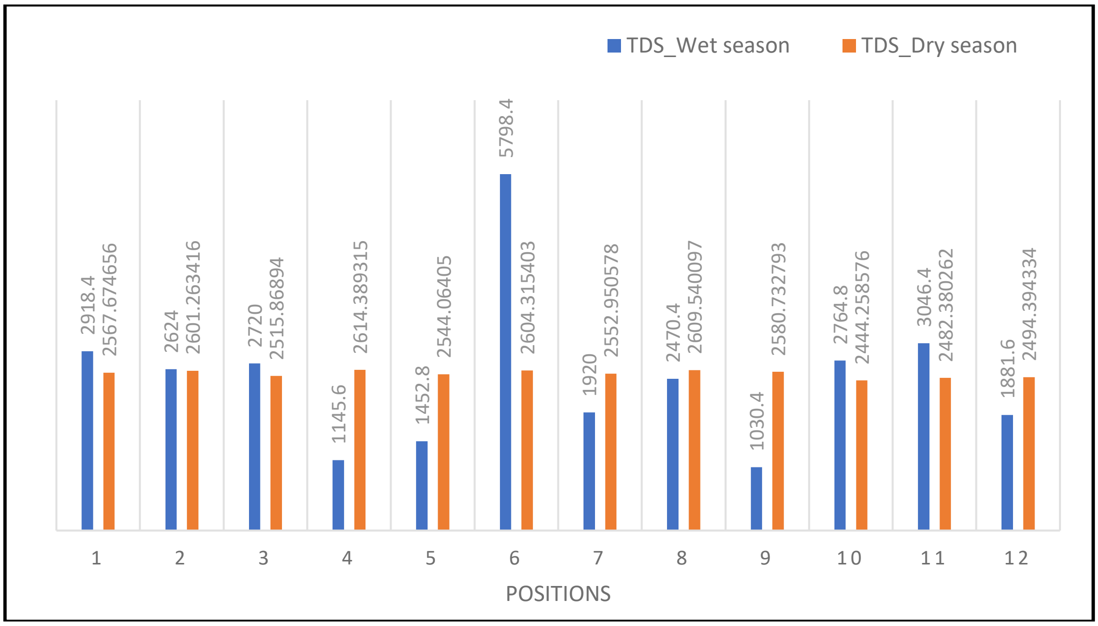


Figure 10. The variation between the TDS_wet season of soil samples (fieldwork output) with TDS_dry season for the year 2020 (curve fitting output).

Spatial prediction of TDS values using salinity index over 20 years from 2000 to 2020: To study the extent of the variation in the total dissolved salts (TDS) concentration for the (2000-2020) years for the soil samples positions of the study region, the TDS values for the wet season years of 2000, 2005, 2010, 2015, 2018, 2020, and 2020_dry season are calculated (see table (4)). The wet season years for the period between 2000 to 2020 were chosen as the best time to study the TSD in the soil In this research. Where the water releases increase in September month, due to the rainy season in Turkey starts in this month, so the water shares of Iraq are increased. The highest concentrations of TDS during the mentioned years were at the following positions:

1. The position_4 in two years (2010 and 2020_dry season). The precipitation average for these years was reached to (0.0 & 0.05) mm at a temperature of (38.3 & 48) c°, and the relative humidity (66 & 99) %, respectively.
2. The position_6 in three years (2000, 2005, and 2020_wet season). The precipitation average was reached (5.4, 9.7 & 33) mm at a temperature of (25, 26 & 35) c°, respectively.
3. The position_8 in two years (2015 and 2018). The precipitation average was (5) mm for two years at a temperature of (21 & 12) c°, and the relative humidity (83 & 86) %, respectively.

Table 4. TDS values of the adopted years (2000-2020) in this study for each position.

Positions	TDS 2000 (mg/l)	TDS 2005 (mg/l)	TDS 2010 (mg/l)	TDS 2015 (mg/l)	TDS 2018 (mg/l)	TDS 2020_wet season (mg/l)	TDS 2020_dry season (mg/l)
1	2489.309	2285.225	2154.991	2571.071	2543.823	2918.4	2567.675
2	2449.247	2252.777	2213.461	2587.093	2543.703	2624	2601.263
3	2409.155	2184.570	2086.784	2552.496	2560.036	2720	2515.869
4	2272.072	2288.168	2311.018	2573.982	2587.588	1145.6	2614.389
5	2323.418	2221.535	2000.046	2559.496	2528.07	1452.8	2544.064
6	2495.156	2295.954	2260.455	2607.391	2552.951	5798.4	2604.315
7	2437.010	2222.605	2043.902	2561.218	2325.961	1920	2552.951
8	2483.017	2237.182	2295.713	2624.764	2608.729	2470.4	2609.54
9	2428.500	2289.146	2029.027	2467.336	2219.927	1030.4	2580.733
10	2076.842	1852.627	1977.18	2429.248	2199.551	2764.8	2444.259
11	2204.486	1894.640	2029.027	2505.736	2228.999	3046.4	2482.380
12	2152.965	1903.259	1856.328	2338.059	2211.836	1881.6	2494.394

This increase in the values of the total dissolved salts for these positions is attributed to several causes, including the soil texture in these regions as their sandy or loamy, the effect of the lack of water discharges from the rear of the Qal'at Saleh dam, which reached of the years 2000, 2010 and 2015 to (51, 49 and 53) m^3/sec, and the difference of seasons in position_4. Likewise, the role of climate elements in the soil salinity of these positions, which have a little vegetation cover, where they directly expose to solar radiation, with variation in the amount of precipitation, temperatures, and relative humidity. They suffer from high evaporation, which helps to concentrate salts in them. In addition to the available data (scenes) were not downloaded on the same date due to the bad climate during the satellite capture period in this season, as shown in table 1.
Table 5 displays a summary for the highest concentrations of TDS values, as the results of a comparison between the adopted years (2000-2020) on this research.

Table 5. The highest TDS values for the soil sample positions for the period (2000-2020).

Position	Position name	Year	TDS (mg/l)
4	Al-Zubair desalination station	2010 & 2020_dry season	2311.018 & 2614.389
6	The sports club on Al Zubair-Safwan road	2000, 2005 & 2020_wet season	2495.156, 2295.954 & 5798.400
8	The Safwan highway near the Safwan gas station	2015 & 2018	2624.764 & 2608.729

Conclusions

Through the laboratory analyzes of the separate soil samples for the study region in 2020_wet season, was found the TDS values ranged between (1030.4) mg/l in poition_9 near Al Najat school to (5798.4) mg/l in poition_6 near the sports club on Al Zubair-Safwan road.
Some of the soil sample positions suffer from severe salinization, especially in position_6 (near the sports club on Al Zubair-Safwan road). The soils that contain large concentrations of TDS and sodium ion (Na+) with PH no more than 8 are called saline-sodic soils.
Salinity directly affects the growth and development of plants. As that the sodium conditions (increased relative sodium concentrations (Na %), may cause a significant deterioration in the physical properties of the soil, it forms a surface crust that prevents water penetration into the soil and reduces aeration. Increasing the concentrations of chemical elements such as chlorine, calcium, magnesium, and potassium at high levels in the soil, so that they are toxic to plant growth, which leads to deterioration of the soil structure, reduced movement of water, air, and nutrients, and hindered the extension of roots due to mechanical resistance. So, some of the soil samples positions for the study region unfit for agriculture and other uses.
The high level of salinity in position 6 can be attributed to several factors, the soil texture, the absence of drains to wash the soil of this region and drain the saltwater, thus salts will accumulate and leads to soil degradation, the scarcity of water imports that affects this geographical region, as one of the most important causes of soil salinization and the level of region in this position is lower than the surrounding areas. In addition to the varying depth of the sample in this position of the study region due to the presence of sedimentary barrier formed of silica layer under the soil sample layer. It leads to a change in the soil structure and some physical properties, thus reducing the permeability of these soils, and leads to the retention of salts in them and the difficulty of washing operations. The geological formations also play a role in the concentration of salts in this region's soil.
In (4 and 9) positions near Al Zubair desalination station and Al Najat school, the EC value was more than 1500 µs/cm, and the SAR value low than 15 %, as illustrated in table 2. Therefore, the soil of these positions is saline does not affect the agriculture of crops. Because the land of the study region is sandy soil, that does not retain salinity as a result of soil washing operations by rain or irrigation

operations. Therefore, the type of soil is suitable for growing tomato plants, and plants whose roots are fibrous that tolerate the rate of this salinity.
Since Sanam mountain and its surroundings are a desert area and its soil is salty and there are no surface water sources, it is proposed to dig wells and improve the quality of its water using magnetic water devices and use that water in agriculture as well as in other uses. Cultivation of this region with plants that tolerate salinity to take advantage of this region and to increase the vegetation cover. As well as, increasing the water emissions from the rear of the Qala'a Saleh regulator is suggested. Results of the research may be useful for land and water management for works related to this region being this region is suffered from the scarcity of arable land.

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References

[1] R. Jafari, M. M. Lewis and B. Ostendorf, "An image-based diversity index for assessing land degradation in an arid environment in South Australia," *Journal of Arid Environments,* vol. 72, no. 7, pp. 1282-1293, 2008.

[2] V. K. Sissakian, N. Al-Ansari and S. Knutsson, "Geomorphology, Geology and Tectonics of Jabal Sanam, Southern Iraq," *Journal of Earth Sciences and Geotechnical Engineering,* vol. 7, no. 3, pp. 97-113, 2017.

[3] R. W. Fairbridge, The Encyclopedia of Geomorphology, 1 ed., New York: Reinhold, 1968.

[4] B. Soltan, A. Al-Fregi and Z. A. Abdulnabi, "Petrogenesis of sedimentary ironstones in jabal sanam structure southern Iraq," *MARINA MESOPOTAMICA ,* vol. 22, no. 1, pp. 93-105, 2007.

[5] G. A. K. Hussain, "Study of Some physical and chemical properties of sand dune of lower Mesopotamian Plain," *Ibn Al-Haitham Jour. for Pure & Appl. Sci.,* vol. 22, no. 1, pp. 33-50, 2009.

[6] L. A. Richards, Diagnosis and Improvement of Saline and Alkaline Soil, Washington: USDA, 1954.

[7] H. M. Abduljabbar, A. J. Hatem and A. A. Al-Jasim, "Desertification Monitoring in the South-West of Iraqi Using Fuzzy Inference," *NeuroQuantology,* vol. 18, no. 5, pp. 01-11, 2020.

[8] D. K. K. Al-Khuzaie, "Physio-chemical properties of tidal flats sediments In iraqi coastline, northwest of arabian gulf," *Iraqi Geological Journal,* vol. 53, no. 2E, pp. 107-116, 2020.

[9] A. H. Al-Zubaidi, "Soil salinity, theoretical and applied foundations," University of Baghdad, Baghdad, 1989.

[10] M. A. Al-Dabbas, "High concentrations of boron in groundwater at the safwan – zubair, and karbala – najaf areas s. and m. Iraq," *Iraqi Geological Journal,* Vols. 34-38, no. 1, pp. 122-133, 2005.

[11] T. A. H. Naji and A. J. Hatem, "New Adaptive Satellite Image Classification Technique for Al habbinya Region West of Iraq," *Ibn Al-Haitham Jour. for Pure & Appl. Sci.,* vol. 26, no. 2, pp. 143-149, 2013.

[12] T. A. H. Naji and H. M. Abduljabbar, "The seasonal effect on the water bodies in Iraqi Marshlands," *Plant Archives,* vol. 19, no. 2, pp. 4397-4403, 2019.

[13] R. A. Hassan and A. Al-Shamma, "Environmental change detection using remote sensing and gis techniques in the area around al-ahdeb oil field, wasit governorate, iraq," *Iraqi Bulletin of Geology and Mining,* vol. 15, no. 1, p. 123–133, 2019.

[14] O. M. AL-Waeli, "Geometric scale building for soil chemical degradation classification by remote sensing data using," *Iraqi Agricultural Research Journal,* vol. 23, no. 2, pp. 44-54, 2018.

[15] U. S. G. Survery, "Earth Explorer-Home," 2020. [Online]. Available: https://earthexplorer.usgs.gov/.

[16] A. Phocaides, Handbook on pressurized irrigation techniques, Second Edition ed., Rome, Italy: FAO, 2007.

[17] M. Seilsepour, M. Rashidi and B. G. Khabbaz, "Prediction of Soil Exchangeable Sodium Percentage Based on Soil Sodium Adsorption Ratio," *American-Eurasian J. Agric. & Environ. Sci.,* vol. 5, no. 1, pp. 1-4, 2009.

[18] H. M. Abduljabbar and T. A. H. Naji, "Separating the terrain cover of Iraqi marshes region using new satellite band combination," *Iraqi Journal of Agricultural Sciences,* vol. 51, no. 6, pp. 1504-1516, 2020.

[19] M. A. Mohammed, T. A. H. Naji and H. M. Abduljabbar, "The effect the activation functions on the classification accuracy of satellite image by artificial neural network," *Energy Procedia,* vol. 157, pp. 164-170, 2019.

[20] M. H. Mahdi and H. M. Abduljabbar, "An analytical study of soil temperature with respect to its salinity," *AIP Conference Proceedings,* vol. 2190, pp. 020009-1-020009-8, 2019.

[21] E. I. Hernández, g. Melendez-Pastor, J. Navarro-Pedreño and I. Gómez, "Spectral indices for the detection of salinity effects in melon plants," *Scientia Agricola,* vol. 71, no. 4, pp. 324-330, 2014.

[22] WHO, World Health Organization, "Guide Lines for drinking Water Quality," vol. 1, no. 1, 1984.

[23] S. Abawi and S. A. Muhammed, "Practical environmental engineering (water assays)," *Dar al-Hekma,* pp. 50-89,255-258, 1990.

[24] Ministry of Water Resources, "Monthly averages of expenditures of the Qalaa Saleh blocker," *Data Minist. Water Resour.,* 2020.

[25] NASA, "MERRA-2 Weather Maps," 2020.