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Survey and characterization of water resources and soils around Wadi Rehana region in the western desert of Iraq

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ABSTRACT

The research was conducted in Wadi Rehana area within the Upper Euphrates region in the Iraqi Western Desert. A number of samples of groundwater wells were collected randomly on a seasonal basis and were chemically analysed to obtain concentrations of some important elements to determine the quality of water resources. The results showed that various wells with the water quality within the classes C5S1 and C6S1, are considered very salty and unsuitable for irrigation operations and rarely used for some types of crops. The results showed that all five soil pedon had SL and Sil textures, and they are within the medium texture soil of the surface layers. The EC values ranged from 11.5 dS m^{-1} to 0.94 dS m^{-1}. The digital average of the acidity function in the soil ranged from 7.7 to 7. The $CaCO_3$ values ranged between 23.3 and 64.8%, while $CaSO_4$ between 0.4 and 47.9%. Furthermore, organic carbon was between 0.10 and 0.6%, SAR values ranged from 0.27 to 6.1, CEC across soil sections from 18.4 to 32.3%, and the total nitrogen ratio for the surface layer from 533 to 9207 ppm. Phosphorus ranged from 2.0 to 7.4 ppm, while potassium from 9.2 to 28.7 ppm.

Keywords: Irrigation water; Physical and chemical characteristics; Land evaluation, Agricultural development.
Article type: Research Article.

INTRODUCTION

Soils vary in their chemical, physical and biological properties according to the variation of the parent material, topographical situation, climatic conditions, biotic factor, time and others. In recent times, population growth has increased in the western part of Iraq in an unplanned manner and it is necessary to think about decisions related to water management in this region. There are areas that are largely unexploited combined with poor precipitation and most of its parts are far from the Euphrates River. Hence, it is necessary to use different integration techniques. To determine the ideal locations for investing on groundwater and assessing its suitability for agricultural irrigation use, researchers at the US Salinity Laboratory (1954) and Wilcox (1955) developed standard schemes for irrigation water. The groundwater was classified according to American Salinity Laboratory (1954). They found that all wells are not suitable for irrigation operations for crops which tolerate high salinity due to the high content of sodium ion and high degree of salinity in the studied well water. Abeyou *et al.* (2019) reported that the vast majority of farmers in sub-Saharan Africa depend on rain-fed agriculture for food production and there are various determinants that impede the agricultural productive process such as uneven rainfall, land degradation and low soil fertility in the Robit and Dangishta watersheds (Ethiopia). Potential resources for maintaining irrigation during the dry season in order to expand food by growing vegetables, and the reasons for hindering the production of tomatoes, *Solanum lycopersicum* L and onions, *Allium cepa* L during the dry season (November - April) were identified by collecting data on the field level of 36 households. The Integrated Decision Support System (IDSS) programs, Soil and Water Assessment Tool (SWAT) and the Environmental Extender for

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Agricultural Policy (APEX) were used respectively to assess the impacts of drought in watersheds and field scale levels. The results indicated a large amount of surface and shallow runoff for groundwater recharge on the scale of the studied watersheds, and gave recommendations on preserving soil and irrigation water for vegetable production by reducing soil evaporation and thus increasing water in the crop root area. Maps of land capacity and suitability are useful tools for conserving soil resources (Mauro De *et al.* 2020). They investigated the land capacity and suitability maps using a multi-subject approach by means of geographic information systems in areas affected by salt accumulation of the coastal region of Italy and useful tools for conserving soil resources. Their study aimed to build land capacity and suitability maps using a multi-subject approach by GIS in the salt-affected regions of the coastal region of Italy. Talen (1979) studied the botanical environment of desert plants in Iraq and its relationship to soil and climatic conditions, reporting a variation in the biomass with the variation in the amount of rainfall and the type of soil. Buringh (1960) reported that the desert lands in Iraq constitute more than 1/2 the area of Iraq, as they are widely spread in the western and southern part of the country. Most of the land soils belong to the rank of aridsols due to the prevailing environmental conditions. Al-Taie (1968) identified all types of soils present in this region of Iraq and classified them as the lithic calciorthids, with different phases of the appearance in the eastern part and the stripped pebbles with the erosion manifestations in the western part of the Western Desert. The diameter had a low content of organic matter, ranging between 2.1 - 1.6 g Kg^{-1} of soil, thus, the solidified limestone horizon developed in it from the mother rocks after re-dissolving calcium carbonate, and also re-depositing a hard crust of secondary carbonate, as a high content was observed. These carbonate soils ranged between 307 g kg^{-1} of soil at depth of 0-20 cm and 470 g kg^{-1} of soil at depth of 60-40 cm, as for valleys, different types of tissues were recorded with containment. This study is an attempt to provide a database on those soils for further investment and establishing agricultural development.

MATERIALS AND METHODS

Study area

The study area is located in the western part of Al-Anbar Governorate, at a distance of 169.8 km. It includes the coastal strip on the Euphrates River for the Anah area with a length of 23.1 km and their desert extension inland for about 49.2 km until the beginnings of Wadi Al-Kasr within the western desert of Iraq with an area of 82.4 square hectares. From the point view of geographical coordinates, it is located within the latitude between 4154.007 and 4142.444 east and longitude between 3426.809 and 345.342 north. In this study, the GPS map 60CS Garmin was used to ascertain some sites and natural phenomena in the study area as a guide. The maximum height in the study area was 318 m above sea level, while the minimum level of the land surface is within 140 m above sea in the north-eastern region of Rehana City. Based on Saleem *et al.* (2018), Fig. 1 shows the climatic regions and the location of the study area.

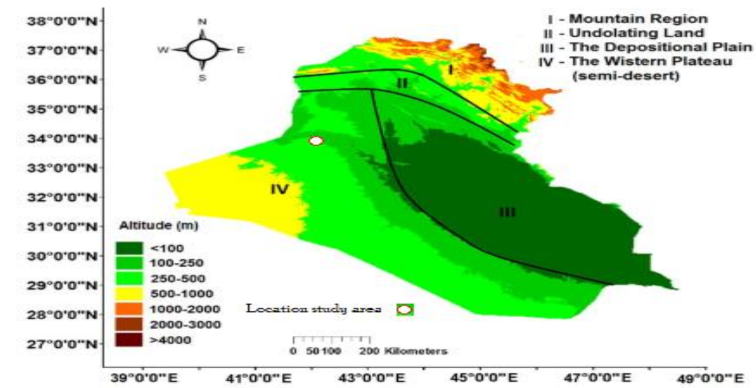

Fig. 1. The location of the study area within the Iraqi geographical regions (Saleem *et al*. 2018).

Field work

Depending on the topographic (contour) map at a scale of 1: 25000, including the general area of the study area and the aerial image (Free Lance Soil Survey), covering an area of 82.4 square hectares, and 5 representative pedons were chosen. These areas were chosen due to the current trend to study desert lands and the possibility of their exploitation and the establishment of agriculture. A number of punch holes were carried out with 80 punch holes to determine the separating boundaries of the soil units, some photographs of the survey were taken with a digital camera (SONY-cyber-shot, HD 1920 × 1080 / 50i). Then the aforementioned characteristics were adopted in the diagnosis of LV units quality within the study area and its location signed on maps at a scale of 1: 50,000. Afterward, samples were taken from all horizons of soil sections to the laboratory of the Centre for Desert Studies, Anbar University to conduct the required analyzes for describing these soils according to methodology obtained from Department of Agriculture (2012) and Munsell Soil Color Charts (2009).

Soil fertility status

Three characteristics of the studied soil were used to know the fertility status of the studied soils, including cation exchange capacity (CEC), acidity function and organic matter for available nutrients. A comparative study was performed to assess the fertility of the study area soil using the guide (Storie 1933; Storie 1944) and the soil fertility was assessed according to the critical fertility levels in the soil for the soil characteristics used as shown in Table 1 (Verma *et al.* 2005, Enang *et al.* 2016).

Soil analysis	Methods	References
Mechanical analysis	mechanical analysis in a hydrometer method	Jackson (1973)
Bulk density	Tube core	Chapman (1965)
Ca^{+2} and Mg^{+2}	Correct calibration.	Page *et al.* ،1982
Soil pH	pH meter	Jackson (1973)
Electrical conductivity	Conductivity meter	Richards (1954)
Organic carbon	Walkley and Black's method	Jackson (1967) Black,1982.1086
Cation exchange capacity	leaching the soil with 1N NH4OAC, pH 7.0 followed by distillation method	Chapman (1965)
Total nitrogen	Kjeldahl method	Bremner&Mulvaney (1982)
Available potassium	Flame Photometric method	Jackson (1973)
Available phosphorus	Bray and Kurtz No. 1	Jackson (1973)
Na^{+}	Flame Photometric method	Jackson (1973)
SAR	$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$	Al-Zubaidi, 1980

Evaluating the potential land for agricultural using the Storie Index Rating System

The storie index rating system, modified by O'Geen *et al.* (2008), classifies soils according to their cultivation suitability. The ratings ranged from grade 1 soils (from 80 to 100 rating), with little or no limitations to the agricultural process of agricultural production, through the soils within grade 6 (less than 10), which are not suitable for cultivation. The classification system was based on four factors including soil characterization and topsoil texture, general slope of the land, and other soil profile characteristics such as natural drainage type, base element content, or erosion. The percentage values of the four factors were multiplied to obtain the STORIE INDEX classification (University of California, 1978, p.1), as follows:

Adjusted Storie Rating Index = A × B × C × X × Y

A = Percentage rating of soil profile

B = surface horizon tissue percentage classification

C = the percentage of the classification of the earth's slope

X = Percentage classification of soil characteristics such as salinity, soil pH, Carbonates content, gypsum content, organic matter, etc.

The percentage rating of each factor (A, B, C, X) increases by the elevation in the suitability of the trait, thus, this means that as the land productivity index reaches 100%, the agricultural quality of the land upraises. Conversely, unwanted lands have low indexes of the trait value, the following are the revised Storie Index percentages and the associated overall productivity ratings.

Groundwater samples, techniques field and laboratory analyses

Four wells were identified within the study area, the location of their coordinates was determined by the GPS device. The water samples were modelled for the examined wells of the two study areas and in several stages. The first started in March and ended in October 2019, and for a whole year using sterile plastic bottles (sealed). The electrical conductivity of the water and the degree of its reaction were estimated directly using field devices. Thereafter, a few drops of formalin were added to it and kept in a field refrigerator until it was transported and preserved in the laboratory. Then, chemical analyses were performed on it and classified according to (Richards, 1954), by estimating the percentage of sodium, magnesium and calcium to obtain the percentage of sodium absorption (SAR), which is an important factor in determining its suitability for irrigation. Four samples were obtained. The different groundwater wells samples were collected on a seasonal basis for laboratory analyses. Fig. 2 represents the locations of the selected wells in the study area.

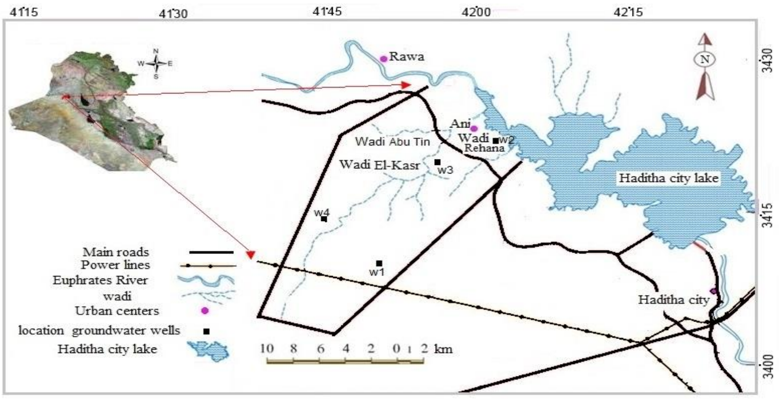

Fig. 2. Distributions of wells sites in the study area.

Climate of the region

The study area is characterized by a dry climate, the climatic elements were obtained from the meteorological station for the Anah area (west of Baghdad). The hot season continues for a period of 4 months, from March 23 to September 23, with an average degree of daily high temperatures above 36.11 ºC. The hottest day of the year is July 21, with an average high of 41.11 ºC and a low of 29.44 ºC. The cold season lasts for 3.2 months, from November 27 to May 3 with an average daily high temperature of less than 21.11 °C. The coldest day of the year is January 15, with an average low of 6.11 ºC and a high of 16.11 ºC. As for the rainfalls, where the difference appears during the months and not only the monthly totals, the accumulated precipitation over a period of 31 days is concentrated every day of the year. Anah area experiences some seasonal differences in monthly rainfall, from January 21 through February 15. The lowest precipitation falls around June 29, with an average total accumulation of 0.0 cm.

Geology of the study area

In the study area, sedimentary rocks and formations ranging in ages from Oligocene to Pleistocene are exposed in the study area, with different types of quaternary deposits. The most important of these existing formations and according to their ages from the oldest to the newest are:

Anah Formation

This formation appears to the west of the study area in the middle or axis of a fold of it convex, and the main detectors are submerged in the Qadisiyah Dam reservoir. Its main components are soft, cream-colored limestone that contains very solid fossils.

Lime Euphrates Formation

The Euphrates Formation is one of the most widespread geological formations in western Iraq, as this formation is exposed in the Al-Baghdadi area and extends to the Iraqi-Syrian borders. As for the study area, it is near the downstream area. This formation appears in the western parts of the study area.

Fatha Formation

It appears in several areas of the study area, especially in the central and southern parts. The rocks in this formation consist of intertwining gypsum with layers of limestone, and these rocks are fragile and have a great ability to melt, which negatively affect the quality of the groundwater in the area.

Quaternary deposited deposits

Sediments are traced back to the Pleistocene and the Holocene. It is difficult to separate the quadruple sediments from the triple sediments due to repeated sedimentation and erosion, as they are deposited in the valleys and rocky depressions that have been affected by the movement of faults, as well as at elevated areas and their foothills (Shaker 1989).

Geomorphology of the study area

The geomorphic units in the region were classified by Sissakian *et al.* (1994) on the basis of the factors causing their formation (their origin) including units produced by erosion and structural effects include terraces and plateaus.
-The units produced by differential erosion factors (climatic factors such as rain and floods) such as the Bad Lands unit (Pediment) and hills.

-Units resulting from erosion and sedimentation of surface waters (rivers and valleys) including the flood plain, river terraces, as well as the valley fill sediments and depressions.

-Units resulting from physical and chemical erosion of rocks due to surface water.

-Units of evaporative origin with climatic effects such as salt crust and sabkha.

According to the geomorphological description, the study area was characterized by a plateau surface surrounding the main course of the valley and a wide plain, crossed by several valleys with seasonal flow. Some of them are permanently flowing by the action of the flowing artesian water throughout the year. Based on the differences in erosion factors and their effects, the geomorphic phenomena in the region varied as follows:

Plateau

The plateaus are located on both sides of the valley course and at a number of levels of elevation from sea level, ranging between 119-90 m.

Rocky terraces

The rocky terraces are found in the gypsum plateaus, as they are cut off from the original plateaus due to the erosion factors of running water. The presence of these terraces gives an advanced analysis of the erosion action along with its effect on the surface of the plateaus and how the valleys are formed.

Terraces along Wadi

The geomorphology of the study area according to Iraq Geomphological Map (1997) is a plateaus consisting of limestone, dolomitic limestone, dolomite, clay and chalky limestone, while the north-western part of the study area is convex rock cliffs and naughty basins of concave folds, which are within units of structural origin.

RESULTS AND DISCUSSION

Morphological characteristics of the soil of the study area

The study of the morphological characteristics of the pedons in the studied area indicated that the source material for all the sites was limestone and gypsum materials, located within the physiographic unit (lower Wadies). The topography of the area is almost flat with a slight slope towards Euphrates River, with deep ground water. The thickness of the surface horizons ranged between 0 and 22 cm depending on the nature of the formative processes of those soils. The surface horizon tissue varied between medium-smooth SiL tissue and SL tissue of moderate roughness with a variation of the vertical joints with the dominance of the SiL tissue in the first horizon of the pedons 4, 3, 2 and 1 respectively, while the SL tissue in the fifth pedons, which is spread within the Wadi bottom. From the point view of the colour, it was found from the morphological description of the study and from Table 2 that the predominant wavelength of all horizon materials was 10 YR with a difference in the values of intensity (value) and clarity (Chroma) and also with the difference of these two indicators in both the dry and wet measurement cases. The intensity values ranged between 5 and 8, while the wet was between 4 and 6. The purity (Chroma) in the dry state ranged between 3 and 4, while the wet ranged between 2 and 6. As shown in Table 2, the composition of the sub-angular blocky and massive type ranged between weak and moderate, while the size characteristic was between medium and soft for all the horizons of the studied evidence. The consistency values changed between the firm and very friable in the dry state, while the slightly sticky and slightly plastic in the wet state, depending on the size distribution of the soil separators. The variations in the quantities and sizes of the roots were observed according to the depths of the horizons as well as the surface distribution of them (Table 2). The Table depicts the distribution of roots in the soil body from the morphological description of the studied tides. These roots are very fine and coarse, based on the distribution and size of the pores. The boundaries ranged between clear and sudden in relation to the width of the border and flat due to the nature of the processes that affected its formation.

Table 1. Summary of morphological Distribution of the studied soil profile.

Physiographic unit	Profile No.	Topography	Depth (cm)	colour		Texture	structure	consistence			Lower boundary	Common features
				Dry	moist			Dry	Moist	Wet		
			0-7	10YR6/4	10YR5/4	SiL	ma,1,m	SH	FR	SS,SP	C;S	
Plateau	1	Almost flat	7-30	10YR6/4	10YR5/4	CL	ma,2,f	SH	VFR	SS	D;S	hi, gy
			30-60	10YR6/4	10YR5/6	CL	ma,2,m		FR	S,P	C;S	
			0-18	10YR6/3	10YR5/3	SiL	Sbk ,1,m	S	FR	S,P	C;S	M, fr, lim, gr
tresses	2	1-2%	18-33	10YR8/4	10YR6/4	SiL	ma, 2,m	HA	FR	S,P	D;S	Me, fr, lim
			+50	-	-	-	-	-	-	-	C;S	
	3	Almost flat	0-12	10YR5/4	10YR4/4	SiL	Sbk ,1 ,m	L	FR	SS,SP	G;S	Co, f, m, lim
Plateau			12-29	10YR8/3	10YR6/4	SL	sg,0,vf	L	FR	SO, PO	D;S	Gy, lim, nodules
			29-47	10YR8/4	10YR6/4	SL	sg,0,vf	SH	FR	SO, PO	D;S	Hi, gy
			47-65	-	-	-	-	-	-	-	-	Lim
	4	Almost flat	0-10	10YR6/4	10YR5/4	SiL	Sbk,1, m		FR,	S,P	G;S	-
Plateau			10-30	10YR7/3	10YR6/3	CL	Sbk,2-1,m		FR	S,P	C;S	-
			30-60	10YR8/3	10YR6/4	SL	ma,2,m	L	FR	SO,PO	D;S	Gy
			60-80	2.5YR6/4	2.5YR5/4	SC	ma,2,m		FR	SO, PO	D;S	Gy
	5	1-2%	0-22	2.5Y5/2	2.5Y4/2	SL	ma,2,m	SH	L	SO, PO	A;S	-
bottom Wadi			22-52	10YR6/3	10YR4/4	L	Sbk ,1,f	HA	FR	SS,SP	C;S	-
			52-77	10YR6/3	10YR4/4	CL	Sbk ,2,m	HA	FR	S,P	C;S	-
			77-107	10YR6/3	10YR4/4	CL	Sbk ,2,f	HA	FR	S,P	C;S	-

Texture: S: Sand; LS: loamy sand; SiL: silt loam; SC: sandy clay; CL: clay loam; L: loam; SL: sandy loam;
Stricture: sg: single grain; ma: massive; 1: weak; 2: moderate; Sbk: sub-angular blocky; f: fine;
Consistence: **Dry**: S: soft; SH: slightly hard; HA: hard; L: loose;

Moist: FR: friable; VFR: very friable; **Wet:** SO**:** non-sticky; SS: slightly sticky, SP: slightly plastic; PO: non-sticky; S: sticky; P: plastic.
Lower boundary: C: clear; S: smooth; D: diffuse; G: gradual.
Common features: hg: highly gypsiferous; m:many; fr: fragment lim: limestone ; gr: gravel; hi: high ; gy: gypsiferous; co: common; nd: nodules.

Chemical characteristics of the soil of the study area

According to USDA (2013) the electrical conductivity ranged between Nonsaline (0) to Strongly Saline (4) for pedons 5 and 2 respectively. It appears from Table 3 that the values of the estimated pH of soil reaction ranged between 7.7-7.3 for soils, meaning that it is Neutral to Slightly Alkaline. The organic carbon contents of the area's soils ranged between 0.6 and 0.1%, where pedon 5 recorded the highest value on average, while the lowest value for this trait was recorded for pedon 2. The carbonate values in the studied soils ranged between 23.3 and 64.8% for pedons 4 and 3 respectively, with a variation in the carbonate content with depth and for all pedons. The presence of this high percentage of this component in the soils of the region and under our dry conditions, it can be considered as the main binder in the soils with low organic matter content which made the soil structure more solid and cohesive due to its work of the pores between the grains. The soil calcium sulphate contents ranged between 0.4 to 47.9% in pedons 5 and 2 respectively. In the case of fertile soil and the nitrogen, phosphorus and potassium contents in the surface horizons, according to Table 2, the type of land use exhibited a significant effect on the soil content of total nitrogen. Its highest value was recorded in pedon P5 inside Wadi bottom (9207 ppm), while the lowest was observed in pedon 1 (average 521 ppm). The highest value of available phosphorus quantities was observed in pedon 5 (7.4 ppm), while lowest in pedon 4 (2.0 ppm). The potassium values ranged between 9.2 and 28.7 in pidons 3 and 5, respectively. The cation exchange capacity ranged between 18.4 to 32.3 cmol $^{(+)}$ Kg^{-1} in albedos 2 and 5 respectively, where the cation concentration ranged from 0.27 to 6.2 mEq L^{-1} (milli-equivalent per litre) for pedons 3 and 1 respectively. Enang *et al*. (2016) and Velma *et al*. (2005) classified the critical fertility levels in the soil using soil characteristics. In terms of fertility and based on these criteria in the soil condition of the study area, it was found that nitrogen in the study area fall within the High level. The potassium condition was within the class Low, while the organic carbon was between Low-Medium. All these characteristics were taken into consideration when evaluating the possibility and viability of these soils for establishing agricultural development in future.

Estimating the potential of the study soil for agricultural use

In this study, a modified Storie index estimation system was used to assess the ground capacity of the studied soil. Table 3 obviously reveals the Storie index for estimating the soil of the study area. The area of class I excellent (Excellent) reached 1.31 ha^2 (square hectares), and 1.6% represented by soils distributed in the valleys and flood plains. The soil in this type is well suited for agricultural use of irrigated crops, depending on the adoption of some administrative methods that would secure suitable water for irrigation operations, regardless of its source (rain pools, water harvesting methods, or the construction of dams on those dry valleys or from other water sources). This type represents the pedon 5. The category III (fair) encompasses the pedons 1, 3 and 4, with areas of 9.06, 19.69 and 30.9 ha^2, (11.0, 23.9 and 37.5% of the total studied area) respectively. These lands in this category are characterized by being well suited only for general agricultural use and have limitations when using due to the presence of slopes and dry valleys.
The fourth category IV is weak (Poor) encompasses pedon 2 which its soil is not well suited. It is very limited in its agricultural potential, due to the shallow depths of the soil, and with variable topography that permeates the lands of that unit from the paths of dry Wadies as well as the presence of small heights and rocks, and with fertility levels ranging from low to moderate.

Current agricultural use and natural vegetation

Through a field survey of the study area, it was found that it was grown in the past with wheat and barley crops, with dry cultivation and irrigated with well water flowing in complementary irrigation of rain during the winter season. However, in the summer season it is distinguished by the cultivation of summer crops and vegetables such as watermelon, watermelon, pistachios and onions, due to the distinction of the area's soils, since it is light and has medium to coarse textures., It helps the success of cultivating such crops. However, the salinity of the water wells used in agriculture, especially during the summer, as well as the wrong management method in irrigation operations and the use of flood irrigation, led to the deterioration of the lands of the region, and reduced its productivity. Over time, farmers had to leave their lands, due to the processes of salinization and the accumulation of salts as well as the poor economic situation of individuals along with the difficult security situation as a result of the successive wars that the country went through during the previous and current years.

Table 2. Chemical properties of soils.

Depth (cm)	EC dS m^{-1}	pH	$CaCO_3$ (%)	$CaSO_4$ (%)	OC (%)	SAR	CEC Cmol (+)kg^{-1}	N	p	K
								Ppm		
P1										
0-7	1.8	7.8	44.5	0.9	1.0	0.2	21.4	600	5.7	15.6
7-32	4.2	7.2	43.9	33.4	0.4	0.7	29.7	500	1.3	31.2
32-70	11.3	7.6	34.8	52.0	0.2	0.5	32.8	-	-	-
70-100	11.2	7.6	42.8	28.3	0.4	19.1	31.6	-	-	-
Average	8.83	7.5	40.1	36.6	0.3	6.1	30.8	521.8	2.26	27.78
P2										
0-12	5.7	8.0	48.5	0.6	0.4	0.31	19.6	400	8.9	12.0
12-35	12.4	7.8	23.4	60.2	0.07	0.91	20.1	600	0.3	15.6
35-60	13.5	7.7	27.5	59.3	-	2.10	16.4	-	-	-
60-90	-	-	-	-	-	-	-	-	-	-
Average	11.5	7.7	30.1	47.9	0.10	1.28	18.4	631.4	3.24	13.97
P3										
0-12	2.1	7.5	65.4	3.5	0.4	0.24	20.3	800	5.9	0.31
12-29	2.5	7.4	62.1	25.4	0.1	0.16	22.7	500	3.8	15.5
29-47	2.6	7.3	67.2	10.6	0.02	0.4	23.6	-	-	-
47-89	-	-	-	-	-	-	-	-	-	-
Average	1.18	7.3	64.8	14.1	0.14	0.27	22.4	624.1	4.6	9.2
p4										
0-10	2.1	7.1	42.1	0.31	0.9	0.20	21.5	400	3.8	15.7
10-30	2.5	7.4	46.8	0.40	0.4	0.5	29.8	600	1.2	19.5
30-60	3.0	7.3	14.2	35.5	0.07	0.5	35.2	-	-	-
60-80	3.2	7.3	4.1	40.4	-	0.6	23.2	-	-	-
Average	2.8	7.3	23.3	23.5	0.23	0.48	29.1	533	2.0	18.2
P5										
0-22	0.89	7.7	19.7	0.53	0.8	1.13	23.7	8400	6.9	20.2
22-52	0.84	7.7	25.1	0.52	0.77	1.11	33.4	9800	7.8	35.1
52-77	0.72	7.7	27.9	0.39	0.54	1.32	35.1	-	-	-
77-107	1.39	7.9	31.9	0.37	0.4	3.68	36.2	-	-	-
Average	0.94	7.7	25.7	0.4	0.6	1.7	32.3	9207	7.4	28.7

Table 3. Rating of limitations and land capability (***Storie index***) of the studied soil profile.

Pedon No.	Factor A	Factor B	Factor C	Factor X	Soil Rating	classes	%	Area
	Physical profile	Texture	Slope	Soil condition	%		area	Do.2
1	95	95	95	60	51.4	III	11.0	9.06
2	80	100	95	50	38.0	IV	19.9	16.39
3	80	95	95	60	43.3	III	23.9	19.69
4	80	95	95	60	43.3	III	37.5	30.9
5	100	100	100	95	85.5	I	1.6	1.31
Other	-	-	-	-	-	-	5.8	4.70

Water resources in the study area

The water resources in the study area are of two types, either surface water from Euphrates River in the north of the study area and collected in experiences, or running water within valleys during the rainy season, or underground water located within the study area, as well as water resources from rain fall on the slopes of valleys and plateaus. The study assessed the validity of groundwater within the Euphrates formation for irrigation operations in the study area. In various seasons, the total dissolved solid salts indicated that the quality of the subterranean flushes within the study area had very poor qualities and by 100%, and the ranges were high between 3240 and4065 ppm for the third and first well, respectively. There is an increased salts in the southern regions of the study area. Some agricultural activities were observed during the field work and some pivotal irrigation methods using this salty water. The use of this water affected the productivity of crops and elevated the accumulation of salts in the soils of these farms. A scheme Richards (1954) was applied to identify the rate of sodium absorption (SAR) in groundwater and its relationship to the electrical conductivity of the general water was well studied. The result exhibited that the samples were distributed in two ranges. The first range is between C5-S1, meaning that the water has a very high salinity and a low percentage of sodium. Therefore, it is not suitable for many types of crops, while the second range (C6-S1), reflects that the water is very salty without limits. It has a low percentage of sodium which is also not suitable for irrigation operations. Based on the results of this study, there is the possibility of using it for irrigation purposes to cultivate according to the various administrative methods and irrigation techniques. However, these technologies are costly and raise the aspect of production costs. Standard deviation is the most used value among the statistical dispersion measures the extent of statistical dispersion.

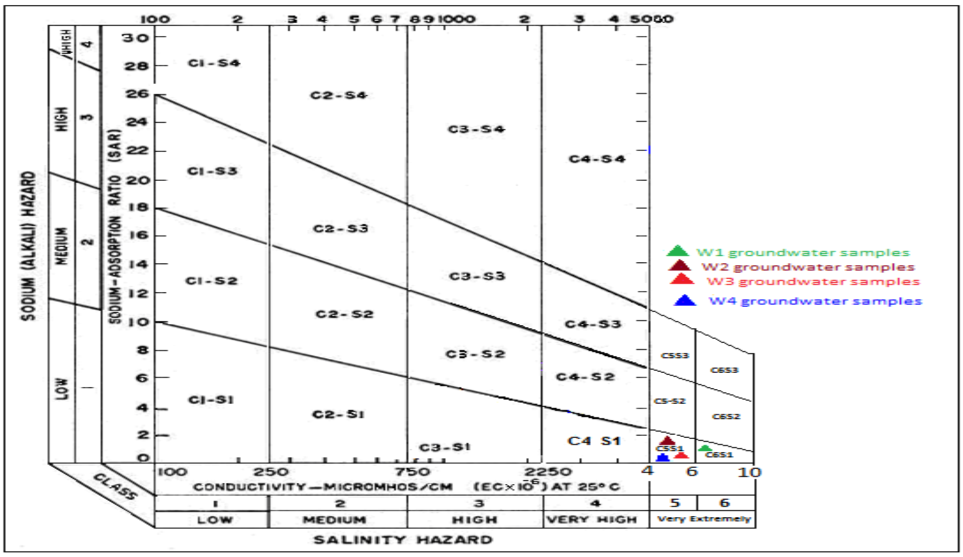

Fig. 3. Suitability of water for agricultural purposes according to Richards (1954).

Recommendations

-The necessity of conducting more accurate future studies of the lands of these regions and geological formations in order to invest them in a more beneficial economic condition.

- Considering the quality of groundwater in those areas with the classes (C5S1, C6S1) and the high content of salt concentrations that affect soils and plants, the study recommends limiting the use of that water for agriculture and increasing the saline accumulation in those soils and using the transportation of the Euphrates River water towards those lands by a network of pipes. And the pumps, especially since the riverbed and Haditha Dam Lake are close to the study area.
- Establishing a network of paved roads and linking them with Baghdad railway station - Akashat, which helps to find a market for cultivated crops and develop agricultural projects, which include poultry projects.

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