Iraq Salinity Project **Technical Report 12B**

Relationship between groundwater table depth, groundwater quality, soil salinity and crop production

Reports:
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This technical report series captures and documents the work in progress of the Iraq Salinity Project, in its six research themes, working at the regional, farm and irrigation system scales. Technical reports feed into the *Iraq Salinity Assessment*, a synthesis and solutions to solving the problem: Situation Analysis (Report 1); Approaches and Solutions (Report 2) and Investment Options (Report 2).

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Key words:, cropping pattern, table depth, crop yields, fertilizer use, soil property, ground water quality, soil salinization, drainage infrastructure, Dujailah and Mussaiab.

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Contents

SUMMARY

This technical report presents the first results of the study that looks at how intensive irrigation and rising groundwater tables have increased soil salinity. It assesses the current state of groundwater levels, groundwater and soil salinity, irrigation and drainage practices and their combined impact on crop production and soil salinization.

Salinity problems are most observed in central and southern Iraq where the alluvial plain has become a discharge area for saline ground water. While large scale salt accumulation is the result of soil evaporation, salinity may have been caused by intensive irrigation and rising groundwater table due to high seepage losses from canals and irrigated fields.

The slight slope of the river plains and the low rainfall limit natural drainage. As a result, salts from the irrigation water of some millennia have accumulated in the topsoil. To this end, cropping patterns and selected yields were examined; soil properties and quality of irrigation and ground water quality in Mussaiab and Dujailah were also analyzed.

Findings to date

The findings to date indicate that increased groundwater tables are a result of faulty irrigation practices and a lack of development schemes in the drainage system. The absence of drainage facilities and low quality of groundwater indicate that investment is needed to ensure long-term food security for the country.

Large tracts of irrigated lands in southern and central Iraq are now salinized which has reduced crop yields significantly, threatening the food security of the Iraqi people. Areas adversely affected by irrigation return flows are located in the lower basin of the Euphrates River. These areas cannot be irrigated without providing adequate drainage facilities. In the absence of drainage, large areas have already and for the future will go out of production. Poor quality of groundwater is not only creating problems for irrigators but also affecting the quality of life for nearby communities, who use this water for their domestic needs. Many villages and small towns in this area have become desolate due to deterioration of water quality in the Euphrates River.

For Iraq it seems necessary to intensify the study of groundwater issues due to increasing soil salinity and drainage problems. Equally important is the study of soil solutions because they are more directly related to crop production. The findings show that the soil solution is much higher (2 to 3 times) than in the groundwater as a consequence of higher temperature in the upper parts of the soil. Iraq has to invest, and invest soon, in improving its drainage facilities in order to ensure future food security

Background and context

Salinity occurs through natural and/or human-induced processes that result in the accumulation of dissolved salts in the soil[i]. The genesis of if soil salinity in Iraq as a whole must be attributed to the salty content of the irrigation water[ii]. Annual loss of cultivated lands in Iraq is estimated to be about 5% due to salinization and water logging (Committee of Agriculture and Water Resources Sector, 2009).

Salinity in shallow groundwater and the root zone is closely correlated (Schoupset al., 2005). The coincidence of irrigation and salinization threatens the sustainability of agricultural productivity (Flowers and Yeo, 1995). Yields of wheat, barley and corn in Iraq are estimated at 1700, 1288 and 3159 kg ha^{-1}, respectively. Use of marginal quality soils and irrigation water and lack of innovative production technologies are considered to be responsible for these low productivities (Committee of Agriculture and Water Resources Sector, 2009).

Study area

This study is being done in two project areas of central and northern Iraq i.e. Mussaiab project area and the Dujailah project area. The Mussaiab project area is located 90 km south of Baghdad in Babil Province on both the east and west banks of the Euphrates River, which splits into the Hindiya and Hilla branches. The Mussaiab project area consists of 83500 ha, of which a large part is severely affected by salinity due to the occurrence of highly saline groundwater (18-12 mmhose/cm) (Al-Zubaidi 1992). The groundwater depth in uncultivated soils is 200 cm and 90-160 cm in both state and farmer fields due to seepage from irrigation fields and inefficient drainage. In order to solve the salinity problems of this area, a large scale project was initiated in 1954.

The Dujailah area is the largest and oldest settlement project in Iraq, which was started in 1946 (Dieleman, 1963). The project is located in Wasit province, on the right side of the Tigris River and on the left side of al-Garraf River. The total area of the project is 99000 ha (land irrigated and non-irrigated).The project is divided into three areas i.e: reclaimed, semi-reclaimed and non-reclaimed. Reclamation of soils was stopped in 1983.

Climatically, both Al-Mussaiab and Dujailah areas represent a hot sub-desertic climate. It is characterized by short cool winters and long hot summers with almost no spring or autumn season. Rainfall is very seasonal and occurs in winter from December to February. Average annual rainfall is estimated at (133.5mm and 137.2mm) for Al- Mussaiab and Al-Dujailah project areas, respectively. Winters are cool to cold and short, with a day temperature of about (18.3°C, 19.7 °C) dropping at night to7.3°C and 8.5°C during November to February for Al-Mussaiab and Al-Dujailah project areas, respectively. Summers are dry and hot to extremely hot and long season with shaded temperature of over 44°C during July and August and dropping at night to 26.4°C. The crops cultivated in both project areas are wheat, barley, corn, millet, sorghum and sunflower in summer and mostly vegetables in winter. Cotton and sunflower is also grown on a limited area in summer.

Research Strategy

Cropping patterns, crop yields and fertilizer use

For this study, secondary data regarding climate, cropping patterns, crop calendars, consumptive use of main crops, volume of irrigation water applied to each crop, fertilizer use and soil fertility, quality of Euphrates and Tigris River water, permeability and infiltration rates of soils, soil salinity, groundwater table and quality, chemical and physical and hydrological properties of soils was all collected from different national organizations and institutions. These data were used to evaluate the trends in soil salinization over time in two project areas.

Three piezometers were installed in a sub-project area (50 ha) of the Al-Mussaiab project area to monitor the groundwater table and salinity on a monthly basis. Similarly three locations in Al-Dujailah Project were selected (Reclaimed area, Semi reclaimed area and Non-reclaimed area with total area of 62 ha for each) to monitor the behavior of groundwater table and salinity. In May 2011, field data was collected to determine the physical and chemical properties of soil profile at various points located in the two study areas of Al-Mussaiab and Al-Dujailah.

Table 1 Illustrates the crop calendar and average yields of major crops in both project areas. The lower yields of these crops are attributed to traditional farming methods, insufficient extension services relating to modern farming techniques, soil salinity and limited availability of fresh irrigation water.

Table 1. Crop calendar and yield of main crop

Crops	**Sowing and Harvesting dates**	**Yields kg/ha**
Wheat	01/Dec. – 30/Apr.	1200 - 3000
Barely	01/Dec. – 30/Apr.	1000 - 2800
Corn	15/Jul. – 01/Nov. 15/Mar. – 01/Jun.	1000 - 2800
Cotton	15/Mar. – 15Aug.	2000 - 2400
Sunflower	15/Feb. – 01/Jul. 01/Jul. – Nov.	1000 - 2000

The consumptive use of water for different crops cultivated in Al-Mussaiab and Al-Dujailah Project areas is affected by many factors (soil, climate, topography, length of growing season, etc). The data of consumptive use for main crops in Project sites show that winter crops such as wheat and Barley use less irrigation water (irrigated for six times with 5140 m3/ha of applied water) compared with summer crops such as corn, sorghum cotton and tomato (irrigated for 10 times with an average of 9760 m3/ha of applied water) .

The Iraqi farmers in Al-Musaib and Al-Dujaila project areas use two kind of fertilizers i.e. Urea and DAP or Urea with NP. DAP fertilizer is newly introduced to Iraqi farmers in the last two decade. The use of micronutrients and potassium is not common. It seems that the farmers in these project areas use an extra quantity of fertilizers as explained in Table 3.

Table 3.Rate of application of fertilizers in Al-Musaib and Al-Dujailaproject areas.

Crop	Urea Kg/ha/season	Applied	DAP Kg/ha/season	Applied	NP 18:18 Kg/ha/season
Wheat	500 divided into 3 portion	With	240	OR	600
Barely	400 divided into 2 portion	With	Not applied	OR	400
Corn	500 divided into 3 portion	With	400	OR	No Applied

Physical and chemical soil properties in Mussaiab and Dujailah

According to US Taxonomy (soil survey, 1999), all soils in the Al-Mussaiab and Al-Dujailah project areas belong to Holocene alluvial deposits and are typically torrifluvents with a hyperthemic soil temperature regime and a mixed (calcareous) mineralogy. Table 4 gives the characterization of different pedons in Al-Mussaiab project area.

Table 4.Characterization of different Pedons of the Al-Musaibproject area.

Pedon No.	Soil drainage : well
Location : AlMusaib Project (Selected Area)	Water table depth : 160 cm
Mapping unit	Vegetation : prosopis
Parent material : alluvium	Elevation (m) : 24 m
Soil Classification : TypicTorrifluvents	Surface stoniness : None
Physiographic : levee	Remarks : irrigated
Topography : flat	Date of description : 1977

The physical and chemical properties of the soils of the area selected by the research team in the Al- Mussaiab and Dujailah project are highlighted in tables 5 and 6, respectively. The texture of these soils in Mussaiab is silt clay loam up to the depth of 90 cm. Comparison of data show the soil of both project sites have similar qualifications.

Table 5.Physical and chemical properties of the study area soils in Al-Musaib project.

Location No.	Depth Cm	Soil Texture	Particle size analysis			EC dS m^{-1}	pH
			Sand (%)	Sand (%)	Sand (%)		
1 (a)	0 -15	SiCL	9.0	61.0	30.0	7.03	7.68
	15- 30	SiCL	8.0	62.8	29.2	8.10	7.69
	30- 60	SiCL	5.0	66.4	28.6	4.00	7.81
	60-90	SiCL	11.0	66.0	23.0	7.4	7.73
2 (b)	0 -15	SiCL	11.0	62.0	27.0	8.08	7.51
	15- 30	SiCL	12.4	66.0	21.6	5.50	7.71
	30- 60	SiCL	5.0	64.0	31.0	6.00	7.71
	60-90	SiCL	10.8	63.0	26.2	8.00	7.70
3 (c)	0 -15	SiCL	9.8	60.0	30.2	4.4	7.71
	15- 30	SiCL	12.8	65.4	21.8	2.50	7.86
	30- 60	SiCL	8.5	61.2	30.3	2.50	7.82
	60-90	SL	62.8	36.4	0.8	2.00	7.96

(a) N:324504, E:443840; (b) N:324504, E: 443853; (c) N: 324457, E: 443917

Table 6.Physical and chemical properties of study area in Al-Dujaila project.

Location No.	Depth Cm	Soil Texture	Particle size analysis			EC dS m^{-1}	pH
			Sand (%)	Sand (%)	Sand (%)		
Semi-reclaimed area	0 -15	SiL	20.3	61.6	17.6	37.80	7.68
	15- 30	SiL	20.3	61.6	17.6	24.94	7.75
	30- 60	SiCL	10.8	51.6	37.6	33.44	7.59
	60-90	SiC	9.2	48.4	42.4	24.62	7.73
Reclaimed area	0 -15	C	4.8	39.6	55.6	9.30	7.85
	15- 30	C	8.8	35.6	55.6	9.60	7.85
	30- 60	SiC	4.8	42.0	53.2	11.06	7.68
	60-90	SiC	6.4	40.0	53.6	9.32	7.85
Non-reclaimed area	0 -15	C	12.4	37.2	50.4	10.56	7.71
	15- 30	C	20.8	31.6	47.6	12.94	7.58
	30- 60	C	38.8	15.6	45.6	16.44	7.82
	60-90	SiCL	16.8	52.8	36.0	15.80	7.96

Groundwater quality, soil salinization and drainage

For thousands of years, Iraq has been the home of perennial irrigation, just as Egypt has been the home of the ancient basin irrigation with a single cereal crop per year. The principle sources of irrigation water in Iraq are the Tigris and Euphrates Rivers. The quality of these two sources decreases as they flow towards south (Shaat Al-Arab). The water salinity of the Tigris River increases from 0.44 dS/m at the Turkish – Iraqi border to more than 3 dS/m at Ammarah province (south of Iraq) , and from 1.0-1.3 dS/m at Syrian – Iraqi border to 2.5–4.6 dS/m by the time it reaches the Euphrates River. Historical data on the water salinity of TigrisRiver at Baghdad city shows that its salinity was 0.63 dS/m in 1960 (Buringh, 1960) which has increased to 1.15 dS/m at Al-Dujaila project (200 Km south of Baghdad) by 2011. The same is the situation for Euphrates River where salinity has increased to 1.56 dS/m over the same period of time.

Salinization of soils is a major problem in saline, shallow watertable areas. This is influenced by climate, soil type, crop, irrigation water quality, management practice, groundwater table depth and quality. There is a close relationship between groundwater table depth and capillary rise. In irrigated areas like Al-Mussaiab and Al-Dujailah, groundwater table depths vary significantly depending on the location of the fields. Table 7 shows historical data regarding groundwater table depth in the Al-Dujailah project area (Dieleman, 1963).

Table 7: Groundwater table depth (cm) below soil surface (Dieleman, 1963).

Year and crop	1956-Green gram				1958- Barley			
Month	June	July	Aug	Sept	Jan	Feb	Mar	Apr
Gen. average	65	82	82	100	70	80	100	103
Average minimum	25	45	60	72	40	55	75	85
Average maximum	70	105	102	118	100	110	105	120

The concentration of salts in the groundwater varied in the lower Mesopotamian plain from 10,000 to 60,000 ppm (Buringh, 1960). In many areas it may be much higher, up to 80,000 ppm. Al–Zubaidi (1992) illustrated that salinity of groundwater in Al-Mussaiab before reclamation was 12-18 dSm^{-1}. The chemical composition of Al-Mussaiab groundwater is sodium chloride as the dominant salt along with magnesium and sodium sulphates.

Table 8 shows that in Al-Dujailah project area, groundwater table varies between 45cm in February and 200cm in August. Groundwater salinity at the measured points was extremely high reaching up to 30 dSm^{-1} (point 5), fluctuating from month to month based on irrigation activity and drainage efficiency. This feature seems to be common in many Iraqi soils and as a result of that soil profiles are wet to partially wet especially in the winter season.

Table8. Groundwater table depth and quality of the Al-Dujaila project area in 2007.

Location	GPS Readings		Months						
			February			March		April	
	N	E	Levels (m)	Depth (cm)	EC (dSm^{-1})	Depth (cm)	EC (dSm^{-1})	Depth (cm)	EC (dSm^{-1})
Point 1	3222693	4620238	11.38	45	16.5	45	16.6	90	17.0
Point 2	3222681	4620343	11.24	60	26.6	61	26.6	45	20.8
Point 3	3222632	4620254	11.14	60	12.0	60	12.0	100	10.1
Point 4	3222575	4620227	10.90	85	22.3	85	22.3	90	23.6
Point 5	3222571	4620114	11.17	50	20.4	50	20.3	85	30.5
Point 6	3222393	4620604	11.02	60	21.3	60	21.3	45	19.8
Point 7	3222434	4620438	10.74	62	8.8	62	8.8	45	5.2
Point 8	3222317	4620112	10.94	50	11.7	62	11.7	90	11.7
Point 9	3222283	4619918	11.01	62	9.3	62	9.3	65	9.6
Point 10	3222063	4619871	10.63	62	9.4	64	9.4	65	9.9

Table 8 *(Continued)*

Location	May		June		July		August	
	Depth (cm)	EC (dSm^{-1})	Depth (cm)	EC (dSm^{-1})	Depth (cm)	EC (dSm^{-1})	Depth (cm)	EC (dSm^{-1})
Point 1	100	17.5	180	-	>200	-	>200	-
Point 2	75	21.2	185	-	>200	-	>200	-
Point 3	110	13.8	180	-	>200	-	>200	-
Point 4	110	24.0	190	-	>200	-	>200	-
Point 5	105	31.1	190	-	>200	-	>200	-
Point 6	95	22.0	190	-	>200	-	>200	-
Point 7	95	9.8	200	-	>200	-	>200	-
Point 8	120	12.6	200	-	>200	-	>200	-
Point 9	110	10.1	200	-	>200	-	>200	-
Point 10	110	11.0	200	-	>200	-	>200	-

Al-Mussaiab project is irrigated from the left side of Euphrates River through a 50 km long main non-piped canal (except for the first 500 m) with a discharge capacity of 40 m^3/sec. Total length of main branches and tertiary branches of this canal is 122 km. Drainage system consists of collective and open field drains with a total length of 520 and 1600 km, respectively. The sub-drains discharge their drainage water into northern and southern main drains. These drains are 47.5 km and 59.5 km long with a discharge capacity of 15m^3/sec and 3m^3/sec, respectively. There are seven pumping stations to regulate drainage water.

Soil reclamation is done with the help of covered field drains with a total length of 611 km (http://www.mowr.gov.iq:81/mosoa/FOR4.htm#). The project suffers from re-salinization due to drainage water seepage from the general drain (Al- Zubaidi 1992). Currently, e-Field observations made during 2011project has only one drainage outlet known as Al-Musician southern drain (pump station No. 4), which discharges drainage water from Al-Musician project area to Al-Musician Al-Am river. The salinity of drainage water varies between 3.4-4.7 dSm^{-1}(TDS 2315-3045) during different months.

Al-Fujairah project is irrigated from the Tigris River by a main canal with a maximum design discharge of 42m^3/sec and with an operational discharge of 15m^3/sec. The total length of this canal is 57km and it has 13 branch canals in addition to distribution canals. Al-Fujairah project has four padded canals into reclaimed area with a total length of 40.7 km, in addition to 12 km unpadded canal. Irrigation is done by flooding method. The number of lateral padded canals in reclaimed area is 23 with a total length of 72 km.

Semi-reclaimed area is irrigated by five lateral canals consisting of irregular traditional canals. The main drains of the project area are discharging drainage water to Al-Msandk Lake. The total length of main and sub collected drains is 1121 km. Al-Duajilah project had 3drainage outlets and four pumping stations with a discharge capacity of 3.0 m^3/sec each. According to 1996 estimates, the salinity of Al-Dujailah southern drain varies between 6.7-16.0 dSm^{-1}(TDS 4635–11090 ppm) indifferent months. Al-Dujailah eastern drain discharges into Al-Msandk lack and salinity of drainage water varies between 8.0 -13.0 dSm^{-1}(TDS between 5550–9162 ppm) along different months. Currently, there are three pumping stations with 11 pumps with a total discharge of 6.5 m^3/sec.

The local nomenclature of saline soils in Iraq is Shura and Sabakh soils. Shura soils are often with a white crust. Sabakh soils have the dark brown color and high content of deliquescent salts and occur in irregular patterns generally in silt or loamy textured soils in areas where the surface is still in contact with the ground water by the capillary rise at least during the greater part of the year. They are common in the silt irrigation deposits along old and present day irrigation canals and ditches. Extensive areas covered with Sabakh soils were recognized by Buringh (1960) in Al- Mussaiab.

b. Al-Hassani (1984) reported the analysis of Shura and Sabkha soils in Al-Dujailah area. He found different ionic compositions of the two profiles due to differences in ground water composition. The depth of the saline layer above ground water depends on soil texture, structure, bulk density, porosity and consistency.

Table 9. Soil salinity in non-saline, uncultivated and Al-Mussaiab project soils.

Depth (cm) Non-saline soils	EC dSm^{-1}	Depth (cm) Uncultivated soils	EC dSm^{-1}	Depth (cm) Al-Mussaiab project	EC dSm^{-1}
0-30	3.10	0-20	40.11	0-40	19.57
30-60	2.60	20-40	19.61	40-60	13.00
60-95	2.80	40-75	13.00	60-80	14. 61
95-120	3.80	75-90	7.59	80-100	11.82
120-140	4.40	-	-	100-20	13.10
140-GW	10.96	90-GW	40.80	200-GW	17.90
Source : Al-Jeboory, 1987					

Soil characteristics differ in vertical and horizontal direction particularly in the river deposits. For this reason, occurrence of saline soil layers is irregular. Al-Jaboory (1987) found drastic changes in salinity patternsin the Al-Mussaiab area. In Al-Mussaaib sarea cultivated soils vary between non-saline to saline sodic soils with shallow and very high saline ground water. The uncultivated soilsare also classified as saline sodic soil with saline ground water at 200cm depth. In general, sodium adsorption ratio exceeded 15%.Saline sodic soils are very common in Iraq. Although the pH of the soil paste does not exceed 8.5, exchangeable sodium percentages of over 50 are quite common. The average exchangeable sodium percentage for all saline soils is estimated to be somewhere between 20 and 25 (Dieleman, 1963). The resistance of Iraqi soils to sodification is very high due to the presence of high quantities of soluble exchangeable calcium and magnesium in addition to calcite and gypsum (Al-Zubaidi, 1992).

Analysis of secondary data revealed that 60% of Al-Dujailah surface soils have an electrical conductivity of higher than 16 dSm^{-1} (Dielman,1963).Table 10 gives a typical example of the salt content of the soil under the conditions prevailing in the Dujailah area. Comparison of data and field observations of the last year, we can conclude that there is a decrease in soil salinity which might be the result of land use for agriculture and reclamation practices adopted by farmers in the project area.

Table 10. Soil salinity in the Al-Dujailah project

Depth (cm)	EC dSm^{-1}	Depth (cm)	EC dSm^{-1}	Depth (cm)	EC dSm^{-1}
0-30	65	0-30	64.0	0-31	3.5
30-60	36	30-65	42.0	31-72	4.3
60-100	35	65-105	44.54	72-109	5.2
100-150	34	105-140	57.0	109-131	6.7

150-200	35	-	-	131-150	7.1
Source : Dieleman, 1963; Abbas, 2010					

Field observations made during 2011

The results of the monitoring data on groundwater table depth and groundwater quality from Al-Mussaiab and Al- Dujailah project area by the team of the research team are shown in Figure 1. In general, groundwater salinity was higher in Al-Dujailah project area than Al-Mussaiab project area. In two observed locations, groundwater salinity was up to 5.0 dSm^{-1}, while at the third location it went up to 8.0 dSm^{-1}. In contrast, groundwater salinity at both locations in the Al-Dujailah project area remained above 10 dSm^{-1} during the monitoring period. Groundwater salinity at location 3 went up to 45 dSm^{-1}, which is above even sea water salinity.

The groundwater table depth at all locations of the Al-Mussaiab area remained between 1-2 m with minor fluctuations between months depending upon the irrigation and evapotranspiration activity. This fluctuating behavior is similar to that found in the historical data of 2007 (Table 11) and 1956-1958 (Table 10) although current data showed a declining trend in groundwater table depth comparing to historical data. The groundwater table depth at Al-Mussaiab project remained virtually stable which shows that recharge was equal to discharge and a state of hydrological equilibrium exists. The field data showed that relatively shallow groundwater table depths and high salinity of groundwater is temporarily or constantly causing a serious threat of soil salinization.

Salinity of groundwater of non-reclaimed soil in Al-Dujailah ranged between 42-43.8 dSm^{-1}, while groundwater of semi and reclaimed soils was moderately saline (Rhoades et al. 1992) with a range between 8.2-10 dSm^{-1}during May-September. This groundwater salinity reflects a serious problem and deserves careful consideration. It is also observed that groundwater salinity of semi-reclaimed soil rose in November and reached 20 dSm^{-1}. This rise in groundwater salinity was partly due to the closing of a pumping station. Al-Mussaiab groundwater salinity ranged between 3.5 dSm^{-1} for location 1 and 8.0 dSm^{-1} for location 2. Groundwater salinity for all locations of the Al-Mussaiab project area was classified as moderately saline (Rhoades et al. 1992). Lower groundwater salinity in Al-Mussaiab project area represents a trend of desalinization when compared with historical data (Table 12).

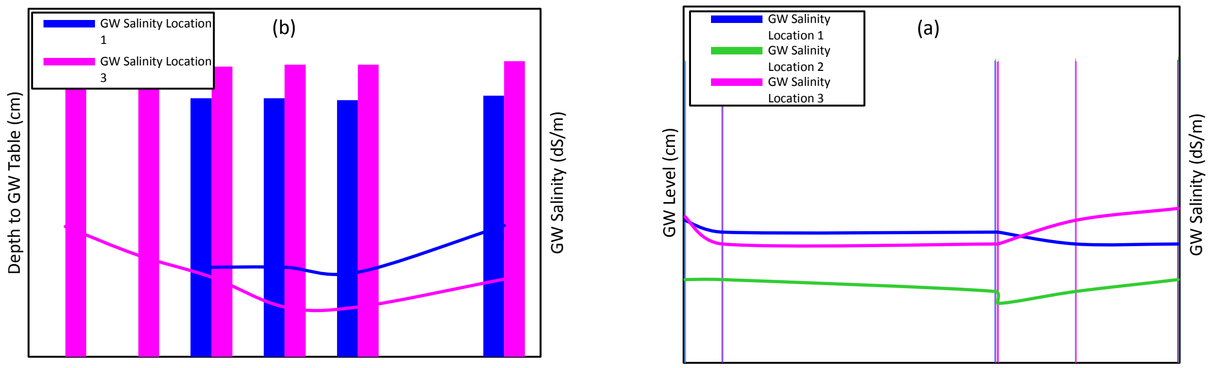

Figure 1.Existing groundwater table depth and quality in (a) Al-Mussaiab and (b) Al-Dujailah project areas.

It was further observed that all studied soils in Al–Dujailah project area were saline – classified as solonchak. Soil EC was increasing in the order: Reclaimed < non- reclaimed< semi-reclaimed. It is obvious that fluctuation of hydromorphic conditions (groundwater table depth and salinity) coupled with lack of drainage led to increased salinization in these soils. However, salt balance is found to be more stable compared with the historical data.

Conclusions and recommendations

Historically, problems of salinity started between 2,000 and 3,000 B.C. in the southern part of Iraq and then spread over other parts of the country. Drainage was never a part of the irrigation development, which led to increased groundwater tables in the alluvial plains in the southern and central Iraq where the main irrigated agriculture is practiced. This rise in saline groundwater tables brought salts in the root zone. The pumped irrigation which is practiced on 25% of the area along the banks of two rivers further compounded the salinity problem.

Large tracts of irrigated lands in southern and central Iraq are now salinized which has reduced crop yields significantly, threatening the food security of the Iraqi people. Areas adversely affected by irrigation return flows are located in the lower basin of the Euphrates River. These areas cannot be irrigated without providing adequate drainage facilities. In the absence of drainage, large areas have already and for the future will go out of production. Poor quality of groundwater is not only creating problems for irrigators but also affecting human beings as they are using this water for domestic needs. Many villages and small towns in this area have become desolate due to deterioration of the Euphrates River water quality.

For Iraq it seems necessary to intensify the study of groundwater issues due to increasing soil salinity and drainage problems. Equally important is the study of soil solutions because they are more directly related to crop production. The findings show that the soil solution is much higher (2 to 3 times) than in the groundwater as a consequence of higher temperature in the upper parts of the soil. Iraq has to invest, and invest soon, in improving its drainage facilities in order to ensure future food security for the country.

References

Abbas, AyadHameed. 2010. Units of North Kut Project and Prediction of Some Soil Physical Properties by Using GIS and Remote Sensing.Ph. D. dissertation - College of Agriculture at University of Baghdad.

Al- Hassani, Ali. Abbas. 1984. characteristics of Shura and Sabakh soils in some Iraq regions. MSc. Thesis- College of Agriculture- University of Baghdad (In Arabic).

Al- Jeboory, S. R. J. 1987. Effect of soil management practice on chemical and physical properties of soil from Great Mussaiab projects.Thesis- College of Agriculture- University of Baghdad (In Arabic).

Al-Taie, F. 1970. Salt – affected and water – logged soils of Iraq. Report to seminar on methods of amelioration of saline and water-logged soils. Baghdad

Al-ZubaidiA .(1992). Land reclamation. Ministry of Higher education and scientific research.(pp 200) (In Arabic).

Buringh P. (1960). Soils and soils conditions in Iraq.Ministry of Agriculture.

Committee of Agriculture and water Resources Sector. 2009. Policy paper of agriculture and water resources sector.2010-2014 Five Years National Plan Technical Committee- Ministry of Planning and development Cooperation- Republic of Iraq.pp. 25- 7.

Darab, K. Redly, M. and J. Csillag. 1997. Salt balance and environmental conditions. Proceedings of the International Syposium on Sustainable Management of Salt Affected Soils in the Arid Ecosystem –FAO workshop (Network Group)-Cairo.P.17-30.

Dieleman, P. J. (ed.). 1963. Reclamation of salt affected soils in Iraq. Intern.Inst. for Land Reclamation and Improvement.Pub.No.11. Wagningen, Netherlands.

Flowers TJ, Yeo AR. 1995. Breeding for salinity resistance in crop plants-where next? Australian
Journal of Plant Physiology 22,875-884.

Ministry of Water of Resources , http:// www. mowr.gov.

Pitman, A.J., G.T. Narisma, et al. (2004), Impact of land cover change on the climate of southwest Western. Australia, J. Geophys. Res.-Atmos., 109(D18). [online] Available from: 7/000224126500001.
Rhoades, J. D.; A. Kandiah, and A. M. Mashali.(1992). The use of saline waters for crop production, FAO irrigation and drainage ,paper 48. Rome, Italy.
Schoup, G., Hopmans; J. W. Young; C. A. , Vrugt, J. A.; Wallender, W. W. ; Tanji, K. K. AND Pandy, S. 2005. Sustainability of irrigated agriculture in San Joaquin valley, California.Proceedings of the National Academy of Science. 102(43)pp. 15352-6.

[i] Saline soils occupy 60 to 70 percent of the alluvial plain. It is estimated that 4 percent of irrigated areas are severely saline, 50 percent moderately saline and 20 percent slightly saline (Al- Taie 1970). Other estimates indicate that the area of salt affected soils in Iraq is about 6.7 million hectares (Mha) (Abrol et al., 1988), while only 1.025 Mha are partially or totally reclaimed (Committee of Agriculture and Water Resources Sector, 2009).

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