



## Assessing Shekh Turab Water Resources for Irrigation Purposes by Using Water Quality Index

Nihal S. Hanna, Faris Z. Jarjes, Janan J. Toma

Department of Environmental Sciences, College of Science, Salahaddin University, Erbil, Kurdistan Region, Iraq.

### ARTICLE INFO

#### Article History:

Received: 18/12/2018

Accepted: 29/07/2018

Published: 28/10 /2018

#### Keywords:

Water Analysis

ShekhTurab

Irrigation

Water Index

#### \*Corresponding Author:

Nihal S. Hanna

nihal.hanna@su.edu.krd

### ABSTRACT

An Attempt was made to analyze the water quality of ShekhTurab stream for irrigation purpose. Water samples were collected from 5 sampling sites with two replications for each during July and November 2016. Studied samples were analyzed for electrical conductivity (EC), sodium adsorption ratio (SAR), sodium ( $\text{Na}^+$ ), chloride ( $\text{Cl}^-$ ) and bicarbonate ( $\text{HCO}_3^-$ ) contents. The results showed that the values of (IWQI) ranged from (41.11) to (53.65) and all sites were fall within the 4<sup>th</sup>category "high restriction", it is clear that the plants have moderate resistance to salts might be grown in July and should be avoided its use for irrigation under normal conditions and only plants with high salt tolerance in November. Based on the obtained results, it is recommended to avoid grow salts sensitive plants to increase agricultural productivity in the study area.

### 1. INTRODUCTION

Water as a renewable source is the key element of sustainable development. Nowadays, and in the future water in the world, and particularly in Iraq becomes critical. In recent decades with the increase in the population around the world, water demand in different sectors (agricultural, industrial, and domestic water) may exert an increasing pressure on the groundwater resources(Gheyi, 2000).Agricultural lands and irrigation will be intensified, particularly in arid and semiarid regions in order to feed an estimated world population of 8.5 billion by 2025. However, approximately 10% of soils of these regions will lose their fertility due to potential irrigation induced problems such as sodicity,

water logging and salinity and new areas need to be converted to irrigation, intensifying the problem (Gheyi, 2000).According to Shalhevet and Kamburov (1976) and Talukder *et al.*(1998) irrigation water quality mainly means the total quantity of dissolved salts and its ionic content depending on the water source and time of water sampling of water is becoming the main problem as well as water quality. The use of low water quality may have a significant impact on the agricultural productivity, especially in arid and semiarid regions due to the accumulation of salts in soil which affect water quality and fertility and permeability of soil (Shalhevet and Kamburov, 1976). Water quality indices (WQI) aims to give a single value to the water quality of a source reducing great amount of parameters into a simpler expression enabling easy interpretation of

monitoring data (Horton, 1965). The (WQI) was first proposed by Horton (1965). Much of the work has been done on the water quality indices of several rivers and lakes in Iraq, Kurdistan and for various purposes such as drinking or agriculture uses by various workers (Abdul Hameed *et al.* (2010b); Abdul Hameed *et al.* (2010a); Shekha and Al-Abaychi (2010); Toma (2012) and Toma *et al.* (2013) Toma (2012) and Toma *et al.* (2013). Abdul Jabbar 2010 developed IWQI was applied to assess the irrigation water quality of Tigris, Euphrates and Shatt Al Arab rivers in Iraq based on observed water quality data. Then Meireles *et al.* (2010) classifies surface water quality in the Acarau Basin, in the North of the state of Ceara, Brazil for irrigation use. Mohammed (2011) used Irrigation Water Quality Index (IWQI) to classify Tigris River within Salahaddin Province in Iraq. The objective of the present study is to assess and classified the water quality of ShekhTurab stream Erbil Province for irrigation purpose by the applied model of (IWQI) developed by (11).

the Greater and Lesser Zab respectively. Boundaries extend from longitudinal  $43^{\circ} 00' 15''$  E to  $45^{\circ} 14'$  E and from latitude  $35^{\circ} 27'$  N to  $37^{\circ} 24'$  N. The climate of the area is characterized by a wide diurnal and annual range of temperature (Zohary, 1950). The climate most closely related to Irano-Turanian type. The annual average rainfall for Erbil city estimated to be 440mm (Razoska, 1980). Details of geology, pedology and limnology of the area may give in (Maulood *et al.*, 1980). Spring and autumn surface water samples were taken from five selected site in ShekhTurab stream located 20km east of Erbil city monthly over a period of two period of July and November-2016 period (July and November-2016) respectively ( Figure 1).

## 2. MATERIALS AND METHODS

### 2.1. Study area

Erbil province (Figure1) is of Kurdistan Region and located in the north east of Iraq. It is bounded to the north east and south east by

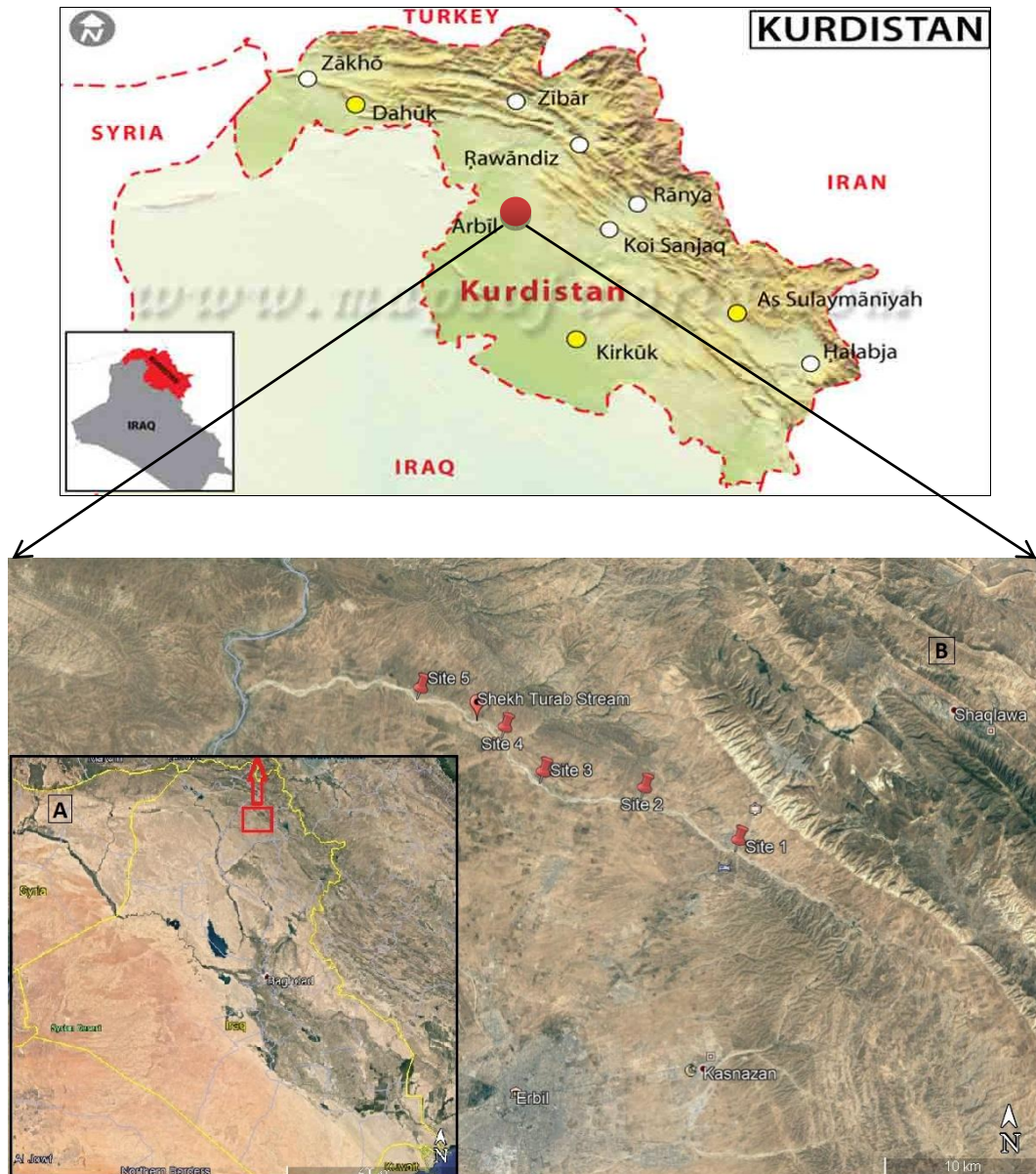


Figure (1):- A- Map of Iraq within Erbil province

B- Map of Erbil province and studied sites indicated with red pins (ShekhTurab Stream)

Studied stream is one of the branches of Greater Zab river, in which located in ShekhTurab village; it is about 75 km far away from Erbil City. The estimate terrain elevation above sea level is 393 m. The water depth is between 30 to 80 cm and width about 8 m. stream water mainly use for irrigation

purposes, and sand mining is common along the stream(Maulood *et al.*, 1980).

## 2.2. Sample Collection and Analysis

The electrical conductivity was measured by using (pH-EC-TDS meter, HI 9812, Hanna instrument), SAR,  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Cl}^-$  and  $\text{HCO}_3^-$  were measured according to(APHA, 2005).

**2.3. The Model of Irrigation Water Quality Index (IWQI)**

The model of (IWQI) developed by Meireles *et al.* (2010) was applied on the observed data according to the following steps:-

**Step1:** Identified parameters were considered more relevant to the irrigation use; EC, Na<sup>+1</sup>, HCO<sub>3</sub><sup>-1</sup>, Cl<sup>-1</sup>, SAR<sup>o</sup>.

**Step2:** The values of quality measurement (Quality rating) (Qi) for each parameter were calculated using the equation (1), based on the tolerance limits shown in table (1), and the observed water quality results. Table (1) was consecrated according to irrigation water quality parameters proposed by (UCCC) and by the criteria established by Ayers and Westcot (1985).

$$Q_i = Q_i \max - \left[ \frac{(X_{ij} - X_{inf}) * q_{iamp}}{X_{amp}} \right] \dots \dots \dots (1)$$

Where Q<sub>imax</sub> is the maximum value of quality rating scale (qi) for the class of table (1) ; X<sub>ij</sub> is the observed value for the parameter; X<sub>inf</sub> is the corresponding value to the lower limit of the class to which the parameter belongs; Q<sub>iamp</sub> is class amplitude; X<sub>amp</sub> is

class amplitude to which the parameter belongs .In order to evaluate sample, of the last class of each parameter, the upper limit was considered to be the highest value determined in the physical-chemical and chemical analysis of the water samples.

**Step 3:** The weight of each parameter has been assigned according to its relative importance in the overall quality of irrigation water, as shown in table (2):

**Step 4:** The water quality index was calculated as:

$$IWQI = \sum_{i=1}^n Q_i w_i \dots \dots \dots (2)$$

IWQI is dimensionless parameter ranging from 0 to 100; (Qi) is the Quality rating of the ith parameter, a number from 0 to 100 (wi) is the normalized weight of the i<sup>th</sup> parameter. Division in classes based on the recommended water quality index was based on present water quality indices, and classes were indicated the potential risk of salinity problems, reducing the osmotic potential of soil, as well as toxicity to plants as observed in the classifications presented by Holand and Amorim (1997). Restrictions to water use classes were characterized as shown in table (3).

**Table 1: Parameter limiting values for (Qi) calculation (AyersandWestcot, 1985)**

(qi)	EC(Meq/L)	SAR°(Meq/L) <sup>1/2</sup>	Na <sup>+1</sup>	Cl <sup>-1</sup>	HCO <sub>3</sub> <sup>-1</sup>
			Meq/L		
<b>85-100</b>	0.20 ≤ EC < 0.75	0.20 ≤ SAR° < 3	2 ≤ Na < 3	1 ≤ Cl < 4	1 ≤ HCO <sub>3</sub> < 1.5
<b>60-85</b>	0.75 ≤ EC < 1.50	3 ≤ SAR° < 6	3 ≤ Na < 6	4 ≤ Cl < 7	1.5 ≤ HCO <sub>3</sub> < 4.5
<b>35-60</b>	1.50 ≤ EC < 3	6 ≤ SAR° < 12	6 ≤ Na < 9	7 ≤ Cl < 10	4.5 ≤ HCO <sub>3</sub> < 8.5
<b>0-35</b>	EC < 2 or EC ≥ 3	SAR° < 2 or SAR° ≥ 12	Na < 2 or Na ≥ 9	Cl < 1 or Cl ≥ 10	HCO <sub>3</sub> < 1 or HCO <sub>3</sub> ≥ 8.5

**Table 2: Weights for the (IWQI) parameters (Meireles *et al.*, 2010)**

Parameters	Wi
EC	0.211
Na+1	0.202
HCO <sub>3</sub> -1	0.202
Cl-1	0.194
SAR°	0.184
Total	1

**Table 3: (IWQI) Characteristics (Holanda and Amorim, 1997)**

IWQI	Water use restriction	Recommendation	
		Soil	Plant
85-100	No restriction (NR)	Could be used for the majority of soil types and it has the lowest probability of salt accumulation which may cause salinity and sodicity problems, being recommended leaching within irrigation practice, except for soils with extremely low permeability	No toxicity risk for most plants
70-85	Low restriction(LR)	Recommended for irrigation is soils with low texture and moderate permeability, being recommended salt leaching. Soils sodicity in heavy texture soils may occur, being recommended to avoid its use in soils with high clay	Avoid low salt resistant plants.
55-70	Moderate restriction(MR)	Recommended for the soil irrigated with moderate to high permeability levels, being suggested moderate leaching of salts.	Plants that have moderate resistance to salts might be grown.
40-55	High restriction (HR)	May be used in soils with high Permeability without compact layers. High frequency irrigation schedule should be adopted for water with EC above 2000 dS m <sup>-1</sup> and SAR above 7.0	Plants with moderate to high resistance to salts may be grown with special salinity control techniques, except water with

			low Na, Cl and HCO <sub>3</sub> concentrations.
0-40	Severe restriction (SR)	Should be avoided its use for irrigation under normal conditions. In special cases, may be used occasionally. Water with low salt levels and high SAR require gypsum application. In high saline content water soils must have high permeability, and excess water should be applied to avoid salt accumulation.	Only plants with high salt tolerance, except for waters with extremely low values of Na, Cl and HCO <sub>3</sub>

which have taken in two seasons, one in winter and the other in autumn-2016 for five stations with two replications for each site, are presented in table (4).

### 3. RESULTS AND DISCUSSION

The values of the physical and chemical measurements of ShekhTurab stream samples

**Table (4). Average measured values of the parameters of IWQI for ShekhTurab spring water sampled at different sites and over two months of 2016.**

Period	Site	Average value of the measured parameters					
		EC(dSm <sup>-1</sup> )	Na <sup>+</sup> (meq/l)	Ca <sup>2+</sup> + Mg <sup>2+</sup> (meq/l)	SAR(meq/l)	Cl <sup>-</sup> (meq/l)	HCO <sub>3</sub> <sup>-</sup> (meq/l)
Jul-16	1	1.20	1.28	7.80	0.92	1.17	3.56
	2	1.16	1.26	7.80	0.91	1.14	3.49
	3	1.18	1.34	7.68	0.97	1.03	3.55
	4	1.16	1.33	7.20	0.99	1.11	3.42
	5	1.13	1.34	7.18	1.00	1.14	3.42
Nov-16	1	1.00	1.54	7.80	1.39	0.81	2.55
	2	0.99	1.56	7.80	1.38	0.90	2.50
	3	0.97	1.60	7.68	1.35	0.83	2.38
	4	1.02	1.63	7.20	1.45	0.97	2.39
	5	0.98	1.60	7.18	1.43	0.86	2.26

### 3.1. Assessment of Individual Hazard Groups

#### 3.1.1. Salinity Hazard

Concentrations of Electrical conductivity (EC) in collected samples from five sites are presented in table (4). It can be seen that EC values are observed to cover a wide range from (0.97 dS/m) which measured at site (3) in (Nov 2016) to (1.20 dS/m) which measured at site (1) in (Jul 2016), this may be attributed to the decreased discharge and increased of evaporation and lower one in (Nov 2016) of the due to rainfall that cause dilution then decrease the amount of salt in water samples. Results of the electrical conductivity throughout this survey come in accordance with the known conductivity values of Iraqi inland waters (Maulood *et al.*, 1980). The gradual reduction in conductivity with time may be due to the uptake of the ions by organisms for their metabolism. Similar observation has been reported by (Mustapha and Osmotosho, 2005). The variation in electrical conductivity of the water depend on the climate, seasonal variation, soil source, geological origin the content of the ionic salts such as calcium, magnesium etc. (Bartram and Balance, 1996 ; Wetzel, 1983).

#### 3. 1.2. Infiltration Hazard

The most common water quality factor that influence the normal rate of infiltration of water is the relative concentrations of sodium, magnesium and calcium ions in water that is also known as the sodium adsorption ratio (SAR). (SAR) the value of irrigation water quantifies the relative proportions of sodium ( $\text{Na}^{1+}$ ) to calcium ( $\text{Ca}^{2+}$ ) plus magnesium ( $\text{Mg}^{2+}$ ) and is computed as:

$$\text{SAR} = \frac{\text{Na} + 1}{\sqrt{\frac{[(\text{Mg}^{2+}) + (\text{Ca}^{2+})]}{2}}}} \dots\dots\dots (3)$$

The calculated values of sodium adsorption ratio (SAR) are recorded in table (4). It can be seen that the minimum value of SAR was observed in site2 (0.91 meq/l) (July 2016) and the maximum value of SAR was observed in site (4) (1.45 meq/l) (Nov. 2016). The increase in the value of (SAR) comes as a result of an increase in the sodium content relative to calcium and magnesium, and this increase can contribute to reduce the infiltration rate to such an extent that sufficient water cannot be infiltrated to supply the crop adequately from one irrigation to the another (Ayers and Westcot, 1985).

#### 3.1.3. Specific Ion Toxicity

Sodium concentrations ranged from higher value (1.26 meq/l) (Jul. 2016) at site (2) to (1.63 meq/l) (Nov. 2016) at site (4) as shown in table (4). The results indicated that the sodium concentrations increases in November are approaching or exceeding (1.63 meq/l). The present results show a slight variation in the sodium distribution patterns during two different seasons. (The main reason is associated with the solubility of salts to reach the sodium balance in the whole water body. However, the highest range of sodium ion concentration were 1.54-1.63meq/l during autumn season because the main sources of sodium ion concentration in water comes from dissolution of rocks and the overlaying water (Wetzel, 1983).

Chloride concentrations were ranged from (0.81 meq/l) measured at site (1) (Nov. 2016) to (1.17 meq/l) measured at site (1) (Jul. 2016) as shown in table (4). This variation in chloride may be due to agricultural drainage water, which disposed into the ShekhTurab stream

and geological formation of the area and also chloride may enter through the household water raised to the river directly (Morteth, 2006).

#### 3.1.4. Miscellaneous Effects

The concentration of bicarbonate ranged from (2.26 meq/l as  $\text{HCO}_3$ ) at site 5 during (Nov. 2016) to (3.56 meq /l as  $\text{HCO}_3$ ) (Jul. 2016) at site (1) as shown table (4). Increase in alkalinity values may be due to decreases in the water level. Bicarbonate increases with decreases in water levels have also been reported by Lashari *et al.* (2009). Variation in alkalinity values in this survey may be related to phytoplanktonic activity such as photosynthesis and respiration processes, and also this may be attributed to the dilution phenomena through the rainfall caused reduction in alkalinity (Lashari *et al.*, 2009)

#### 3.2. Discussion of Irrigation Water Quality Index

Table (5) represents calculation of (IWQI), while the (IWQI) values for ShekhTurab stream are recorded in table (6), it can be seen that there is a strong spatial and temporary variation of (IWQI) values during 2016 due to the dynamics of water quality influenced by human interventions and seasonality of flow at each site. Again it can be recognized that the (IWQI) value had observed with the minimum value (41.11 in Nov) at site (4) and with the

maximum value (53.65 in Jul.) at site (2). Specifically, the table (6) shows that the quality and suitability of ShekhTurab for irrigation, improved more in autumn months. The improvement of the water quality may be attributed to the increased discharge of the stream water, which contributes of salts dispersion and reduces their concentrations (Holanda and Amorim, 1997). It seems that the (IWQI) value in the summer months varied from (53.06-53.65) due to increased concentrations of salts in the river at summer season (Holanda and Amorim, 1997), and the increased evaporation rate because of high temperature at summer season. The values of (IWQI) are observed to cover a wide range between (41.11-41.76) in autumn months. It should be noted from the obtained results that any of irrigation water quality parameters may play an important role in changing the value of (IWQI).

Generally ShekhTurab water was ranked “high restriction”; good for irrigation with some restriction at all stations in 2016, this means the stream water quality is suited to irrigated soils with light texture (Holanda and Amorim, 1997), and since the nature of soil in irrigated lands on both sides of the river is clay loam (heavy texture) so the problem of soil sodicity may occurs, and this requires washing the salts from soil constantly. The farmers also must avoid growing salts sensitive plants as shown in table (6) (Brouwer, 1985).

Table (5). Sample calculation of IWQI for Site 1 during July 2016.

Period	Site	Variable	IQWI Parameters				
			EC(dSm <sup>-1</sup> )	SAR(meq/l)	Na <sup>+</sup> (meq/l)	Cl <sup>-</sup> ( meq/l)	HCO <sub>3</sub> <sup>-</sup> (meq/l)
Jul. 2016	1	Average measured value(x <sub>i</sub> )	1.20	0.92	1.28	1.17	3.56
		Q <sub>max</sub>	85.00	35.00	35.00	100.00	85.00
		Q <sub>ampl</sub>	25.00	35.00	35.00	15.00	25.00
		X <sub>amp</sub>	0.75	2.00	2.00	3.00	3.00
		X <sub>inf</sub>	0.75	0.00	0.00	1.00	1.50
		Q <sub>i</sub>	70.00	18.90	12.60	99.15	67.83
		W <sub>i</sub>	0.21	0.18	0.20	0.19	0.20
		Q <sub>i</sub> W <sub>i</sub>	14.77	3.48	2.55	18.84	13.57
		IWQI	53.14				

Table (6). Water use restrictions based on the calculated values of IWQI for ShekhTurab Spring water sampled at different sites over two months of 2016.

Period	Site	IWQI	Water Use Restriction
Jul. 2016	1	53.14	High restriction (HR)
	2	53.65	High restriction (HR)
	3	53.06	High restriction (HR)
	4	53.28	High restriction (HR)

	5	53.40	High restriction (HR)
Nov. 2016	1	41.48	High restriction (HR)
	2	41.60	High restriction (HR)
	3	41.72	High restriction (HR)
	4	41.11	High restriction (HR)
	5	41.76	High restriction (HR)

## REFERENCES

ABDUL HAMEED M.; JAWAD. A; ABID H. S. and MAULOOD B. K. (2010a). Application of Water Quality Index for Assessment of Dokan , M.; JAWAD .A; MAULOOD .B .K. and ABASS J. K. (2010b). Evaluating Raw and Treated Water Quality of Tigris River within Baghdad by Index Analysis. *J. Water Resource and Protection*, 2, 629-635.

ABDUL JABBAR K. (2010). "A proposed Index of Water Quality Assessment for Irrigation" *Eng. &Tech.Journal*, Vol. (28), No. (22).

ABDULKIDER, A. M. (2013). Assessment of water quality of Al- HusseiniehRiver / Karbala governorate / Iraq for irrigation purpose by using water quality index. *Journal of AL- Taqani*, Vol. 26, No 5: 1-15.

APHA (American Public Health Association). (2005). Standard Methods for Examination of Water and Wastewater. 21<sup>st</sup> Edition. APHA, Washington DC.

AYERS, R. S. and WESTCOT, D. W. (1985). "Water quality for agriculture". FAO Irrigation and Drainage Paper No.(29), Rev.(1), U.N. Food and Agriculture Organization, Rome.

BARTRAM, J. and BALANCE, R. (1996). Water Quality Monitoring (a practical guide to the design and implementation of freshwater quality

Lake Ecosystem, Kurdistan Region, Iraq. *Journal of Water Resource and Protection*, 2, 792-798.

ABDUL HAMEED studies and monitoring). E and FN Spon, an imprint of Chapman and Hall. London. U.K. 383pp.

BROUWER, C. M. (1985). Irrigation Water Management: Training Manual No.1- Introduction to Irrigation", chapter (7), <http://www.fao.org/docrep/R4082E00.htm>

GHEYI, H. R. (2000). Problemas de salinidadenaagricultura irrigada. In: Oliveira, T. S.; Assisjúnior, R. N.; Romero, R. E.; Silva, J. R. C. Agricultura, Sustentabilidade e o Semi-Árido. Fortaleza: UFC; Viçosa: Sociedade Brasileira de Ciências do Solo, 2000. p. 329-356.

HOLANDA, J. S. and AMORIM, J. A. (1997). Manejoe controle da salinidade da aguanaagricultura irrigada. In: Congresso Brasileiro de EngenhariaAgrícola, 26, Campina Grande. Anais. Campina Grande: SBEA, pp. (137-169).

HORTON, R. R. (1965). An index number system for rating water quality. *J. Wat. Pollut.Control.Fed.* 37: 300-306. In Iraq.*Jordan J of Biological Sciences*. Vol3(3): 115-120.

- LASHARI, K. H.; KORAI A. L.; SAHATO G. A. and KAZI, T. G. (2009). Limnological Studies of Keenjhar Lake, District, Thatta, Sindh, Pakistan. *Pak. J. Anal. Environ. Chem.* 10(1-2): 39-47.
- MAULOOD, B. K.; HINTON G.C. F. and AL-DOSKY, H.S. (1980). A study on the blue – green algal flora of Erbil province, Iraq. *Zanco (Sci.J. Univ. of Sulaimaniya, Iraq)*, Series A, 6(2): 67-90.
- MEIRELES, A. C. M. E. M.; ANDRADE, L. C. G.; CHAVES, H. F. and CRISOSTOMO, L. A. (2010). A new proposal of the classification of irrigation water. *J.RevistaCienciaAgronomica.* 41(3):349-357. Centro de CienciasAgrarias - Universidade Federal do Ceara, Fortaleza, CE.
- MOHAMMED, M. N. (2011). Assessment of Tigris River by using Quality Index for Irrigation purpose. *European Journal of Scientific Research*, ISSN 1450-216 X, Vol.(57), No.(1),PP.(15-28), <http://www.earojournals.com/ejsr.htm>.
- MORTETHA, J. I. (2006) "Qualitative Analysis and the Concentration of Salts and Ions for the Waters of Al Razaza Lake", *Journal of Karbala University* Vol. (14), No. (3).
- MUSTAPHA, M. K. and OSMOTOSHO, J. S. (2005).An assessment of the physico-chemical properties of Omoro Lake. *African Journal of Applied Zoology and Environmental Biology.*7: 73-77.
- RAZOSKA, J. (1980) Euphrates and Tigris, mesopotamion ecology and destiny, Vol: 38. Monogr.Biol .W. Junk.The Hague-Boston, London.122pp
- SHALHEVET, J. and KAMBUROV, J. (1976). Irrigation and salinity: A world-wide survey. New Delhi, Caxton Press. 106p.
- SHEKHA, Y. A. and AL- ABAYCHI, J. (2010). Use of water quality index and dissolved oxygen saturation as indicators.
- TALUKDER, MS.U.,SHIRAZI, SM. and PAUL, U.K (1998). Suitability of Groundwater for Irrigation at KirimganjUpazilaKishoreganj. *Progress Agric.* 9:107-112.
- TOMA, J. J.; ASSAD, Z. S. and BAEZ, D. R. (2013).Water Quality Assessment of Some Well Water in Erbil City by Quality index, Kurdistan Region-Iraq. *Journal of Advanced Laboratory Research in Biology.* Volume IV, Issue IV: 125-130.
- Toma, J. J. (2012).Water quality index for assessment of water quality of Duhok Lake, Kurdistan region of Iraq. *J. Adv. Lab. Res. Bio.* Vol. 3 (2):142-147.
- Wetzel, R.G. (1983). *Limnology.* W.B. Saunders. Co. 741pp.
- Zohary, M. (1950). The flora of Iraq and its phytogeographical subdivisions. Dept. Agr. Iraq.Publ. 31: 1-201.