ASSESSMENT OF WATER QUALITY OF AL- HUSSEINIEH RIVER / KARBALA GOVERNORATE / IRAQ FOR IRRIGATION PURPOSE BY USING WATER QUALITY INDEX +

Abdulkider Aziz Mutasher *

Abstract:

water quality index(WQI) in a simplified concept is a way for combining the complex water quality data into a single value or single statement . The present work is a trial to evaluate and classify the water quality of Al- Husseinieh River / Karbala Governorate -Iraq for irrigation purpose, by using the model of Irrigation water quality index (IWQI) developed in Brazil by Meireles et. al. (2010), this index can be reflects soil salinity, sodicity risks, water toxicity to plants and miscellaneous impacts on sensitive salts crops. Seventy two water samples were collected from three stations :(1-Um Al- Hammam, 2-Asalamih and 3-Bab–Baghdad) on Al- Husseinieh river from (January) until (December), 2011. These samples were analyzed for six parameters which were (EC), (Ca^{+2}), (Mg^{+2}), (Na^{+1}), ($HCO3^{-1}$) and (Cl^{-1}). The results showed that the values of (IWQI) ranged from(70.04) to(83.63) and all stations fall within the 2nd category ''low restriction'', That means the river water quality is suited to irrigated soils with light texture . And Since the 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. The researcher also recommends farmers to avoid grow salts sensitive plants to increase agricultural productivity in the study area. **Keywords: Irrigation, Water Quality Index, Al- Husseinieh River, sodicity, Karbala**

تقييم نوعية مياه نهر الحسينيه في محافظة كربلاء المقدسه – العراق لأغراض الري باستخدام مؤشر نوعية المياه

عبدالخضر عزيز مطشر

المستخلص:

إن مؤشر نوعية المياه (WQI) بمفهوم مبسط هو طريقه لربط البيانات المعقدة لنوعية المياه بقيمة واحدة أو عبارة واحده، العمل الحالي هو محاوله لتقييم وتصنيف نوعية مياه نهر الحسينيه لأغراض الري ضمن نطاق محافظة كربلاء المقدسه – العراق بأستخدام موديل مؤشر نوعية مياه الري (IWQI) الذي طور في البرازيل من قبل الباحث ميريس واخرين في عام 2010 ، هذا المؤشر يمكن له أن يعكس ملوحة التربة، المخاطر الصوديه، سمية المياه إلى النباتات والتأثيرات المتنوعةعلى المحاصيل الحساسه للأملاح . . تم جمع اثنان وسبعون نموذج للمياه من ثلاث

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*Assistant lecturer/ Technical Institute / Kerbala

محطات على نهر الحسينيه هي : (1.أم الحمام 2.الصلاميه 3.باب بغداد) للفتره من كانون الثاني إلى كانون الأول للعام 2011.تم تحليل هذه النماذج لستة متغيرات هي : خاصية التوصيل الكهربائي وأيونات الكالسيوم والمغنسيوم والصوديوم والبيكاربونات والكلورايد. لقد أظهرت النتائج ان قيم مؤشر نوعية مياه الري تراوحت بين (70,04) إلى (80,63) وأن جميع المحطات تقع ضمن الفئة (2) " تقييد منخفض" وهذا يعني ان نوعية مياه النهر مناسبه لري الترب ذات النسجه الخفيفه وحيث أن طبيعة التربه في الأراضي المرويه على جانبي النهر هي طينيه مزيجيه (ثقيلة النسجه) لذا فأن مشكلة الصوديه يمكن أن تظهر. كما يوصي الباحث المزارعين بتجنب زراعة النباتات الحساسه للأملاح من أجل زيادة الأنتاجيه الزراعيه في منطقة الدراسه.

Introduction:

There have been a number of guidelines and classifications of irrigation water quality proposed by many researchers. (e.g. Scofield, 1935; Wilcox and Magistad 1943; Doneen 1966 ; Christiansen et al. 1977) [1, 2]; Water quality criteria developed by US Salinity Laboratory (USSL ,1954) has received wide acceptance in many countries . Total salt concentration and probable sodium hazard of the irrigation water are the two major constituents of the criteria. Four classes of salinity and sodium hazard were proposed to assess irrigation water [1]. In (1977) the University of California Committee of Consultants (UCCC) proposed "guidelines", which devolved from long years of experience and research finding of US Salinity Laboratory [3] , The guidelines tackle mainly four areas: salinity, permeability, toxicity and miscellaneous. These "guidelines" then modified in 1985 by (Ayers and Westcot) [4] and becomes uses widely to evaluate irrigation water quality on the world.

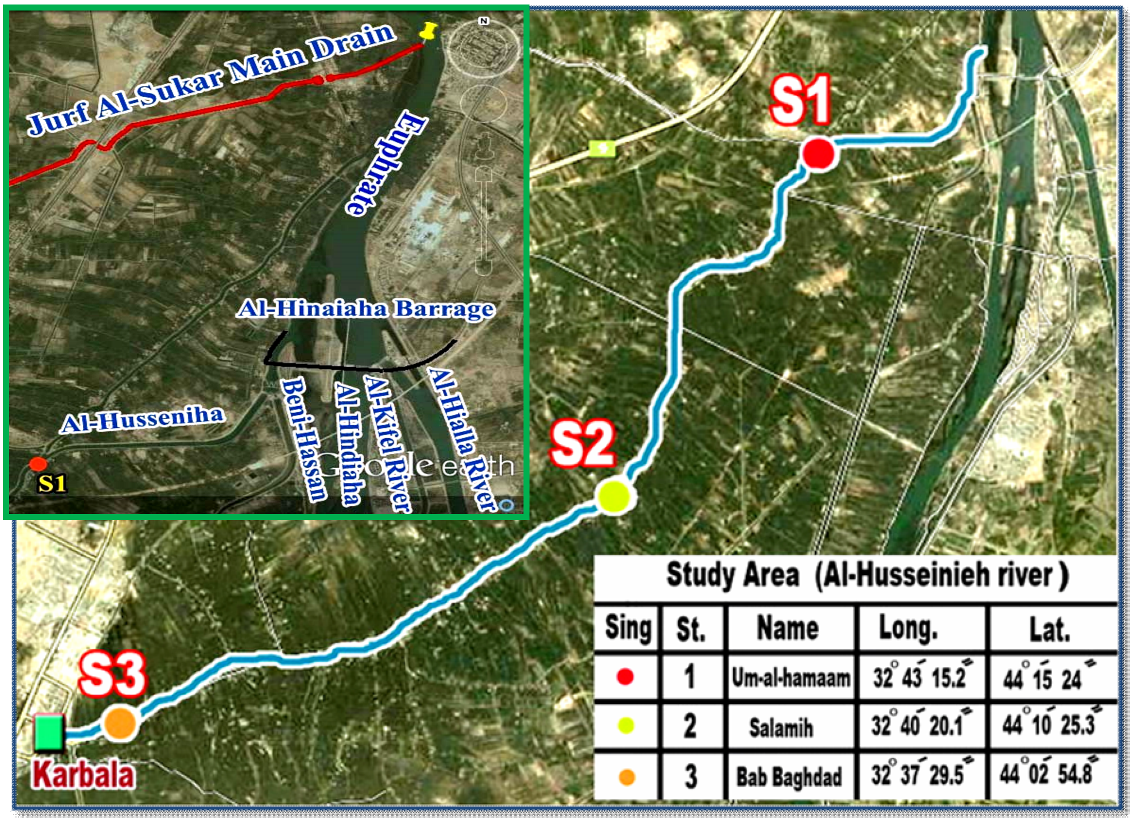
Each of these guidelines are useful but none has been entirely satisfactory because of the wide variability in the field conditions. However, it does not readily give overall view of the spatial and temporal trends in the overall water quality in the main rivers or watershed [5]. The possible solution for this problem is to reduce the multivariate nature of water quality data by employing an index that will mathematically combine all water quality parameters and provide a general and readily understood description of water [6].

The concept of 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 . The (WQI) was first proposed in 1965 by Horton [7].The need for such readily understood evaluation tool was ultimately realized, and several researchers (e.g. Brown et al., 1970; Prati et al., 1971 ; Walski and Parker, 1974; Landwehr, 1979 ; Bhargava, 1985; Dinius, 1987 and Smith, 1990) have developed their own rating schemes [8].

So far, many researches and projects have been conducted to measure surface water quality index. Shihab, A.S and Al-Rawi, S.M. [9] and Al-Hussain,M.A [10] used water quality index (WQI) as a management tool for water quality of Tigris River within Mosul city for different uses. Bhatti and Latif [8] used water quality index to assess the water quality of Chenab River in Pakistan for irrigation use. Fulazzaky, M.A. [11] assessed the status and the suitability of the Citarum River water in Malaysia for agriculture use. Abdul Jabbar.K.Al meine [6] proposed a new technique to development (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. Meireles et. al. [12] classifies surface water quality in the Acarau Basin, in the North of the state of Ceara, Brazil for irrigation use. Mohammed Muthanna, N. [13] used Irrigation Water Quality Index (IWQI) to classify Tigris river within Salah-Alddin Province in Iraq. The objective of the present study is to assess and classify the water quality of Al- Husseinieh river / Karbala city for irrigation purpose by the applied model of (IWQI) developed by Meireles et. al. [12].

Methodolog:

The Study area is Al- Husseinieh river which starts to flow from the downstream of Al Hindiah barrage regulator (lie on the Euphrates river in Al- Mussayab town (70) km south of Baghdad), then the river heading towards the south-west where it passes through agricultural land characterized by groves dense of dates palm and fruit trees categorically distance of about 30 km until it reaches to the city of Karbala, which lies 100 km south of Baghdad. The average annual discharge of the Al- Husseinieh River up to 25 m^3 / s and the nature of soil in irrigated lands on both sides of the river are clay loam and this river represent the main source of the water requirement for Karbala city for different uses (drinking, irrigation, and other purposes). Water samples were taken twice per month from January 2011 until December 2011 from three stations along Al- Husseinieh River; 1-Um Al- Hammam, 2-Asalamih and 3-Bab–Baghdad, Locations coordinates of these sampling stations are shown in figure (1). The samples were analyzed for six parameters which were Electrical conductivity (EC), Calcium, Magnesium, Sodium, Bicarbonate and Chloride, using standard procedures recommended by American Public Health Association (APHA) in 1998 [14].After determining field parameter (EC), All the water samples were collected in 3 L plastic bottles which were washed with distilled water before sampling and transporting them to the laboratory, and all samples were kept in a refrigerator at a temperature below 4C°. Chemical analysis of the water was carried out at the central laboratory of the Environmental directorate of Karbala.



Sing	St.	Name	Long.	Lat.
●	1	Um-al-hamaam	32° 43´ 15.2˝	44° 15´ 24˝
●	2	Salamih	32° 40´ 20.1˝	44° 10´ 25.3˝
●	3	Bab Baghdad	32° 37´ 29.5˝	44° 02´ 54.8˝

Fig. (1) Study area (Al-Husseinieh River) and locations of water sampling stations.

1- Irrigation Water Quality

The quality of irrigation water is highly variable depending upon both the type and the quantity of the salts dissolved in it. These salts originate from natural (i.e., weathering of rocks and soil) and anthropological (i.e., domestic and industrial discharges sources). It is commonly accepted that the problems originating from irrigation water quality vary in type and severity as a function of numerous factors including the type of the soil and the crop, the climate of the area as well as the farmer who utilizes the water. Nevertheless, there is understanding that these problems can be categorized into four major now a common groups [4]:

(a) Salinity hazard: Salts in soil or water reduce water availability to the crop to such an extent that yield is affected.

(b) Infiltration and permeability hazard: Relatively high sodium or low calcium content of soil or water reduces the rate at which irrigation water enters soil to such an extent that sufficient water cannot be infiltrated to supply the crop adequately from one irrigation to the next .

(c) Specific ion toxicity: Certain ions (sodium, chloride, or boron) from soil or water accumulate in a sensitive crop to concentrations high enough to cause crop damage and reduce yields.

(d) Miscellaneous problems: Various other problems related to irrigation water quality occur with sufficient frequency that they should be specifically noted. These include excessive nitrogen, high bicarbonate in water supply and unusual pH value of the water (i.e., above 8.5).

2- The Model of Irrigation Water Quality Index (IWQI)

The model of (IWQI) developed by Meireles et al. [12] was applied on the observed data according to the following steps:-

Step1 : Identified the parameters were considered more relevant to the irrigation use ; EC , Na^{+1}, HCO_3^{-1} , Cl^{-1} , SAR°.

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 [15].

$$Qi = qi_{max} - \left[\frac{(Xij - X_{inf}) * qi_{amp})}{X_{amp}}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where qi_{max} is the maximum value of quality rating scale (qi) for the class of table (1) ; xij is the observed value for the parameter; x_{inf} is the corresponding value to the lower limit of the class to which the parameter belongs; qi_{amp} is class amplitude; x_{amp} is class amplitude to which the parameter belongs .In order to evaluate x_{amp}, 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.

Table 1: Parameter limiting values for (Qi) calculation (Ayers and Westcot [15]).

(qi)	EC (dS /m)	SAR°(Meq/L)$^{1/2}$	Na^{+1}	Cl^{-1}	$HCO3^{-1}$
			Meq / L		
85-100	0.20 ≤ CE < 0.75	2 ≤ SAR° < 3	2 ≤ Na < 3	1 ≤ Cl < 4	1 ≤ HCO3<1.5
60-85	0.75 ≤ CE < 1.50	3 ≤ SAR° < 6	3 ≤ Na < 6	4 ≤ Cl < 7	1.5 ≤HCO3<4.5
35-60	1.50 ≤ CE < 3.00	6 ≤ SAR° <12	6 ≤ Na < 9	7 ≤ Cl <10	4.5 ≤HCO3<8.5
0-35	EC < 0.20 or EC ≥ 3.00	SAR° < 2 or SAR° ≥ 12	Na < 2 or Na ≥ 9	Cl < 1 or Cl ≥10	HCO3< 1 or HCO3 ≥ 8.5

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) :

Table 2: Weights for the (IWQI) parameters (Meireles et al. [12]).

parameters	Wi
EC	0.211
Na^{+1}	0.204
HCO_3^{-1}	0.202
Cl^{-1}	0.194
SAR°	0.189
Total	1

Step 4: The water quality index was calculated as:

$$IWQI = \sum_{i=1}^{n} Qi\ wi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (2)$$

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 ith parameter. Division in classes based on the proposed water quality index was based on existent water quality indices, and classes were defined considering the risk of salinity problems, soil water infiltration reduction, as well as toxicity to plants as observed in the classifications presented by Bernardo [16] and {Holanda and Amorim} [17]. Restrictions to water use classes were characterized as shown in table (3) .

Table 3: (IWQI) Characteristics [Bernardo [16] and { Holanda and Amorim} [17]

IWQI	Water use restrictions	Recommendation	
		Soil	Plant
85-100	No restriction (NR)	May be used for the majority of soils with low probability of causing salinity and sodicity problems, being recommended leaching within irrigation practices, except for in soils with extremely low permeability	No toxicity risk for most plants
70-85	Low restriction (LR)	Recommended for use in irrigated soils with light texture or moderate permeability, being recommended salt leaching. Soil sodicity in heavy texture soils may occur, being recommended to avoid its use in soils with high clay.	Avoid salt sensitive plants
55-70	Moderate restriction(MR)	May be used in soils with moderate to high permeability values, being suggested moderate leaching of salts.	Plants with moderate tolerance to salts may 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-1 and SAR above 7.0	Should be used for irrigation of plants with moderate to high tolerance to salts with special salinity control practices, except water with low Na, Cl andHCO3values
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 HCO3

Result and Discussion:

The values of the chemical measurements of Al- Husseinieh river water samples from January 2011 until December 2011 for three stations ; 1- Um Al- Hammam , 2-Asalamih and 3-Bab–Baghdad , are recorded in table (1) – Appendix(1).

In this study EXCEL is used to describe statistics of water quality parameters (mean, median, standard deviation, minimum and maximum) for three stations along Al- Husseinieh River as shown in table (4).

Table 4. Summary of basic statistics for different water quality parameters

Parameter	Station	Mean	median	St.d.	Min.	Max.
EC (ds / m)	S1	1.230	1.224	0.097	1.062	1.376
	S2	1.242	1.268	0.093	1.081	1.355
	S3	1.292	1.287	0.139	1.107	1.642
SAR $(Meq/L)^{1/2}$	S1	2.105	2.007	0.252	1.798	2.537
	S2	2.062	2.019	0.261	1.661	2.489
	S3	2.160	2.206	0.219	1.677	2.470
Na^{+1} (Meq/L)	S1	4.028	3.946	0.514	3.350	5.000
	S2	3.975	3.994	0.470	3.352	4.783
	S3	4.102	4.180	0.423	3.309	4.565
Cl^{-1}(Meq/L)	S1	3.475	3.469	0.615	2.377	4.783
	S2	3.556	3.620	0.668	2.332	4.760
	S3	3.581	3.684	0.559	2.450	4.537
HCO_3^{-1}(Meq/L)	S1	1.970	2.016	0.191	1.607	2.213
	S2	1.920	1.886	0.197	1.623	2.226
	S3	2.000	2.017	0.140	1.770	2.196
IWQI	S1	76.231	76.332	3.725	71.134	81.120
	S2	76.890	77.398	4.312	70.04	81.53
	S3	79.021	79.746	3.815	70.294	83.63

1. Assessment of Individual Hazard Groups

1.1. Salinity Hazard

The statistics values, of Electrical conductivity (EC) in collected samples from three stations are presented in table (4) and the mean values presented in figure (2). It can be seen that EC values are observed to cover a wide range from (1.062 dS/m) which measured at station (1) in (May 2011) to (1.377 dS/m) which measured at station (3) in (Dec. 2011). We have found that the value (1.642 dS/ m) which measured at station (3) in (Jun 2011) , It's abnormal values so it can be neglected. The mean values of EC had observed to decrease in (May 2011), this may be attributed to the increased discharge of the river due to flood which leads to decrease the amount of salt in the river water.

Furthermore, some amount of salt may fall into Al- Husseinieh river due to agricultural drainage water, which raised into the Euphrates river by Jurf Al-Sakhar main drain as a discharge of (2 m^3 / s).This drain pour into the Euphrates river at the upstream of Al Hindiah barrage regulator at the site of (32° 45′ 8″ North latitude) and (44° 16′ 20.20″ East longitude), approximately 3 km away from the (station 1) as shown in fig(1). In the other hand, the effect of thermal pollution from the electrical power station north Al- Mussayab can be contribute into polluted of the Euphrates river and then affected on the water quality of Al- Husseinieh river. Generally from note, table(4) the mean of EC increased downstream starting from station (1) until it reaches the highest value at station (3) because of agriculture's drainage and household waste that arise in the river and thus increase the accumulation and concentration of salts in the last station (3).

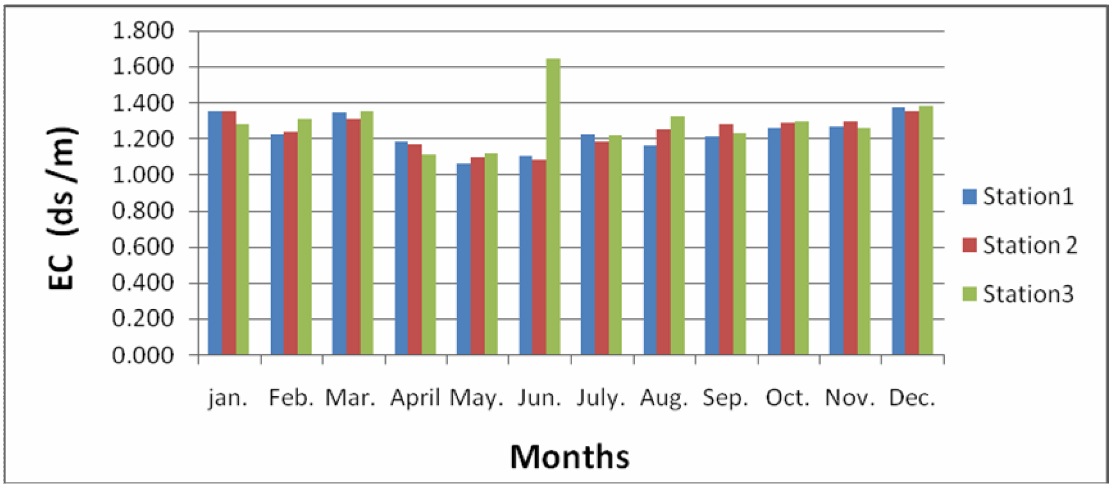


Figure (2): Relationship of Electrical Conductivity with Time for all Stations

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 (Na^{+1}) to calcium (Ca^{+2}) plus magnesium (Mg^{+2}) and is computed as:

$$SAR = \frac{Na^{+1}}{\sqrt{\frac{\{(Mg^{+2}) + (Ca^{+2})\}}{2}}} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

In this equation, the concentrations are expressed as (meq / l) mille equivalents per liter. But the above equation does not take into account changes in calcium in the soil water that take place because of changes in solubility of calcium resulting from precipitation or dissolution during or after an irrigation. So a new term for SAR should be used, this term is adj RNa (adjusted Sodium Adsorption Ratio) or Corrected Sodium Adsorption Ratio (SAR°) [4].

In the present study (SAR°) was estimated according to S. M. Lesch and D. L. Suarez [18] , They described how to compute this term as follows:-

Step 1: Convert (Na^{+1}, Ca^{+2},Mg^{+2}, $HCO3^{-1}$) measurements from (mg /l) to (meq /l) by dividing the concentration on 22.9, 20 , 12.15 , 61 respectively.

Step 2: Calculate the sum of cations (SC) and ionic strength (IS) as:

$$SC = Na^{+1} + Ca^{+2} + Mg^{+2} \ldots\ldots\ldots\ldots\ldots (4)$$

$$IS = \frac{1.3477 + Sc + 0.5355}{1000} \ldots\ldots\ldots\ldots\ldots (5)$$

Step 3: Calculate the log(X) value (using meq/ l ion measurements) as:

$$\log(X) = \frac{1}{3}\left[4.6629 + 0.6103\ \log\ (Is) + 0.0844\{\log\ (Is)\}^2 + 2\log\left\{\frac{Ca}{(2HCO_3)}\right\}\right] \ldots (6)$$

Step 4: Calculate the equilibrated Ca^{+2} concentration (on a meq/ l unit basis) as:

$$Ca_{eq} = 2 * \left[10^{\log(X)}\right] * \left(P_{CO_2}\right) \ldots\ldots\ldots\ldots (7)$$

where P_{CO2} represents the partial CO2 pressure in the near surface soil. If this latter value is assumed to be 0.0007 atm, then (Ca_{eq}) can be calculated as:

$$Ca_{eq} = \left[10^{\log(X)} * 0.17758\right] \ldots\ldots\ldots\ldots\ldots (8)$$

Step 5: Calculate the adjusted SAR as:

$$adj\ RNa = SAR^{\circ} = \frac{Na^{+1}}{\sqrt{(Ca_{eq}^{+2}) + (Mg^{+2})}} \dots\dots(9)$$

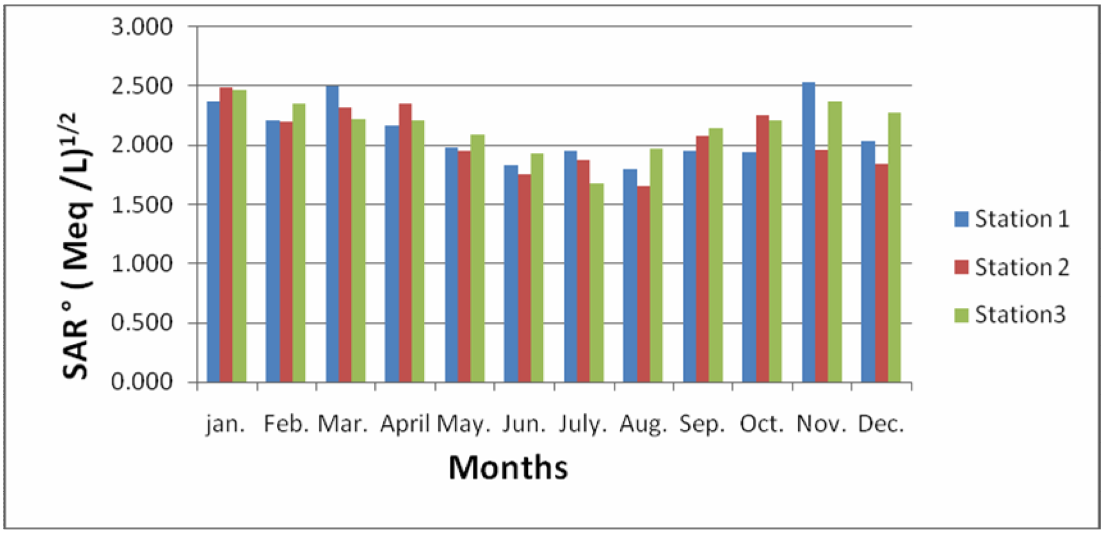


Figure (3): Relationship of SAR° with Time for all Station

The calculated values of (Ca_{eq} and SAR°) are recorded in table (1)–Appendix (1).
The spatial and temporary values of SAR° is presented in figure (3) and table (4) above. It can be seen that the minimum value of SAR° was observed in station (2) (1.661) (August 2011) and the maximum value of SAR° was observed in station (1) (2.537) (Nov. 2011). 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 increases can be contribute to reduced the infiltration rate to such an extent that sufficient water cannot be infiltrated to supply the crop adequately from one irrigation to the next [4] .

1.3. Specific Ion Toxicity

Sodium concentrations were ranged from higher value (5 meq / l)(Nov. 2011) at station (1) to (3.309 meq / l)(July 2011) at station (3) as shown in figure(4) and table(4) . It seems clear from the results that the sodium concentrations increases in autumn months (Sep. ,Oct. , Nov.) and winter months (Dec. , Jan. , Feb.) ; are approaching or exceeding (4meq / l) . Chloride concentrations were ranged from (2.332 meq / l) measured at station (2) (June 2011) to (4.783 meq / l) measured at station (1) (Dec. 2011) as shown in Figure (5) and table (4). High mean of chloride observed in station (1) that may be due to agricultural drainage water, which raised into the Euphrates River by Jurf Al-Sakhar main drain. It be noted also that the concentrations of chloride had increased at winter season (2011).The chloride may enter through the household water raised to the river directly [20].

1.4. Miscellaneous Effects

The concentration of bicarbonate are ranged from (1.607as CaCO3)(Aug. 2011) at station (1) to (2.226)(Feb.2011) at station (2) as shown in figure(6) and table(4). Increasing in bicarbonate concentration was observed in wet period this may be attributed to the increasing of rainfall during the winter season and that leads to dissolution of minerals from lithological composition such as limestone and dolomite , in addition to interfere between ground water and river water [19] .

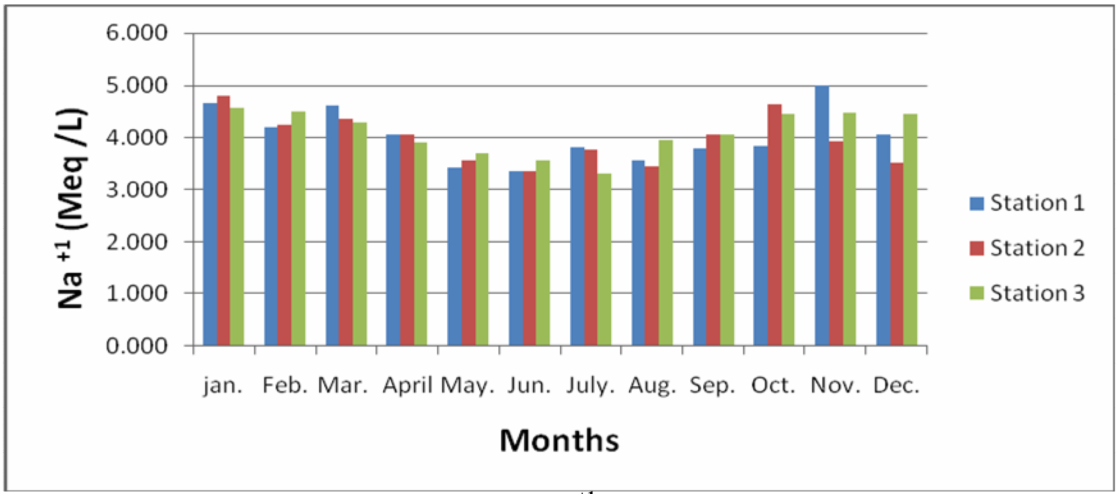


Figure (4): Relationship of Na^{+1} with Time for all Station

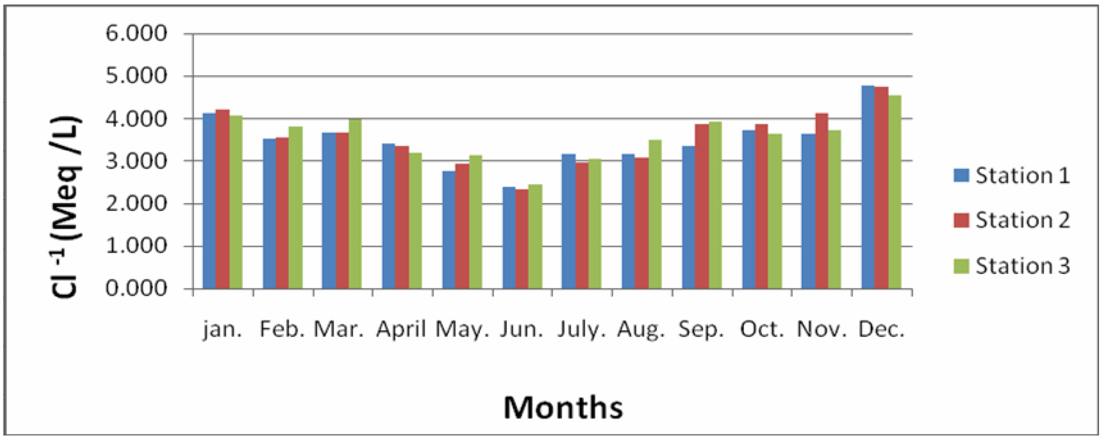


Figure (5): Relationship of Cl with Time for all Stations

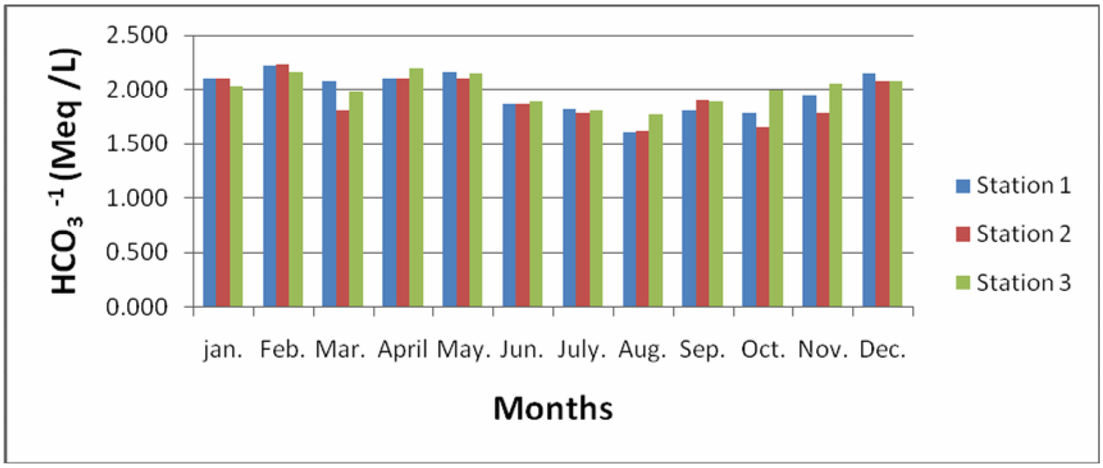


Figure (6): Relationship of Bicarbonate with Time for all Stations

2. Discussion of Irrigation Water Quality Index

The (IWQI) values for Al- Husseinieh river water samples are recorded in table (1) – Appendix (1),which are presented in figure (7). As an overview for figure (7), it can be seen that there is a strong spatial and temporary variation of (IWQI) values during 2011 due to the dynamics of water quality influenced by human interventions and seasonality of flow at each station. From the same figure, again it can be recognized that the (IWQI) value had observed with the minimum value (70.04 in Nov) at station (2) and with the maximum value (83.63 in May) at station(3). Specifically, the figure shows that the quality and suitability of AL-Husseinieh river water for irrigation , improved more in winter months (Dec , Jan. , Feb.), as well as the improvement in the two months of spring season (Mar. , Apr.) , where the value of (IWQI) is approaching or exceeding (80%) in all stations. The improvement of the water quality may be attributed to the increased discharge of the river water, which contributes of salts dispersion and reduces their concentrations.

It seems that the (IWQI) value in the summer months (Jun., July, Aug.) ranged between (70.3% -77%) was less than the values recorded in most months for winter and spring, because of the increased concentrations of salts in the river at summer season. This mainly due to less availability of water for dilution, because of the decreased discharge of the river. And the increased evaporation rate because of high temperature at summer season. The values of (IWQI) are observed to cover a wide range between (70.04% -81.67%) in autumn months (Sep. ,Oct. , Nov.)

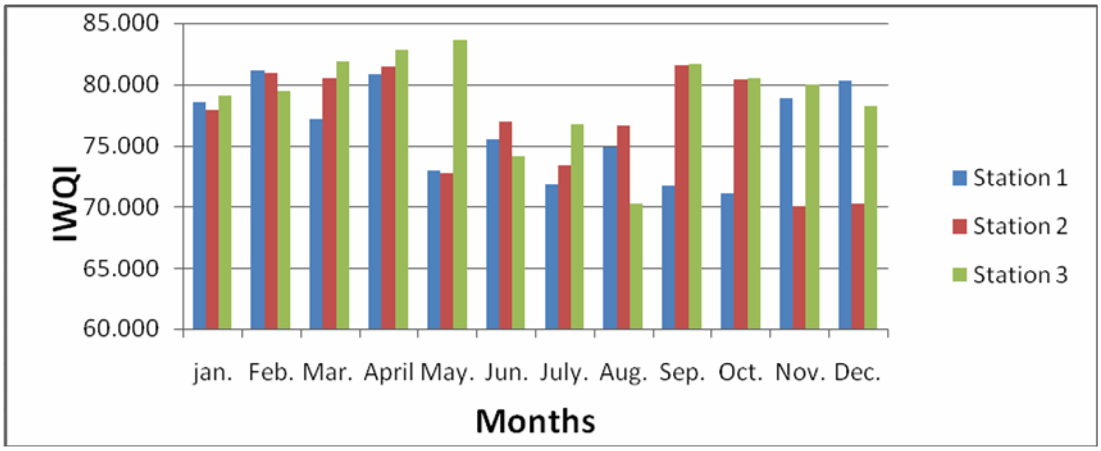


Figure (7): Relationship of (IWQI) with Time for all Station

From observed the results it should be noted that any of irrigation water quality parameters may play a major role in changing the value of (IWQI) and this can be seen clearly in the example as shown below in table (5) , where the value of SAR is less than (2 meq / l) , thus belong in class (4) according table (1), and that leads to reduce the value of (Qi_{SAR}) to (38) that was calculated according to equation (1) and hence this reduce the final value of the (IWQI) at station (2) in (Nov. 2011) to 70.04 .

Table (5): calculations of (IWQI) for station (2) (Nov. 2011)

Parameter	Xij	Wi	Qi	Wi*Qi	class
EC (ds / m)	1.298	0.211	66.734	14.1	2
Na^{+1} (meq/ l)	3.935	0.204	77.21	15.751	2
HCO_3^{-1}(meq/l)	1.787	0.202	82.61	16.687	2
Cl^{-1}(meq/l)	4.11	0.194	84.1	16.315	2
(meq/l)$^{1/2}$ SAR	1.958	0.189	38	7.182	4
				IWQI= $\sum = 70.04$	

$$Qi_{EC} = 85 - \left[\frac{(1.298 - 0.75) * 25}{(1.5 - 0.75)}\right] = 66.734 \qquad Qi_{(Na^{+1})} = 85 - \left[\frac{(3.935 - 3) * 25}{(6 - 3)}\right] = 77.21$$

$$Qi_{(HCO_3^{-1})} = 85 - \left[\frac{(1.79 - 1.5) * 25}{(4.5 - 1.5)}\right] = 82.61 \qquad Qi_{(Cl^{-1})} = 85 - \left[\frac{(4.11 - 4) * 25}{(7 - 4)}\right] = 84.1$$

$$Qi_{(SAR^*)} = 100 - \left[\frac{(1.958 - 2) * 35}{(2.489 - 2)}\right] = 38$$

Generally Al- Husseinieh river water was ranked ‘‘low restriction’’ ; good for irrigation with some restriction at all stations in 2011 according to table (3) , That means the river water quality is suited to irrigated soils with light texture [Bernardo (16) and { Holanda and Amorim (17) }]. 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) [21]. Therefore, the solution to address the problem is to control the sources of pollution of river water to be suitable to irrigate most types of crops and plants or cultivation of crops with highly or moderaty tolerant to salt as shown in table (6) [21] to get higher productivity (kg of the crop / liter of water).

Table (6) after C. Brouwer, et al. [21].

Highly tolerant	Moderately tolerant	Sensitive
Date palm	Wheat	Red clover
Barley	Tomato	Peas
Sugar beet	Oats	Beans
Cotton	Alfalfa	Sugarcane
Asparagus	Rice	Pear
Spinach	Maize	Apple
	Flax	Orange
	Potatoes	Prune
	Carrot	Plum
	Onion	Almond
	Cucumber	Apricot
	Pomegranate	Peach
	Fig	
	Olive	
	Grape	

Conclusion:

1. The IWQI for Al- Husseinieh river water samples ranges from (70.04 in Nov) at station (2) to (83.63 in May) at station(3) and all these values lies in 2nd class of IWQI through the study period.
2. Station (1) was observed to have lower mean value of IWQI (76.231) while station (3) was observed to have higher mean value of IWQI (79.021).
3. The value of (IWQI) that approaching or exceeding (80%) at winter and spring seasons in all stations was more than the values recorded at summer season , that means the irrigation water quality of Al-Husseiniya River improved more at winter and spring comparing with summer season.

4. Al- Husseinieh river water quality can be considered suited to irrigated soils with light texture or moderate permeability.Thus, the soil sodicity problem may occur for the fact that the nature of soil in irrigated lands on both sides of the river is clay loam (heavy texture).
5. The quality of river water is suited to irrigate crops with highly or moderaty tolerant to salt. Therefore, farmers in the study area should avoid salts sensitive plants.
6. Groups: salinity hazard , sodium ion toxicity and miscellaneous problems lies in second class . While Chloride toxicity lies in first and second class and infiltration problem lies in first and forth class for whole study periods.

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Appendix (1)

Table (1): Water quality parameters used in the study.

	Param.	Jan.	Feb.	Mar.	Apr.	May	Jun	July	Aug.	Sep.	Oct.	Nov.	Dec.
Station (1)	EC	1.354	1.226	1.342	1.184	1.062	1.100	1.222	1.158	1.212	1.260	1.264	1.376
	Ca^{+2}	4.150	4.925	4.750	4.365	4.864	5.434	6.380	7.224	6.085	4.794	4.828	4.583
	HCO_3^{-1}	2.100	2.213	2.082	2.100	2.164	1.869	1.820	1.607	1.803	1.787	1.950	2.148
	Na^{+1}	4.652	4.191	4.617	4.054	3.413	3.350	3.800	3.565	3.787	3.837	5.000	4.070
	Ca (equ.)	3.400	3.667	3.723	3.482	3.627	4.327	4.970	5.866	4.836	4.142	3.967	3.575
	Mg^{+2}	4.262	3.525	3.115	3.520	2.320	2.360	2.635	1.997	2.713	3.720	3.800	4.426
	SAR°	2.377	2.210	2.497	2.167	1.979	1.832	1.945	1.798	1.949	1.935	2.537	2.035
	Cl^{-1}	4.113	3.535	3.662	3.402	2.767	2.377	3.169	3.159	3.360	3.720	3.648	4.783
	IWQI	78.52	81.12	77.14	80.80	72.99	75.52	71.86	74.84	71.70	71.13	78.88	80.26
	Param.	Jan.	Feb.	Mar.	Apr.	May	Jun	July	Aug.	Sep.	Oct.	Nov.	Dec.
Station (2)	EC	1.354	1.236	1.310	1.167	1.094	1.081	1.182	1.253	1.282	1.290	1.298	1.355
	Ca^{+2}	4.250	5.100	4.825	4.520	4.939	5.439	6.375	6.539	5.973	4.906	5.489	5.020
	HCO_3^{-1}	2.100	2.226	1.803	2.100	2.100	1.869	1.787	1.623	1.902	1.656	1.787	2.082
	Na^{+1}	4.783	4.246	4.367	4.052	3.550	3.352	3.760	3.441	4.059	4.630	3.935	3.522
	Ca (equ.)	3.450	3.750	4.129	3.534	3.762	4.352	5.042	5.465	4.626	4.467	4.556	3.847
	Mg^{+2}	3.934	3.689	2.951	2.398	2.840	2.960	2.992	3.117	2.997	4.000	3.522	3.434
	SAR°	2.489	2.202	2.321	2.353	1.954	1.753	1.876	1.661	2.079	2.250	1.958	1.846
	Cl^{-1}	4.197	3.563	3.676	3.348	2.928	2.332	2.955	3.071	3.863	3.864	4.110	4.760
	IWQI	77.84	80.93	80.47	81.43	72.8	76.95	73.42	76.60	81.53	80.43	70.04	70.25
	Param.	Jan.	Feb.	Mar.	Apr.	May	Jun	July	Aug.	Sep.	Oct.	Nov.	Dec.
Station (3)	EC	1.282	1.311	1.353	1.107	1.114	1.642	1.214	1.320	1.230	1.292	1.262	1.377
	Ca^{+2}	4.050	4.810	4.850	4.615	4.864	5.866	6.535	6.420	5.323	4.944	4.869	4.590
	HCO_3^{-1}	2.033	2.164	1.984	2.196	2.148	1.885	1.803	1.770	1.885	2.000	2.050	2.082
	Na^{+1}	4.565	4.500	4.300	3.897	3.689	3.559	3.309	3.957	4.060	4.456	4.478	4.457
	Ca (equ.)	3.389	3.672	3.905	3.489	3.662	4.547	5.071	5.105	4.285	3.962	3.829	3.654
	Mg^{+2}	3.443	3.648	3.566	2.760	2.600	2.230	2.716	2.922	2.917	4.200	3.276	3.996
	SAR°	2.470	2.352	2.225	2.205	2.085	1.933	1.677	1.975	2.140	2.206	2.376	2.279
	Cl^{-1}	4.060	3.800	3.972	3.179	3.120	2.450	3.050	3.503	3.935	3.649	3.719	4.537
	IWQI	79.04	79.49	81.81	82.84	83.63	74.12	76.72	70.29	81.67	80.46	80.00	78.17

Note 1: The units for all parameters are in (meq / l) except(Ec) in(ds / m) ,(SAR°) in (meq / L)$^{1/2}$ and(IWQI) which has no units.
Note 2: To convert Na^{+1}, Ca^{+2},Mg^{+2}, $HCO3^{-1}$, Cl^{-1} from (meq /l) to(mg / l) multiply concentration by 22.9, 20 , 12.15 , 61 , 35.5, respectively.