The Assessment of the Quality of Water Treatment Plants Effluent of Basrah City for Irrigation

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Abstract

The study included the assessment of the quality of the effluent of water treatment plants for irrigation uses. Eleven water treatment plants were selected in Basrah city center and surrounding areas which are Al-bradaiah1, Al-bradaiah2, Al-Ribat, R-Zero, Garmma1, Garmma2, Al Maqil, Al Jubila, Shatt Al_Arab, Al Hartha, and Al Basrah unified. One sample monthly were taken from these stations' effluent during January to December 2013, and the water samples were analyzed for pH, electrical conductivity (EC), alkalinity, calcium (Ca^{++}), magnesium (Mg^{++}), chloride (Cl^{-}), sulphate (SO4), total dissolved solids (TDS), sodium (Na^{+}), potassium (K), bicarbonate(HCO3), and carbonate ($CO3^{-2}$). Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Exchangeable Sodium Percentage (ESP), Residual Sodium Carbonate (RSC) were calculated by using standard equations, but EC and SAR were plotted on Richard diagram it is illustrated that water samples of R- Zero and Al- Maqil located in the class of C3-S1 representing high salinity with low sodium, which can be used for irrigation to all soil types with a minimum risk of exchangeable sodium, water samples of Al- Bradaiah1, Al- Bradaiah2, Garmma1 , Garmma2, Al Jubaila and Shatt Al-Arab located in the class of C4-S2, of very high salinity and medium sodium which is considered poor. Al- Basrah unified, Al Hartha and Al Ribat located in the class of C3-S2, of high salinity and medium sodium, which is considered as Marginal. The results of the study revealed that R- Zero, Al Maqil has a good water quality for irrigation and the rest need a more interesting in treatment, or reduce the rate of mixing with Shatt Al–Arab River.

Key words: Water treatment plant, Irrigation water, quality assessment, Piper diagram, Richard diagram, SAR

تقييم جودة المياه الخارجة من محطات معالجة المياه في البصرة للري

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المستخلص

تشمل الدراسة تقييم نوعية المياه الخارجة من محطات معالجة المياه لاستخدامات الري. وقد تم اختيار احد عشر محطة لمعالجة المياه في مركز مدينة البصرة والمناطق المحيطة بها والتي هي البراضعيه1، البراضعيه2، الرباط ، ار زيرو، كرمه1، كرمه2، المعقل، الجبيلة، شط العرب، الهارثة، ومشروع البصرة الموحد. وقد تم اخذ نموذج واحد للتحليل شهريا من مخارج محطات المعالجة من كانون الثاني لغاية كانون الاول 2013، وقد تم تحليل عينات المياه للاس الهيدروجيني (PH)، التوصيل الكهربائي(EC) ، القلوية، الكالسيوم (Ca^{++})، المغنيسيوم (Mg^{++})،

الكلوريد (Cl^-)، الكبريتات (SO_4) ، المواد الذائبة الكلية (TDS) ،الصوديوم (Na^{++}) ،البوتاسيوم (K) ، البيكربونات (HCO_3) ، والكربونات ($CO3^{-2}$) .تم حساب نسبة امتزاز الصوديوم (SAR)، النسبة المئوية لقابلية ذوبان الصوديوم (SSP)، النسبة المئوية لتبادل الصوديوم (ESP)، كربونات الصوديوم المتبقية (RSC) باستخدام المعادلات القياسية، الموصلية الكهربائية EC ونسبة امتزاز الصوديوم (SAR) فرسمت على مخطط ريجارد. لقد اتضح أن عينات المياه من أر زيرو والمعقل تقع في فئة C3-S1 والتي تمثل نسبة ملوحة عالية مع انخفاض الصوديوم، والتي يمكن استخدامها لأغراض الري لجميع أنواع التربة مع الحد الأدنى من خطر تبادل الصوديوم ، اما عينات المياه من آلبراضعيه 1، آلبراضعيه 2 ، كرمه 1 ، كرمه2، الجبيلة وشط العرب تقع في فئة C4-S2، والتي تكون ذات ملوحة عالية جدا وصوديوم متوسط والذي صنف بالضعيف . البصرة الموحد ، الهارثة وآلرباط تقع في فئة C3-S2، ذات ملوحة عالية وصوديوم متوسط، والذي صنف بالحدي.

كما كشفت نتائج الدراسة أن ار زيرو والمعقل لديه نوعية مياه جيدة لأغراض الري والباقي يحتاج إلى أكثر اهتمام في عمليات المعالجة، أو خفض معدلات الخلط مع مياه شط العرب.

1. Introduction

Basrah is the second largest city in Iraq and has had a water supply problem for decades. Basrah governorate with a population of more than two million is located at the farthest downstream end of the Euphrates-Tigris river system. Historically the urban areas in the governorate obtained their water supply from adjacent surface waters. In Basrah, the Shatt al Arab River served as the main source for water supply. There is several treatment plants located alongside Shatt Al Arab River and some further away. Most of these plants are old, conventional treatment plants, due to the increase in total dissolved solids (TDS) to the level of more than 2000 mg/l and an increase in contamination levels, an alternate source of water had to be found. This new source was the Gharraf River, which is a tributary of the Tigris, but with a TDS level of about 700 mg/l which made it acceptable as a source for drinking water. In the 1990's Sweet Water Canal (SWC), was constructed to bring this new source of water to Basrah. This untreated water flowed to a point (R-Zero) just west of Basrah. Some of the water was treated near R-Zero, but most of it was piped to the intakes of existing plants in Basrah and other cities in the governorate where it replaced the water formerly withdrawn from Shatt Al Arab river or the adjacent stretches of the Euphrates river. Water treatment in the governorate uses the conventional coagulation-filtration process which is suited for most surface water but will not lower TDS levels. Since people begin to notice and find disagreeable TDS levels which is in the range of 800 to 1500 mg/l range, or more than that in certain days of the year. In general the treated water quality at the tap is poor and is only acceptable for purposes other than drinking and cooking. Drinking water is usually purchased (RO water) from private suppliers in containers or delivered in bulk by tanker. Agriculture areas such as homes' garden is dependent on treated water supply of usable quality for Irrigation, but it has seen in recent years a deteriorate in agriculture. The suitability of water for irrigation depends on a variety of factors, most relevant and important are; salinity concentration of Total Dissolved Solid (TDS), expressed in EC unit, in irrigation water, which mainly affects crop yields, element toxicity concentration of certain ions, which may be toxic to plants or have unfavorable effects on crops, soils and public health and sodality concentration of cations, which may cause de-flocculation of clays in soils resulting damage to soil structure and permeability (SAR). The suitability of water for irrigation varies according to crops,

types and permeability of soils and climate. Therefore irrigation water quality criteria developed by US salinity laboratory has received acceptance in many countries [1]. The present study was mainly lead to measure and analyze the treated water which were come from conventional water treatment plant and multiple package units (MPUs) in Basrah city for availability for irrigation, water quality parameters of treated Water such as EC, TDS, Sodium adsorption ratio(SAR), Soluble Sodium Percentage(SSP), Exchangeable Sodium Percentage (ESP) , Residual Sodium Carbonate (RSC), pH Affect, chloride hazard, Magnesium Hazard, and Sulfate that could probably impact food safety of irrigation crops.

2. Potable Water Treatment

Table 1 list the water treatment plants in the governorate of Basrah and some of nearest districts which is subsidiary to it, which give some details of the processes used at each plant. Most of the treatment plants receive raw water from R-Zero, located at the end of the Sweet Water Canal (SWC), The intake of the SWC is at Bada'a near Ash Shatra on the Gharraf River, a branch of the Tigris, north of An Nasiriya in the Governorate of Dhi Qar, The SWC ends near Al- Basra International Airport at a spot called R-Zero. Many of the plants are located near to Shatt al Arab River (SAA), (see Fig.1), and can also draw raw water from the Shatt al Arab River if required. Shatt Al Arab River was Basrah's original freshwater source and hence all the water treatment plants were constructed on its banks. However, the reduction of fresh flows from the Tigris and Euphrates Rivers over time resulted in seawater intrusion advancing inland, increasing the salinity of the Shatt Al Arab river water, also using the Iraqi river system as a point of discharge for agricultural drainage water and sewage has further aggravated the problem of water quality in the Shatt Al Arab river, increasing the TDS levels in Shatt Al Arab river from an average of 1,792 mg/l in 1997 to an average exceeded the 3,000 mg/l in the year of 2001, that's due to dams that were constructed on the Tigris and the Euphrates upstream of Basra in Iraq, Turkey, and Syria. Almost all water treatment plants use aluminum sulphate (alum) as a coagulant, but it is rarely fully effective because of dosing equipment breakdowns. Universal disinfection using chlorine gas is intended but very few items of dosing equipment function as designed.

Table 1: Water treatment plans in Basrah city

Name	LONGITUDE	LATITUDE	Year Starts	Water source	Type
Al-bradaiah	47.855	30.503	1958	SWC & SAA	Con
Al-bradaiah	47.852	30.507	1963	SWC & SAA	Con
Al-Ribat	47.8305	30.535	1985	SWC & SAA	MP
R-Zero	47.7094	30.5302	2000	SWC	MP
Garmma 1	47.7455	30.5714	1986	SWC & Garmat Ali	MP
Garrma 2	47.765	30.576	1986	SWC & Garmat Ali	MP
Al Maqil	47.799	30.553	1936	SWC & SAA	Con

Al Jubila	47.8131	30.55	1986	SWC & SAA	Con
Shatt Al	47.857	30.537	2002	SWC & SAA	Con
Al Hartha	47.7572	30.65	1986	SWC & SAA	MP
Al Basrah	47.7483	30.6486	1978	SWC & SAA	Con

Fig.1: Water treatment plant locations in Center of Basrah city and surrounding areas.

3. Methodology

Eleven water treatment plant effluent were selected to study the availability of water supply for Basrah city to irrigate the agricultural areas, as shown in Fig.(1), The samples were taken monthly from each WTP during one year of 2013. Each sample was analyzed to determined twelve parameters including pH, electrical conductivity (EC), alkalinity, calcium (Ca^{++}), magnesium (Mg^{++}), chloride (Cl^-), sulphate (SO_4), total dissolved solids (TDS), sodium (Na^+), potassium (K), bicarbonate (HCO_3), and carbonate (CO_3^{-2}), by using standard procedures guidelines from Examination of Water and Wastewater (APHA 1998), [2] . These parameters essentially consist of certain physical and chemical characteristics of water that are used in the assessment of water quality for agricultural. The suitability of water for drinking, domestic and irrigation purposes were assessment depending on the classification of US Salinity Laboratory (USSL) by calculating irrigation quality parameters like, Sodium adsorption ratio(SAR), Soluble Sodium Percentage(SSP), Exchangeable Sodium Percentage (ESR), Residual Sodium Carbonate (RSC), pH Affect, chloride hazard, Magnesium Hazard, and Sulfate.

Correlation of analytical data has been attempted by plotting a graphical representation called Piper diagram [3].

4. Irrigation Water Quality Assessment

The characteristics of irrigation water which are important in determining its quality are:

4.1 Salinity Hazard

Salinity hazard is the main powerful water quality guideline on crop productivity as measured by electrical conductivity, it reflects TDS in water. The amount of water transpired through a crop is directly related to yield; therefore, irrigation water with high EC reduces yield potential and can result in a physiological drought condition. That is, even though the field appears to have plenty of moisture, the plants wilt because the roots are unable to absorb the water, Table 2, shown the criterion which used to assess the quality of water for use in agriculture concerning to salinity hazard.

Table 2: Salinity hazard guidelines for determination of water quality for irrigation Source FAO, 1985 [4]

Potential irrigation problem	Units	Degree of restriction on use		
		None	Slight to moderate	severe
Salinity				
EC_w	ds/m	< 0.7	0.7-3.0	> 3.0
TDS	mg/l	< 450	450-2000	> 2000

4.2 Sodium Hazard

Sodium hazard is normally expressed as the sodium adsorption ratio (SAR). This index quantifies the proportion of sodium (Na^{+}) to calcium (Ca^{+2}) and magnesium (Mg^{+2}) ions in a sample, SAR is considered a better measure of sodium hazard in irrigation as it is directly related to the adsorption of sodium by soil and prevent water supply which needed for the crops by reducing the permeability of soil [5], SAR is calculated using the equation:-

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

Where,

Na^{+}, Ca^{+2} and Mg^{+2} are in milli equivalent per liter (meq/l).

There is a major relationship between SAR values of irrigation water and the amount to which sodium is absorbed by the soils. Continued use of water with high SAR value leads to a breakdown in the physical structure of the soil caused by immoderate amounts of colloidal adsorbed sodium. The soil then becomes hard and compact when dry and increasingly impervious to water infiltration, Table 3 represent a classification of irrigation water based on SAR values.

Table 3. Irrigation water classification based on SAR values [6]

Level	SAR	Hazard
S1	<10	No harmful effects from sodium.
S2	10–18	Appreciable sodium hazard in fine-textured soils but could be used on sandy soils with good permeability.
S3	18–26	Harmful effects could be anticipated in most soils and amendments such as gypsum would be necessary to exchange sodium ions.
S4	≥26	Generally unsatisfactory for irrigation

4.3 Soluble Sodium Percentage

The sodium is particularly important among the positive ions due to a severe impact on the soil, where the soil contain sodium tends to dispersed and form a coherent crust where drought reduces the growth of plants and seedlings penetrate the Earth's surface, SSP and can be determined using the following equation:-

$$100 \quad .\ 2^* \quad SSP= \frac{Na}{(Ca + Mg + Na + K)} \quad \ldots\ldots\ldots\ldots\ldots\ldots..2$$

Where: all ionic concentrations are in meq/l.

Irrigation water with SSP greater than 60% may result in accumulation of sodium and probably deterioration the structure of soil, infiltration, aeration and reducing soil permeability [7].

4.4 Exchangeable Sodium Percentage

Exchangeable Sodium Percentage (ESP) is an indicator for soil structure deterioration.

If ESP is high that's mean high sodium ion concentration in the water, and that's lead to dispersing soils by replacing the calcium and partly of the magnesium ions from soil exchange complex.

The required value of ESP is 5 or less than 5, if values of ESP between 6 and 9 mean increasing problems with permeability and soil infiltration, especially in clay soil, ESP values greater than 15 mean serious problems for soils [8].

ESP value for irrigation water can be determined from the following empirical equation**:-**

$$\frac{(0.01475 \times SAR - 0.0126)}{(1 + (0.01475 \times SAR - 0.0126))} \times 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots3$$

From above three mentioned formulas, the ratio of SAR was adopted in most irrigation water classifications based on the risk of sodium.

4.5 Residual Sodium Carbonate

The excess sum of carbonate and bicarbonate in the water over the sum of calcium and magnesium also affects the suitability of water for irrigation purposes. In the waters having high concentrations of bicarbonate, there is a tendency for calcium and magnesium to precipitate as the water in the soil becomes more concentrated. An excess quantity of carbonate and sodium bicarbonate is considered to be injurious to the physical properties of soils as it causes dissolution of organic matter in the soil, which in turn leaves a black stain on the soil surface on drying. Hence, the relative proportion of sodium in the water is increased in the form of sodium carbonate, denoted as residual sodium carbonate (RSC), [9] . Table (4), show RSC range values and corresponding potential use. RSC is determined by the following equation:- [10]

$$RSC= (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+}\ Mg^{2+}) \quad \ldots\ldots\ldots\ldots\ldots\ldots 4$$

All ion concentrations are expressed in meq/l.

Table 4: Classification of irrigation water based on SAR values [6]

RSC Value (meq/l)	Potential Use
≤1.25	Generally safe for irrigation.
1.25 to 2.5	Marginal as an irrigation source
>2.5	Usually unsuitable for irrigation without amendment

4.6 PH Affect

Normal PH range of water for irrigation is between 6.5 to 8.4, irrigation water with a pH outside the normal range may cause nutritional imbalance or may contain toxic ion, where low pH may cause accelerated irrigation system corrosion in which they occur. High pH above 8.5 are often cause accelerated irrigation system corrosion where they occur. High pH above 8.5 are often caused by high bicarbonate (HCO_3) and carbonate (CO_3^{-2-}) concentrations [11]**.**

4.7 Chloride Hazard

Chloride is a common ion in irrigation water. Although chloride is necessary to plant in very low amount, it can cause toxicity to sensitive crops at high concentration (see Table 5). If the chloride contamination in the leaves exceeds the tolerance of the crop, injury symptoms are developed such as leaf burn or drying of leaf tissue. These symptoms occur when leaves accumulate from 0.3 to 1.0 percent chloride. It is not absorbed by the soil but moves readily with the soil water [12].

Table 5: Irrigation Water Classification regarding to chloride

Potential irrigation problem	Degree of restriction on use		
	None	Slight to moderate	Severe
Surface irrigation	< 4	4-10	>10
Sprinkler irrigation	<3	>3	

4.8 Magnesium Hazard

Calcium and magnesium ions are essential for plant growth but they may be related with soil aggregation and friability. High concentration of calcium and magnesium in irrigation water might be leads to increase soil pH, resulting in reducing availability of phosphorus. Water contains calcium and magnesium concentration higher than 10 meq/l (200mg/l) cannot be used in agriculture. Magnesium ion concentration also plays an important role in productivity of soil. It has been noted that if magnesium hazard is less than 50, the water is safe and suitable for irrigation. Magnesium hazard can be calculated from the following equation:

$$\mathbf{MH} = \frac{Mg}{\mathrm{Mg+Ca}} * 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

Where,
Ca and Mg ions are expressed in meq/l

4.9 Sulfate

Sulfate (SO_4) is relatively common in water and has no major effect on the soil other than contributing to the total salt content. If irrigation water contain high sulfate ions that leads to reduce phosphorus availability to plants. If SO_4 less than 400 mg/l that mean a preferred range but higher than 400 mg/l will leads to acidify the soil[13].

4.10 US Salinity Laboratory's diagram (Richard diagram)

The US salinity diagram (Richard diagram), Fig.2 which is based on the combined effect of EC and SAR, has been used to assess the suitability of water for irrigation [10]. The diagram was divided into 16 areas that were used to rate the degree to which a particular water may give rise to salinity problems and undesirable ion exchange effects in soil (Hem, 1989), table 6, show classification of water samples according to Richard diagram .

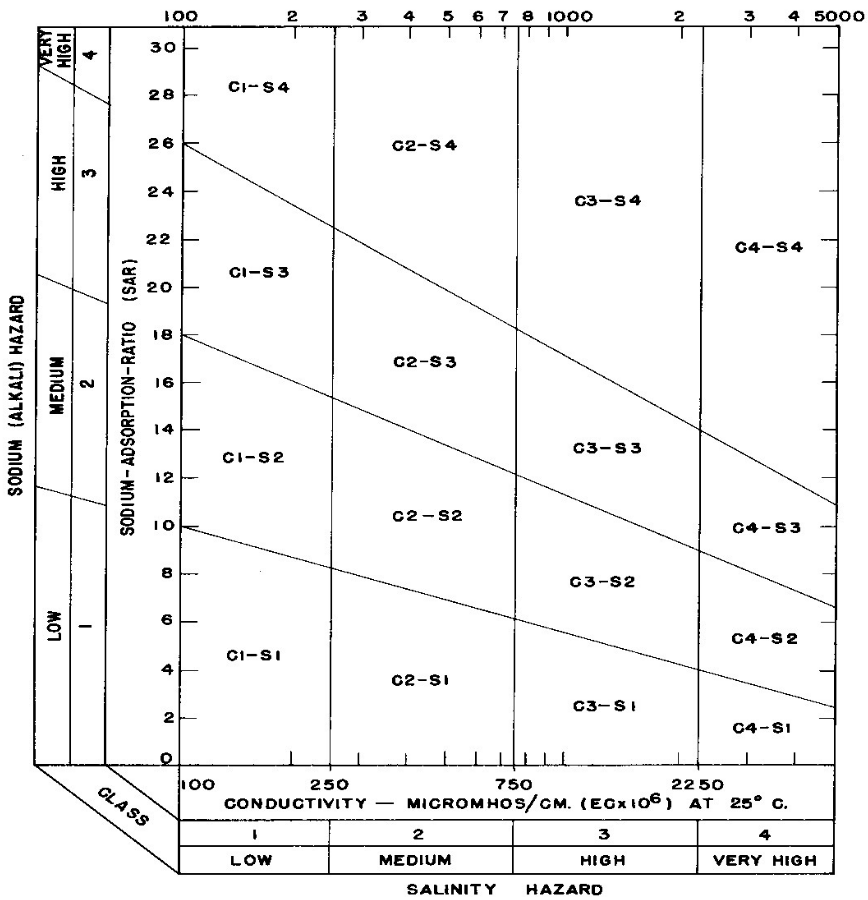


Fig.2:US Salinity Laboratory's diagram

Table 6 : Classification of water samples according to Richard Diagram

Index	Water class	Index	Water class
C1S1	Excellent	C3S1	Admissible
C1S2	Good	C3S2	Marginal
C1S3	Admissible	C3S3	Marginal
C1S4	Poor	C3S4	Poor
C2S1	Good	C4S1	Poor
C2S2	Good	C4S2	Poor
C2S3	Marginal	C4S3	Very Poor
C2S4	Admissible	C4S4	Very Poor

4.11 piper diagram

piper diagram is a graphical representation of the chemistry of a water samples. Separate ternary plots show the cations and anions. The apexes of the cation plot are calcium, magnesium and sodium plus potassium cations. The apexes of the anion plot

are sulphate, chloride and carbonate plus hydrogen carbonate anions. The two ternary plots are then projected onto a diamond. The diamond is a matrix transformation of a graph of the anions (sulfate + chloride/ total anions) and cations (sodium + potassium /total cations).

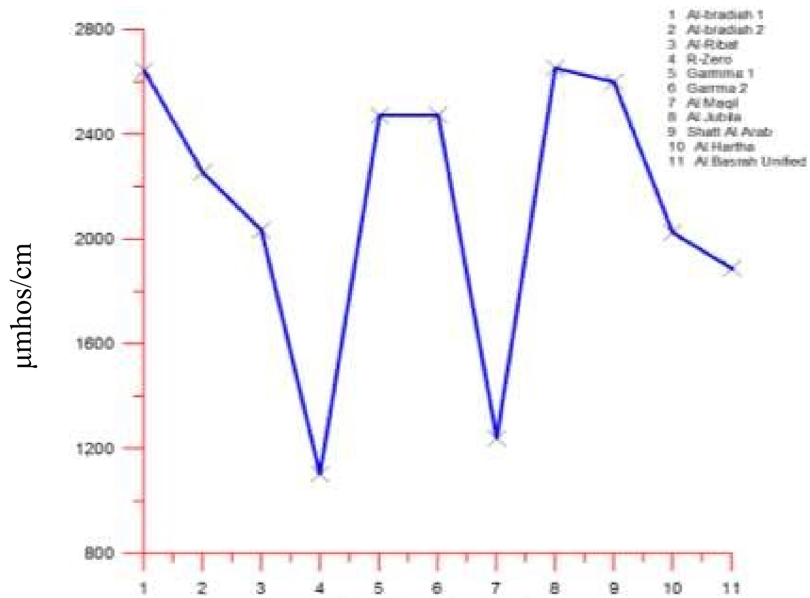
5. Results and Discussion

Statistical analysis of parameters for mean annual of year 2013, for physical and chemical characterization of the eleven stations samples are shown in Table 7.

Table. 7: major ions concentrations

Name	PH	EC	Alk	Ca	SO_4	TDS	Na	K	HCO_3	co_3	Cl
Al-bradiah 1	7.6	2644	153	131	476	1636	324	7.1	170	15	516
Al-bradiah 2	7.6	2255	146	122	418	1378	253	6.2	170	15	409
Al-Ribat	7.6	2036	143	107	346	1242	233	5.6	130	14	383
R-Zero	7.9	1104	130	88	226	655	65	3.2	100	9	133
Garmma 1	7.5	2471	146	128	454	1520	277	6.6	120	10	464
Garrma 2	7.6	2476	146	128	453	1528	284	7	120	9.6	472
Al Maqil	7.6	1241	132	90	321	736	90	3.7	125	11	170
Al Jubila	7.6	2654	142	103	531	1052	175	4.8	130	11.4	293
Shatt Al Arab	7.6	2599	154	131	456	1600	314	7.1	150	15	459
Al Hartha	7.7	2027	151	113	373	1226	217	5.3	98	9	353
Al Basrah Unified	7.8	1890	149	106	338	1148	204	4.9	100	9.3	330

Table 7 shows that, minimum Electrical conductivity (EC) of water was in R-Zero station which was 1104 µS/cm= 1.104 dS/m and maximum EC was in Al- Jubila station which was 2654 µS/cm= 2.654 dS/m,(see Fig. 3), All stations were in slight to moderate range as shown in table 2. Minimum TDS was in R Zero which equals to 655 mg/l and the maximum was in Al-bradiah1 which was equal to 1636 mg/ l, (see Fig.4). All stations were located in slight to moderate range as illustrated in table 2. For chloride concentrations (Cl^-) all samples ranged from (133 to 516 mg/l), the minimum value was in R- zero (133 mg/l = 3.75 meq/l) and the maximum value was in Al-bradiah1 (516 mg/l= 14.56 meq/l), the irrigation water classification regarding to chloride (table 5), shows that R- zero indicates a none degree of restriction on use for surface irrigation and slight to moderate degree of restriction for sprinkler irrigation. Al Jubaila, Al-Maqil, Al-Hartha and Al Basrah unified, are located in the range of slight to moderate degree, and the rest were greater than 10 meq/l and this was unsuitable for tolerant plants. The stations of Al-bradiah1, Al-bradiah2, Garmma1, Garmma2, Al Jubila and Shatt Al Arab have values of SO4 greater than 400 mg/l, indicating a problem of acidifying the soil, and the rest are good and suitable for irrigation purposes.



Water Treatment effluent Samples

Fig 3: Annual average values of EC for WTP samples during the year of study.

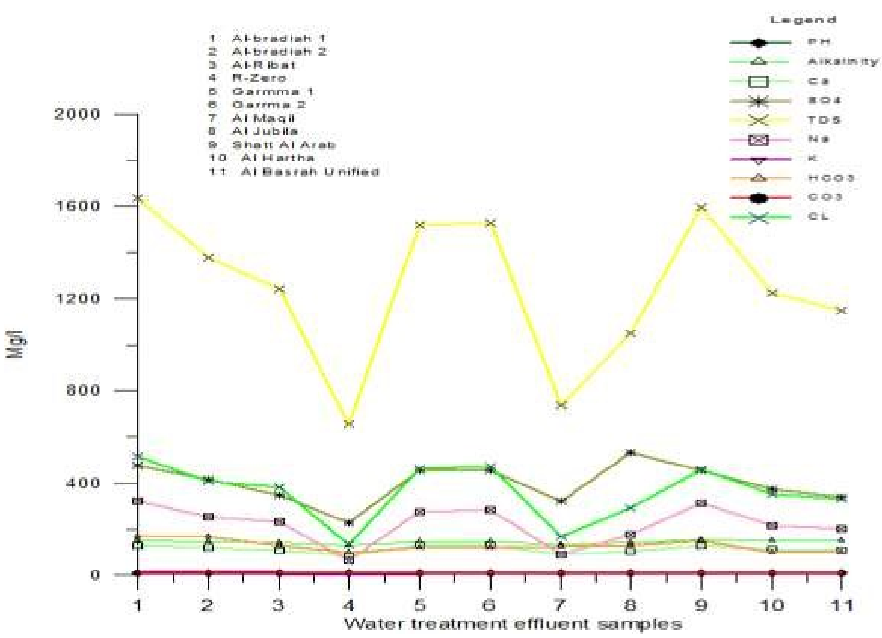


Fig 4: Annual average values of parameters concentrations for WTP samples during the year of study.

It was observed from table 8 that, for SAR in all stations ranged from 1.4 to 5.5, the minimum value was in station R-Zero, and the maximum value was in station Al-Bradaiah1. All stations are classified as having no harmful effects of sodium, regarding sodium hazard as shown in table 3. No samples have SSP greater than 60 %. Therefore, the water is safe from accumulation and deterioration of soil structure. Only R-Zero, Al-Ribat, Al-Jubaila, Hartha, Al Basrah unified and Al-Maqil, have ESP less than 5 and has no problem in soil infiltration and permeability. All water samples were less than 1.25 for RSC. Thus, regarding to carbonate and bicarbonate levels, all samples are safe for irrigation. pH of all stations varies from 7.5 to 7.9, which indicates that pH is within normal range. Al Bradhaia1 and Garmma1 exceed the value of 50 % of Magnesium Hazard (MH), and the rest is under the allowable ratio and therefore they are suitable for irrigation.

Table 8: Irrigation Quality Characteristics Calculation.

Station	Sodium Adsorption Ratio (SAR)	Soluble Sodium Percentage SSP	Exchangeable Sodium Percentage (ESP)	Residual Sodium Carbonate (RSC)	PH	Magnesium Hazard
Al- Bradhiaia1	5.5	51.544	6.444	-9.832	7.6	50.2
Al- Bradhiaia2	4.51	47.752	5.135	-8.642	7.6	49
Al- Ribat	4.4	48.629	4.995	-8.007	7.6	49.7
R-Zero	1.4	25.580	0.804	-6.236	7.9	46.3
Garmma 1	4.76	48.250	5.474	-10.504	7.5	50.1
Garmma 2	4.9	49.012	5.654	-10.435	7.6	49.8
Al-Maqel	1.88	30.917	1.499	-6.271	7.6	48.3
Al-Jubaila	3.39	42.834	3.625	-7.565	7.6	49
Shatt- Al Arab	5.38	51.229	6.290	-9.913	7.6	49.2
Al – Hartha	4.01	45.821	4.472	-9.162	7.7	49.1
Al- Basrah	3.91	46.057	4.332	-8.359	7.8	48.7

When the analytical data of EC and SAR plotted on the Richard diagram (Fig.5), it is illustrated that water samples of R- Zero and Al- Maqil, located in the class of C3-S1 which are considered as "admissible" regarding to Richard classification (see table 6), they represent high salinity with low sodium, which can be used for irrigation on all types of soil with only a low risk of exchangeable sodium, water samples of Al-Bradaiah1, Al- Bradaiah2, Garmma1 , Garmma2, Al Jubaila and Shatt Al-Arab located in the class of C4-S2 which are considered as "Poor" regarding to Richard classification, they represent very high salinity and medium sodium. Generally class C4 is unsuitable for irrigation, but may sometimes be used under very special situations, such as when the soils must be porous, drainage must be adequate, irrigation water must be applied in excess to provide considerable filtrate, and very salt-tolerant crops should be selected. Al- Basrah Unified, Al Hartha and Al Ribat are located in the class of C3-S2, of high

salinity and medium sodium, which is considered as "Marginal" regarding to Richard, classification [4].

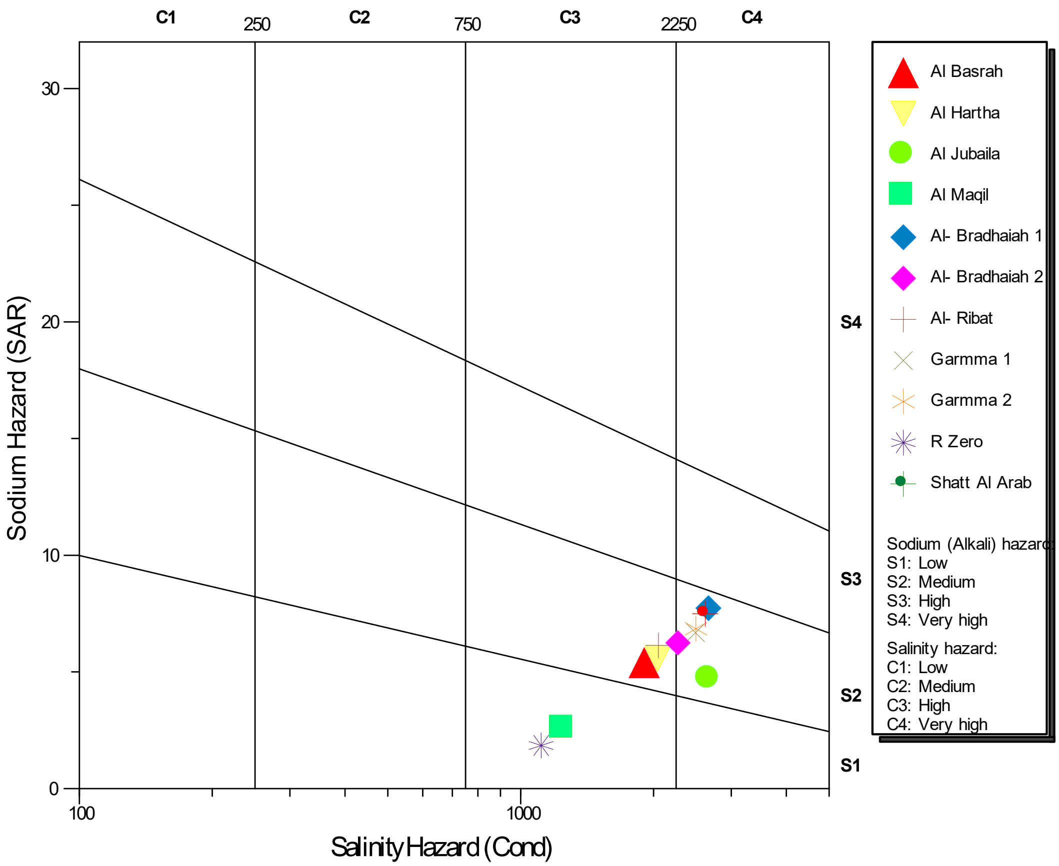


Fig. 5: Water samples evaluation in relation to salinity and sodium hazard

The values of Cl^-, $SO4^{-2}$, Ca^{+2}, Na^+, K^+, Co3, HCO^- and Mg^{+2} for each sample were plotted on a Piper diagram to indicate the type of water and overall composition and trends for the sample [14]. For plotting Piper diagram, the Schlumberger water services AquaChem software version, 2015, 1.5.0 software was used to display the relative concentrations of the different ions from individual water samples for the study area. Piper diagram for the study area is given in Fig 6. A software report was classified the water type and salinity hazard as shown in table 9, the measures are included between Ca-SO4 facies, which is typical of sodium bicarbonate water for fluvial origin (by dissolution of gypsum and other rocks) these were found in R- Zero and Al Maqil stations, and NaCl facies, which is typical of sea origin (i.e. they indicate the presence of brackish water), that is due to the effect of Shatt Al Arab river for these stations.

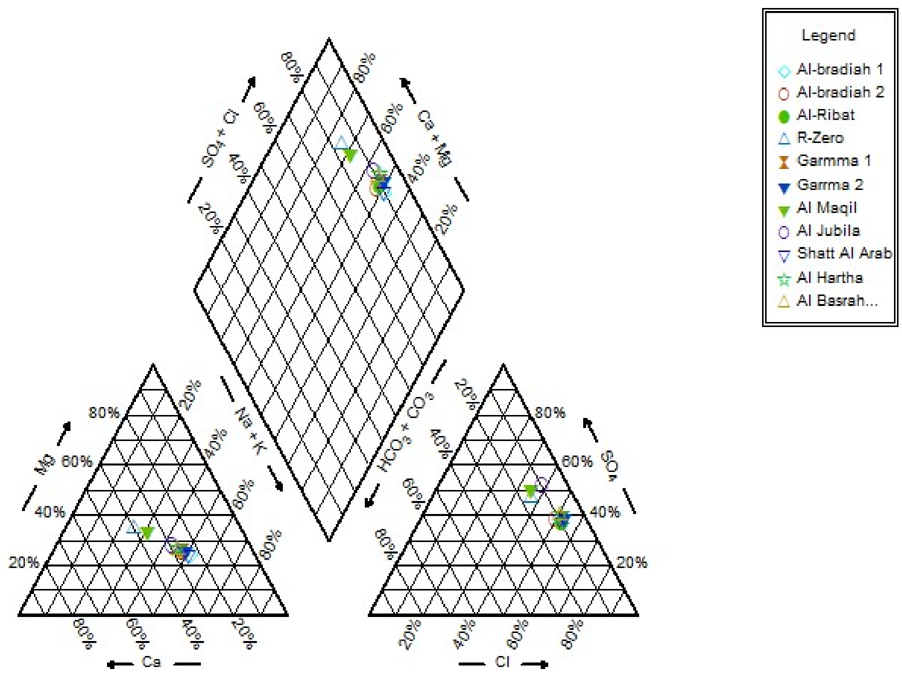


Fig. 6: Piper diagram for water treatment plant effluent samples

Table 9: Chemical type of water sample according to piper diagram

Station	Water Type	Salinity Hazard
Al- Bradhiaia1	Na-Cl	Very High
Al- Bradhiaia2	Na-Cl	Very High
Al- Ribat	Na-Cl	High
R-Zero	Ca-SO4	High
Garmma 1	Na-Cl	Very High
Garmma 2	Na-Cl	Very High
Al-Maqel	Ca-SO4	High
Al-Jubaila	Na-So4	Very High
Shatt- Al Arab	Na-Cl	Very High
Al – Hartha	Na-Cl	High
Al- Basrah Unified	Na-Cl	High

6. Conclusions

The ultimate conclusions of the research are:

1. All stations were in slight to moderate rang regarding to Salinity hazard guidelines.
2. All stations are classified as having no harmful effects of sodium, regarding to sodium hazard.

3. Cl^- for R- Zero indicates a none degree of restriction on use of surface irrigation and slight to moderate degree of restriction of sprinkler irrigation, Al Jubaila, Al-Maqil, Al-Hartha and Al Basrah unified, located in the range of slight to moderate degree, and the rest are unsuitable for tolerant plants.
4. Stations of Al-bradiah 1, Al-bradiah 2, Garmma 1, Garmma 2, Al Jubila and Shatt Al Arab indicate a problem of acidifying the soil, and the rest are good and suitable for irrigation purposes.
5. No sample has SSP greater than 60 %, therefore all water samples for all stations were safe of accumulation and deterioration of soil structure.
6. Only R-Zero, Al-Ribat, Al-Jubaila, Hartha, Al Basrah unified and Al-Maqil, have ESP less than 5 and have no problem in soil infiltration and permeability.
7. All water samples were less than 1.25 for RSC, therefore all samples are safe for irrigation, regarding to carbonate and bicarbonate levels.
8. pH of all stations was within normal range.
9. Al Bradhaia1 and Garmma1 exceed the value of 50 % of Magnesium hazard (MH), and the rest are under the allowable ratio and therefore they are suitable for irrigation.
10. water samples of R- Zero and Al- Maqil are located within class C3-S1 indicate high salinity with low sodium, which is considered "admissible" regarding to Richard diagram.
11. water samples of Al- Bradaiah1, Al- Bradaiah2, Garmma1 , Garmma2, Al Jubaila and Shatt Al-Arab are located within class of C4-S2, of very high salinity and medium sodium, which is considered "poor" regarding to Richard diagram.
12. Al-Basrah unified, Al Hartha and Al Ribat are located within class of C3-S2, of high salinity and medium sodium, which is considered "marginal" regarding to Richard diagram.
13. AquaChem software showed that the measures are ranged between fluvial origin for R- Zero and Al Maqil stations and sea origin for others that is due to effect of Shatt al Arab River for these stations.
14. R- Zero and Al Maqil have a good water quality for irrigation and the rest need a more considerate treatment.

7. Suggestions

1- The sustainable use of water treatment plant effluent water for agriculture can be considered arable for the areas irrigated by R- zero effluent or if water treatment plants pumped the water which taken from R-zero directly without mixing it with Shatt Al Arab river water.

2- Increasing the efficiency of water treatment plant, or more considerate treatment must be taken.

3- Improving water softening in water treatment plant for removal of calcium, magnesium, and certain other metal cations in hard water.

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