Study and Evaluation of Drainage Water Quality for the Upper Al_Masab Al_A'am Channel

Ameer Hashim Hussein

Al-Mussaib Technical Institute /Al-Furat Al-Awsat Technical University, 51009 Babylon, Iraq

ameer.almashhadany@yahoo.com

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Abstract

There is water shortage problem in Euphrates River, with the water quality problem of river water. The important cause behind that need to monitor water quality to verify whether the examined water quality suitable for intended usage or not. The study is conducted Abo-Ghareeb to Al-Masib city for Al_Masab Al_A'am Channel in Iraq to make valid assessment for level of parameters measured and realize their effects on irrigation. The collected samples for different elements were analyzed chemically, which affect water quality for irrigation, These elements are Calcium (Ca^{+2}), Sodium (Na^{+}), Magnesium (Mg^{+2}), Chloride (Cl), Potassium (K^{+}), Bicarbonate (HCO_3^{-}), Nitrate (NO_3^{-}), Sulfate (SO_4^{-2}), Phosphate(PO_4^{3}), Carbonate (CO_3^{-2}), Electrical Conductivity (EC), Total Dissolved Solids (TDS) and pH-values (PH). Sodium Adsorption Ratio (SAR), Sodium Content (Na %) and Residual Sodium Carbonate (RCS) have been also calculated. The Irrigation Water Quality Index (IWQI) will be examined and upgraded (integrated with *GIS*) In order assess the drainage water quality for irrigation purposes with a high accuracy, to make classification for drainage water. For this purpose, twelve samples of drainage water were taken from different four location of the study area. The results analysis of (IWQI) maps confirms that: 61% of drainage water in study area falls within "Low restriction" and 36% of study area has water with (Moderate restriction), While 3% of drainage water in study area classified as (Sever restriction). So, the drainage water should use with soil having high permeability with some constraints imposed on types of plant for specified tolerance of salts.

Key words: GIS, Irrigation Water Quality Index, Salinity, Al_Masab Al_A'am.

1. Introduction

Water has been used for different purposes in human life. The use of irrigation water is important subject for many scientific and social concerns, it’s shown limited in a country such as Iraq because it contains various water resources such as rivers and lakes. With the scientific and technological development, the water environment was greatly affected. The increase in agricultural and industrial activities led to the consumption of large quantities of water, As a result of spread in agricultural land and limited water of rain and rivers in addition to the suffering of Iraq from the control of some neighboring countries in the amount of Tigris and Euphrates Rivers, we must think about finding alternatives for the limited water specially in irrigation field.

The use of drainage water for the purpose of irrigation is very important if the properties of the water are in accordance with the accepted standards. The use of marginal quality water has the potential of causing serious problems of soil degradation and reduction in crop productivity because of irrigation water quality,[1]. The amount of lake and river water is less than 3% of fresh water on the earth's surface, while the remaining 97% is usually under-ground storage water,[2],[3] .

One of the ways to classify water quality is by adopting indices where a serious of parameters examined are joined a single value to facilities the interpretation of extensive lists of variables or indicators, to underlie water quality classification,[4]. With the inappropriate use of groundwater for irrigation purposes especially in the agricultural field, it became necessary to extent the possibility of using the drainage water for the purposes of irrigation, especially in the field of irrigation of non-sensitive plants.

Analysis of drainage water quality and geographic information system (GIS) mapping are significant sides for a strategy to plan drainage water. GIS can be adopted to identify harmed areas by drainage water pollution and get other reliable information over scenarios of current drainage water quality that can be basic side for the effective and productive implementation of water management programs, [5].

2. Review of Literature

Many studies have been conducted in the field of surface and groundwater exploitation for irrigation purposes, because the rivers and streams are characterized by standard specifications. Most of the studies focused their research efforts on the specification of groundwater and drainage water for their variation from region to another and their suitability for irrigation purposes.

The researcher [6] explained that the adequacy of surface and groundwater for irrigation is determined by the definition of mineral components of water and its soil. Another study showed the effect of the quality of surrounding groundwater in the irrigation of some agricultural crops in Naynawa governorate, [7]. The researchers [8], [9] have shown the effect of Chloride and magnesium ions in groundwater on the growth of sensitive agricultural crops. The researcher [10] analyzed the quality of groundwater around the lake of Mosul Dam and the extent of pollution in this water.

3. Aim of this Study

A study of possibility Al_Masab Al_A'am Channel for irrigation purposes, since it is classified as a main drainage channel in Iraq and extends from Saqlawiyah city to Basra city. Measure the major concentration elements cations and anions (Ca+2, Mg+2, K+, Na+, CO3-2, SO4-2, Cl-, HCO3), minor elements (NO3-, PO4-3), and physical properties (pH, Ec, TDS, Temperature and TH) and determine the relation between discharge and elevation of the upper part of Al_Masab Al_A'am Channel. The variables SAR, Na% and RCS were calculated.

4. Methodology

A specific area to the Al_Masab Al_A'am Channel from Abo-Ghareeb to Al-Masib city were selected to be evaluated for its drainage water quality. The research involved in data collection stage in which maps and references about it have been collected. Twelve samples in four stage (Abo-Ghareeb, Al-Radhwania, Al-Latefia and Al-Masib) of drainage water were taken from different locations of the study area and the laboratory analysis carried out from those samples. Laboratory work in which physical and chemical tests at sites were carried out. Spatial integration to the drainage water quality mapping was carried out using ArcGIS Spatial Analysis extension.

5. Study Area

The area of study is located from Abo-Ghareeb to Al-Masib city, it is considered one of the most important drains of central because it is the main drain for the north east and the western stable Arabian plateau in south west. The study area extends between longitudes (460 03’ – 430 22’) E and latitudes (350 22’ – 36o 40’) as shown in fig(1). The study area covers about of 22341 dunums while Al-Furat Al-sharqi drain covers an area of 1.5 million dunums,[11].

6. Field And Laboratory Works

Twelve samples in four stage (Abo-Ghareeb, Al-Radhwania, Al-Latefia and Al-Masib) of drainage water were taken from different locations of the study area and the laboratory analysis carried out from those samples. The collected samples were analyzed chemically for different elements which affect water quality, these elements are Calcium (Ca+2), Magnesium (Mg+2), Potassium (K+), Sodium (Na+), Carbonate (CO3-2), Sulfate (SO4-2), Chloride (Cl-), Bicarbonate (HCO3), Nitrate (NO3-), Phosphate (PO4-3), pH values (pH), Electrical Conductivity (EC), Total Dissolved Solid (TDS) , Water Hardness (TH) and Boron (B). Sodium Adsorption Ratio (SAR), Sodium Contents (Na %) and Residual Sodium Carbonate (RCS).

7. Discharge and Elevation Relationship for the Study Area

Al_Masab Al_A'am Channel (Third River) is the main drain, was added as third great water to the two historic rivers, the Tigris and the Euphrates. The functions of Al_Masab Al_A'am Channel is to reclaim new lands or to reduce water logging by collecting drainage water between two main rivers the Tigris and the Euphrates for more than 1.5 million of agricultural and lands from north of Baghdad to the Gulf, [12]. This giant project is to collect drain water from agricultural land, improving water quality to the two historical rivers, controlling sand dunes movement at area creating new jobs for many farmers and improving fish in saline water. Al_Masab Al_A'am Channel is the largest project suggested by British engineers in 1951 as a mean of removing highly saline irrigation drainage water from 1.5 million hectares of agricultural land between Tigris and Euphrates in central Iraq.

Al_Masab Al_A'am Channel was constructed in 1950 completed in 1960,[13] ,the water discharge of upper section to the Al_Masab Al_A'am Channel was measured by river surveyor. As shown in table (1) the discharge ranges between maximum values of 210 m3/s in Al-Masib Station Sta. (4), the minimum value in Abo-Ghareeb station is 123 m3/s (Sta.1), and the average values is 113.8 m3/s , Fig(2) shows the discharge values in different locations.

The ranges value to the water elevations above mean see level were the maximum value 14.35m in Sta.(1) to the minimum value 1.71m in Sta.(4) with average value of 6.25m as shown in Fig.(3).

Table (1): The values of Discharge and Elevation for Four stations (Upper Section of Al_Masab Al_A'am Channel)

Sta. No.	Location	Discharge (m^3/s)	Elevation above mean see level (m)
1	Abo-Ghareeb (Baghdad)	123	14.35
2	Al-Radhwania(Baghdad)	159	6.39
3	Al-Latefia (Baghdad)	172	2.53
4	Al-Masib (Babylon)	210	1.71
Average		113.8	6.25

8. Criteria for The Irrigation Water Quality

The suitability of irrigation water are determined by the amount and type of salt. There are main group for limitation which are associated with irrigation water quality, [14]:

1. Soluble salts total concentration (Salinity hazard).
2. Sodium relative proportion to the other cations (sodium hazard).
3. *pH* values and concentration of bicarbonate and nitrate (Various effects).
4. Specific ions toxicity such as Chloride, Sodium and trace elements.

The probability of plant toxicity and viability for water irrigation could be define by the combination of these substances, [15]:

I. Salinity Risk

The salinity hazard (dissolved salts in all major water irrigation sources) could be happen when salts accumulates at the crop root zone to reduce the sum of water existing at the roots. Plant's growth gets slow rate and drought-like symptoms begins to build up when the water pressure is extended,[2]. Plants roots can be burnt and foliaged by some salts with a toxic effect. Salinity of water irrigation is expressed both of indicators Electrical Conductivity (EC) and Total Dissolved Solids (TDS).

i) Total Dissolved Solids (TDS)

Total dissolved solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, Total dissolved solids are normally discussed only for freshwater systems, as salinity includes some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects), it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants, [16].

The TDS calculated in units of milligrams per letter (mg/l) or parts per million (ppm), the range of TDS for irrigation water is between 0 – 2000 ppm, [17]. The TDS values of Al_Masab Al_A'am Channel as shown in Table (2) ranges from maximum value of 12334 ppm to minimum value of 3034 ppm. Fig (4) shows the TDS meter.

Table (2): The water salinity classification according to the American Classification USRS, [3]

No.	EC value µm/cm	Classification
1	100 < EC ≤ 250	Very low salinity water
2	250 < EC ≤ 750	Medium salinity water
3	750 < EC ≤ 2250	High salinity water
4	2250 < EC	Very High salinity water

ii) Electrical Conductivity (EC)

An electrical conductivity meter (EC meter) measures the electrical conductivity in a solution as shown in Fig (5). It is commonly used in hydroponics, aquaculture and freshwater systems to monitor the amount of nutrients, salts or impurities in the water. It is closely related to TDS due to the function of the ionic solutes concentrations. The EC calculated in unit's mmhos/cm or ds/m, [17]. Tables 2, 3 and 4 show the classification of water quality according to EC with USRS, RC and TC respectively.

Table (3): The water salinity classification according to the Russian Classification [8]

No.	EC value µm/cm	Group	Classification
1	200 < EC ≤ 1000	A	Good water quality
2	1000 < EC ≤ 2000	B	Acceptable water and has little effect on sensitive plants
3	2000 < EC ≤ 7000	C	Acceptable water provided that there is washing and drainage soil

Table (4): The water salinity classification according to the Taylor Classification [8]

No.	EC value at 25 0C µm/cm	Group	Classification
1	EC ≤ 750	A	Low
2	750 < EC ≤ 1500	B	Medium
3	1500 < EC ≤ 3000	C	Intense
4	3000 < EC	D	Very Intense

II. Sodium Risk

Sodium reacts quickly with water, and also with snow and ice, to produce sodium hydroxide and hydrogen. When it's exposed to air, metallic sodium recently cut loses its silvery appearance and acquires an opaque grey color due to the formation of a sodium oxide coating, large amounts of sodium in irrigation effects on soil, [18]. Sodium toxicity is modified or reduced if sufficient calcium is available in the soil. The factor of Na could cause many problems to the crop, such as formatting crusting the beds of seed, temporal saturation of soil surface soil corrosion and insufficient nutrient obtainability. There are more factors related to these problems such as the rate of salinity and soil type. Sodium risk expressed by Soluble Sodium Percent (SSP) and Sodium Absorption Ratio (SAR),[4].

i) Soluble Sodium percent (SSP)

Sodium content calculated by the unit of meq/l (miliequivalents per liter) to the sum cations multiplied by 100. When the SSP more than 60% in water, it products in Sodium accumulation that will give rise to a collapse in physical properties of soil,[19]. According to [20] and classification of [15] all water samples of Al_Masab Al_A'am Channel (upper section) are good irrigation water kind (Na% < 50%).

Sodium content (Na%) is determined by the following equation [15] :

$$Na\% = \frac{(Na^{+}+K^{+})}{(Ca^{+2}+Mg^{+2}+Na^{+}+K^{+})} * 100 \quad ...(1)$$

ii) Sodium Absorption Ratio (SAR)

The Sodium adsorption ratio (SAR) is an irrigation water quality parameter used to the management of sodium-affected soils. It is an indicator of suitability of water for use in agricultural irrigation, as determined from the concentrations of the main alkaline and earth alkaline cations present in the water. It is a standard diagnostic parameter for the sodium hazard of a soil, as determined from analysis of pore water extracted from the soil,[15]. The formula for calculating the sodium adsorption ratio (SAR):

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

Where sodium, calcium, and magnesium concentrations are expressed in milliequivalents /liter. According to the Table (5) and classification of, [15] all water samples of Al_Masab Al_A'am Channel (upper section) are excellent kind, because of (SAR < 10).

Table (5): The water classification according to the SAR American Classification [15]

No.	SAR value	Water Classification	Specifications
1	$0 < SAR \leq 10$	Low sodium water	It can be used to irrigate most of the soil with a note showing a few harmful sodium levels.
2	$10 < SAR \leq 18$	Medium sodium water	It is possible to cause sodium risk in soft soils where there are few conditions of washing and can be used in rough soil with high permeability.
3	$18 < SAR \leq 26$	High sodium water	May result in sodium risk and need special soil management.
4	$26 < SAR$	Very High sodium water	It is usually not suitable for irrigation purposes.

iii) Soluble magnesium percent (Mg %)

Soluble magnesium percent is very important for the effects on plant growth. When this percent less than 50% then none of important on the plant growth, but it is dangerous when this percent more than 50%. This percent could be calculate by the eq. (3):

$$Mg\% = \frac{Mg^{+2}}{(Ca^{+2}+Mg^{+2})} * 100\% \quad ...(3)$$

III. Various Effects

There are another parameters besides the hazards such parameters should be estimated in water irrigation. These parameters are thought to be inside the field of various effects to sensational crops and involve the concentrations of bicarbonate, pH value and nitrate ions, [1].

IV. Bicarbonate

Bicarbonate, or hydrogen carbonate is a simple single carbon molecule that plays surprisingly important roles in diverse biological processes. Carbonate (CO3-2) and Bicarbonate (HCO3) are the main components of alkalinity in charge for large pH > 8.5, [15]. Bicarbonate ion is an anion that consists of one central carbon atom surrounded by three oxygen atoms in planar arrangement, with a hydrogen atom attached to one of the oxygen. The concentration of Boron (B) doesn’t effect on sensitive plant when B<1.

i) pH value

In general, the pH value is the major use in a water analysis to detect unusual water. It is affects the carbonate stability, weight mineral content and the rate of nitrogen constituents that consequently influence on the quality on soil and plant development.

ii) Nitrate

Nitrate is the fundamental exporter of nitrogen to most plants, it's could reduce the yield or the crop quality because it delays the crop ripeness, unsightly deposit on fruit or plants leaves or untimely growing. Applying nitrate to soils must be with in suitable limits with maximum attention.

iii) Residual Sodium Carbonate (RSC)

A high concentrations of bicarbonate at irrigation water may lead precipitation of magnesium and calcium values in the soil, which will be increase of sodium concentration. The RSC expressed the bicarbonate risk and determined by the following formula, [1].

$$RSC = \left(CO_3^{-2} + HCO_3\right) - \left(Ca^{+2} + Mg^{+2}\right) \quad \text{... (4)}$$

According to the table (6) and classification of [15] all water samples of Al_Masab Al_A'am Channel (upper section) are safe water class and it's suitable for irrigation uses because of the RSC values less than zero.

The accuracy to the results of water sample analysis could be indicated from the results of reaction error test according to eq. (5) and eq. (6), [21]:

$$U\,\% = (\,\Delta/S\,) * 100 \quad \text{... (5)}$$

$$A\,\% = 100 - U\% \quad \text{... (6)}$$

Where U is reaction error or uncertainly and A is accuracy or certainly of the results of water samples, when U% ≤ 5% that means results could be accepted for interpretation (Certain), if U% > 10% then the results unacceptable (Uncertain) and if 5% < U% ≤ 10% then the results acceptable with risk (P-Certain). Table (7) shows the accuracy and physical properties for water samples to the Al_Masab Al_A'am Channel (upper section), it has been shown that reaction error analysis ranges between Certain to P-Certain then the results could be used for interpretation purposes, also table (8) shows the water quality that measured in laboratory for the samples. The factors (Δ and S) are obtained from eq. (7) to eq. (10):

$$\Delta = \sum Cation - \sum Anion \quad \text{... (7)}$$

$$S = \sum Cation + \sum Anion \quad \text{... (8)}$$

$$\sum Cation = Ca^{+2} + Mg^{+2} + Na^{+} + K^{+} \quad \text{... (9)}$$

$$\sum Anion = Cl^{-} + SO_4^{-2} + CO_3^{-2} + (HCO_3^{-} + NO_3^{-}) \quad \text{... (10)}$$

Table (6): The water classification according to the American Classification RSC value [22]

No.	RSC value	Classification
1	RSC ≤ 1.25	Few problems or nonexistent
2	1.25 < RSC ≤ 2.5	Medium problem
3	2.5 < RSC	Problems with risk

Table (7): The accuracy and laboratory tests for water samples to the Al_Masab Al_A'am Channel (upper section)

Sta.	No.	K^+		Na^+		Mg^{+2}		Ca^{+2}		HCO_3^-		NO_3^-		CO_3^{-2}		SO_4^{-2}		Cl^-		U%	class
		ppm	epm	ppm	Epm	Ppm	epm	Ppm	epm	ppm	epm	Ppm	epm	Ppm	epm	ppm	epm	Ppm	epm		
Abo-Ghareeb	1	12.7	0.32	354	15.39	239	19.66	366	18.26	393	6.44	6.1	0.10	13.5	0.45	1212	25.23	580	16.36	4.95	Certain
	2	12	0.31	390	16.96	249	20.48	341	17.02	422	6.92	5.6	0.09	14	0.47	1263	26.30	640	18.05	2.76	Certain
	3	12.2	0.31	375	16.31	233	19.16	340	16.97	435	7.13	6.3	0.10	14	0.47	1275	26.55	630	17.77	0.70	Certain
Al-Radhwania	4	13.2	0.34	373	16.22	249	20.48	251	12.52	440	7.21	8.2	0.13	15	0.50	1219	25.38	540	15.23	1.13	Certain
	5	13	0.33	320	13.91	310	25.49	265	13.22	444	7.28	9.7	0.16	15	0.50	1380	28.73	403	11.36	4.89	Certain
	6	15	0.38	210	9.13	345	28.37	316	15.77	431	7.06	7.2	0.12	11.5	0.38	1580	32.90	220	6.20	6.97	P-Certain
Al-Latefia	7	12	0.31	480	20.87	286	23.52	371	18.51	346	5.67	5.8	0.09	15	0.50	1930	40.18	233	6.57	8.77	P-Certain
	8	14	0.36	331	14.39	257	21.14	392	19.56	420	6.88	7.1	0.11	14	0.47	1871	38.95	223	6.29	2.53	Certain
	9	14	0.36	350	15.22	271	22.29	283	14.12	440	7.21	5.9	0.10	15	0.50	1610	33.52	241	6.80	3.86	Certain
Al-Masib	10	12	0.31	380	16.52	341	28.04	313	15.62	532	8.72	6.7	0.11	14.5	0.48	1783	37.12	259	7.30	5.91	P-Certain
	11	9	0.23	350	15.22	371	30.51	253	12.62	447	7.33	5.1	0.08	15	0.50	1801	37.50	273	7.70	4.91	Certain
	12	10	0.26	310	13.48	312	25.66	219	10.93	490	8.03	3.8	0.06	16	0.53	1130	23.53	380	10.72	8.00	P-Certain
Average		12.43	0.32	351.9	15.30	288.6	23.73	309.2	15.43	436.7	7.16	6.5	0.10	14.4	0.48	1504.5	31.32	385.2	10.86	4.61	Certain
Sta.dev.		1.67	0.04	62.51	2.72	46.44	3.82	54.97	2.74	45.50	0.75	1.51	0.02	1.13	0.04	291.00	6.06	168.73	4.76	-	-

Table (8): The water quality that measured in laboratory for the samples and SAR, RSC, Mg% and Na% calculation to the Al_Masab Al_A'am Channel (upper section)

Sta.	No.	*TDS* Ppm	*EC* μm/cm	*pH* mol/l	*T* ^{0}C	*TH* Ppm	*PO_4* ppm	*B* ppm	*SAR*	*RSC*	*Mg%*	*Na %*
Abo-	1	3421	4147	7.6	29	1703	0.35	≈ 0	3.5	-31.0	56.1	29.3
	2	3765	4780	7.1	29.5	1670	0.36	≈ 0	3.9	-30.1	54.7	31.5
	3	9753	11632	7.4	31.5	1700	0.32	≈ 0	3.8	-28.5	54.0	31.5
Al-	4	4891	6721	7.6	32	2108	0.45	≈ 0	4.0	-25.3	55.8	33.4
	5	5632	7760	8.2	32	1692	0.69	≈ 0	3.2	-30.9	64.7	26.9
	6	4356	8612	8	31.5	1970	0.45	≈ 0	1.9	-36.7	75.7	17.7
Al-	7	5876	6723	8.5	31.5	1911	0.24	≈ 0	4.6	-35.9	53.0	33.5
	8	5342	7710	8	31.5	1815	0.16	≈ 0	3.2	-33.3	59.5	26.6
	9	6189	7845	8	31	1580	0.2	≈ 0	3.6	-28.7	59.4	30.0
Al-	10	5870	8734	7.3	32.5	1966	0.19	≈ 0	3.5	-34.5	62.9	27.8
	11	5749	7850	7	32.5	1740	0.19	≈ 0	3.3	-35.3	66.7	26.4
	12	6988	9001	7.2	33	1741	0.17	≈ 0	3.2	-28.0	65.6	27.3
Average		5653	7626	7.7	31.5	1800	0.31	≈ 0	3.5	-31.5	60.7	28.5
Sta.dev.		1648.5	1956.3	0.5	1.2	155.9	0.2	≈ 0	0.6	3.6	6.7	4.2

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

The values of quality measurement (Qi) and the aggregation weights (wi) for each parameter were established based on acceptance limits shown Table(9) by using eq.(11) according to irrigation water quality parameters proposed by University of California Committee of Consultants (UCCC),[22]. Water quality parameters were presented by non-dimensional equation as follow:

$$Q_i = q_{i\,max} - [(X_{ij} - X_{inf}) * \frac{q_{iamp}}{X_{amp}}] \quad \text{... (11)}$$

Where;

$q_{i\,max}$: the maximum value of q_i for the class (unit less), X_{ij}: the observed value for the parameter, X_{inf} : the equivalent value to the lower limit of the class to which parameter refer, q_{iamp}: the class amplitude and X_{amp}: is the class amplitude to which parameters belong.

To evaluate X_{amp} of the final category of every parameter, the upper limit was considered to be the highest value obtained from physico-chemical and chemical examination of water samples. Every parameter weight w_i used in *IQWI* was gotten by **[23]** as 0.211, 0.204, 0.202, 0.194 and 0.189 for EC, Na^+, HCO_3, Cl^- and SAR respectively.

The Irrigation Water Quality Index was calculating by eq.(12):

$$\boldsymbol{IQWI = \sum Q_i w_i} \quad \text{... (12)}$$

IQWI is dimensionless parameter ranging between (0 - 100). The categories were divided based on the proposed water quality index, which is developed according to existent water quality indexes. The hazard of water salinity and toxicity to plants are summarized in classifications developed by **[23]**, which gives the restrictions for using water as shown in Table (10).

Table (9): parameter-limiting values for q_i calculation [23]

Q_i	EC value at 25 ^{0}C µm/cm	SAR $(meq/l)^{1/2}$	Na^+ meq/l	Cl^- meq/l	HCO_3 meq/l
85 – 100	200 ≤ EC < 750	2 ≤ SAR < 3	2 ≤ Na^+ < 3	1 ≤ Cl^- < 4	1 ≤ HCO_3 < 1.5
60 – 85	750 ≤ EC < 150	3 ≤ SAR < 6	3 ≤ Na^+ < 6	4 ≤ Cl^- < 7	1.5 ≤ HCO_3 < 4.5
35 – 60	1500 ≤ EC < 3000	6 ≤ SAR < 12	6 ≤ Na^+ < 9	7 ≤ Cl^- < 10	4.5 ≤ HCO_3 < 8.5
0 – 35	3000 ≤ EC < 200	12≤ SAR < 2	9 ≤ Na^+ < 2	10≤ Cl^-< 1	8.5 ≤ HCO_3 < 1

Table (10): Restrictions of water uses based on IQWI, [23]

IQWI	Restriction	Recommendation	
		Plant	Soil
85-100	No Restriction (NR)	No toxicity risk for most plants	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
70-85	Low Restriction (LR)	Avoid salt sensitive plants	Recommended 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
55-70	Moderate Restriction (MR)	Plants with moderate tolerance to salts may be grown	May be used in soils with moderate to high permeability values, being suggested moderate leaching of salts.
40-55	High Restriction (HR)	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 and HCO_3 value	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.
0-40	Severe Restriction (SR)	Only plants with high salt tolerance, except for waters with extremely low values of Na, Cl and HCO_3^-	Should avoid 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.

9. Results And Discussion

Statistical measurement with Excel software for water quality parameters to the taken period are found, such as minimum, maximum, average and standard deviation as shown in table(8). There was no significant differences through points depending on analysis of variance.

The water quality parameters database measured in laboratory is transferred into GIS platform, grid datasets were create for each parameter with in domain of interest. The Figures from (6) to (19) are showing distribution of most elements that affect surface water quality for irrigation in Al_Masab Al_A'am Channel (upper section).

1. Irrigation Water Quality Index

Map of (IWQI) was produced by overlap of thematic maps (Na, Cl, HCO3, EC, and SAR) as the result of geostatistical analysis. Spatial integration to the drainage water quality mapping was carried out using ArcGIS Spatial Analysis extension, eq.(12) applied for it. This integration gives IWQI map shown in Figure (20). It represents the spatial distribution of IWQI within the domain of acceptable and could be considered as a general suitability map for providing irrigation water from the studied area. Since the map shows the spatial distribution of drainage water quality in the plain as index values, it is easy for a decision maker to assess the quality of drainage water for irrigation purposes.

2. Salinity Hazard

There are many types of factors that increase salinity in irrigation water such as evaporation, sewage effluent, agricultural drainage, evaporate bedrock, and dissolution of limestone. The salinity of water irrigation leads to accumulation of salt in root zone of crop, thus reducing ability of plant to get sufficient water from the soil and causes yield reduction,[24].

The water samples of Al_Masab Al_A'am Channel (upper section) are colorless with Temperature range between the minimum value is (29 0C) in satation1 (Abo-Ghareeb), the maximum value is (33 0C) in satation1 (Al-Masib) and the average value (31.5 0C) as shown in table (5). The TDS values to the samples shown in table (4) ranges between the minimum value of (3421) ppm in satation1 (Al-Masib), the maximum value is (9753) ppm in station3 (Abo-Ghareeb) and average value is (5653) ppm, the classification of water depending on TDS according to [Boyd, 2000], all water samples are considered to be brackish water(1000-10000) ppm, the general increase of TDS values is due to increase of salt concentration down Al_Masab Al_A'am Channel.

The water hardness of Al_Masab Al_A'am Channel (upper section) as shown in table (4) ranges from the minimum value of 1580 ppm in station 9 (Al-Latefia), to the maximum value of 2108 ppm in station 4 (Al-Radhwania), and the average value is 1800 ppm. The water hardness is derived to the solution of carbon dioxide released by bacteria lection in the soil. All water samples considered very hard because of high concentrations of Ca and Mg.

The sodium concentrations are range between Min. of 210 ppm and Max. of 480 ppm with average value of 351.9 ppm, because the primary sources of most sodium in natural water come from the release of soluble products during the weathering of plagioclase field,[23] , according to the classification of [23] shown in Table (10) all samples considered Severe Restriction (SR) . The Potassium concentrations are range between Min. of 9 ppm and Max. of 15 ppm, with average value of 12.43 ppm; because of Common sources of potassium are products formed by weathering of orthoclase, biotite, leucite, and nepheline in igneous and metamorphic rocks. The Magnesium concentrations are range between Min. of 233 ppm and Max. of 371ppm with average value of 288.6 ppm, magnesium carbonates of sedimentary rocks and Ferromagnesian mineral igneous rocks are considered increasing principal sources of magnesium in natural waters, and the calcium concentrations are range between Min. value of 219 ppm and Max. of 392 ppm with average of 309.2 ppm shown in Table (4), the increasing in calcium concentration may be due to Ca^{2+} precipitation from the water with SO_4^{-2} to form $CaSO_4$, [15].

The concentration of chloride is present in all natural water, but mostly this concentrations are low, the chloride concentrations are range between Min. of 220 ppm and Max. of 640 ppm with average value of 385 ppm. In most Surface River, the chloride concentrations are lower than those of sulphate or bicarbonate. Exceptions occur where rivers receive inflows of high–chloride ground water or industrial waste water or affected by oceanic tides [21], according to the classification of [23] all samples are considered with Low Restriction (LR) and No Restriction (NR).

The carbonate concentrations (CO_3^{-2}) are range between Min. of 11.5 ppm and Max. of 16 ppm, with the average value of 14.4 ppm and the sulfate concentrations (SO_4^{-2}) range between Min. of 1130 ppm and Max. of 1930 ppm with the average value of 1504.5 ppm. The concentrations Ca^{+2} precipitates with SO_4^{-2} to form gypsum, the concentration SO_4^{-2} concentration is still high compared with other ions and with locations worldwide,[23]. The nitrate concentration NO_3^- ranges between 3.8, 9.7 and 6.5 ppm with the Min., Max. and average values respectively, if its levels exceeded 10 ppm nitrate has a significant influence on plant growth and may present a hazard for drinking water sources, [21].

3. Various Effects

Total Dissolved Solids (TDS) or Electrical conductivity (EC) analysis could be used for monitoring the salinity of water because it is a strong function of the total dissolved ionic solids. In this study, the average values of EC and TDS which were measured in 12 different locations, where values of 4147, 11632 and 7626 ppm are the Min., Max. and average respectively. According to classifications of American Classification USRS, Russian Classification and Taylor Classification the water very high salinity water with Acceptable water provided that there is washing and drainage soil.

According to American classification and table (10) all the water samples with low sodium SAR<10 and it can be used to irrigate most of the soil with a note showing a few harmful sodium levels, it was recommend 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.

According to [20] and classification of [15] all water samples of Al_Masab Al_A'am Channel (upper section) are good irrigation water kind (Na% < 50%).

According to table (6) and American classification, all water samples of Al_Masab Al_A'am Channel (upper section) and the RSC< 0, are Safe water class and it is suitable for irrigation uses.

Soluble magnesium percent Mg% is very important for the effects on plant growth. When this percent less than 50% then none of important on the plant growth, but it is dangerous when this percent more than 50%.

10.Conclusion

The water discharge are range between Min. value of 123 m3/s in Abo-Ghareeb (St.1) with Elv. 14.35 m, Max. value is 210 m3/s in Al-Musab (St.4) with Elv. 1.71m and avg. of 113.8 m3/s with Elv.6.25m.

According to IWQI and table (10), salinity, specific ion toxicity and miscellaneous effects problems in Al_Masab Al_A'am Channel (upper section) were under the categories slight to moderate hazard, while there was no infiltration hazard. Also, the water characterized as high sulfate anion and Calcium cation content. The water samples are suitable for irrigation purposes according to variables following SAR, Na%, Mg% and RSC.

The assessment of irrigation water should not be depended on laboratory test only, but it must include study soil properties, type of grown crop, climate factor and efficiency of irrigation and drainage network.

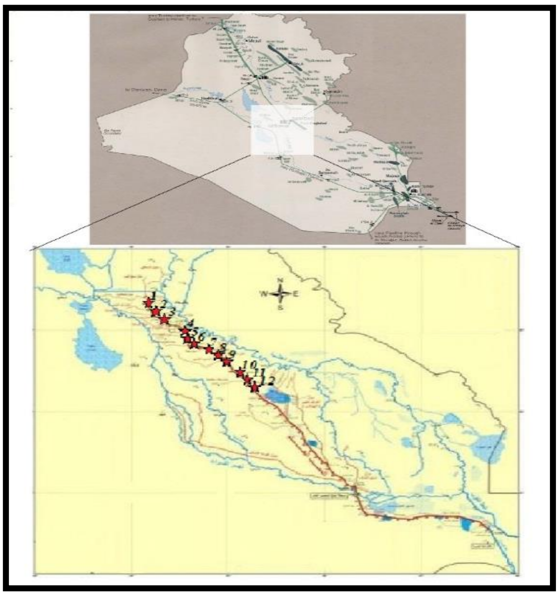

Fig. (1): Water sampling sites at the area of study

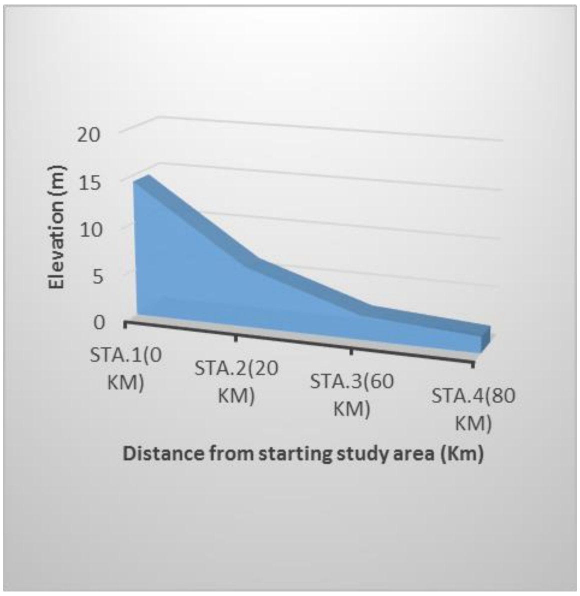

Fig. (2): The Elevation along Al_Masab Al_A'am Channel (upper section)

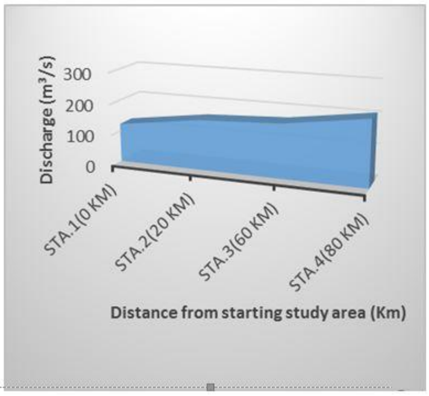

Fig. (3): The discharge along Al_Masab Al_A'am Channel (upper section)

Fig. (4): TDS Meter

Fig. (5): An Electrical Conductivity Meter

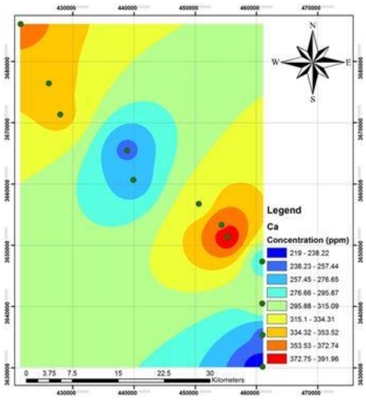

Fig. (6): Distribution map of Ca^{+2}

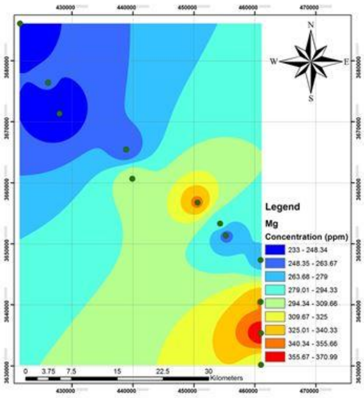

Fig. (7): Distribution map of Mg+2

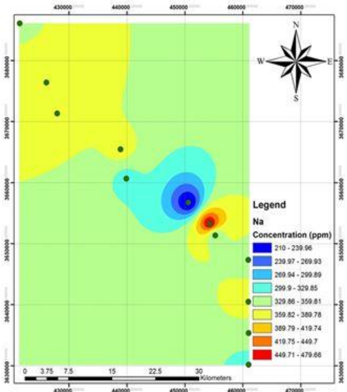

Fig. (8): Distribution map of Na^{+}

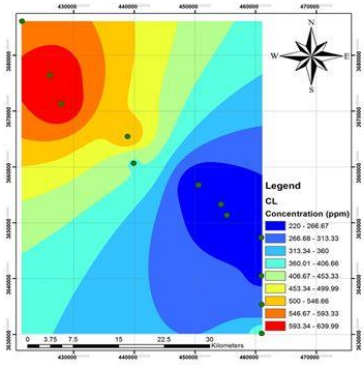

Fig. (9): Distribution map of CL^{-}

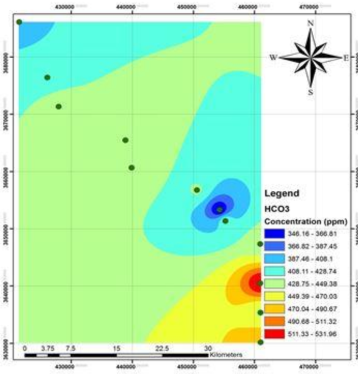

Fig. (10): Distribution map of HCO3-

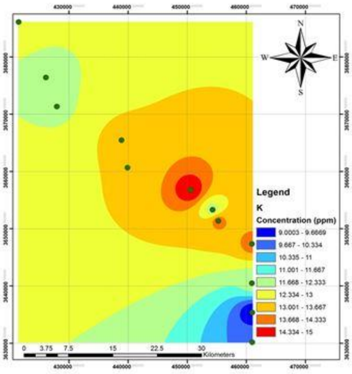

Fig. (11): Distribution map of K^{+}

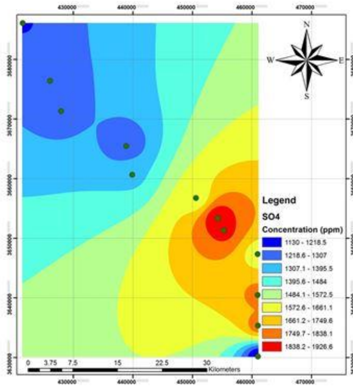

Fig. (12): Distribution map of SO_4

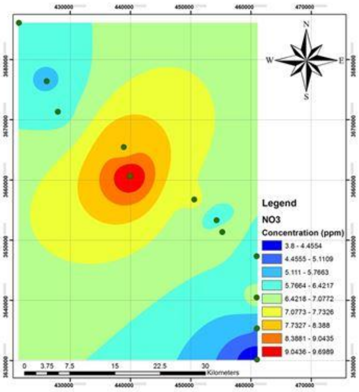

Fig. (13): Distribution map of NO3

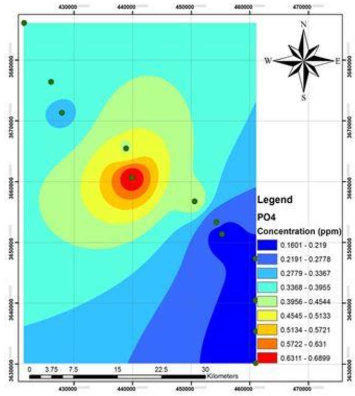

Fig. (14): Distribution map of PO_4

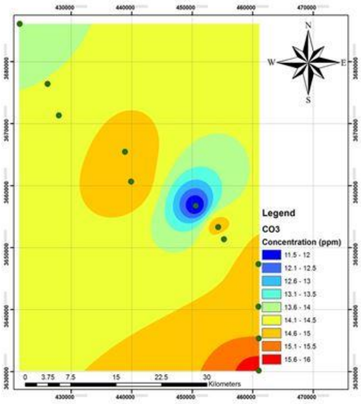

Fig. (15): Distribution map of

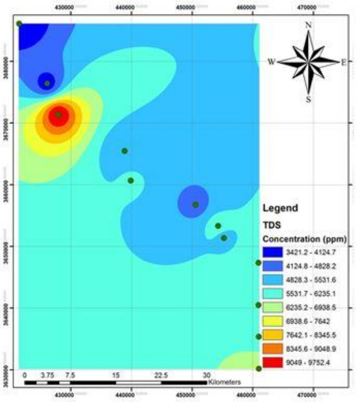

Fig. (16): Distribution map of

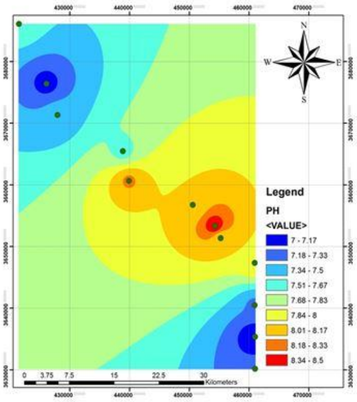

Fig. (17): Distribution map of pH

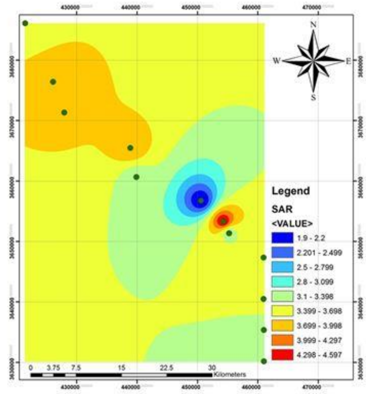

Fig. (18): Distribution map of SAR

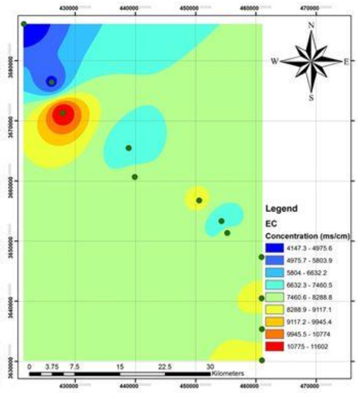

Fig. (19): Distribution map of EC

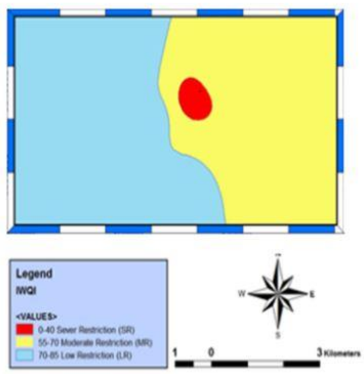

Fig. (20): Distribution map of IQWI

CONFLICT OF INTERESTS.

- There are no conflicts of interest.

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دراسة وتقييم نوعية مياه البزل للقاطع الشمالي لقناة المصب العام

أمير هاشم حسين

المعهد التقني المسيب ، ٥١٠٠٩ ، بابل، جامعه الفرات الاوسط التقنية / العراق

ameer.almashhadany@yahoo.com

الخلاصة

هناك مشكلة في كمية ونوعية مياه نهر الفرات، لأن الملوحة أعلى من المعدل. الغرض من البحث هو مراقبة نوعية المياه والتحقق من جودة المياه التي تم فحصها وهل هي مناسبة للاستخدام المقصود أم لا. تم إجراء الدراسة من أبو غريب إلى مدينة المسيب للمصب العام في العراق لإجراء تقييم صحيح لمستوى التراكيز وتأثيرها على الري. تم تحليل العينات المجمعة لعناصر مختلفة كيميائيا، والتي تؤثر على نوعية المياه للري، هذه العناصر هي كالسيوم (Ca^{+2}) والصوديوم (Na^{+}) والمغنيسيوم (Mg^{+2}) والكلوريد (Cl^{-}) والبوتاسيوم (K^{+}) والبيكربونات(HCO_3^{-}) والنترات (NO_3^{-}) والسلفات (SO_4^{-2}) والفوسفات (PO_4^{-3})والكربونات (CO_3^{-2}) والموصلية الكهربائية (EC) والمواد الصلبة الذائبة كلياً (TDS) وقيم الأس الهيدروجين.(PH) تم حساب نسبة امتزاز الصوديوم (SAR) ومحتوى الصوديوم (Na%) وكربونات الصوديوم المتبقية.(RCS) كذلك تم فحص جودة مؤشر مياه الري (IWQI) متكامل مع نظم المعلومات الجغرافية من أجل تقييم جودة مياه الصرف لأغراض الري بدقة عالية، لتصنيف مياه البزل، تم أخذ اثني عشر عينة من مياه البزل من أربعة مواقع مختلفة للمنطقة الدراسة. يؤكد تحليل نتائج خرائط (IWQI) أن: ٦١٪ من مياه البزل في منطقة الدراسة تقع ضمن "تقييد منخفض" و٣٦٪ من منطقة الدراسة تقع ضمن (تقييد معتدل)، في حين أن ٣٪ من مياه البزل في منطقة الدراسة مصنفة على أنها (تقييد القيد). لذا، ينبغي استخدام مياه االبزل مع التربة ذات نفاذية عالية مع بعض القيود المفروضة على أنواع النباتات للتسامح المحدد من الأملاح.

الكلمات الداله: – نظم المعلومات الجغرافية، مؤشر نوعية مياه البزل، الملوحة، المصب العام.