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Case Study

STUDY AND EVALUATION OF THE HYDROLOGICAL CHARACTERISTICS IN AL- MASAB AL-AAM CHANNEL (MIDDLE SECTOR) OF IRAQ

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ABSTRACT
This research deals with the hydrological and hydrochemical characteristics of Al-Massab Al-Aam channel(middle sector), which could be useful for the intended restoration efforts. Analyzing and interpreting the chemistry of water can provide valuable insights into surface water interactions. Major elements cations and anions(Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, SO_4^{-2}, Cl^{-}, CO_3^{-2}, HCO_3^{-}), minor elements (NO^{-}_3, PO^{-3}_4), and physical properties (pH, EC, TDS, temperature, color, odor, and TH). The Water discharge ranges between 88-220m^3/s, and the average value is 169.5m^3/s, while the water elevations above sea level ranges between 1.92-17.9 m and the average value is 8.35 m .The water samples are suitable for irrigation purposes according to the variables: SAR, Na% and RSC .

KEY WORDS: Water, Major elements, minor elements.

INTRODUCTION

Location of the Study Area

The study area occupies some of the central and southern parts of the Mesopotamian plain, along 199km, it is located within Babylon , Al-Qadissiya, Wasit and Thi-Qar Governorates and bounded by Al-Shomaly district (Hilla-Waist road) from east and Al-Nasriya city from west, the study area extends between longitudes (45° 06' - 46° 17') E and latitudes (31° 04'- 32°26') N as in Fig. (1)

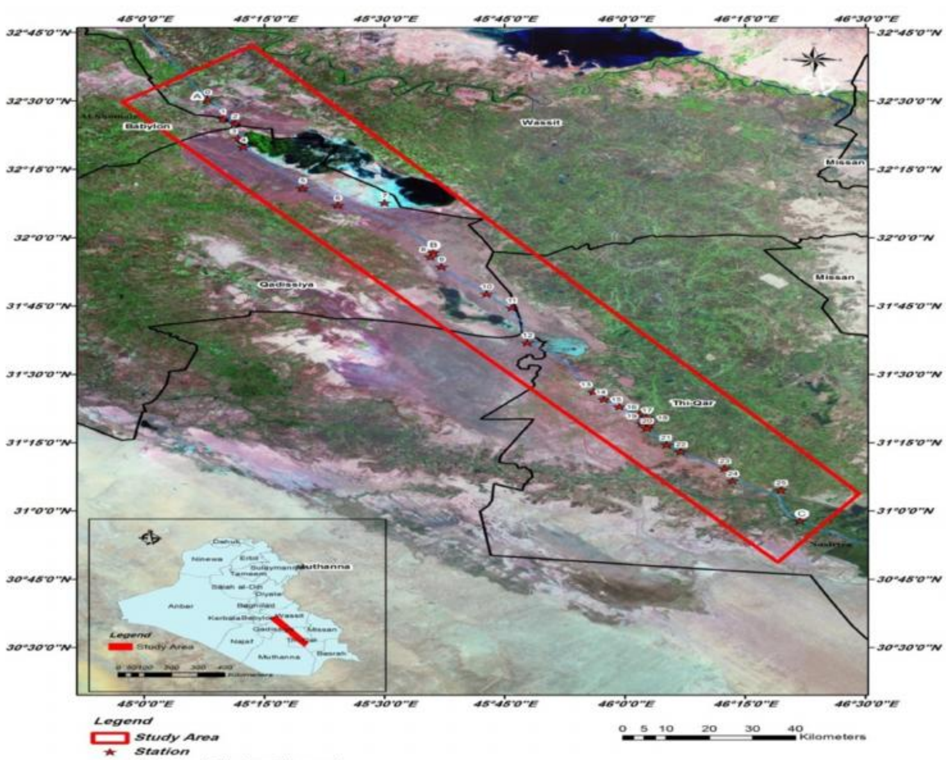

FIGURE 1: Location map of the study area in the southern part of Iraq from satellite image**.**

Aims of this Study

Measure the concentrations of the major elements cat ions and anions (Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, SO_4^{-2}, Cl^{-}, CO_3^{-2}, HCO_3), minor elements (NO^{-}_3, PO^{-3}_4), and physical properties (pH, EC, TDS, temperature, color, odor and TH) and determine the discharge and the elevation of the middle part of Al-Massab Al-Aam channel. Evaluation of the water samples for the irrigation purposes according to the variables: SAR, Na%, and RSC respectively.

METHODOLOGY

The research involved in data collection stage in which maps and references about the study area have been collected. Field work, where the number of sites for slope stability assessment was (25) stations. Water samples from the river were collected and the laboratory analyses were carried out for those samples. Then Laboratory work in which the physical and chemical tests of the water samples at sites were carried out. Sedimentology, previous studies are almost focused on Geomorphology 1-4. Hydrogeology and an environmental study (Abdul Ameer, 2012, Imran *et al*., 1996, Al-Husseini 1998, Al-Ezerajawi, 2012 respectively).

Geology of the study area

The study area is located within the Mesopotamian plain in the area of Unstable Zone relative to the tectonic divisions of Iraq (Buday, 1980) within the geosyncline basin, between the Zagros Mountains in the north east and the Western Stable Arabian Plateau) in south west . The Mesopotamian plain is a broad syncline formed since the Pliocene period, the delta Plain province is a vast alluvial plain with a slight southeast gradient. It is filled with an accumulation of flood plain, deltaic and lacustrine deposits, and due to human activities for several thousand years many artificial irrigation canals have behaved as rivers, eroding the original sedimentary cover of the plain. From geological point of view the study area is covered by Quaternary deposits particularly of Holocene, these deposits were accumulated in thick sequence that consist of clastic deposit composed mainly of sand, silt, and clay which are represented by depression fill deposits, flood plain deposits, and Aeolian deposits in (Barwary, 1992).

Hydrological characteristics evaluation in the Study Area

The Al-Massab Al-Aam channel or the "Third River" or main drain, was added as third great waterway to the two historic rivers, the Tigris and the Euphrates. The functions of Al-Massab Al-Aam channel is to reclaim new lands or to reduce water logging by collecting drainage water between the two main rivers Euphrates and Tigris for more than 1.5 million of agricultural and lands from north of Baghdad to the Gulf. The importance of this giant project is to collect drain water from agricultural land, improving the water quality of Tigris and Euphrates rivers, controlling the sand dunes movement in the area, creating new agricultural land using saline water in irrigation, wide plantation on both sides of river, improving fish and aquatic life in saline water, navigation, creation new settlements and villages, collecting shallow ground water in the area, creating new jobs for local farmers with hope that if there is additional water (some times in both rivers in future) a mixing might help to decrease the salinity of this saline water channel. It has a watercourse of 566 km, and a total discharge of 210 m^3/s. In 1995 an estimated 17 million tons of salt was said to have been transported to the Gulf through Al-Massab Al-Aam channel. The engineering schemes of the drainage systems in Iraq were designed to reduce salinities problems on millions of hectares of agricultural lands and to reclaim lands for food production. The largest single project, Al-Massab Al-Aam channel, was first suggested by British engineers in 1951 as a means of removing highly saline irrigation drainage water from 1.5 million hectares of agricultural land between the Tigris and Euphrates in central Iraq. Parts of Al-Massab Al-Aam channel were constructed in 1950 and more were completed in the 1960 (ministry of water res resources, 2010) (Al-Ezerajawi, 2012). The Water discharge of AL-Massab AL-Aam Channel (middle sector) was measured by river Surveyor in Hilla Station (st.A) from table (1) the discharge ranges between the maximum value is 220m^3/s in Nasirya station (St.C), the minimum value is 88 m^3/s in Hilla station (St.A), and the average values is 169.5 m^3/s as in fig.No(2),the most important thing was observed in the site of AL-Massab AL-Aam Channel (middle sector),it is the water pumps of farmers which are installed along AL-Massab AL-Aam Channel (middle sector) specially in Dewaneya Governorate because they used the water for irrigation purposes. This process returns the salts to the soil and cancels the role of AL-Massab AL-Aam as drainage channel.

TABLE 1**:** The discharge and elevation values for three stations along Al-Masab Al-Aam channel (middle part)

St.No.	Location	Discharge (m^3/s)	Elevation (m) Above mean see level
A	(Hilla),Al-Nomaneya-Shomaly bridge	88	17.9
B	Dewaniya ,before Dalmaj marsh feeding	200	5.24
C	(Nasirya),Al-Nasirya pump station	220	1.92
	The average	169.5	8.35

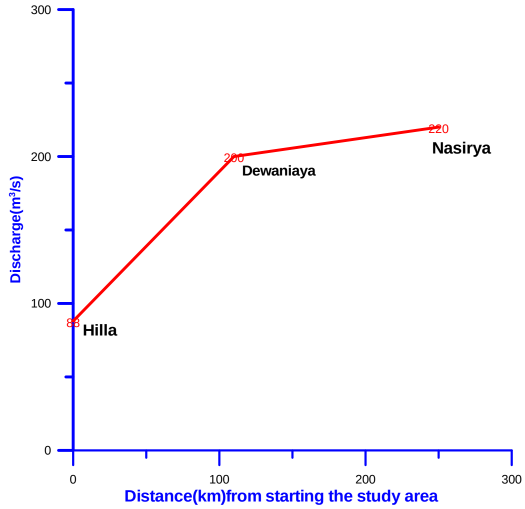

FIGURE 2: Shows the discharge values along Al-Massab Al-Aam channel(middle sector).

While the water elevations above mean see level of the AL-Massab AL-Aam Channel(middle sector) as in table(1)ranges from the maximum value is 17.9m in Hilla station (St.A), to the minimum value is 1.92m in Nasirya station (St.C), and the average value is 8.35m as in fig. No(3).

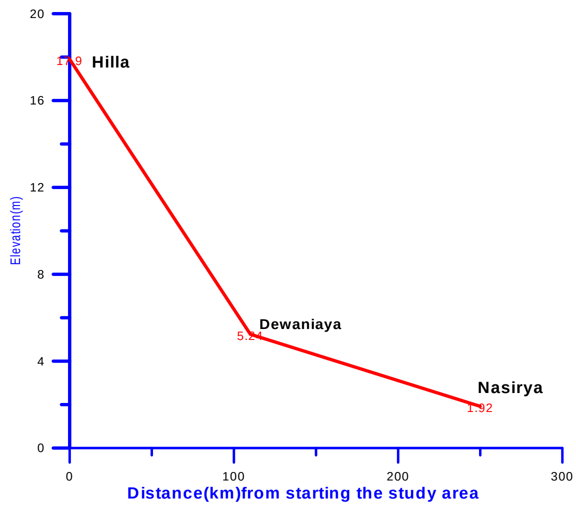

FIGURE 3: Shows the elevation values along Al-Massab Al-Aam channel (middle sector).

Hydrochemical investigation

Twenty three surface water samples were selected as random distribution in order to cover the study area along AL-Massab AL-Aam Channel, also to use available data about the distribution and characters of the AL-Massab AL-Aam Channel. The locations of the selected water samples are shown in fig.(1).

Accuracy

The accuracy of the results of the water samples analysis can be indicated from the results of the reaction error test (U) (Hem, 1985);

$r \sum Cation = r\ K+\ r\ Na+\ r\ Mg + r\ Ca$ …………………...(1)

$r \sum Anion = r\ HCO_3 + r\ SO_4 + r\ Cl + NO_3$……………...(2)

$\Delta = r \sum Cation - \sum Anion$ ………………………………(3)

$S = r \sum Cation + \sum Anion$ ………………………………(4)

$U\% = (\Delta/S) * 100$ ……………………………………….(5)

$A = 100 - U$……………………………………………..(6)

Where:

Δ = absolute value of sum. of Cation and Anion

S = sum. of Cations and Anions

U = (uncertainty) or reaction error

A = certainty or Accuracy

The classification of accuracy shown in table (2), (Stoodly *et al.*, 1980in Hem, 1989).

TABLE 2: Classification of accuracy according to (Stoodly et al., 1980in Hem,1989)

U	A	Class or type
$U \leq 5\%$	$A \geq 95\%$	Certain
$10\% \geq U > 5\%$	$90\% \leq A < 95\%$	Probable certain
$U > 10\%$	$A < 90$	Uncertain

When (U) uncertainty or reaction error is (U ≤ 5 %) then the results could be accepted for interpretation, but if (5 %≤ U≤ 10 %) then the results acceptable with risk and if (U >10 %) means the results uncertain. The reaction error in AL-Massab AL-Aam Channel (middle section) analysis was ranges between the acceptable values, to acceptable with some risk as in table (2) . Table (3) chemical analysis in (epm)unit and the accuracy for water samples of the study area. Therefore, from the samples analysis of AL-Massab AL-Aam Channel (middle section) in table (3) and classification in table (2) showing the results can be used for interpretation purposes.

TABLE 3: Analysis in (epm) unit and the accuracy for water samples of the study area

St	Ca^+	Mg^+	Na^+	K^+	Cl^-	SO_4^{--}	CO_3^-	HCO_3^-	∑Cation	∑Cation	U%	A%	Type
1													
2	14.7	16.5	14.7	0.24	16.8	27.2	0.23	5.11	46.1	49.3	3.3	96.7	Certain
3	14.8	16.9	14.8	0.25	15.1	27.2	0.26	5.62	46.8	48.1	1.4	98.6	Certain
4	13	18	15.1	0.23	17.1	26.6	0.30	5.5	46.3	49.5	3.3	96.7	Certain
5	13.6	17.4	15.7	0.23	16.9	28.3	0.30	6.1	46.9	51.6	4.9	95.1	Certain
6													
7	13.5	18.1	14.9	0.24	17.1	28.6	0.30	6.34	46.7	52.3	6	94	P. certain
8	11.7	22.6	16.5	0.23	17.7	29	0.33	5.7	51	52.7	1.6	98.4	Certain
9	15.9	16.1	13.7	0.24	16.9	20.5	0.36	5.75	45.9	43.4	2.7	97.3	Certain
10	9	17.5	15	0.25	15	21.1	0.36	6.5	41.7	42.9	1.4	98.6	Certain
11	13.9	25.7	15.6	0.28	12.6	34.4	0.35	7.2	55.5	54.5	1	99	Certain
12	19.5	28.4	12.4	0.25	17.4	30.8	0.36	6.4	60.5	54.9	6	94	P. certain
13	9.7	22.5	12.6	0.28	10.1	29.8	0.26	6.6	45.1	46.7	1.8	98.2	Certain
14	12.3	25	8.2	0.35	3.7	37.1	0.20	7.9	45.8	48.9	3.2	96.8	Certain
15	15.6	22.5	19.3	0.27	2.22	44.8	0.30	4.85	57.6	52.4	4.6	95.4	Certain
16	15	20.5	19.6	0.24	3.14	41.4	0.36	5.75	58.5	50.6	7.2	92.8	P. certain
17	16	18.8	13.4	0.30	3.5	37.5	0.34	6.06	48.5	47.4	1.1	98.9	Certain
18	13.5	18.8	16.9	0.28	4.5	43.1	0.30	5.8	49.5	53.7	4.1	95.9	Certain
19	10.6	19.3	13.9	0.30	3.7	41.1	0.36	6.5	44	51.6	7.9	92.1	P. certain
20	12.2	25.1	15.2	0.25	4.4	42	0.31	7.9	52.7	54.6	1.8	98.2	Certain
21	9	24.7	14.5	0.28	9.2	30.1	0.32	7	48.5	47.3	1.2	98.8	Certain
22	9.1	24.1	13.9	0.33	5.1	39.3	0.36	6.2	47.5	50.9	3.6	96.4	Certain
23	10.8	25.75	15.6	0.2	6.17	39.6	0.33	6.7	52.35	52.8	0.4	99.6	Certain
24	6.9	23.8	13.9	0.28	8.74	20.4	0.36	10.32	44.93	39.8	6.1	93.9	P. certain
25	7.8	16.6	15.2	0.25	9	25	0.3	9	39.85	43.3	4.1	95.9	Certain
AV											3.4	96.6	Certain

TABLE: physical properties of water

St	Ca^+	Mg^+_2	Na^+	K^+	Cl^-	SO_4^{-2}	CO_{3-}	HCO_3^-	TDS	EC µm/s	PH	T (^{0}C)	TH	PO_4	NO_3
1															
2	290	198	339	9.5	590	1300	7	332	2950	3766	7.1	30.5	1675	0.24	4.6
3	296	199	324	9.7	530	1305	8	343	3080	4090	7.8	30.5	1696	0.36	5.1
4	260	216	347	9	**600**	1280	9	336	3160	4450	8.0	31	1659	0.22	4.3
5	271	209	361	9	593	1361	8.5	372	3890	4700	7.0	30.5	1662	0.34	5.5
6															
7	270	218	343	9.2	598	1374	9	387	**13400**	**15900**	7.3	32.5	1695	0.30	6.9
8	318	193	316	9.3	594	983	11	350	5430	7899	8.2	32.5	1737	0.32	5.7
9	181	209	343	10	522	1012	11	391	4820	6600	7.7	33	1395	0.43	8.0
10	279	309	359	11	443	1651	10.5	441	5170	7900	8.0	33	2097	**0.86**	7.4
11	195	270	290	11	353	1480	11	393	6800	8760	8.3	33	1688	0.67	**9.3**
12	195	270	290	11	353	1430	8	402	6956	9100	7.8	32.5	1688	0.77	6.8
13	246	300	188	**14**	130	1780	6	482	4160	6800	8.0	32.5	1963	0.44	7.4
14	312	264	443	10	78	**2150**	9	296	4990	6230	7.1	32	2011	0.74	6.6
15	301	246	**452**	9.5	110	1987	11	351	5500	7790	**8.4**	32.5	1904	0.23	5.5
16	**320**	216	301	12	123	1801	10	370	5230	7650	8.0	32.5	1807	0.12	6.8
17	270	226	390	11	160	2071	9	355	6270	8800	7.8	33	1728	0.19	7.2
18	213	231	320	12	131	1974	11	400	6005	8707	8.0	33.5	1572	0.17	5.4
19	243	301	350	10	154	2017	9.5	482	5940	7540	7.4	33.5	1958	0.18	6.3
20	180	291	335	11	321	1481	9.8	413	6800	9300	7.0	33	1730	0.22	4.8
21	183	289	320	13	179	1887	11	380	6800	9034	7.3	33.5	1731	0.16	4.9
22	212	**310**	360	8	216	1900	**12**	412	6700	9119	8.1	34	1903	0.18	3.8
23	139	286	320	11	306	980	11	**630**	6778	8755	8.0	33	1587	0.20	3.3
24	156	200	350	10	315	1200	9	552	6880	9930	8.1	33	1258	0.19	4.5
25	181	209	343	10	522	1012	11	391	6450	9600	8.0	33	1395	0.15	4.8
AV	**239**	**246**	**338**	**10.4**	**344**	**1540**	**9.6**	**402**	**58**31	**7931**	**7.7**	**32.5**	1719	**0.33**	**5.8**

Physical properties

The water samples of the AL-Massab AL-Aam Channel (middle section) are colorless and While the temperature of water is important for geochemical reactions and the life of organism (Hem, 1989). The Water temperatures of the AL-Massab AL-Aam Channel(middle section) as in table(4) ranges between the maximum value is 34 ^{0}C in station No.22 ,the minimum value is 30.5 ^{0}C in station

No.2, and the average values is 32.5 ^{0}C . The TDS values of AL-Massab AL-Aam Channel sample as in table (4) ranges between the maximum value is 13400 ppm in station No.7, the minimum value is 2950 ppm in station No.2, and the average values is 5831 ppm. Classification of water depending on(TDS) according to (Davis and DeWiest,1966), (Drever, 1997), (Altoiviski, 1962) and (Todd, 1980, all water samples are considered to be of brackish water (TDS>1000ppm) except station No.7 is classified as salt water (TDS>10000 ppm). The general increase in TDS values is due to the increase of salt concentration down Al-Massab AL-Aam channel. According to Todd (1980), the hardness in water is derived from the solution of carbon dioxide released by bacteria lection in the soil, in percolating water**.** The Water hardness of the AL-Massab AL-Aam Channel(middle sector) as in table(4) ranges from the maximum value is 2097 ppm in station No.10 ,to the minimum value is 1258 ppm in station No.23, and the average values is 1719 ppm. All water samples considered to be very hard because of the high concentrations of Mg and Ca according to classificationof total hardness (Todd, 2007) and (Boyd, 2000).

Chemical properties

The sodium concentrations range between 188 ppm and 452ppm with average of(338) ppm; because the primary sources of most sodium in natural water come from the release of soluble products during the weathering of plagioclase feldspars (Hem, 1985). In area of evaporate deposits, the solution of halite is important. Clay minerals under certain condition, release large quantity. Potassium ranges between 8 ppm and 14 ppm, with average of (10.4)ppm; because Common sources of potassium are the products formed by the weathering of orthoclase, biotite, leucite, and nepheline in igneous and metamorphic rocks. Waters percolated through evaporate deposits may contain very large quantities derived from the dissolution of sule. Magnesium concentration ranges between 193 ppm and 310 ppm with average value of(246)ppm Ferromagnesian mineral igneous rocks and magnesium carbonates in sedimentary rocks are generally considered the principal sources of magnesium in natural waters, and Calcium concentrations ranges between 139 ppm and 320 ppm with average of (239)ppm (Table 4) . This increasing in Calcium concentration may be due to Ca^{2+} precipitation from the water with $SO4^{-2}$ to form $CaSO_4$, which is abundant in the area. Ca^{2+} is also consumed by aquatic species which build carbonate shells and skeletons (Sholkvitz and Price, 1980). The Chloride concentrations range between 78 ppm and 600ppm with average of(344)ppm. Chloride is present in all natural waters, but mostly the concentrations are low .In most surface streams, chloride concentrations are lower than those of sulphate or bicarbonate. Exceptions occur where streams receive inflows of high –chloride ground water or industrial waste or are affected by oceanic tides (Hem, 1989). Bicarbonate concentrations ranges between 296 ppm and 630ppm , with average of (402)ppm, while the carbonate concentrations range between 6 ppm and 12ppm, with average value of (9.6) ppm, and the sulfate concentrations ranges between 980 ppm and 2150 ppm with average of(1540)ppm. The lithological units of the Fatha Formation, which contains gypsum and anhydrite, are believed to be the major source of $SO4^{-2}$ in the water. Although $SO4^{-2}$ precipitates with Ca^{2+} to form gypsum, $SO4^{-2}$ concentration is still high compared with other ions and with locations worldwide. The nitrate concentration ranges between 3.3ppm and 9.3 ppm with average of (5.8) ppm nitrate has a significant influence on plant growth and may present a hazard for drinking water sources if its levels exceeded 10 ppm (Landschoot, 2007). Nitrate originates mainly from fertilizers used in agricultural activities (AL-Qaraghuli, 2005). Phosphate concentrations ranges between 0.12ppm and 0.86 ppm, with average of (0.33)ppm. Table (4) Some of chemical analysis in (ppm) unit and some physical analysis for Al-Massab AlAam water samples

Water Uses for Irrigation purpose

Irrigation water criteria depend on the types of plants amount of irrigation water, soil and climate (Davis and Deweist, 1966). The suitability of water for irrigation depends upon its own quality as well as upon the other factors, the same quality of water may be considered as suitable for a certain type of soil or crop but is unsuitable for other (Al-Shammary, 2008). The quality of irrigation water which is considered the most important factor is determined by their soluble component which includes its total salt content ionic composition, and presence of minor elements.

Sodium Adsorption Ratio (SAR)

The sodium hazard is determined by the absolute and relative concentrations of the cataions and can be evaluated through the sodium adsorption ratio (SAR), because of its direct relation to the absorption of sodium by soil (Todd, 1980), it is defined by:

$$SAR = \frac{Na^{+}}{\sqrt{(Ca^{+2} + Mg^{+2})/2}} \quad \ldots\ldots\ldots\ldots\ldots(7)$$

According to table (5)and classification of (Todd, 1980), all the water samples of AL-Massab AL-Aam Channel(middle sector) are excellent water class, in which SAR < 10

Sodium Percent Na% 3- 2

Sodium content is usually expressed in term of percent sodium (also known as soluble sodium percentage SSP), it is an estimation of the sodium hazard of irrigation water, it expresses out of the total cataions. Na% is calculated by the following formula (Todd, 1980):

$$Na\% = \frac{(Na + K)*100}{Ca + Mg + Na + K} \quad \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

According to table (5)and classification of (Todd, 1980), all the water samples of AL-Massab AL-Aam Channel(middle sector) are good irrigation water class, except station number(14)classify as excellent water class.

Residual Sodium Carbonate (RSC)

A high concentration of bicarbonate in irrigation water may lead to precipitation of calcium and magnesium in the soil and thus to a relative increase of sodium concentration. Thus, the sodium hazard will increase (Van Hoorn, 1970). The bicarbonate hazard expressed by residual sodium carbonate (RSC) which introduced by (Eaton1950 in Todd, 1980):

$$RSC = (CO_3^{-2} + HCO_3^{-}) - (Ca^{+2} + Mg^{+2}) \quad \ldots\ldots\ldots\ldots 9$$

RSC=Residual sodium carbonate

According to table (5) and classification of (Eaton1950 in Todd,1980),all the water samples of AL-Massab AL-Aam Channel (middle sector), all the (RSC) values less than zero, therefore, all the samples are Safe water class and it is suitable for irrigation uses.

TABLE 5: Shows the values of SAR, Na% and RSC in AL-Massab AL-Aam Channel (middle sector)

Station NO.	SAR(epm)	Na%	RSC (epm)
1			
2	3.7	32.4	-25.8
3	3.7	32.1	-25.8
4	3.8	33.1	-25.2
5	4	33.9	-24.6
6			
7	3.7	32.4	-24.9
8	4	32.8	-28.2
9	3.4	30.3	-25.8
10	4.1	35.5	-19.6
11	3.5	27.1	-23
12	2.5	21	-41
13	3.1	28.5	-25.2
14	1.9	18.6	-30
15	4.4	34	-32.9
16	4.5	33.2	-29.3
17	3.1	28.2	-28.4
18	4.2	34.7	-26.2
19	3.5	32.2	-23
20	4.1	29.3	-29
21	3.5	30.5	-26.4
22	3.4	29.9	-26.6
23	3.6	30.1	-29.4
24	3.5	31.5	-20.3
25	4.3	38.7	-15.1

CONCLUSION

The Water discharge ranges between a maximum value of (220)m^3/s in Nasirya station (St.C) and a minimum value is(88)m^3/s in Hilla station (St.A). The average of (169.5) m^3/s, while the water elevations above mean sea level ranges between a maximum value of (17.9)m in Hilla station(St.A) and, a minimum value of (1.92)m in Nasirya station (St.C), and the average value of (8.35)m. The sodium concentrations range between 188 ppm and 452ppm with average of (338)ppm; Potassium concentrations ranges between 8ppm and 14ppm with average of (10.4)ppm; magnesium concentration ranges between 193 ppm and 310 ppm with average value of (246)ppm, and Calcium concentrations ranges between 139 ppm and 320 ppm with average of (239)ppm. The Chloride concentrations range between 78 ppm and 600ppm with average of(344)ppm; bicarbonate concentrations ranges between 296 ppm and 630ppm , with average of (402)ppm, while the carbonate concentrations range between 6 ppm and 12ppm , with average value of (9.6)ppm and the sulfate concentrations ranges between 980 ppm and 2150 ppm with average of (1540)ppm. The nitrate concentration ranges between 3.3ppm and 9.3 ppm with average of(5.8)ppm ; phosphate concentrations ranges between 0.12ppm and 0.86 ppm, with average of (0.33)ppm. The water samples are suitable for irrigation purposes according to variables following SAR, Na% and RSC .

REFERENCES

Al-Amar, H., A. (2014) Study and evaluation of soil slope stability of main out fall drain (middle sector) of Iraq. Ph.D Thesis, University of Baghdad .P-180.

Abdul Ameer, E.A. (2012) The geomorphological study of dune fields and their environmental effects at Al-Muthana Governorate-Iraq. Ph.D Thesis, University of Basrah.P-140

Al-Ezerajawi, W. M. (2012) Environmental study of Dalmaj marsh area /Wasit Governorate/Iraq. Unpublished, M.Sc., thesis Univ. of Baghdad

Al-Husseini, R. A. (1998) The interference of surface water in Al- Massab AL-Aam channel with the groundwater adjacent to it in the area between Mahmudiya and Al-Suwaira. M.Sc Thesis, in civil Eng. University of Baghdad.P-201 (In Arabic).

Al-Qaraghuli, N. A. (2005) Contents of nutrient elements (Total, water soluble and available) in the fertilizers (TSP, MAP, NP & NPK) produced from AL-Qaim plant, Iraq, Iraqi Journal of Agricultural Sciences, Vol. 36, pp 35-41.

AL-Shammary, H.S. (2008) Hydrology of Galal basin – Wasit-east iraq. M.Sc., thesis Univ. of Baghdad, unpublished.

Al-toviski, M. E. (1962) Handbook of hydrogeology, Gosgeolitzdat, Moscow, USSR, (in Russian) pp.614.

Barwary, A. M. (1992) The Geology of Karbala Quadralogyies, Sheet NE-38-14, Scale, 1:250000, (GEOSURV).

Buday, T. (1980) Regional Geology of Iraq stratigraphy and palegeography state organization of minerals, Baghdad, 445 p.

Boyd, C. E. (2000) Water quality an introduction, Kluwer Academic Publisher, USA.330p.

Drever, J. I. (1997) The Geochemistry of Natural Water-Surface and Ground water Environments (3red.) prentice Hall, USA, 436 P.

Hem J. D. (1985) Study and interpretation of the chemical characteristics of natural water. 3rd. ed .U.S.G.S. water supply paper.336 P.

Hem, J. D. (1989) Study and interpretation of the chemical characteristics of natural water U.S. Geological Survey, Water Supply paper 2254, 246p.

Imran (1996) study of the distribution of sediments in the northern sector of Al- Masab AL-Aam channel. Technology research, P32. (In Arabic).

Landschoot, P. (2007) Irrigation Water Quality Guidelines for Turfgrass Sites, College of Agricultural sciences The Pennsylvania State University, USA.

Todd, D. K. (1980) Groundwater Hydrology, John Wiley, New York, USA, 535 p.

Todd, D. K. 2007, Groundwater hydrology second edition, Jhon Wiley and Sous,Third Reprint. Inc. India. 535p.

Van Hoorn, J. W. (1970) Quality of irrigation water, limits of use and prediction of long term effects, salinity seminar Baghdad, Irrigation and Drainage paper No. 7, FAO, pp 117-135.