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HYDROCHEMICAL ASSESSMENT OF THE FEED WATER IN THE WESTERN PART OF HUWAIZA MARSH, MAISSAN GOVERNORATE, SOUTH OF IRAQ

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ABSTRACT

The aim of this study is to evaluate the hydrochemistry of the western part of Huwaiza Marsh, in Maissan Governorate; southern Iraq. This study was conducted during April to August 2013, where 13 stations have been selected: four stations represent the feed water and nine stations located in the western part of Huwaiza Marsh. The total dissolved solids (TDS) range from (1175 to 1387) mg/L and from (1594 to 2481) mg/L for the feed water and Huwaiza Marsh water, respectively. Electrical conductivity (EC) values for the feed water and Huwaiza Marsh range from (1782 to 2400) µs/cm for the former and from (2630 to 3517) µs/cm for the later. The pH values range from (7.7 to 8.2) for the feed water and from (7.4 to 7.5) for the Huwaiza Marsh water. The results of chemicals analysis of dissolved cations and anions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, HCO_3^{-} and NO_3^{-}) showed different values, and the concentration is decreasing during winter season, because of the high water levels, and increasing during the summer season due to low water levels. The marsh water is unsuitable for human drinking, because most of the variable's rates exceeded the permissible limits and they are acceptable grade for livestock and poultry.

Keywords: : Hydrochemistry, water suitability, Huwaiza Marsh, south Iraq.

INTRODUCTION

The Huwaiza Marsh lies to the east of the Tigris River, straddling the Iran - Iraq border, southeast Amara City, south of Iraq. It is roughly bounded by latitudes: (31° 00') and (31° 45') N, and longitudes (47° 25') and (47° 50') E (Fig. 1).

The Huwaiza Marsh is largely fed by two main distributaries departing from the Tigris River near Amarah city, known as Al-Musharrah and Kahla channels. The Huwaiza Marsh area is characterized by cold winter and dry-hot summer, with mean temperature of 24.8 °C, annual rainfall of 136 mm/yr; for the period (1990 – 2012), mean relative humidity of 45%, mean wind speed of 4 m/sec and mean annual evaporation from Pan (A) of 3367 mm. Accordingly, the climate of the region is classified as sub arid to arid climate based on annual rainfall/ annual temperature (Al-Kubaisi, 2004, and Ash-Shammari, 2014).

The studied area is considered one of the most important ecological systems with high biodiversity; in addition to its economic importance because it represents excellent source for food to the local people. The study area represents a part of the Mesopotamian Plain in the southeastern Iraq. Huwaiza Marsh occupies an area of about 1500 Km^2; it covers about (2500 – 3500) Km^2 during the flooding season (mid of March to the end of May). The western part of Huwaiza Marsh is called Turaba Marsh covers an area of about 300 Km^2 (CRIM, 2006). The fresh water input to the marsh is from Tigris river through Al Imsharrah and Kahlaa streams (Fig. 1). Geologically, Huwaiza Marsh is generally underlain by the recent younger alluvium consisting of alluvial, marine, lacustrine, and playa sediments reaching high thicknesses (Banat *et al.*, 2006).

A considerable amount of researches have been carried out previously on the Mesopotamian Marshes, in general and Huwaiza Marsh, in particular (Iraqi Foundation, 2003 and 2004; Al-lamy, 2007; Al-Saady, 2008, and Al-Khafaji, 2008). The aim of the present study is to evaluate the hydrochemical specifications of Huwaiza Marsh and feeding rivers to identify the hydrochemical differences between them.

MATERIALS AND METHODS

A total number of twenty six water samples were collected in two periods, 13 samples were collected during April (2013), they represent high water level period, and the same number of samples during August (2013), they represent the low water level. The location of the selected water samples were accurately determined using a GPS device, as shown in Figure (1). The measurements were performed following procedure of APHA (1999) that includes hydrogen number (pH), electrical conductivity (EC), and TDS using TDS-EC-pH and HANA, type HI 9811. All collected samples were analyzed for major cations (K^+, Na^+, Ca^{2+} and Mg^{2+}), major anions (HCO_3^-, SO_4^{2-} and Cl^-) and minor anions (PO_4^{3-} and NO_3^-) at the Laboratories of the Environmental Research Centre, University of Technology, Baghdad, Iraq. The sodium and potassium was analyzed using flame photometer. The calcium, magnesium, chloride, carbonate and bicarbonate were determined by titration and well known methods. The sulfate was determined by using of spectrophotometer. The analytical accuracy was calculated according to Hem (1985); accordingly, the accuracy of the results is acceptable. Hydrochemical formula was computed as average formula based on Kurlolov formula, which is referred in Ivanov *et al.* (1968).

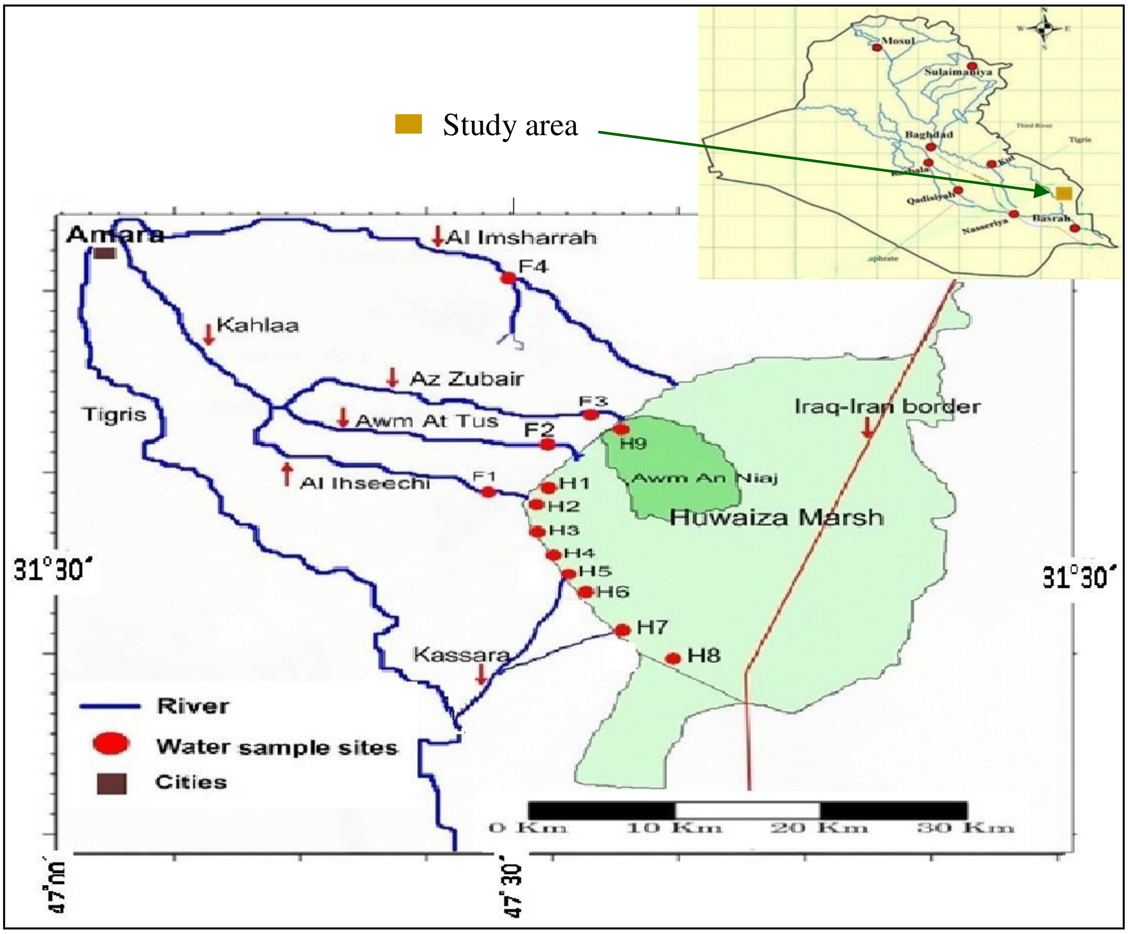

Fig. 1: Location map of the study area showing the location of water samples {The feed water samples are indicated by (F) and for the Western Part of Huwaiza Marsh indicated by (H), Maissan Governorate}

RESULTS

Before discussing of the physical and chemical variables, it has to be noted that the marsh is not a regular water body; mixing regularly from the surface to the bottom and from one side to the other, and from beginning to its end. In fact, the marsh has physical, chemical and biological heterogeneous variables. Samples have been collected from the feeding channels and marsh water; specifically from 13 sites to identify the physical and chemical specifications of the water; as well as to find out variations in these specifications with different sites within the marsh area and over time.

A. Total Dissolved Solid (TDS)

The Total Dissolved Solids may come from inorganic materials; such as rocks, air and may contain calcium bicarbonate, nitrogen, iron phosphorous, sulphur, and other elements. Other sources come from runoff, fertilizers and pesticides used on lawns and farms (Hem, 1985). The average TDS value in Huwaiza Marsh is about 1594 mg/L, on April, 2013 and 2481 mg/L, on August, 2013. The maximum TDS value was recorded in sample H5 (3100 mg/L) and the minimum value was recorded in sample H9 (2150 mg/L) during April, 2013. While during August, 2013, the maximum value of TDS was recorded in sample H7 of Huwaiza Marsh to be 5300 mg/L and the minimum value recorded in sample H9 (1560 mg/L). Whereas in the feeding water samples, it is from (1280 to 1542 mg/L) on April, 2013 and from (1744 to 1886 mg/L) on August, 2013. The TDS values on August, 2013 are more than the TDS values on April, 2013, in all the samples. By comparing the TDS values with those classified by Todd (1980), it is concluded that the water is of brackish type.

B. Electrical Conductivity (EC)

The Electrical Conductivity measurement (EC) is directly affected by the amount of dissolved solids in the solution, and will increase as the amount of the dissolved solids increases. The water conductance is a function of temperature, type of present ions and the types of dissolved constituents, (Boyd, 2000). The average EC value in Huwaiza Marsh is about 2630 μS/cm. The maximum and minimum values are 3100 μS/cm and 2150 μS/cm, respectively for samples H5 and H9 on April 2013, respectively. The EC values on August 2013 are as follows, average value is 3517 μS/cm, the maximum is 5300 μS/cm and the minimum is 1560 μS/cm in stations H7 and H9, respectively.

While, for the feeding water samples, the EC values range from (2290 to 2650) µS/cm on April 2013 and from (1744 to 1886) µS/cm on August 2013.

C. Hydrogen Ion Concentration (pH)

The Hydrogen number (pH) is controlled by the equilibrium achieved by dissolved compounds in the system (UNEP GEMS, 2006). The maximum and minimum pH values of Huwaiza Mars's water were recorded on April 2013 in sample H9 and sample H3; as 8.1 and 7.1, respectively. The maximum and minimum pH values were recorded on August 2013 for Huwaiza Marsh's water, in samples H1 and H2 and were 7.8 and 7.1, respectively. While in the feeding water samples, it varies from 8.0 to 8.5 on April 2013 and from 7.1 to 8.8 on August 2013.

D. Major Cations

Ionic composition of surface water and groundwater is related to the exchange processes with the geological situation of the basin and the impact of atmosphere and human activities within the discharge basin. As well as the nature of the climate and the discharge system can generally affect the concentrations of the elements in water (UNEP GEMS, 2006). The concentration ranges and averages of major ions and secondary components of the Huwaiza Marsh and feed water are shown in Tables (1 and 2).

The low Potassium concentrations in water are due to high degree of stability of potassium-bearing alumina silicate minerals (Hem, 1991). The concentration of Potassium in the study area ranges from (9 to 14) mg/L on April 2013 and from (8 to 26) mg/L on August 2013 for Huwaiza Marsh's water samples and from (9 to 10) mg/L on April 2013 and on August 2013 for the feeding water samples.

Feldspars and alkali minerals, clay minerals and evaporaite rocks are the main sources of Na as well as human activities; like domestic need (Hem, 1985 and 1991). The concentration of sodium in the study area, ranges from (214 to 350) mg/L on April 2013 and from (250 to 790) mg/L on August 2013 for Huwaiza Marsh's water samples and from (250 to 300) mg/L on April 2013 and from (230 to 270) mg/L on August 2013; for feeding water samples.

Table 1: Physical – Chemical properties of the water in the study area during the period of high water level (April 2013)

Sample No.	K^+	Na^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	HCO_3^-	NO_3^-	PO_4^{3-}	pH	EC	TDS	TH
	Mg/L								(µg/l)		(µs/cm)	Mg/L	
H1	9	270	114.7	52	440	460	24.41	7	0.05	7.7	2230	1263	501.7
H2	10	270	110	55	450	450	22	5.9	0.07	7.5	2200	1304	495
H3	9	300	80	39	300	484	24	5	0.05	7.1	2290	1326	410
H4	9	300	84.7	42	306	497	23.6	3.7	0.04	7.2	2300	1300	435
H5	14	295	172	86	520	610	19.4	4.7	0.03	7.15	3100	1790	760
H6	14	290	172	86	550	605	19.4	5	0.03	7.2	2900	1810	750
H7	14	350	137	69	550	690	24	5	0.03	7.3	2850	1830	660
H8	14	350	135	68	560	688	23.5	6.8	0.03	7.2	2800	1826	655
H9	10	214	112	78	410	450	26	3	0.02	8.1	2150	1218	600
F1	10	280	102	60	465	445	20.5	5.3	0.1	8.5	2320	1280	501.7
F2	9	250	108	63.7	450	395	24.41	4.9	0.22	8.1	2290	1326	533
F3	9	290	121	71	504	430	26.85	3.8	0.2	8.0	2510	1400	595.8
F4	10	300	133	67.5	534	495	19.53	18	0.18	8.14	2650	1542	611.5
R. Max	10	300	133	71	534	495	26.8	18	0.22	8.5	2650	1542	611
R. Min	9	250	102	60	450	395	19.5	3.8	0.1	8.0	2290	1280	501
R. Average	9.5	280	116	66	488	441	22.8	8.0	0.18	8.2	2400	1387	560
M. Max	14	350	172	86	560	690	26	7	0.07	8.1	3100	1830	760
M. Min	9	214	80	39	300	450	19.4	3	0.02	7.1	2150	1218	410
M. Average	11	294	139	71	471	575	23.2	5	0.04	7.4	2630	1594	646

Table 2: Physical and chemical properties of the water in the study area during the period of low water level (August 2013)

Sample No.	K^+	Na^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	HCO_3^-	NO_3^-	PO_4^{3-}	pH	EC	TDS	TH
	Mg/L								µg/l		µs/cm	Mg/L	
H1	11	250	102.1	64.7	375	460	29.2	1.33	0.19	7.1	1975	1268	521
H2	9.5	260	116.2	60.8	365	445	26.8	0.0	0.23	7.8	1827	1190	541
H3	11.6	280	101	71.3	390	430	39.0	1.8	0.19	7.5	2000	1344	545
H4	8	320	117.8	68.5	460	450	51.2	1.8	0.15	7.3	2300	1516	576
H5	16	500	149.2	153.2	849	900	53.6	1.8	0.25	7.4	4130	2795	1003
H6	26	620	259.2	142.7	940	970	59	0.9	0.09	7.7	4600	3247	1235
H7	26	788	263	180	1085	1195	54	0.0	0.01	7.3	5300	3780	1398
H8	26	790	266	179.8	1090	1200	53.6	0.0	0.01	7.2	5260	3779	1403
H9	9.5	250	96.6	59	345	440	32.3	1.33	0.05	7.8	1560	1198	500
F1	10	270	94	61.8	365	470	26.8	1.8	0.12	8.8	1886	1210	490
F2	9	260	98.9	64	325	440	31.7	0.44	0.14	7.7	1744	1191	509
F3	9	260	110	55	330	430	34.2	5.3	0.15	7.2	1747	1148	501
F4	9	230	98.9	63.7	300	455	31.7	3.10	0.07	7.1	1750	1150	509
R. Max	10	270	110	64	365	470	34.2	5.3	0.15	8.8	1886	1210	509
R. Min	9	230	94	55	300	430	26.8	0.44	0.07	7.1	1744	1148	490
R. Average	9.3	255	101	61	330	449	31.1	2.7	0.12	7.7	1782	1175	502
M. Max	26	790	266	180	1090	1200	59	1.8	0.25	7.8	5300	3780	1403
M. Min	8	250	97	59	345	430	26.8	0.0	0.01	7.1	1560	1190	500
M. Average	16	519	173	125	737	792	46.1	1.0	0.14	7.5	3517	2481	949

Calcium is one of the major ions in the freshwater derived from several sources that include gypsum, anhydrate, calcite, dolomite, fluorite, and apatite as well as silicate minerals (Boyd, 2000). The concentration of calcium in the study area ranges from (80 to 172) mg/L on April 2013 and from (97 to 266) mg/L on August 2013 for Huwaiza Marsh's water samples and from (102 to 133) mg/L on April 2013 and from (94 to 110) mg/L on August 2013 for the feeding water samples.

Magnesium oxide and other compounds are also used in agriculture as well as chemical and construction industries (WHO, 2008). The concentration of magnesium in the study area ranges from (39 to 86) mg/L on April 2013 and from (59 to 180) mg/L on August 2013 for Huwaiza Marsh's water samples and from (60 to 71) mg/L on April 2013 and from (55 to 64) mg/L on August 2013 for the feeding water samples.

E- Major Anions

In most surface streams, chloride concentrations are lower than those of sulfate or bicarbonate (Hem, 1985 and 1991). The concentration of chloride in the study area ranges from (300 to 560) mg/L) on April 2013 and from (345 to 1090) mg/L on August 2013 for Huwaiza Marsh's water samples and from (450 to 534) mg/L on April 2013 and from (300 to 365) mg/L on August 2013 for feeding water samples.

The source of the Sulfate ion ($SO4^{2-}$) in natural water is mainly from dissolution of evaporaite rocks; like gypsum and anhydrite (WHO, 2008). The concentration of sulfate in the study area ranges from (450 to 690) mg/L on April 2013 and from (430 to 1200) mg/L on August 2013 for Huwaiza Marsh's water samples and from (395 to 495) mg/L on April 2013 and from (430 to 470) mg/L on August 2013 for the feeding water samples.

The bicarbonate ions are mainly originated from weathering of carbonate rocks, as well as CO_2 gas in the atmosphere, which dissolves in water, and is the principle source of bicarbonate (Hem, 1985 and 1991). The concentration of bicarbonate in the study area ranges from (19.4 to 26) mg/L on April 2013 and from (26.8 to 59) mg/L on August 2013 for Huwaiza Marsh's water samples and from (19.5 to 26.8) mg/L on April 2013 and from (26.8 to 34.2) mg/L on August 2013 for the feeding water samples. No carbonates were detected in the water samples of the study area, because carbonates are usually found in high pH value water (Hem, 1985 and 1991). The bicarbonates are associated with water in which its pH is less than 8.3, and this is the case of the study area.

F. Minor Anions

The presence of high nitrogen concentration represents a serious pollution problem' where it stimulates the growth of plants and then decay after death. The concentration of nitrates ranges from (3 to 7) mg/L on April 2013 and from (0.0 to 1.8) mg/L on August 2013 for Huwaiza Marsh's water samples and from (3.8 to 18) mg/L on April 2013 and from (0.44 to 5.3) mg/L on August 2013 for the feeding water samples.

The Phosphates (PO_4^{-3}) can enter the aquatic environment by natural weathering of minerals in the discharge basin, and by biological decomposition as well as by discarding of the household wastes and agricultural activities (UNEP GEMS, 2006). The concentration of the phosphate in the study area ranges from (0.02 to 0.07) mg/L on April 2013 and from (500 to 1403) mg/L on August 2013 for Huwaiza Marsh's water samples and from (501 to 611) mg/L on April 2013 and from (490 to 509) mg/L on August 2013 for the feeding water samples.

G. Total Hardness

Water is classified into several types according to Todd (2007) and Boyd (2000) classification of the total hardness of water. The degree of hardness becomes higher as the calcium and magnesium content increases (Skipton and Dvorak, 2009). The mean total hardness values in the study area range from (410 to 760) mg/L on April 2013 and from (0.01 to 0.25) mg/L on August 2013 for Huwaiza Marsh's water samples and from (0.1 to 0.22) mg/L on April 2013 and from (0.07 to 0.15) mg/L on August 2013 for the feeding water samples.

H. Water Classification

1. Water type

The water type, in the studied area in both periods was basically defined depending on the hydrochemical formula stated by Ivanov's (1968). As for the feeding water, water type was sodium chloride; during both seasons, except the sample F4, which was sulfate type during summer season with contrasting concentrations of cations and anions. As for the marsh water during spring season, 7 samples were chloride water type and 2 samples were sulfate water type. While at summer season, all 9 samples were sodium – chloride type.

The change in the water quality within the marsh body may be due to ion exchange with the groundwater, which is in shallow depth to the surface and the impact of the agricultural activities surrounding the marsh body. Moreover, to the variation in the amount of water entering the marsh during the both seasons and the wide differences in air temperature. As for the feeding water, the high concentration of chloride during the two seasons may be due to the impact of the agricultural activities, especially cultivation of wheat, barley and rice crops and which are accompanied with washing operations of the soil along the banks of the Tigris River and draining the excess water into the river.

2. Piper diagram

The water types for the wet and dry periods of the study area are defined according to Piper (1944). Two different water types are identified in Huwaiza Marsh's water during the period of water increase (April), the first type occupies the class "e" (Earth alkaline water with increase portion of alkali with prevailing sulfate and chloride) and the second type occupies class "g" (Alkaline water with prevailing sulfate and chloride). The dominant cation is sodium followed by calcium and magnesium ions, while the dominant anion is chloride followed by sulfate and bicarbonate ions (Figure 2A).

Huwaiza Marsh's water samples of summer season (August) have occupied class "e", the dominant cation is sodium followed by calcium and magnesium ions, while the dominant anion is chloride followed by sulfate and bicarbonate ions (Figure 2B).

According to Piper classification, all feeding water samples of Huwaiza Marsh during two seasons fall in the field of class "g". The dominant cation in both seasons is sodium followed by calcium and magnesium ions, while the dominant anion is chloride followed by sulfate and bicarbonate ions (Figures 3A and 3B).

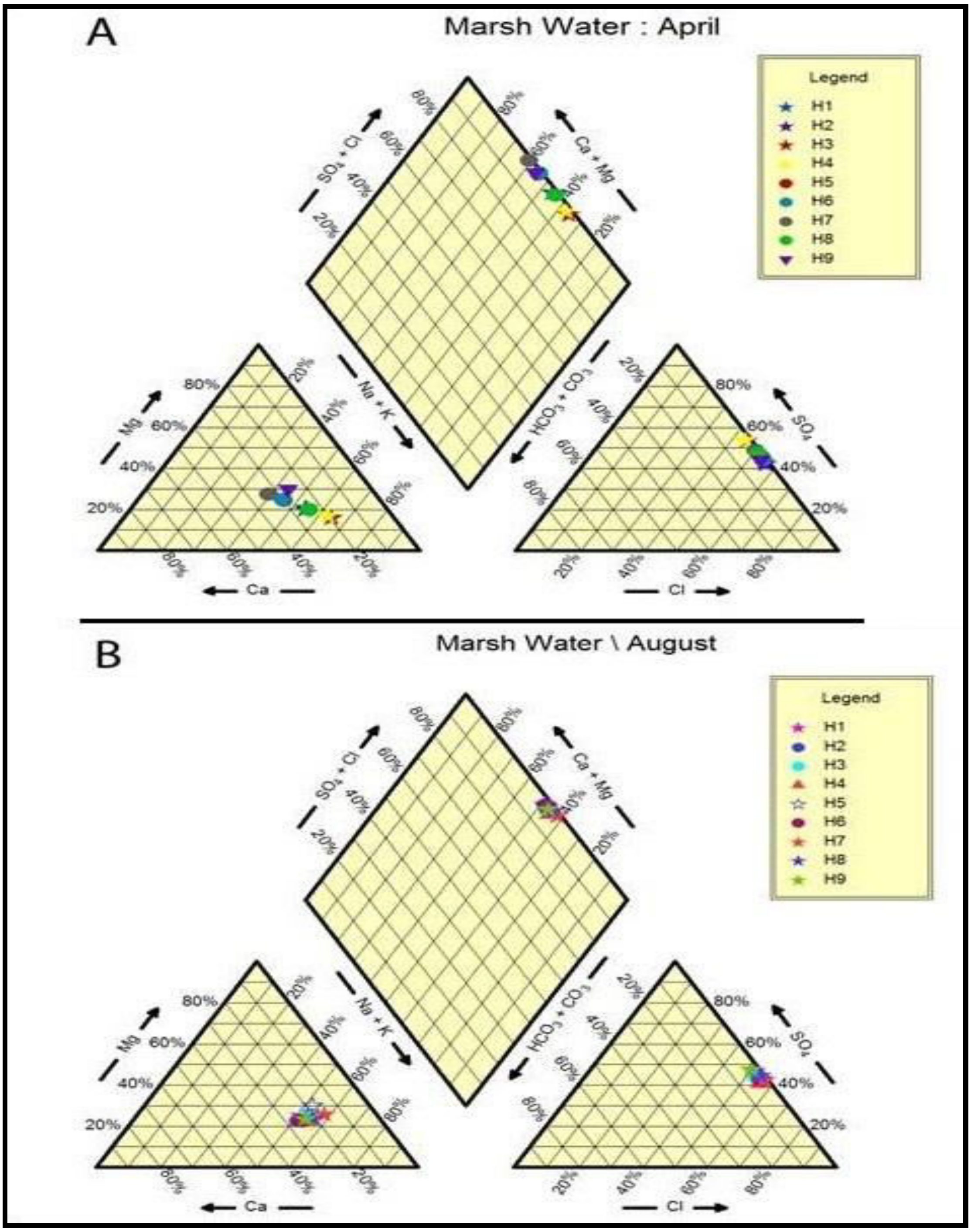

Fig. 2: Piper diagram of marsh water
A: High water level (April), B: low water level (August)

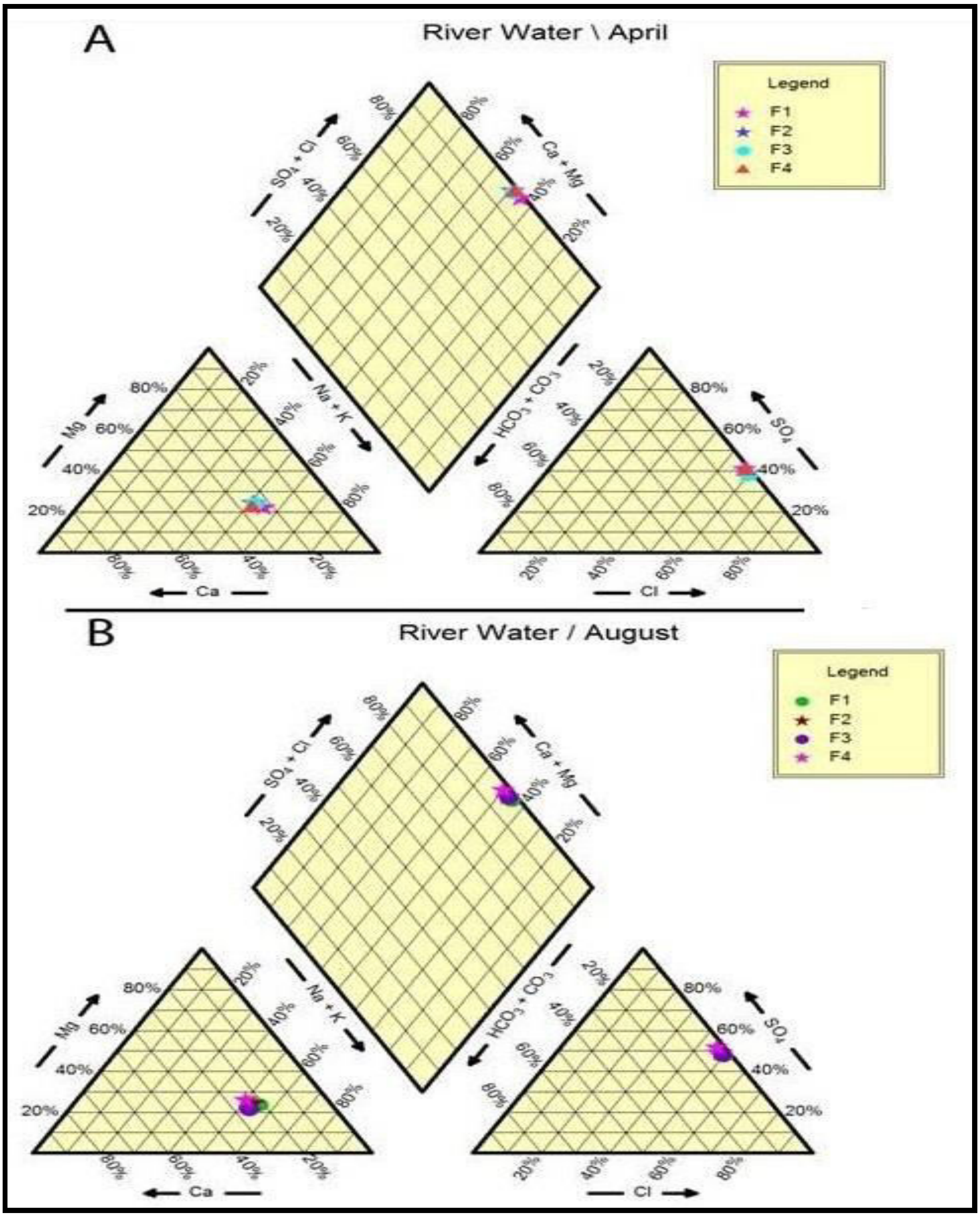

Fig. 3: Piper diagram of feeding water
A: High water level period (April), B: Low water level period (August)

3. Water uses

Validity of water for various uses depends on a number of world and local criteria and standards, after comparing the results of hydrochemical variables of water samples, which are analyzed with those standards and criteria and determining the validity of such uses according to the Iraqi standards (IQS, 2009), specifications of the World Health Organization (WHO, 2008) and U.S. Environmental Protection Agency (EPA, 2003) for the purpose of evaluation of the water of the study area.

The results showed that the marsh and feed waters are unsuitable for human's drinking, because most rates of the variables exceeded the permissible limits, while they are of acceptable grade for livestock and poultry; as compared with the specifications of Ayers and Westcott (1989). The classification of irrigation water; according to the values of SAR, the marsh water is up to 5.38 for spring season and 2.75 for summer season, whereas those of the feeding water is up to 4.93 and 2.23 during spring and summer seasons, respectively. It is clear that the values are within the "Used for sensitive crops" class (Todd, 2007; and Johnson and Zhang, 2007). When comparing the results of the current study with the criteria in the classification of Ayers and Westcott (1989) it is noted that some of the variables, especially TDS, Na^+ and Cl^- have exceeded the normal ranges for using the water for irrigation purpose; according classification of Ayers and Westcott (1989).

DISCUSSION AND CONCLUSIONS

The results showed a significant increase in the concentrations of dissolved salts in the water of Huwiza Marsh, which may be is attributed to the excess water that has being drained directly into the marsh from the rice farms, through a number of agricultural drains in addition to wheat and barley farms. As well as the influence of other factors, including the surface area of the marsh, which contributes to increase the rates of evaporation, beside the large surface area of water contact with the marsh floor, and the dropping in the floor of the marsh leads to be mixed with groundwater near the surface. The impact of the groundwater percolation coming from agricultural lands when the water level in the marsh decreases and the length of the retention period of the water, which increases the mineral decomposition processes of salts in the sediments of the marsh floor (Al-Lamy, 2007).

According to the classification of Altoviski (1962), the water type in the study area is slightly brackish water type. Electrical conductivity values of the feeding water samples show that the range of EC decreases in spring season more than summer season because of the dilution resulted from increasing of the discharges, which lead to decrease in ion concentrations in the water. The presence of a significant rise in the values of conductivity of the marsh's water in summer season is due to high evaporation rates and the far distance from the feeding areas. It is noted that the pH values of the feeding areas is greater than those of the marsh's water. This shows that the water of the marsh is slightly basic to neutral, which is less alkaline from the water of the feeding rivers. This decrease in alkaline of marsh's water may be is due to the decomposition of complex organic compounds (Banat, 2006). Also, the average of pH values of the marsh's water for high water level period is slightly less than that of the low water level period. This may be is attributed to the increase of air temperatures for summer season as compared to those of the spring season, which increases the decomposition processes of organic matter, as well as increasing oxygen consumption that is accompanied with an increase of carbon dioxide.

The relative low ion concentration of the spring season can be attributed to a rise in the water level of the river and then dilution in addition to low rates of evaporation (Al-Saady, 2008).

The results of chemical analysis of dissolved cations and anions (Ca^2+, Mg^2+, Na+, K^+, Cl-, SO_4^2-, HCO_3-, NO_3-) showed different values depending on the amount of the water-recharge during the year, and that concentration is decreasing during winter season because of the high water levels, and increasing during the summer season due to low water levels.

It is clear from the results of the feeding water concentrations that the concentrations of high water level values are higher than those of low water level; this is mainly attributed to the discarded water of agricultural land into the feeding rivers, especially from wheat and barley farms in this season by drainage canals. The high increase of ion concentration in marsh's water as compared to the feeding water is attributed to several reasons, including the washing processes of the salt-rich soils that are close to the marsh; as well as the discharged water, which is drained into marsh, besides the impact of the evaporation due to the large surface area of the marsh (Al-Saady, 2008).

The results showed that the marsh's water is unsuitable for human's drinking, because most rates of the variables exceeded the permissible limits and they are acceptable grade for livestock and poultry; according to the specifications of the World Health Organization Standards (WHO, 2009), U.S. Environmental Protection Agency Standards (EPA, 2003) and the Iraqi Standard (IQS, 2009 and WHO, 2009).

It is observed that there has been some increase in the total hardness during low water level period due to increase in calcium and magnesium ion concentrations, in particular calcium ion, as a result of increase in air temperatures and rates of evaporation in this season. The total hardness values of the feeding rivers are almost similar in values for both seasons. Generally, all water samples of the study area are classified as very hard according to Boyd (2000) and Todd (20070).

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