Marshes waters sources hydrochemistryof the Bahr Al-Najaf at Najaf Province, Iraq

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Abstract: Bahar Al- Najaf basin is located in the western part of Al-Najaf governorate, center of Iraq. This work was aimed to determine the water sources for marshes, water discharges and factors which causing to the rise and low of the water level in these marshes. Five sources recharge for the marshes water were detected; rainwater, Al-Dammam confined aquifer flowing wells, sieve factures, water of springs and the irrigation water. The hydrochemistry analysis was investigated for all water sources of marshes using major and minor elements (Ca, Na, K, Mg, Cl, SO4, NO3, HCO3 and Br) and field measurements such as (T, pH, EC, TDS). The hydrochemical results shows that the all sources of water are not suitable for drinking water, while it’s classified as a good to permissible water for irrigation except water of marshes. Water quality standards for livestock is vary from very good water type in the irrigation streams to the can be used in a water marshes.

Keywords: Marshes, waters sources, Bahr Al-Najaf, Water quality, Hydrochemistry

1. Introduction
Marshes are wetland that dominated by herbaceous rather than woody plant species [1]. Marshes are transition from the aquatic and terrestrial ecosystems which dominated by grasses, rushes or reeds, thus that form of vegetation is what differentiates marshes from other types of wetland such as swamps, which are dominated by trees, and mires, which are wetlands that have accumulated deposits of acidic peat [2]. The marshes are low land, where the water is collecting; in case of flood seasons it causing many problems such as sinking the farms, many of the residential houses and brick factories in the region. Several investigative conducted in the province of Al-Najaf for causes of flooding and drowning the buildings since 2012 -2013. The Iraqi farmers have been challenged for many years from poor environmental conditions, with few affordable measures for adapting to salinity, climate, drought, pests, crop and livestock diseases, and input shortages, as well as related challenges of poor technology and institutions, and inadequate science-formulated policies [3]. Recently, the Iraq faces special problems connected to water and food security due to poor water management plans and the policies of neighboring countries where most of the surface water resources (the Euphrates and Tigris rivers and their attributes) are located [4]. In addition, the shortage of precipitation aggravates the problem in the last ten years on those lands away from the river or those that do not have groundwater, to increase non-planted areas, although those areas are cultivable (Fig.1). More than that, the rise in temperature significantly led to...
highlighting the phenomenon of desertification and drought, which led to a clear impact on the areas of arable land and thus on the agricultural sector in general (MOWR, 2015). Therefore, the proper management of surface and groundwater resources is crucial to avoiding water shortage and can be achieved through the integrated use of water resources. The optimal use of surface water (such as floodwater through storage in surface reservoirs, lake and marshes) and its hydrochemical characteristics studying are useful strategies for coping with water scarcity [5]. Hydrochemical methodology offer effective tool for solving various problems in hydrology, in particular in the arid and semi-arid regions [6-11]. Multi-tracer investigations are commonly used to understand surface movement, salinity origin, evaporation processes, and recharge periods [12]. Such information which is needed to improve water resource management strategies is of particular importance for aquifers located in arid and semi-arid areas and characterized by complex lithology. This is the case of the west desert plain in Central Iraq. The maximum value of rain may be attended during November and the minimum in May. The maximum and minimum of monthly rainfall rate of the study area for the period (1962-2018) are 27.17 mm and 4.04 mm respectively with average 8.29 mm. The maximum and minimum value of evaporation rate is 499.88 mm and 77.88 mm, respectively. Several previous studies have been conducted on groundwater and have not been interested in studying the sources of marshes and its hydrochemistry. Therefore, this study aimed to determine source of the marshes water and the chemical characteristics for these waters, the most relevant controls on the water quality, and the dominant chemical processes, which control. Thus, using the hydrochemical analysis to conjunction between these sources of water and to knowledge of water hydrochemistry of water marshes and their suitability for the different purposes in addition to the possible of use.

2. Materials and Methods

2.1. Study area

2.1.1 General and geological description

The study area is located in Bahr Al-Najaf, west of Al-Najaf province, Iraq. The East side of Bahr Al-Najaf is graveyard, which formed a permanent marsh, where the waters is collecting throughout the year. The marshes are extends at North west-South east direction of an area about 360-750 Km2, of coordinates longitude 43˚ 40’ - 44˚ 25 E and latitude 31˚ 40’ - 32˚ 10 N and altitude elevation of about 11 m a.s.l. [12,13], (Fig.1). Geologically, Bahar Al-Najaf area is located within the boundaries of Al-Salman subzone including the stable shelf that specializes in its simple structures, [14]. The exposed rocks are sedimentary rocks of upper Cretaceous and Quaternary period [15,16]. Tar Al-Najaf is limits the marshes from the east side while the Sothern Desert is bordering the marshes from Western side. The common climate in the area is Sub-arid to arid [17].

The geomorphology districts the flow regime of (sub) -surface water (Wadis) and (dis) -recharge areas depending on the gravity forces, which inclines to the East and Northeast down to the discharge zone. As well as, it is affected by the climate elements like distribution of precipitation. Geomorphological, a few reliefs mark the studied area, and it has a ground surface elevation range (15-267m) approximately, above sea level. The area slopes gradually from the West and Southwest towards the North and Northeast. Where the land surface rises gradually from Northeast to Southwest 50m every 10-15 km, [18]. On the other hand, at the eastern edge of the study area, it’s seen as a closed topographic depression, which isa lower land relative to the surrounding, and it represents as a discharge zone (Bahir Al-Najaf). Generally, the study area is characterized by some Wades,
which can discharge of rainwater from the West and South-West to East and Northeast directions which be coincide with the decline direction of the regional topography ([19]).
Such of these Wades are Wade Haussab and Wade Al-Khur and other smaller valleys as Al-Rhimawi and Abo Kumssat which could participate the pooled of water and recharge the aquifers of the basin [20]. This situation makes some eastern and Northeastern parts of the studied area periodically contain amounts of water, and appear as marshes. A huge fault which extend in the far eastern side forms the limits of the stable boundary which is called the Euphrates fault, this fault and the rest of the faults in the area play an important role for controlling with ground water movement in study area, existing of the spring which considered as a good evidence of the presence of deep faults [21]. It could be considered that the fault zone represents a transitional zone between the two shelves the stable and the unstable zones (Mesopotamian plain), which marked by a shelf system known as (Heet-Abu Jir) that extends from Hadeetha in the north to Abu Jir and pass through Najaf in its way to Samawa in the south [22]. Abu jir fault zone, including the Euphrates fault extends perpendicular to the other trending faults, which make a barrier that allow the water to pass through and circulate within this net of faults.

2.1.2 Hydrological setting
The studied area are characterized with a rolling and / or undulating terrain, most parts of the study area, it is a slightly rolling or flat, and decreasing in its height towards the East and northeast. Despite the studied area has a climate of dried desert, the rainfall sometimes happens as sporadic heavy flushes occur once every several years, usually one or two times every four years, which causes a superficial flux for the rainwater which creating many of the ephemeral and temporarily rivers in the desert, most of these rivers are flowing to the large Wadies, whereas the small valleys have gathered its water in the small spaces in a form of temporary ponds called “Al-fidah”, its waters are infiltrating through the soil column and the other part is evaporated to the atmosphere over the time (Fig.2). All of these Wadies within the study area are discharging its water towards the marshes, which it lay to the East of the studied area bordering of Tar Al-Najaf, the most important of these Wades are Wade Hassoub, and Wade Al-Khur, in addition to Wade Waaar, Abu Khamesat and Wade Al-Rahimawi. Marshes has a water depth exceeds 2 m in some of the regions and its ground surface elevation is 10 m at the sea level, while the maximum elevation is 217 m (a.s.l), in the West and Southwest of the study area. Therefore, the Wades is collecting the rainwater and transfer it to the marshes, which makes them to be one of the sources of marsh waters, (Plate -1). Wades also are represented as facilitates from operation of surface water filtration, where the draining system in the Southern Desert is internal, with most of the surface water percolating to underground through permeable strata, fractures, fissures and karats cavities [23].

Fig 2. Surface features and surface water resources in the study area.

2.2. Methods analysis
Several of the field tours have been conducted to investigate from sources of marshes water in the Bahar Al-Najaf. Five sources of water have been found in the study area, which they feeding the marshes. These sources are (floods water that come via Wadies, creeks that come from lakes of breeding fish, Creeks that come from the Euphrates River, water that come from sieve factures and springs), all of these sources of the water are ending its
water in the marshes. Eleven samples have been collected from eleven station of water in November 2017. The samples represent the sources of surface water in Bahr Al-Najaf, these stations are (Marshes Water (MW), Irrigation Creeks (IC), Springs Water (SW), Factories Water (FW), Creeks that come from Fish Lakes (FLC)). The sampling locations are shown in Fig. 2. Physicochemical parameters including EC (μS/cm) and pH were measured in the field using portable measuring instruments. The bottles were washed with the water to be sampled before sampling. Two water samples were collected for each sample point using polyethylene bottles. The samples taken for cation analysis were acidified using pure HNO₃ to prevent precipitation and preserved in refrigerator at a temperature of about 4°C until analysis. The parameters were determined by following standard and recommended analysis methods [24]. All samples were analyzed for major cations (K⁺, Na⁺, Ca²⁺, and Mg²⁺) and major anions (CO₃²⁻, HCO₃⁻, SO₄²⁻, and Cl⁻), as well as the secondary anions (NO₃⁻) and trace elements (Cd, Mn, Zn, Fe and Pb), in the Sciences and Technology Ministry Laboratories, Baghdad, Iraq. The majority of the analyzed samples show ion balance errors within ±5%, indicating the results are generally acceptable. The TDS concentration was calculated using the results of the chemical analyses. The distribution of major ion concentrations and correlation analysis of parameters and elements in groundwater samples were studied through the statistical and hydrochemical graphs. The correlation coefficient was determined to reveal the relationship between parameters by means of SPSS (version 15.0). The results of the chemical analyses in the study area compare with Iraqi standards and WHO to detect the validity of the surface water for the different purposes. The variations of element concentrations and parameter values in aquifer were illustrated on zoning maps through ArcGIS 10.5 [25].

3. Results and Discussion

3.1. Sources of marshes waters

There are different sources of marshes water and they have a different origin. Generally, these sources can be summarized as follows:

1. Rainwater that comes via the Wadies (RW).
   The rainwater flows in the study area from the high topography toward the low land (Bahr Al-Najaf) and it pours into the marshes. Rainfall occurs during winter months in the form of heavy showers and rather sporadic, but occurs very rapidly during a short time; mean annual amount of rainfall ranges between (75 – 100 mm) [26]. Marshes in Bahr Al-Najaf is receiving surface waters from the western side via the watercourses that bring water on a seasonal basis from the upland desert to the west after any heavy rains [27]. Although the climate of the study area is arid to semi-arid but it, flood waves may happen every a few years, causing many problems in the region, the most important is the smashing of bridges, destruction of the paved roads, fish breeding lakes and agricultural land. Also, the sinking of the brick factories, and residential buildings (Plate.1 and plate.2).

2. Irrigation creeks (IC)
   Many of the creeks (streams) are existing in the maximum of the Southeastern side of the study area, these creeks are established to irrigation the farmlands that is characterized by cultivation of rice crop (fig. 2). Most of these creeks are ending its waters in the marshes either directly or through drainage of water surplus that resulting from irrigation of rice crop. There are four creeks of water that have different lengths and they vary in its discharge that feeding the agricultural lands in the study area. These creeks are received its water from the right side of Chhaty stream (Table.1); (General Commission of groundwater in Najaf). Chhaty stream by discharge of water reach to (15 m³/Sec), received its water from the right side of the Euphrates River by raising the water level to (19.20 m) a.s.l in the main channel via Al-Mashkhab regulator. However, the amount of water that discharging from these crakes to the marshes is about 2-3 m³/Sec.

Table 1. Characteristics of irrigation creeks in the study area (General Commission of groundwater in Najaf).
Creek name | Length | Design discharge (m$^3$/sec)
---|---|---
Al-Gazi | 31 km | 6
Al-Badriyah | 28 km | 5
Al-Hashemi | 15 km | 4
Abu Jdoua | 26 km | 3

3. Groundwater Creeks (GWC).
Groundwater creeks means that waters which come from the flowing wells (Self-flow wells) which intervention to the lakes of fish, then drains to the marshes via the main creek which it collecting the waters from several small creeks which outs from the lakes. There are two main creeks from the groundwater flowing wells, one of them lies in the northeast of the study area, which is the biggest (creek A) due to the large numbers of fish lakes in these regions, while the other creek is located in the south side of the study area (creek B). The amount of drainage waters from these creeks is depending on the numbers of fish lakes in the region that mean numbers of flowing wells. Hundreds of flowing wells exist in the study area, some of these wells have a discharge reach more than 75 L/Sec; subsequently the water of these wells reaches to the marshes. However, the amount of water have been calculated for both creeks which drains its water to the marshes depending on equation no.1, after the field measurements were done for both creeks, as it following [28].:

Q= V × A ............................................................................................................................................ (1)

Where:
Q: is the discharge of water.
V: Velocity of water and can be obtained via divided the distance over the time, for a float body
A: Cross-section area for the main creek and can be obtained via multiplying the width of channel with its depth.

I. Discharge of water in the creek A.
The velocity of water has been measured by calculating a float body time for a distance 15 m. However, the time is $15, 20^\circ$, depth of channel is 0.75m, width of channel is 3.71m.

$V = \frac{15}{20} = 0.1875$ m/Sec.

$A = 0.75 \times 3.71 = 2.782$ m$^2$.

$Q = 0.1875 \times 2.782 = 0.521$ m$^3$/Sec.

II. Discharge of water in the creek B.
In the same way in above, the discharge of creek B was (0.274) m$^3$/Sec. So, the total amount of waters that come from the self-flow wells through lakes of fish and across the water creeks is (0.795 m$^3$/Sec) on a daily basis.

4. Waters that come from the sieve factories (SFW).
It is difficult to determine the amount of water that come from the sieve factories due to it is a large number and different locations. Generally, more than a hundred of these factories are existing in the study area. They are used a submersible pump to extract the groundwater with an average discharge reach 7 l/sec for 8 hours per day. Some of these factories are thrown its water after use into the marshes directly, other of these factories are using the artificial channels to drain its water to the marshes, and some of the other dropping its water in a specific region to form a swamp and therefore, the water does not reach to the marshes. However, if we assume that 50 of these factories are reaching its water to the marshes directly or indirectly (by channels), the amount of water that results from multiplying the number of these factories by the value of the discharge for one pump it is equal to (0.35 m$^3$/sec). Knowing, the numbers of working hour's in the factories is eight hours per day.

5. Springs water (SW).
There are a few amounts of water that come from the springs. This water is seeping from joints and the cracks, which are existing in limestone rocks and it mixed with the water of sieve factures due it drains its water in the same channel which it ending to the marshes. As a result of the points above, the amount of water that reaches to the marshes can be summarized in (Table.2). Could not calculate the amount of water that coming via the wadies due to the lack of sufficient rainfall to get on runoff during the study period.

Table 2. Amounts of waters that discharging in the marshes.
Source of water | Discharge (m³/sec) |
--- | --- |
Irrigations streams | 3 |
Groundwater creeks | 0.795 |
sieve factories water | 0.35 |
Total Discharge | 4.145 |

3.2. Hydrochemistry of waters.
Understanding the water quality is important as it is the main factor determining its suitability for drinking, domestic, agricultural and industrial purposes [28]. Evaluations of water provides an idea about the reactions that produce natural water chemistry [29]. Marshes is the lowest land in the region, thus all surface water resources are accumulating in it.

3.3. Physical properties
There is a marked variation in water temperature due to differ its sources and locations. Generally, temperature of water creeks is lowest than temperature of marshes due to flow of the water. The range of the surface water temperature was (28.7-34.9 °C) with an average 31.27 °C. pH of water sources is moderate to alkaline in nature, where the variation of pH value is depends on temperature of water. The pH values were within the range of (7.1-7.6) with an average 7.3. A high variation was found in EC and TDS, where the maximum values of TDS were found in the samples of marshes water, while the lowest values were in the samples of irrigation creeks, the high values of TDS its a result to the evaporation process which happen in the marshes and concentrated the salts. TDS and EC in water samples were within the range of (1130-12690 ppm), with an average 4798 ppm. Therefore, the waters are varying from brackish water to saline water according to [30] water classification (Table 3). The EC ranging of (1525-17131 μS/cm), with an average 6478 μS/cm. Total Hardness (T.H) showed that all water samples is very hard according to [31] classification (Table 4), where the values were ranging of (650-7471 ppm) with an average 2633 ppm. All physical parameters are shown in (Table 5 and Fig. 3).

**Table 3. Classification of water according to TDS (ppm)**

| Water class            | (Drever, 1997) | (Todd, 2007) |
|------------------------|----------------|--------------|
| Fresh water            | < 1000         | 10 - 1000    |
| Slightly water         | 1000 – 2000    | ----         |
| Slightly-brackish water| 2000 – 20 000  | 1000 – 10 000|
| Brackish water         | ----           | 10 000 – 100 000|
| Saline water           | 35 000         | ----         |
| Brine water            | > 35 000       | > 100 000    |

**Table 4. Classification of water according to the total hardness [31]**

| Term                  | Degree of Water Hardness |
|-----------------------|--------------------------|
| Soft                  | 0 < TH ≤ 60              |
| Moderately hard       | 60 < TH ≤ 120            |
| Hard                  | 120 < TH ≤ 180           |
| Very hard             | 180 < TH                 |
Table 5: physical analytical data for the samples water in the study area.

| Type of water | E  | N   | pH  | TDS (mg/l) | EC (μs/cm) | T (°C) | TH (mg/l) |
|---------------|----|-----|-----|------------|------------|--------|-----------|
| FLC 1         | 428590 | 3527199 | 7.2 | 3265 | 4407 | 30.7 | 1525.74 |
| FLC 2         | 417268 | 3544415 | 7.4 | 3212 | 4336 | 30.2 | 1701.42 |
| FLC 3         | 416204 | 3542895 | 7.6 | 2530 | 3415 | 28.7 | 1101.76 |
| CE 1          | 439889 | 3533899 | 7.4 | 1930 | 2605 | 29.3 | 950.37  |
| CE 2          | 444369 | 3534297 | 7.4 | 1130 | 1525 | 31.3 | 650.37  |
| SW 1          | 427425 | 3524875 | 7.2 | 2022 | 2199 | 32.1 | 1207.26 |
| SW 2          | 427119 | 3524406 | 7.2 | 1570 | 2119 | 32.7 | 808.59  |
| SFW           | 426459 | 3525993 | 7.3 | 3215 | 4339 | 30.1 | 1703    |
| MW1           | 425555 | 3538919 | 7.1 | 12690| 17131| 34.9 | 7471.23 |
| MW2           | 420040 | 3542648 | 7.4 | 5950 | 8032 | 29.6 | 2437.04 |
| MW3           | 433775 | 3538298 | 7.1 | 11070| 14944| 33.4 | 6554.22 |
| Min           | -    | -    | 7.1 | 12690| 17131| 34.9 | 7471.23 |
| Max           | -    | -    | 7.6 | 12690| 17131| 34.9 | 7471.23 |
| Average       | -    | -    | 7.3 | 4798 | 6478 | 31.27| 2633    |

CE: Creek water that come from Euphrates River.

Fig3. Physical parameters chart for the water samples in the study area.

3.4. Major ions
The major ions are consisted of Cations and Anions; naturally, it has a wide variety in the surface and groundwater due to local geological, climatic and geographical conditions. Major ions in the samples of water sources within the study area are listed in (Table 6) and they are illustrated in (Fig. 4). The most dominant Cation is Na⁺, where it forms 45.39 % in average, Calcium consist of (33.91%) in average, whilst Cl⁻ and SO₄²⁻ are the most dominant anions and they forms 48.57 %, 47.39% respectively from the total Ions. The detail ionic constituents in the sources of water are clearly displayed by Pie diagram (Fig.5). Piper diagram displays that most of surface water samples is fall in class (E); (Fig.6). The class E means Calcium carbonate type; secondary alkalinity (Hardness more than 50%), which reflects solubility of calcium ion from Al-Dammam formation by the groundwater. While the other samples fall in class (g) which represents alkaline water with prevailing Sulfate and Chloride. Cations (Na, Ca, Mg and K) they have an average values 908ppm, 742ppm, 238ppm and 29.5ppm respectively, while the anion are (Cl, SO₄ and HCO₃⁻) with un average values 1709ppm, 1994ppm and 29.5ppm. Sodium chloride; primary salinity; secondary alkalinity, the hydrochemistry reflects the image of rocks; limestone and dolomite in addition to mainly gypsum and halite. Marshes water have high values from major cations and anions. Which mean that the main water source in the marshes are from the groundwater.

Table 6: Major Cations, Anions data of water samples in the studied area.

| Type of water | E  | N ppm | K ppm | Ca ppm | Mg ppm | SO₄ ppm | HCO₃ ppm | Cl ppm | CO₃ ppm |
|---------------|----|-------|-------|--------|--------|---------|----------|--------|---------|
| FLC 1         | 428590 | 3527199 | 780 | 18 | 390 | 134 | 1590 | 39 | 1090 | 0 |
Fig. 4. Major ions chart for the surface water within the studied area.

Fig. 5. Pie diagram displays the average ionic constituents of water samples.
Fig. 6. Piper diagram displays sources of water facies.

3.5. Minor elements
Nitrate have been analyzed as a minor element, where it has represents very important element to water quality and for the agriculture. In lakes and rivers, nitrate concentration associated with inorganic nitrogen, usually the enrichment in nitrate is due to enrichment of dissolve oxygen [32]. The increase of nitrate concentrations in the sources of surface water may be due to the transformation of ammonia that produced by the fish into nitrite by the nitrification process.

\[
2\text{NH}_3 + 3\text{O}_2 \rightarrow 2\text{NO}_3^- + 2\text{H}^+ + 2\text{H}_2\text{O} \quad (2)
\]

Therefore, the high concentrations were found in the creek of lakes (FLC1) and in the position of creek that come from the lakes, which it drops its waters in the marshes (MW2); (Fig.1). The concentration of nitrate for sources of surface water in the study area were ranged of 0.8-34ppm with an average 10.13ppm, (Table 7). Fig. 7 shows the ranges of Nitrate in the sources of surface water within the study area.

Fig. 7. Chart of Nitrate values in the sources of surface water within the study area.

3.6. Trace elements
The values concentrations of trace element in water samples within study area are listed in (Table 7) and its diversity are exhibited in (Fig.8). Generally, manganese concentration as a water quality must not exceed more than 0.1 mg/l [7] and [32]. The concentration of manganese in the surface water in the study area were ranged of (0.003-0.06ppm) with an average (0.024ppm). Cadmium is relatively rare in the geological deposits, it is occupying 0.0013 mg/l in the earth's crust, thus it is mainly exists as carbonate and hydroxide forms (Boyd, 2000). The concentrations of Cadmium range from (104 to 105 ppb) in most surface waters, while in seawater it has an average of 0.11ppb [6,7]. Concentration of Zinc ion usually is low due to the controlled minerals have low solubility within the pH range of most natural waters [31]. Zinc concentration in fresh water ranged between (0.2-100ppb) and in the seawater (0.2─48ppb) [22]. The concentration of zinc for the surface water in the study area were ranged of (0.09-0.19ppm) with an average (0.117ppm). Iron in water may come from dissolution of iron containing minerals, organic matter decay, and human activities and the iron concentration in the sea water it has an average of 0.01mg/l, while the average of iron concentration are 0.7 mg/l in the surface water [20]. Whoever, the USEPA (2012) and WHO (2011) they has recommended for drinking water standards for the Iron at 0.3 mg/l. The concentration of iron for the surface water in the study area were ranged of (0.11-0.31ppm) with an average (0.192ppm). Lead is a relatively common element in the earth’s crust. Freshwaters usually contain more lead than the oceans which has a residence time is approximately 100-200 years [12]. Seawater have an
average Lead concentration of (0.03 ppb), (Boyd, 2000), while the rainwater have an average of (1ppb), [7]. The concentration of lead for the surface water in the study area were ranged of (0.001-0.02ppm) with an average (0.006ppm).

Table 7. Concentration of minor and trace elements in the surface water samples in (ppb).

| Stations | NO3 (ppm) | Mn (ppb) | Cd (ppb) | Zn (ppb) | Fe (ppb) | Pb (ppb) |
|----------|-----------|----------|----------|----------|----------|----------|
| FLC1     | 12        | BDL      | 0.03     | 0.11     | 0.15     | 0.002    |
| FLC2     | 12        | BDL      | 0.002    | 0.19     | 0.22     | 0.002    |
| FLC3     | 3         | BDL      | BDL      | 0.12     | 0.11     | 0.02     |
| CE1      | 3.3       | 0.06     | BDL      | 0.09     | 0.31     | 0.002    |
| CE2      | 12        | 0.014    | 0.002    | 0.1      | 0.2      | BDL      |
| SW1      | 6.1       | 0.01     | BDL      | 0.1      | 0.31     | BDL      |
| SW2      | 0.8       | 0.02     | BDL      | 0.09     | 0.11     | BDL      |
| SFW      | 1.8       | 0.003    | 0.004    | 0.12     | 0.13     | 0.009    |
| MW1      | 9         | 0.02     | 0.03     | 0.1      | 0.3      | 0.002    |
| MW2      | 34        | 0.01     | 0.02     | 0.12     | 0.12     | 0.001    |
| MW3      | 3         | 0.04     | 0.002    | 0.11     | 0.12     | 0.009    |

BDL: Less than measurement

Fig.8. Chart of minor and trace elements values in the sources of surface water within the study area.

3.7. Uses of water.
The knowledge of water quality can provide an important insight into the nature of the resource that it is very important to uses for deferent purposes; where it will be used for drinking water, industrial and irrigation. In order to set criteria for quality of water, measurements of chemical, physical and biological properties must be done under standards methods [29].Many methods have been used in classification of water to evaluate the quality of water for all purposes. All these methods depend on absolute values (epm, epm %) for Cations and Anions. However, according to [7, 30], all surface water are not suitable for drinking water (Table 8).

Table 8. Water Samples with [7,30] the standards of Drinking Water

| Parameter | IQS 2009 | WHO 2007 | Water Samples | Exceeding limits |
|-----------|----------|----------|---------------|------------------|
|           | Range    | Average  |               |                  |
| TDS       | 1000     | 1000     | 1130-12690    | Exceed          |
| PH        | 6.5-8.5  | 6.5-8.5  | 7.1-7.6       | 7.31             | Not Exceed     |
3.8. Surface water suitability for irrigation purposes

One of the earliest systems of classification of water for use in irrigation was given by Wilcox, (1955) which is based on electrical conductivity (EC), percent of sodium (% Na) and boron concentration (fig. 9). The classification has been achieved based on sodium adsorption (SAR), electrical conductivity (EC) and Na% [12], to assess the water suitability for irrigation purpose. Thus, the sources of surface water in the study area are classified as a good to permissible water for irrigation except water of marshes. Water quality standards for livestock purposes depend on Altoviski (1962); They are variation from very good water type in the irrigation creeks to be used in water of marshes (Table 9). Water quality standards for building purposes compared with Cations and Anions of water in the area, according to [13]. The sources of surface water were within permissible except marshes water.

Plants tolerance differs for total dissolved solids and electrical conductivity [31], (Table 11,12). Comparing groundwater with those standards (specifications), it is clear that the groundwater of the studied area is suitable for all kind of crops.

\[
\%Na = \frac{Na^+ + K^+}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \times 100
\]

\[
SAR = \frac{Na^+}{\sqrt{Ca^{2+} + Mg^{2+}}}
\]

Table 9: Classification of irrigation waters according to Don (1995)

| EC μSi cm | TDS ppm | SAR | Na% | pH | Water Quality |
|-----------|---------|-----|-----|----|--------------|
| 250       | 175     | 3   | 20  | 6.5| Excellent    |
| 250-750   | 175-525 | 3-5 | 20-40| 6.5-6.8| Good         |
| 750-2000  | 525-1400| 5-10| 40-60| 6.8-7.0| Permissible  |
| 2000-3000 | 1400-2100| 10-15| 60-80| 7-8| Doubtful     |
| >3000     | >2100   | >15 | >80  | >8 | Unsuitable   |
Table 10. Values of (SAR & Na %) for wells in the studied area

| Well No. | Na% ratio | SAR (meq/l) |
|----------|-----------|-------------|
| FLC1     | 52.850    | 8.69        |
| FLC2     | 45.34     | 6.86        |
| FLC3     | 57.54     | 8.98        |
| CE1      | 48.71     | 5.80        |
| CE2      | 36.40     | 2.92        |
| SW1      | 45.74     | 4.71        |
| SW2      | 36.79     | 4.02        |
| SFW      | 45.33     | 6.70        |
| MW1      | 37.27     | 10.07       |
| MW2      | 60.16     | 14.63       |
| MW3      | 40.30     | 10.75       |

Continued use of water with high SAR value leads to a breakdown in the physical structure of the soil caused by excessive amounts of colloidally adsorbed sodium. The soil then becomes hard and compact when dry and increasingly impervious to water penetration. SAR in all samples ranged from 2.92 to 10.75 meq/l, as shown in Table 10. In this respect, the US salinity diagram (Fig. 9) which is based on the integrated effect of EC (salinity hazard), and SAR (alkalinity hazard), has been used to assess the water suitability for irrigation. When the analytical data of EC and SAR plotted on the US salinity diagram, it is illustrated that water samples of FLC3 fall in the class of C3-S1 indicating high salinity with low sodium water, which can be used for irrigation on almost all types of soil, with only a minimum risk of exchangeable sodium. This type of water can be suitable for plants having good salt tolerance but restricts its suitability for irrigation, especially in soils with restricted drainage, while water samples of FLC1 and CE1 fall in the class of C4-S3 and the rest fall in the class C4-S2 indicating very high salinity with medium to high sodium water, generally very high salinity water (C4) is not suitable for irrigation.

![Classification of irrigation Water](image)

**Fig 9.** Classification of irrigation Water (After U.S. Salinity Laboratory Staff 1954)

Table 11. Relative tolerances of crops to salt concentrations [31]

| Crops Division         | Low salt tolerance crops Ec (µs/cm) | Medium salt tolerance crops Ec (µs/cm) | High salt tolerance crops Ec (µs/cm) |
|------------------------|------------------------------------|---------------------------------------|-------------------------------------|
| **Fruit Crops**        | 0 - 3000                           | 3000 - 4000                           | 4000- 10000                       |
| Limo, Apricot, Orange, |                                    |                                       |                                    |
| Apple, Pear, Peach.    |                                    |                                       |                                    |
| **Vegetable Crops**    | 3000 - 4000                        | 4000 —10000                          | 10000-12000                       |
| Green beans, Celery,   |                                    |                                       |                                    |
| Radish.                |                                    |                                       |                                    |
| Cucumber, Onion, Carrot |                                    |                                       |                                    |
| potatoes. Lettuce      |                                    |                                       |                                    |
| Tomato, Cauliflower.   |                                    |                                       |                                    |
| Spinach, beets         |                                    |                                       |                                    |
Field Crops | 4000 - 6000 | 6000- 10000 | 10000- 16000  
|----------------|-------------|-------------|-------------| 
| Fields beans | Sunflower, Flax, Corn, Rice, Sorghum | Cotton, Sugar beet, Barley( grains) | 

Table 12. Specifications of waters for Livestock consumption purposes [13].

| Elements & Parameters | Very good Water | Good Water | Acceptable Water for use | Can be used | High limits |
|-----------------------|-----------------|------------|--------------------------|-------------|-------------|
| Na+                   | 800             | 1500       | 2000                     | 2500        | 4000        |
| Ca+2                  | 350             | 700        | 800                      | 900         | 1000        |
| Mg+2                  | 150             | 350        | 500                      | 600         | 700         |
| Cl                    | 900             | 2000       | 3000                     | 4000        | 6000        |
| SO\textsuperscript{2}\textsuperscript{-} | 1000 | 2500 | 3000 | 4000 | 6000 |
| TDS                   | 3000            | 5000       | 7000                     | 10000       | 15000       |
| T.H                   | 1500            | 3200       | 4000                     | 4700        | 54000       |

Unit(ppm)

4. Conclusions
- Five sources of waters, that form marshes of Bahar Al-Najaf and they representing sources of the surface water in the study area including marshes water. The amount of water that discharged to the marshes from these sources are 4.145 m\textsuperscript{3}/s daily, and can be increased or decreased. Except the water that come from the Wadies. Twice in the year,a large quantity of water is freed from the lakes of breeding fish to the marshes in case of marketing of fish, this occur in the Spring and Autumn season usually that mean excess in amount of discharging water. A huge amount of rainwater reach to the marshes across the Wadies, One or more times every four years that causes flooding in the marshes.
- Most of water samples is Calcium carbonate type; secondary alkalinity (Hardness more than 50%). While the other samples is alkaline water with prevailing Sulfate and Chloride which reflects the groundwater origin.
- Evaporation is very effective process in the marshes, where the Sodium Chloride was found deposited on the edges of the marshes after the dropsthe water level to more than 1 m during the summer.
- All sources of water are not suitable for drinking water, while its classified as a good to permissible water for irrigation except water of marshes. Water quality standards for livestock is vary from very good water type in the irrigation streams to the can be used in a water marshes. Water quality standards for building purposes compared with Cations and Anions of water in the area; so, all water samples are within permissible except the marshes water.
- Many factors that effect on (quantity, quality and fluctuate of water level ) in the marshes, the most important are:
  1. Amount of rainwater that come via the Wadies.
  2. Amount of water that release from lakes of fish.
  3. Ratio of evaporation from water of marshes.
  4. Amount of irrigation water that released from agriculture lands.

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