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Assessment of the physio chemical properties and hydro chemical formula of water in some wells south of Baghdad in 2020

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ABSTRACT

The study was conducted during the summer season of 2020 to see the quality of eighteen wells with different depths ranging from 6-25 m within three areas south of Baghdad, namely Al-Saouira, Al-Mada'in and Jisr Diyala distributed in different locations, agricultural orchards and residential villages and these wells depend mainly on groundwater and designed for various uses. Water samples were taken from wells directly by clean, sterile bottles and bimonthly sample spots, heat, acidity, turbidity, total dissolved salts and electrical conductivity were carried out in the field using field measuring devices. Color, taste and smell were examined based on the senses, while positive ions (Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}) and negative (Cl^{-}, HCO_3, CO_3^{-2}, SO_4^{-2}, NO_3^{-}) were measured. Total hardness was measured in the indication of magnesium and calcium ion concentrations, in the laboratory of the Department of Geology/ General Commission for Groundwater/ Ministry of Water Resources, and hydrochemical formulae were identified by knowing the concentrations of ions to find out the origin of well water. Temperatures and acidity rates were 24, 7.3 respectively, which are natural proportions of groundwater characterized by moderate and stable temperature throughout the year, tending to be the light basicity of the presence of bicarbonate, which consists of melting limestone rocks and sometimes organic pollutants. As for the color, all the wells are colorless except for the wells 7 and 9 because of their proximity to the Tigris River and the filtering of part of the clay soils surrounding them, and the wells were odorless except the wells dug in orchards for grazing animals and the use of fertilizers and animal waste in agriculture as in wells 1, 2, 3 and 4 or close to the Diyala River contaminated with sewage coming from Al-Rustamiyah as in well 11. All wells have a salty taste except the wells; 7, 8, 10,17, 18 wells, as they are close to the Tigris River. The majority of wells were characterized by the high total dissolved salts and this is normal for the rise of ion concentrations in them, which in turn led to a rise in electrical conductivity. Total hardness showed that all wells were having hard water except wells; 7, 10, 17, 18 which were within the standard specifications quality set by the World Health Organization, but for positive and negative ions, they were high in most wells except wells 7, 17, 18 were within the quality for all ions and no height of nitrate ion was recorded in all the wells. While well 3 was characterized by high potassium and sulfates only and well 8 showed a rise in sulfates while the well 10 recorded increased concentration of sodium and sulfates. The vast majority of the NaCl and Na_2SO_4 well water type had seven wells per hydrochemical formula, three $MgSO_4$ wells and one $CaCl_2$ well.

Key words: *Hydrochemical formula, Turbidity, Total hardness, Total dissolved salts, Quaternary era.*

Introduction

Fresh water is a valuable resource necessary for sustaining life and health and ensuring the preservation of ecosystems, and the pattern of human settlement is often determined throughout history by its availability, where good quality drinking water can be consumed in any desirable amount without adverse health effects (Al-Dulami and Younes, 2017). Civilization has succeeded in polluting our water supply to the point where we have to purify water for drinking, the United Nations estimates that 2.7 billion people will face water shortages by 2025, although the earth is largely made up of water, fresh water accounts for only about 3% of the total water available to us, that means we can easily reach only 0.006%. This is reflected in the fact that more than 80 countries are now suffering from water shortages, it is clear that water is a rare and valuable commodity and we need to maintain its quality and use wisely to ensure its permanence (Ahuja, 2013). Groundwater, as a result of the severe shortage of water sources, has been one of the most important sources of water supply in recent years, and the focus is on its quality considerations as a result of the consumerism of human life, increased urbanization and industrialization without adequate measures to dispose of waste, agricultural activities, etc., the groundwater environment is contaminated by an increasing number of pollutants and over time the massive groundwater reservoir that was relatively clean a few decades ago is gradually deteriorating (Akram *et al*., 2011). Although Iraq has two rivers stretching from north to south, in recent years, due to the spread of the agricultural area and the scarcity of rainwater, as well as the control of the Tigris and Euphrates rivers by neighbouring countries, many farmers have adopted groundwater as a source of drinking and irrigating crops (Ragheb, 2013). The research aims to assess the physical and chemical properties of well water taken in the study area as well as to assess the hydrochemical properties (water quality) of the wells selected in the study area by determining the levels of ions of the main elements dissolved in their water, for the purpose of knowing the extent of their powers for different uses of humans in terms of drinking, grazing, irrigation,.

Area site Study

The area studied is located within the Mesopotamian Plain consisting of three areas located southeast of Baghdad about 17 kilometers from Jisr Diyala, which is the areas of Jisr Diyala, Al-Mada'in and Al-Saouira, and lies between the 15-length lines. 33°.15/ 32.15° North and latitudes 44°.55/ 44°.20 East.

Description of the study area

The study area includes the area south of Baghdad, which extends from the Al-Saouira area and Al-Mada'in to Jisr Diyala in its entirety agricultural land and residential houses and depends mainly on groundwater for drinking, irrigation and various uses, eighteen wells have been identified within this area for study sampling, and Table 1 represents the locations of selected wells, depth and use in the study area.

Field work and laboratory analysis

A survey of the study area was conducted in July 2020 for the purpose of identifying the selected wells, which included three areas: Jisr Diyala, Al-Mada'in and Al-Saouira, which are agricultural areas, some of which are residential areas, 18 wells were selected from many wells engraved in these areas on the basis that the wells are water-producing, where these wells were sampled during August 2020, which is the hot, not raining summer period. The following tests have been carried out.

Field tests

Physical characteristics at sample collection sites were measured directly, including temperature measurement, pH, EC, TDS. Using field devices, color, smell and taste have been relied upon.

Chemical tests

For studies of the chemical properties of well water, which included the ions of the main and secondary elements Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, Cl^{-},HCO_3^{-},CO_3^{-2} SO_4^{-2},NO_3^{-}. Water samples were collected from the wells selected for the study and numbered after the well water pump was operated from 10-15 minutes by an electric pump to dispose of contaminated and stagnant water and placed samples directly in plastic bottles of 250 ml after being washed several times with well water before being filled to the edge of the bottle and then closed tightly to preserve the physical and chemical properties of sample water and sent to the laboratory of the Geology Department/ General Commission for Groundwater/ Ministry of Water Resources for the necessary examinations.

Table 1. Well locations and quality in the study area.

Well No.	Location of well	Depth/m	Using
1	Wasit/Al-Saouira/ orchard of Al-Haj Shamel Agricultural)	6	Irrigation
2	Wasit/Al-Saouira/ orchard of Abass Al-Mageed)	9	Irrigation
3	Wasit/Al-Saouira/ orchard of Haydar Al-Obiedy)	16	Irrigation
4	Wasit/Al-Saouira/ orchard of Ali Hassain	18	Irrigation
5	Wasit/Al-Saouira/ orchard of (Salman Frees house)	7	Irrigation and household uses
6	Wasit/Al-Saouira/ orchard of HussainTurky/Al-Adala village	7	Irrigation and daily use
7	Wasit/Al-Saouira/ orchard of Yahia Abed/Al-Baghdadia	13	Irrigation and daily use
8	Wasit/Al-Saouira/ orchard of Obeed Al-Hassan/Al-Rahmania	6	Irrigation and daily use
9	Wasit/Al-Saouira/ Al-Jooz village	25	Irrigation and daily use
10	Wasit/Al-Saouira/ Al-Resala village	15	Drinking animals and daily use
11	Baghdad/ JisrDiyala / ArhaifKarem House	12	Residential/ornamental fish breeding ponds
12	Baghdad/ JisrDiyala / Al-Oraifia region	9	Residential / Use of RO Water
13	Baghdad/ JisrDiyala / Al-Oraifia region	16	Residential / Use of RO Water
14	Baghdad/ Al-Kargolia (orchard)	9	Irrigation and daily uses
15	Baghdad/ Al-Kargolia/ orchard of Mahmoud Al-Suaidi	6	Residential/ home uses
16	Wasit/Al-Saouira/ Al-Hussainia region/ Al-Aza	9	Irrigation/ animal drinking/ daily uses
17	Wasit/Al-Saouira/ Al-Bu Ammer region/ Assy	6	Irrigation/ daily use and animal drinking
18	Wasit/Al-Saouira/ Khlibias castle region	6	Irrigation and drinking animals

Results and Discussion

Physical properties of well water

Color, smell and taste

Drinking water must be aesthetically acceptable and free of color, smell, any unacceptable taste, and water that meets these conditions is the right water for our health (Saleem and Al-Gamal, 2016). Taste and smell are based on stimulating future human cells in tasting buds for tasting and nose cavity (Ojo *et al.*, 2012). Taste and smell problems come from water contact with natural materials such as rocks, plants and soils as well as human activities (Spielman and Whittenk, 2012). We note from Table 2 that most of the wells studied are colorless except for wells 7 and

Table 2. Characteristics of color, taste and smell of well water in the study area

Well No.	Color	Smell	Taste
w1	Colorless	Strong, bad smell	salty
w2	Colorless	The smell of rotten eggs	salty
W3	Colorless	The smell of rotten eggs	salty
W4	Colorless	Lack of strong smell	salty
W5	Colorless	odorless	salty
W6	Colorless	odorless	salty
W7	Present	odorless	Tasteless
W8	Colorless	odorless	Tasteless
W9	Present	odorless	salty
W10	Colorless	Present	Tasteless
W11	Colorless	Present strong, bad smell.	salty
W12	Colorless	odorless	salty
W13	Colorless	odorless	salty
W14	Colorless	odorless	salty
W15	Colorless	odorless	salty
W16	Colorless	odorless	salty
W17	Colorless	odorless	Tasteless

9, this may be due to the fact that the soil surrounding these wells is wet agricultural soil because of its proximity to the Tigris River and thus part of this soil is filtered into this water and this is consistent with the findings of the researcher (Ali Mohammed, 2015). Most of the odorless wells except wells (1, 2, 3, 4, 11) have a permeable smell, as well as a smell similar to that of rotten eggs due to the use of pesticides and animal waste, as well as sewage leakage from the Al-Rustamiyah project to Jisr Diyala, which is close to well 11. As for the taste, most wells have a salty taste due to the rise of ions due to geological composition and to filtered water with its ions through the permeable layers of the earth and dessolved salts during their running out (Shukri *et al*., 2011) except for some wells that are tasteless such as wells (7, 8, 10, 17, 18) which are close to the Tigris River.

Temperature is not one of the factors used to conduct evaluation when conducting water tests to determine its suitability for consumption, but it affects many other factors of water quality, such as the dissolving of oxygen in water, the rate of bacterial activity, the rate of transmission of gases to and from water, as well as the rate at which chemicals dissolve and their reaction rate. Although groundwater appears relatively cold in summer and warm winter, its temperature remains almost constant throughout the year (Spielman and Whittenk, 2012), and in the study area the lowest water temperature was 22 °C in the wells (7, 14, 17) and the highest value was 25 °C. The highest value is 25 °C, which is found in the majority of wells as in Table 3, which is generally characterized by groundwater because the degree of temperature variation is narrow compared to the river temperature, which depends primarily on the depth of the groundwater carrier layer, geographical location, rock quality of the water reservoir, in addition to the type of underground reservoir and the source of the continuity of this water (Abdul Jalil and Al-Khafaji, 2016).

pH

Logarithmic is a measure of the concentration of hydrogen ions in aquatic circles to determine their acidity or base, with a neutral value of seven, if the pH of the water medium is less than seven seen as acidic and when more than seven is considered base or alkaline (Liden and Saglamoglu, 2012). The lowest value of the hydrogen number was 6.9 in wells (1, 2, 14) and the highest value was 7.9 per well 11 as in Table 3. This indicates that the quality of the water of the study area is approximately equivalent to a light base and the results are similar to Al-Obaidi and Salman (2011) and this may be due to the relative stability of temperatures or to the water contained in carbonate and bicarbonate.

Table 3. Shows the physical properties of the water of the study area wells

Well No.	pH	Temp. °C	EC Ms/cm	Tur.(NTU)	TH(ppm)	TDS (ppm)
W1	6.9	25	6940	1.49	1836	4492
W2	6.9	25	5130	1.94	994	3300
W3	7	25	2010	2.75	741	1360
W4	7.1	24	3610	1.74	1038	2340
W5	7.1	25	6270	9.83	1934	4064
W6	7.4	25	8180	1.48	2166	5277
W7	7.2	22	1384	99.6	404	894
W8	7.4	24	1737	1.86	569	1123
W9	7.3	23	6610	7.06	2058	4255
W10	7.7	25	1551	34.3	188	1005
W11	7.9	25	4370	1.57	1226	2884
W12	7.1	24	3000	1.48	1002	1982
W13	7.1	25	5350	44.9	1353	3485
W14	6.9	22	7920	134	2116	5082
W15	7.8	25	9320	1.46	2457	5993
W16	7.1	23	3000	1.84	996	1983
W17	7.6	22	1355	2.42	413	873
W18	7.6	25	1226	1.44	367	794
Average	7.3	24	4387	19.5	1214	2844

Turbidity

It is an expression of some of the properties of light dispersion and light absorption of the water sample, which result from the presence of impurities of clay, silt, suspended substances, colloidal particles, plankton and other microorganisms, affects other water quality standards such as color and negatively affects the microbiological quality of water because it enhances the spread of microbes in addition to its impact on the chemical quality of drinking water through the formation of complexities between the causes of the turbidity and heavy metals (Ojo *et al.*, 2012). Observed in the study area the lowest value of the turbidity was recorded at 1.44 at the well 18 but the highest value recorded is 134 at well 14 as in Table 3. We note that most of the wells had values of less than five, this mean located within the acceptable specifications for the use of water for drinking, except for six wells whose values were high: (5, 7, 9, 10, 13, 14) due to the proximity of these wells to the Tigris River and the filtering of part of this water with dust to the ground and this is consistent with what it reached (Dalas, 2017).

Total Hardness

Hardness is caused by a variety of dissolved polyvalent mineral ions, especially calcium and magnesium ions, which are usually expressed in mg of calcium carbonate per liter (WHO, 2017). In the study area, the lowest total hardness value was 188 mg/ l in well 10 and the highest value was 2,457 mg/l at the well 15. As in Table 3, this means that most of the values of the study area are very hardness due to the high concentrations of magnesium and calcium ions (Ali Mohammed, 2015), which are not suitable as a source of drinking except wells (7, 10,17, 18) which were among the standard specifications quality for their proximity to the Tigris River.

Electrical conductivity (EC)

It is a measure of the ability to connect an electrical current in a water solution (Liden and Saglamoglu, 2012), found in natural waters with light concentrations of mineral salts and as a result they all participate in electrical conductivity and produce high conveyor either naturally from the nature of rocks and waterways or by human action caused by wastewater released within the waterway (Al-Hayek, 2017). The electric conveyor is measured by microsiemens units (μS) as the presence of dissolved salt at a concentration of one gram per liter equals 2 microsiemens (Hassan, 2000), it was found in the study area that the lowest value of electrical conductivity recorded was 1226 in well 18 and the highest value was 9320 in the well 15 Tables 3. We note that the electrical conductivity is high in the wells of the study area, which depends mainly on the concentration and quality of the salts in it, as it is known that electrical conductivity has an positive relationship with total dissolved salts and this corresponds to what it reached Ragheb (2013).

Total dissolved salts (TDS)

Total dissolved solids consist of organic matter and inorganic salts that may arise from sources such as wastewater, liquid waste discharge, urban runoff or natural bicarbonate, chlorides, sulfates, nitrates, sodium, potassium, calcium and magnesium (Ojo *et al*., 2012). In the study area, 794 mg/l was recorded as the lowest value at well 18, but the highest value was at well 15, which is 5993 mg/l Table 3. We note that the concentrations of dissolved salts in the wells of the study area are high according to the who scale and unacceptable and have an positive relationship with the electrical conductivity.

Chemical properties

Mean positive ions

Calcium Ca^{+2}

The average calcium abundance in the earth's crust is 4.9% and in groundwater from 1 to less than 500 mg/L, the most common form of calcium are calcium carbonate (calcite), magnesium (dolomite). Calcium is essential in the nutrition of plants and animals and is an essential component of bones and plant structures and produces its presence in the water supply from passage over limestone deposits, dolomites and gypsum (APHA, 2017) the lowest value in the study area was 39 mg/l at the well 10, and the highest value was 551 mg/l at well 15 (Table 4). Most calcium ion concentrations in wells are unacceptable, according to the World Health Organization (WHO), and this rise was due to geological composition as well as the incorrect use of fertilizers and chemical pesticides, which is consistent with its findings (Abdullah and Majid, 2015).

Magnesium Mg^{+2}

The concentration of magnesium in natural water is lower than calcium due to slow dolomite decay with a greater abundance of calcium in the Earth's crust (Davis and De Wiest, 1966), magnesium is present in the earth's crust by 2.1% and in groundwater less than 5 mg/l (APHA, 2017). with the lowest value in the study area of 22 mg/l at the well 10, while the highest value was 264 mg/l at well 6 as in Table 4. We note the high concentration of magnesium ion in most of the study wells due to the abundance of this ion from natural rock sources containing minerals with a content of this ion or by feeding the waters of the Tigris and Diyala rivers to wells near the river enriched the water with this ion.

Sodium Na^+

The abundance of sodium 2.5% in the earth's crust and in groundwater 75 ml/l (APHA, 2017) is one of the beneficial and necessary elements of plants and animals, it is particularly important for maintaining the osmotic pressure in cells and although it is an essential element it is toxic in concentrations or large amounts in humans and animals where chronic excessive intake leads to high blood pressure, drinking water containing high sodium concentrations of more than 200 ml/l has an unacceptable salty taste (Al-Jumaily and Ahmed, 2018). We note that the values of sodium ion concentrations vary in the wells of the study area and more than the global measurement in most wells and this is the result of the filtering of water from the surface to groundwater loaded with the remnants of various human and agricultural activities and this is consistent with what it reached Shehab *et al.* (2013).

Potassium K^+

Potassium is available in the earth's crust at 1.84% and in groundwater at 0.5-10 mg/l (APHA, 2017). WHO has also set a maximum concentration of 10 mg/l in potable water (WHO, 2018). The lowest value in the study area was 2 mg/l at the well 18, and the highest value was 130 mg/l at well 9, We also note the disparity in potassium ion concentrations in the study area water samples and their values are more than the global values in most wells due to the incorrect use and effect of chemical fertilizers, as well as the degradation of organic matter in agricultural areas that use organic waste as fertilizers for agriculture.

Mean negative ions

Chloride Cl^-

It is one of the main inorganic anions in water and sewage, the salty taste resulting from chloride concentrations is variable and depends on the chemical composition of water, some water containing 250 mg/L may have a salty taste that can be detected if the positive ion is sodium on the other hand the typical salt taste may be absent in water containing up to 1000 mg/L when the prevailing positive ions are calcium and magnesium. The concentration of chloride is higher in wastewater than in raw water because sodium chloride is a common substance in the diet and passes unchanged through the digestive system and increases through industrial processes and may harm the high content of chloride in pipes and infrastructure (APHA, 2017). The lowest value in the study area was 158 mg/l at the well 10, while the highest value was 1200 mg/l at well 15 (Table 5). Ion chloride concentrations are high in most of the wells studied in varying proportions and this is due to its different sources of groundwater, which include clay minerals, evaporations and high temperatures that lead to the dissolving of chloride and the outputs of human events filtering into groundwater and this is consistent with its findings (Abdullah and Majid, 2015).

Bicarbonate and Carbonate HCO_3^-, CO_3^{-2}: Carbonate and bicarbonate are the primary sources of alkaline in groundwater and are an important indicator of their suitability for drinking and irrigation (Al-Salman *et al.*, 2012). The source of bicarbonate salts is produced by the effect of underground water on limestone or limestone rocks (Al-Sarawi, 2012). In the study area, the lowest value at well 17 was 47 mg/l, while the highest value of 845 mg/l was at the well 15 (Tables 5). We note that its concentrations are different in well water and depend on the primary source of bicarbonate ion in groundwater, namely the melting of limestone rocks in water containing dissolved carbon dioxide and the presence of hydrogen ion caused by carbonic acid decay and this is consistent with what it went to (Al-Fiqi and Sawid, 2016). The increased concentration of bicarbonate from the limits allowed in groundwater may also be caused by the leakage of some organic pollutants, which are the main source of alkaline in water as a result of the disintegration of organic compounds due to microbiology activity to produce carbon dioxide, which in turn leads to the formation of bicarbonate, which is consistent with its findings (Dalas, 2017).

Sulfates SO_4^{-2}: One of the most important natural

Table 5. Shows the ions of the main negative elements measured by ppm and epm concentrations

Anions	Wells no.	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18
Cl^-	ppm	809	629	270	552	756	1140	280	206	788	158	646	599	674	1080	1200	598	276	234
	epm	22.7	17.7	7.6	15.5	21.2	32.2	7.8	5.8	22.1	4.4	18.1	16.8	18.9	30.4	33.8	16.8	7.7	6.5
	Epm%	33.9	35.9	36.1	44.1	34.6	40.0	56.5	33.9	34.8	31.6	41.5	52.8	36.0	40.2	37.2	52.9	56.2	54.1
HCO_3^-	ppm	634	415	85	464	488	634	48	66	520	197	518	213	515	573	845	213	47	61
	epm	10.2	6.6	1.3	7.4	7.8	10.2	0.7	1.0	8.3	3.1	8.3	3.4	8.3	9.2	13.6	3.4	0.7	0.9
	Epm%	15.2	13.3	6.1	21.0	12.7	12.7	5.0	5.8	13.0	22.3	19.0	10.6	15.8	12.1	14.9	10.7	5.1	7.5
SO_4^{-2}	ppm	1632	1203	581	586	1550	1815	257	499	1584	309	830	557	1214	1730	2079	556	255	225
	epm	34	25.0	12.1	12.2	32.2	37.8	5.3	10.3	33	6.4	17.2	11.6	25.2	36.0	43.3	11.5	5.3	4.6
	epm%	50.8	50.7	57.6	34.7	52.6	47.1	38.4	60.2	52.0	46.0	39.4	36.4	48.0	47.6	47.7	36.2	38.6	38.3
NO_3^-	ppm	1.4	1.2	0.7	1.1	1.2	1.1	0.4	1.1	1.1	1.2	1.3	1.2	2	2.1	1.1	1.2	0.6	1.3
	epm	0.02	0.01	0.01	0.01	0.01	0.01	0.006	0.01	0.01	0.01	0.02	0.01	0.03	0.03	0.01	0.01	0.009	0.02
	Epm%	0.02	0.02	0.04	0.02	0.01	0.01	0.04	0.05	0.01	0.07	0.04	0.03	0.05	0.03	0.01	0.03	0.06	0.1
	Anions	66.9	49.3	21.0	35.1	61.2	80.1	13.8	17.1	63.4	13.9	43.6	31.8	52.4	75.6	90.7	31.7	13.7	12.0

sources of sulfate is the process of gypsum decay ($CaSO_4$). H_2O) and sulfur oxidation to air sulfate in the medium of the water in addition to that most industries use sulfate acids and salts and then subtract them through wastewater, WHO has determined the percentage of sulfates in drinking water by 200-400 mg/l, although the high percentage of it does not pose a risk to human life, although it leads to diarrheal disorders, especially in children, and plants are less sensitive to sulfates than chloride (Al-Hayek, 2017). The lowest value of sulfate in the study area was 225 mg/l in the well 18 but the highest value was at well 15 which is 2079 mg/l (Table 5) we note that the values of sulfates are high relative to what has been determined It is by the WHO for drinking because its sources in the water of the study area are due to the presence of sulfate salts dissolved from its various natural sources, in addition to the effect of the use of chemical fertilizers and this is consistent with the findings of Al-Obaidi and Al-Salman (2011); Don (1995).

Nitrates NO_3^-: There has been considerable interest in the problem of high nitrate in groundwater since the 1980s after medical research proved nitrate damage to health in general and infants in particular, in addition to the increased concentration of nitrates in surface and groundwater, which resulted from the significant expansion of the use of chemical fertilizers as a high percentage of nitrates in surface water is caused by the use of nitrogen fertilizers in agriculture, which may reach 60%. The plant consumes part of this amount while the other part is transmitted to surface water through torrents and into groundwater through the earth's influential layers (Al-Hayek, 2017). In the study area, the lowest value was 0.4 mg/l at well 7, while the highest value of 2 mg/l at the well was 13, in Table 5 we note that its concentrations are very low and within acceptable limits for drinking purposes, nitrates are present in well water from the use of industrial and natural fertilizers such as animal waste in addition to the filtering of sewage and this is consistent with what it reached (Alia *et al.*, 2018).

Hydrochemical formula

This formula is based on the main ion ratios in descending order for each of the anions at the top of the equation, while the canteens are at the base based on the percentage of epm% per ion, taking into account the values of pH and TDS (Al-Qazwini *et al.*, 2009).

Table 6. Shows the hydrochemical formulas of water samples in the study area

Well No.	Hydrochemical formula	Water type
W1	$4492\frac{SO4(50.8)Cl(33.9)HCO3(15.2)NO3(0.02)}{Na(39.5)Ca(28.1)Mg(26.6)K(5.6)}7.25$	Na-Ca-Mg-K-NO_3-HCO_3-Cl-SO_4-(Na_2SO_4)
W2	$3300\frac{So4(50.7)Cl(35.9)Hco3(13.3)No3(0.02)}{Na(59.6)Mg(20.4)Ca(19.4)K(0.6)}7.18$	Na-Mg-Ca-K-NO_3-HCO_3-Cl-SO_4 (Na_2So_4)
W3	$1360\frac{So4(57.6)Cl(36.1)Hco3(6.1)No3(0.04)}{Mg(37.3)Ca(31.7)Na(29.4)K(1.4)}7.30$	Mg-Ca-Na-K-NO_3-HCO_3-Cl-SO_4 ($MgSO_4$)
W4	$2340\frac{Cl(44.1)So4(34.7)Hco3(21.0)No3(0.02)}{Na(41.1)Ca(30.9)Mg(27.6)K(0.2)}7.12$	Na-Ca-Mg-K-NO_3-HCO_3-SO_4-Cl (NaCl)
W5	$4064\frac{So4(52.6)Cl(34.6)Hco3(12.7)No3(0.01)}{Mg(31.6)Ca(31.2)Na(31.0)K(5.1)}7.20$	Mg-Ca-Na-K-NO_3-HCO_3-Cl-SO_4 ($MgSO_4$)
W6	$5277\frac{So4(47.1)Cl(40.0)Hco3(12.7)No3(0.01)}{Na(44.3)Mg(26.8)Ca(26.6)K(2.0)}7.14$	Na-Mg-Ca-K-NO_3-HCO_3-Cl-SO_4 (Na_2SO_4)
W7	$894\frac{Cl(56.5)So4(38.4)Hco3(5.0)No3(0.04)}{Na(41.0)Mg(30.2)Ca(28.0)K(0.7)}7.28$	Na-Mg-Ca-K-NO_3-HCO_3-SO_4-Cl (NaCl)
W8	$1123\frac{Cl(33.9)So4(6)Hco3(5.8)No3(0.05)}{Ca(35.8)Na(33.5)Mg(30.0)K(0.5)}7.15$	Ca-Na-Mg-K-NO_3-HCO_3-SO_4-Cl ($CaCl_2$)
W9	$4255\frac{So4(52.0)Cl(34.8)Hco3(13.0)No3(0.01)}{Mg(34.2)Ca(31.0)Na(31.0)K(5.1)}7.19$	Mg-Ca-Na-K-NO_3-HCO_3-Cl-SO_4 ($MgSO_4$)
W10	$1005\frac{So4(46.0)Cl(31.6)Hco3(22.3)No3(0.07)}{Na(73.7)Ca(13.1)Mg(12.4)K(0.6)}7.22$	Na-Ca-Mg-K-NO_3-HCO_3-Cl-SO_4 (Na_2SO_4)
W11	$2884\frac{Cl(41.5)So4(39.4)Hco3(19.0)No3(0.04)}{Na(43.4)Ca(32.9)Mg(22.7)K(0.9)}7.23$	Na-Ca-Mg-K-NO_3-HCO_3-SO_4-Cl (NaCl)
W12	$1982\frac{Cl(52.8)So4(36.4)Hco3(10.6)No3(0.03)}{Na(36.2)Mg(32.5)Ca(30.3)K(0.9)}7.13$	Na-Mg-Ca-K-NO_3-HCO_3-SO_4-Cl (NaCl)
W13	$3485\frac{So4(48.0)Cl(36.0)Hco3(15.8)No3(0.05)}{Na(44.4)Ca(27.9)Mg(23.3)K(4.1)}7.24$	Na-Ca-Mg-K-NO_3-HCO_3-Cl-SO_4 (Na_2SO_4)
W14	$5082\frac{So4(47.6)Cl(40.2)Hco3(12.1)No3(0.03)}{Na(43.6)Ca(29.2)Mg(26.1)K(1.0)}7.20$	Na-Ca-Mg-K-NO_3-HCO_3-Cl-SO_4 (Na_2SO_4)
W15	$5993\frac{So4(47.7)Cl(37.2)Hco3(14.9)No3(0.01)}{Na(44.2)Ca(30.0)Mg(23.7)K(1.9)}7.18$	Na-Ca-Mg-K-NO_3-HCO_3-Cl-SO_4 (Na_2SO_4)
W16	$1983\frac{Cl(52.9)So4(36.2)Hco3(10.7)No3(0.03)}{Na(36.5)Mg(32.4)Ca(30.2)K(0.6)}7.12$	Na-Mg-Ca-K-NO_3-HCO_3-SO_4-Cl (NaCl)
W17	$873\frac{Cl(56.2)So4(38.6)Hco3(5.1)No3(0.06)}{Na(41.2)Mg(29.8)Ca(28.4)K(0.4)}7.24$	Na-Mg-Ca-K-No_3-Hco_3-So_4-Cl (NaCl)
W18	$794\frac{Cl(54.1)So4(38.3)Hco3(7.5)No3(0.1)}{Na(41.1)Mg(31.4)Ca(27.4)K(0.4)}7.17$	Na-Mg-Ca-K-NO_3-HCO_3-SO_4-Cl (NaCl)

$$TDS\left(\frac{mg}{l}\right)=\frac{Anions\ epm\%\ in\ decreasing\ order}{Cations\ epm\%\ in\ decreasing\ order}PH$$

We note from Table 6 that the water quality in the wells of the study area was mostly Na_2SO_4 and NaCl with a few of them $MgSO_4$ and $CaCl_2$ due to the fact that dissolved salt ions of sodium, sulfate and chloride are present in high concentrations in well water, which led to the quality of water in the wells as described in the Tables 4, 5.

Assessing the suitability of groundwater for various uses

Drinking a human

For the purpose of evaluating water in the study area, the results of the tests for well samples were compared with the Iraqi determinants of 2009 and who (WHO,2018) in addition to some other global determinants (Al-Sarawi, 2012) as described in schedule (7) and it was found that there was a clear disparity between different wells in total salt and ions and that most wells are not suitable for human drinking except w7,w8,w18 wells were within the standard specifications.

Table 7. Standard Limits for Iraqi and International Drinking Water

Parameters (mg/l)	Iraqi Specifications 2009 (IQS)	WHO (2018)	European Specifications	Canadian Specifications	USA Specifications
Temperature		25			
PH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Turbidity	5	5 NTU	4	5	1-5
EC					
TDS	1000	1000		500	500
TH	500	500			
Na^+	200	200	150-175		
Mg^{+2}	100	100			
Ca^{+2}	150	150			
K^+		10			
Cl^-	350	250	25	250	250
HCO_3^-					
SO_4^{-2}	400	250	25	500	250
NO_3^-	50	50	50		

Conclusion

Most welled water are not fit to drink in the study area. they exceed the ion concentrations as compered WHO standard specifications, except for 7, 17, 18 wells that were in the standard specifications. The validity of wells 3, 7, 10, 17, 18 for irrigation while the rest of the wells need to be treated to varying degrees before being used for irrigation. The improper use by farmers of chemical and organic fertilizers has led to a rise in ions concentrations in the study area.Most of the well water was Na_2SO_4 and $NaCl_2$, due to the high concentrations of sodium ions, chloride and sulphate.

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