Assessment of Physical and Chemical Properties of Domestic Well Water and Its suitability for Drinking in AL-Dora and AL-Yosifia Area

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Abstract

The research aimed to assess the suitability of domestic well water for drinking, this topic has been chosen for the study due to environmental degradation and climate change with a decline in rainfall therefor, resort to well water as an alternative solution and to assess the suitability for drinking various test has been conducted to measure the properties of the water physically and chemically according to the standard methods of water .Twenty six samples were collected from Al-dora and Al-youssifia regions, the results of the research showed most of domestic well water were not suitable for drinking because of highness of values that doesn't subjected to Iraqi Stander Limits among the most prominent minimum concentration, the total dissolved salts in the water of the wells of AL- Dora area was (590 ppm) in W4 and the maximum was (2520 ppm) in W11, while in AL- Yosifia area the minimum was (1110 ppm) in W8 and the maximum was (3040 ppm) in W13 from this study conclude the water is not suitable for drinking.
Keywords: Domestic Wells, Groundwater, Iraqi Standard Limits**.**

تقييم الخصائص الفيزيائية والكيميائية لمياه الآبار المنزلية ومدى ملائمتها للشرب في منطقة الدورة واليوسفية

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الخلاصة

هدف البحث إلى تقييم مدى صلاحية مياه الآبار المنزلية للشرب، اختير هذا الموضوع للدراسة بسبب التدهور البيئي وتغير المناخ مع انخفاض هطول الأمطار وانحسار مصادر المياه وارتفاع درجات الحرارة التي تساعد على الجفاف وشح المياه لذلك اللجوء إلى مياه الآبار كحل بديل ,ولتقدير صلاحيتها للشرب اجريت اختبارات مختلفة لخصائصها (مياه الابار) الفيزيائية والكيميائية وحسب الطرق القياسية للمياه. جمعت ستة وعشرون عينة من منطقتي الدورة واليوسفية أظهرت نتائج البحث أن معظم مياه الآبار المنزلية غير صالحة للشرب لارتفاع قيم الخصائص الفيزيائية والكيميائية التي لا تتوافق مع الحدود القياسية العراقية ومن أبرزها, بلغ الحد الأدنى لتركيز الأملاح الذائبة الكلية في مياه آبار منطقة الدورة (590 جزء في المليون) في البئر4 وأعلى مستوى (2520 جزء في المليون) في البئر11، أما في منطقة اليوسفية فقد بلغ الحد الأدنى (1110 جزء في المليون) في البئر 8 وكان الحد الأقصى (3040 جزء في المليون) في البئر13 وبذلك نستنتج ان المياه غير صالحة للشرب .
الكلمات المفتاحية: الابار المنزلية, المياه الجوفية, المحددات القياسية العراقية.

Introduction

Water considered one of the renewed natural sources on this planet and one of the essential elements on the earth surface .Due to the importance of water in life and the increasing consumption of it and the decrease in its dependencies led to significant changes in the situation of Iraq, the shortage in surface water levels and rainfall during the past years led to a decrease in the water level in the Tigris and Euphrates rivers, which are the main water source in the country (Youni and Darwesh ,2023).

There are some facts about the water system in Iraq that can be reviewed before delving into the details of groundwater, including that the general average annual rainfall depth < 100-1000 mm, and that the dates of the rainy season are in specific months between October and April, and that the average total annual evaporation depth from water surfaces is 1300 mm north, 2000 mm in the middle, 2400 mm in southern Iraq (monthly during the months of July and Augustmay reach 300 mm) (AL-Amery,2005) and (Cushman and Tartakovsky,2016). A new report was issued by the International Committee of the Red Cross and the Norwegian Red Cross on climate change in three Arab countries, including Iraq, in which it was stated that Iraq will witness environmental degradation and a significant change in climate with a decline in water sources and rainfall, and stated that the northern region of it will become drier than before. With regard to the annual average temperatures, he mentioned that they will be 2 to 3 higher in high areas and 2 to 4 in low-lying areas (Lakitsch, 2024).

The sources of national water resources amount to 40% of the total of them, including 8% of groundwater sources (Cushman and Tartakovsky, 2016) and (Aguide for private domestic well owners, 2019).

Groundwater is fresh water formed as a result of melting ice, snow or rain and is stored between soil particles and rock pores and then rises to the surface and is pumped into wells. The quality of water retention between soil particles and rock pores depends on the size and arrangement of those particles (Sousa *et al*., 2015) and (Roy *et al*., 2020) for example, the uniform size in sand tends to retain more water than rock layers with materials of different sizes, because smaller rock materials settle in the distances between larger rock materials, which reduces the amount of open space that can hold water. presence of pollutants that which produce from mining, paper industry, mercury and radioactive contaminants which produce from radium which produce from crumble of stones of underground stock and radioactive nuclides resulting from the decomposition of uranium, granite, sedimentary rocks and wastewater, which includes sulfate, chlorides, phenols that reduces the biochemical oxygen demand of water (Hussien,2018) and (AL-Saadi,1994),the fragility of soil structure at the top of the aquifer which is highly permeable to allow contaminants to pass through it and biological pollution that resulting from pathogenic bacteria, organic microorganism resulting from human waste (Khalid, K. S,2019) and (Greenberg,1998). A study on 28 domestic wells in Baghdad conducted to find out the quality of their water, where some physical and chemical tests were conducted on them, and the results showed that they are not suitable for drinking when compared with the Iraqi standard limits for drinking water .In another study conducted for the areas extending between the Tigris and Lower Zab rivers and their villages south of Jabal Makhmour, where the results showed that most wells are not suitable for drinking validity due to the high content of salinity and severe hardness that exceeded the limits

of Iraqi specifications, except for one well, while 36 well that was suitable for irrigation and agriculture (Saleh, *et al*.,2016) also stated that all the groundwater samples examined in his study are suitable for irrigation and human use, because the salinity concentration falls within the permissible limits. In another study conducted in the Daquq area, it was found that some groundwater wells are free of pollutants and suitable for domestic use, some are close to permissible limits, and others exceed Iraqi standard limits (Hamed, 2014). The study of (Faleh,*et al*., 2013) conducted by to evaluate the validity of the water of some artesian wells south of Baghdad For domestic use and irrigation; the study showed that the water of these wells is unfit for human consumption and irrigation because of its exceedance Limit allowed by the World Health Organization and the American Salinity Laboratory (Faleh, 2013). Another study showed the concentrations of the water components extending between the city of Mosul and the district of Bashiqa rise to higher limits than permitted for the purposes of drinking this is due to the nature of the geological formations of the region (AL_Mashhadani, *et al.*, 1989). The research aimed to assess the suitability of domestic well water for drinking, this topic has been chosen for the study due to environmental degradation and climate change with a decline in rainfall, receding water sources and high temperatures that help in drought and scarcity of water.

Material and Methods

Twenty six samples of domestic well water were collected using polyethylene containers with a capacity of (1 liter) to collect samples for chemical analysis after rinsing and homogenizing them several times after determining the geographical location of the studied wells that included 12 well in Al- Dora area and 14well in Al-Yousifia area, and the depth of the water that ranged (16 to 65 meter). Then, pH by pH meter model of it was Crison as showed in fig.1, Electrical conductivity by conductivity meter a martini model as showed in Fig, 2 and temperature by a thermometer were measured for sample.

The tests as showed in tables (1-3) included positive ions and negative ions, as well as hardness and total dissolved salts. Total hardness was measured in the manner described in the reference (APHA, 1999) and (Youni and Darwesh,2023)**.** Calibration was done with a solution EDTA -2Na after adding 1-2 ml of buffer solution and using a reagent called Eriochrome Blackt, and following the same method described in the reference (Shil ,*et al*, 2019)**.**

the magnesium ion concentration was calculated by calibration with a solution EDTA-2Na and adding a solution NaOH using dye named Murexide as a guide and by using a digital photometric spectrometer sodium was measured, chloride,Fe,Pb,Cd ions were measured as method shown in (Shil .S, *et al*,2019) and (Youni and Darwesh,2023) .

While sulfate and nitrates were measured using an optical spectrometer at successive wavelengths of (420, 543 and 885). These tests were conducted in the laboratories of the Ministry of Science and Technology.

Results

The physical and chemical tests that showed in tables (1, 2) for well water were carried out according to standard methods of water testing to assess the suitability of using well water for drinking, and the results were evaluated according to the permissible limits according to the Iraqi standard specifications (Iraqi Standard limits of Drinking Water, 2022) as shown in Table (3). This topic was chosen due to the

scarcity of water therefor we resorted to well water as alternative solutions:

1.Temperature; The temperatures of the water of the research wells ranged between (20 - 25), the lowest temperature was 20 for the wells (W1,W3,W7,W11) and the highest temperature was 25 for the wells (W5,W14,W8,W9,W12). The temperature variation of well water depends on the source of water, the depth of the well as showed in fig 3 and the type of rock in which the water is stored.

2.pH; The results showed that the acidity function of all the water of the wells of the research is within the permissible limits of the Iraqi Standard specifications the water of the study wells in AL- Dora area recorded the lowest value (7.0)in (W10,W11) and the highest value of (7.8) in W1 and the rest is neutral, the cause of its neutrality was a result of presence of bicarbonate that works to stop the change in pH, while the lowest pH value in AL-Yosifia area was 7.5in W1 and the highest value8.2 in (W2,W5,W9,W11,W12).

3. EC; The lowest value of the electrical conductivity of the study wells was (2680 Ms/ cm) in W2 and the highest value was (5440 Ms/ cm) in W4. While the lowest value was recorded in AL- Yosifia region (278 Ms/ cm) inW1 and the highest value was (5800 Ms/ cm) in W13. The reason for the difference in electrical conductivity values is due to rain factors, as they work to sweep salts from neighboring lands (Cushman and Tarakovsky, 2016) as well as the calcareous nature of the land and the depth of the water-containing layers as Fig.5, and this is what studies have shown.

4.TDS; The presence of the diversity of total dissolved salts in groundwater depends on the source of the water and the type of rock forming the well area (Amanatidou, *et al*,2007). The results showed that all wells are not within the permissible limits of the Iraqi standard specifications except for one well belonging to AL- Dora area, which is the fourth well. The minimum concentration of total dissolved salts in the water of the wells of AL- Dora area was (590 ppm) in W4 and the maximum was (2520 ppm) in W11, while in AL- Yosifia area the minimum was (1110 ppm) in W8and the maximum was (3040 ppm) in W13.

5. SO_4; One of the signs of the presence of sulfates, especially magnesium sulfate and sodium sulfate, is the bitterness of the taste of water (Cushman and Tarakovsky,2016) and (Khalid, K. S,2019). The results showed that five of the wells located in the Dora area and two from AL-Yosifia area are not within the permissible limits of the Iraqi standard specifications. The values of sulfate concentrations in the water of the wells of the Dora area reached a minimum of (6.3 ppm) in W4 while the maximum reached (758 ppm) in the well W11, while in the water of the wells of AL- Yosifia area, the minimum reached (256 ppm) in the well W6 and the maximum of (2000 ppm) in the well W4.

6. NO_3; the presence of nitrates is evidence of the presence of dissolved oxygen that converts nitrites into nitrates (Youni and Darwesh, 2023). The results showed most of well water in the Dora area, the concentration of nitrates in it is within thepermissible limits according to the Iraqi standard specifications, except for the fourth well, it reached (2000 ppm) and eight wells in AL-Yosifia, nitrate concentrations are within the permissible limits, and the rest are not within the permissible limits. The concentrations of nitrates in the water of the wells of the Dora area reached a

minimum of (3.1 ppm) inW9,11 and the maximum of (2000 ppm) in the well W8, while in AL- Yosifia area it reached a minimum of (27.2ppm) in the well W9 and reached a maximum of (59.2 ppm) in the well W6.

7.T.H; The groundwater is more hardness than surface water, and this because of the geological nature of the land through which it passes, as the Iraqi soil is characterized by its calcareous nature, which is the reason for the high total hardness in the water wells, in addition to the high sulfate and dissolved solids(Khalid, K. S,2019). The results of the current study in the water wells of AL-Dora area showed that the rate of total hardness was in the two areas not within the permissible limits according to Iraqi and standard specifications and showed that the minimum (ppm 650) in the well W4 and the maximum (1750 ppm) in the well W5, while in AL- Yosifia area, the lowest value was (1100 ppm) in the well W4 and the highest value of (2006 ppm) in the well W11.

8.Ca; The results of the study showed that the values of calcium in the water of the wells of AL-Dora area ranged from (91 - 570ppm) in the fourth and fifth wells respectively, while the concentration of calcium in the water of the wells of AL-Yosifia area reached a minimum of (241 ppm) in the well W7 and the highest concentration of (703 ppm) in the wellW10 and that there is one well in the Dora area where the concentration of calcium is within the permissible limits, while in the rest of the wells for the AL-Dora and AL-Yosifia area, it was not within the permissible limits according to Iraqi and standard specifications.

9. Mg; The results of the study showed that the values of magnesium in the water of the wells of the Dora area ranged from (60 ppm) in well W2 to (290 ppm) in the well W4, while the concentration of magnesium in the water of the wells of AL-Yosifia area reached a minimum (59 ppm) in the well W1 and the highest concentration of (973 ppm) in the well W13. There are only three wells in the Dora area where magnesium concentration is within the permissible limits and only four wells in AL- Yosifia area Magnesium concentration is not within the permissible limits, while in the rest of the wells for AL-Dora and AL-Yosifia area it was within the permissible limits according to Iraqi and standard specifications.

10. Cl; the reason for the availability of chloride in water is the ease and speed of its dissolution, as it is faster than the rest of the salts to dissolve, and its binding to sodium is a component of sodium chloride, which gives water a salty taste that can be distinguished and possible through the taste, we infer the presence of chloride and sodium. The results of the study showed that The concentration of chloride in the water of all wells in AL- Yosifia area is not within the standard Iraqi determinants, but in the water of the wells of AL- Dora area, the most of them were within the determinants except for two wells, the values of chloride in the water of the wells of AL-Dora area ranged from (259 ppm) in well W7 to (833 ppm) in the well W1, while the concentration of it in the water of the wells of AL- Yosifia area reached a minimum (505 ppm) in the well W6 and the highest concentration of (700 ppm) in the wellW13.

11.Na; The results of the study showed that Most of the water from the wells of AL-Yosifia area has a concentration of sodium that is not within the permissible limits according to the Iraqi Standard Limits, as well as seven wells from AL-Dora area ,the values of sodium in the water of the wells of AL-Dora area ranged from (0.02 ppm) in well W4 to (300 ppm) in the well W5, while

the concentration of it in the water of the wells of AL-Yosifia area reached a minimum (420 ppm) in the well W1 and the highest concentration of (501 ppm) in the wellW11 as shown in the tables (1,2).

12.Fe; The results showed that the value of Fe in the wells where iron was found was in the two areas within the permissible limits according to Iraqi standard limits.

13. Cd, Pb; the results were below detection limits. The results of the Pearson correlation coefficient showed there is a strong and significant direct correlation between electrical conductivity and TDS. It amounted to (0.760) in the wells of AL-Yosifia, as shown in Figure 3, and a moderate direct correlation in the water of the wells of the Dora region, as it amounted to (0.315), as shown in Figure 4. When the dissolved solids values increase, the electrical conductivity values increase. The dissolved solids include calcium, magnesium and sodium.

Table (1): Chemical and Physical Tests of Al-Dora Wells

indicator	PH	EC	TDS	So4	NO3	T.H	Ca	Mg	CL	Na	Fe	Pb	Cd
1	7.8	4900	2438	207	6.3	1646	265	215	833	200	0.02	BDL	BDL
2	7.5	2680	1157	288	3.3	850	240	60	271	149	BDL	BDL	BDL
3	7.0	3800	1638	480	9.0	1200	350	79	280	194	BDL	BDL	BDL
4	7.2	5440	590	6.3	2000	650	91	290	280	0.02	BDL	BDL	BDL
5	7.1	4670	2428	280	3.2	1750	570	80	269	300	BDL	BDL	BDL
6	7.2	2682	1250	161	3.5	1621	269	231	270	290	BDL	BDL	BDL
7	7.5	2909	1550	399	3.3	1571	267	221	259	285	0.01	BDL	BDL
8	7.5	2980	1701	487	5.0	1406	232	201	270	230	BDL	BDL	BDL
9	7.4	3900	1730	589	3.1	1092	210	138	300	243	BDL	BDL	BDL
10	7.0	4505	2330	601	3.5	1571	267	220	290	260	BDL	BDL	BDL
11	7.0	4660	2520	758	3.1	1405	240	196	269	281	BDL	BDL	BDL
12	7.5	4000	1630	470	7.0	1100	340	70	280	190	BDL	BDL	BDL

Table (2): Chemical and Physical Tests of Al-Yosifia Wells

indicator	PH	EC	TDS	SO4	NO3	T.H	Ca	Mg	CL	Na	Fe	Pb	Cd
1	7.5	278	1270	696	51.0	1540	256	59	600	420	BDL	BDL	BDL
2	8.2	3707	1700	820	52.0	1727	300	240	588	429	0.01	BDL	BDL
3	8.1	4650	2501	701	52.1	1550	266	221	601	453	BDL	BDL	BDL
4	8.0	3880	2430	695	48.5	2001	671	96	606	422	BDL	BDL	BDL
5	8.2	4789	2520	325	50.1	1800	620	82	590	433	BDL	BDL	BDL
6	8.0	3440	2220	265	59.2	1999	653	95	505	442	0.02	BDL	BDL
7	8.0	2930	1955	557	36.4	1404	241	169	589	500	BDL	BDL	BDL
8	8.0	2580	1110	885	56.1	1753	560	83	590	497	BDL	BDL	BDL
9	8.2	2770	1210	760	27.2	1699	601	90	602	470	BDL	BDL	BDL
10	8.1	2900	1411	750	43.1	1890	703	93	601	472	0.01	BDL	BDL
11	8.2	3660	1530	691	53.2	2006	700	94	609	501	0.01	BDL	BDL
12	8.2	4376	2285	381	51.2	1754	650	80	605	500	BDL	BDL	BDL
13	8.0	5800	3040	460	50.3	2000	670	973	700	380	BDL	BDL	BDL
14	8.0	4500	1600	270	40.5	1100	340	70	600	430	0.02	BDL	BDL

BDL: Below Detectable Level

Table (3): Iraqi Standard Limits

Tests	Maximum limits	Methods of examinations
pH	6.5-8.5	According to guide 726
TDS	1000	According to guide 1\ 205
SO_4	400	According to guide 671
NO_3	50	According to guide 547
T.H	500	According to guide 769
Ca	150	According to guide 755
Mg	100	According to guide 839
Cl	350	According to guide 761
Na	200	According to guide 839
Fe	0.3	According to guide 728
Pb	0.01	According to guide 703
Cd	0.003	According to guide 703

Discussion

Domestic well water in Iraq is often undrinkable for several environmental reasons and biological and chemical contamination. One of the most prominent reasons is the contamination of groundwater with chemicals from agricultural and industrial activities that seep into the water due to the lack of advanced sewage systems. Many rural areas lack water treatment facilities, making well water vulnerable to bacterial and chemical contamination, including heavy metals and nitrates, which pose a public health risk therefor this study was subjected and chose AL-Dora and AL-Yosifia areas .The country is also suffering from a water scarcity crisis as a result of climate change and the policies of neighboring countries, as the water levels of rivers, such as the Tigris and Euphrates, have decreased significantly, which increases pressure on groundwater resources and leads to their deterioration. Other factors, such as desertification and pollution from surrounding industries, contribute to the deterioration of well water quality, making it undrinkable in many cases. the values of the total dissolved solids of most of the well water were very high and therefore this water is considered contact with rocks and soil for long periods as it descends into aquifers, allowing it to dissolve a range of chemical compounds in its path. Over time, the TDS increases due to mineral buildup. Sometimes, groundwater may be contaminated by agricultural activities unsuitable for human drinking as it was noted that the water of these wells is very high hardness and it was found that the ions of magnesium, sodium and calcium are high values in most wells, While sulphates recorded high values in some wells in AL-Dora area and others within the permissible limits, while in AL-YosIfia, all of them were not within the permissible natural limits and unsuitable for drinking.Well water in AL-Dora and AL-Yosifia areas is considered undrinkable because it contains high levels of total dissolved solids (TDS). These solids are formed from minerals and dissolved salts that are present in water as a result of their interaction with rocks and soil. When the TDS value is high, it can significantly affect the quality of water and its suitability for human consumption. Reasons why well water has a high TDS, Well water may contain high levels of salts such as chloride, sulfate, and bicarbonate, as well as minerals such as sodium, calcium, magnesium, and iron. Some of these minerals may be beneficial in certain concentrations, but when the amounts are high, they can make the water unfit for consumption. The second reason Groundwater often comes into

(such as the use of fertilizers and pesticides), or industrial activities (such as leakage of chemicals), resulting in an increased concentration of dissolved solids in the water. There are some studies that agree with the results of the current study, but in different regions of

the country (Saleh,*et al*.,2016) in the Lower Zab and villages in the south of Mount Makhmour due to the highness of salinity and turbidity, while in another study (Hamed,2014) it was stated that home well water is suitable for domestic uses but not for drinking, as researchers (Faleh,*et al*., 2013) mentioned in a study in the south Baghdad stated that domestic well water is used for agriculture, irrigation, and other domestic uses, but not for drinking. Researchers (AL-Mashhadany,*et al*.,1989) also stated in a study of the Bashiqa region regarding the components of the area's domestic well water that it is not suitable for drinking because it exceeds standard Iraqi parameters.

Conclusion

The study the domestic well water concluded:

1. High dissolved solids lead to long-term health problems, such as affecting blood pressure due to high concentrations of sodium, or kidney problems due to mineral buildup.
2. Water with high TDS may harm household appliances such as washing machines and stoves because it leaves deposits of minerals that may corrode these appliances.

Recommendation

1. Water needs additional treatment to reduce the level of dissolved solids before it is used for drinking.
2. Well water with a high TDS may need special treatment such as reverse osmosis or filtration to remove excess salts and minerals, making it more suitable for human consumption.

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