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Evaluation of the water quality of some wells in the village of Shamit - Zab district

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Abstract

The current study included a field survey of the groundwater characteristics in the Zab district, where the bacteriological aspect of this water was examined to determine its quality. The study began in October 2024 and continued until March 2025, where six wells were selected in the area to collect water samples and analyze some of their characteristics. The results of the study showed that the air temperature in the studied area varied significantly between (15°C and 38°C) during October and March, while the temperature of water samples ranged between (19°C and 28.5°C). The pH values ranged between (7.0 and 8.74), the dissolved oxygen values ranged between (7.6 and 36.3) mg/L, while the biological oxygen demand (BOD) values ranged between (3.2 and 13.2) mg/L. Turbidity values in well water ranged between 0.00 and 20.97 NTU, while electrical conductivity values ranged between 1.859 and 3999 microsiemens/cm. Total hardness values in water ranged between 0.105 and 0.79 mg/L. Total dissolved solids (TDS) values ranged between 1.012 and 2000. Phosphate values ranged between 0.226 and 0.549 mg/L, while nitrite values ranged between 0.156 and 0.293 μg/L.

Introduction

Water is the most essential and indispensable element on Earth's surface, and it is one of the most important and widespread substances in nature, the importance of water and its necessity to enter all biological and industrial processes lies in the fact that no object can live without it, regardless of its shape, type, or size. Water pollution in its various forms is one of the main problems at the global level, and different regions in the world suffer from its effects [1]. If groundwater becomes contaminated, it becomes difficult to restore its proper quality, as pollutants cannot be easily prevented at the source. Therefore, it is essential to monitor groundwater quality periodically and regularly, and to identify effective methods and means to protect it from contamination [2]. Ground water is among the Nation's most precious natural resources. Measurements of water levels in wells provide the most fundamental indicator of the status of this resource and are critical to meaningful evaluations of the quantity and quality of ground water and its interaction with surface water [3].

Reliance on well water in Iraq for drinking and agriculture has increased due to the declining levels of the Tigris and Euphrates rivers and the lack of rainfall in recent decades. Groundwater pollution rates have also increased due to increased human activities [4]. Drinking water must be free of any chemical, physical or biological contaminants. In addition, the water must be free of colour, taste or odour [5]. The World Health Organization, the US Environmental Protection Agency, and many other health institutions have paid attention to diseases resulting from water pollution and controlling them [6].

Frequently using polluted drinking water leads to a high incidence of diseases. Therefore, standards and determinants were set by the Iraqi Department of Standardization and Quality Control [7, 8]. The recognized Iraqi standards for the presence of bacteria require no coliform bacteria in drinking water so that the coliform bacteria should not exceed (0) cells/100 ml. In contrast, the total number should not exceed (10) cells/100 ml [9]. The utilization of bacteria as indicators of water quality serves to specify the presence of fecal contamination. Consequently, it can be employed as a means to ascertain the underlying causes for the contamination, gauge its severity, and determine the appropriate measures to eradicate it. It is important to note that the magnitude of indicator bacteria directly corresponds to the level of fecal contamination, thereby amplifying the associated risks of waterborne diseases [10]. Our study aims to evaluate and analyze the Physicochemical properties of some well water in the Zab Subdistrict, Shamit village.

Materials and methods

Study Area and Field Work

The fieldwork of the current study began in October 2024 and continued until March 2025, with a total duration of six months. The study was conducted at the University of Tikrit, College of Science, Department of Biology. The study area is located in Kirkuk Governorate, northeastern Iraq, between longitudes 42°24' – 43°17' E and latitudes 36°33' – 34°50' N. Al-Zab is an Iraqi sub-district (Nahiyah) administratively affiliated with the Hawija District. It was officially designated as a sub-district in 1960 and comprises 28 villages in addition to the town center. The sub-district is located at the confluence of the Tigris River and the Lower Zab River [11].

Sample Collection

Water samples were collected from the six wells in the evenings between 6:00 and 10:00 PM, once a month, starting from October 2024 until the end of March 2025. Prior to sample collection, water was pumped out of the sample containers for approximately 10 minutes to remove stagnant or contaminated water from the pipes. Water samples were then collected directly using 2.5-liter polyethylene containers, minimizing air space to ensure sample properties were maintained during transport. The containers were washed three times with sample water before being filled with sample water for chemical, physical, and bacteriological tests. To estimate dissolved oxygen (DO) and biological oxygen demand (BOD), transparent and opaque 250 ml Winkler bottles were used. Dissolved oxygen was stabilized in the field by adding 2 ml of manganese sulfate ($MnSO_4.H_2O$) and 2 ml of basic potassium iodide

(KI). After 10 minutes, 2 ml of concentrated sulfuric acid was added, the bottle was tightly capped, and the bottle was shaken well.

For the bacterial samples, industrially prepared water bottles were used, emptied at each well site, taking care not to touch the bottle nozzle with hands or any other source that could lead to contamination. After filling them thoroughly, the bottles were tightly capped and transported to the laboratory for bacterial and coliform testing.

Physicochemical parameters

This study involved the analysis of water samples, and the physicochemical parameters were studied. Water temperature at the sampling sites were measured using a mercury thermometer, as temperature can affect the abundance of bacteria [12]. Turbidity, using Turbidity meter, the gravimetric method was used for total dissolved solids (TDS), Electrical conduction (EC) using a conductivity device. The pH was evaluated using a pH meter from Eutech [13].

Biological oxygen demand (BOD) and dissolved oxygen (DO), estimated using the Winkler calibration method (Winkler 1888)(14-16) modified by azide. For five days of incubation in dark conditions and 20°Cat aerobic conditions (for BOD samples). Total Hardness is measured titrating with a standard Na_2EDTA solution. The pH of the sample is then adjusted to 10, and 1 ml of ammonia buffer solution is added. A small amount of dry Erichrom Black-T powder is then added until the solution turns blue.In addition, nitrate (NO_2^{-1}) phosphate (PO_4^{-2}) values were measured using the method of [16], using a UV 9200 spectrophotometer (TER) at wavelengths of 543 nm and 885 nm for nitrite and phosphate, respectively.

Results and discussion

Water Temperature

Temperature is a major factor influencing metabolic processes in living organisms, such as respiration and enzyme activity. At low temperatures, water's ability to dissolve oxygen increases, while at high temperatures, this leads to increased oxygen consumption, causing harm to aquatic organisms due to increased metabolic activities [17]. The water temperatures in the study area's wells depended on several factors, the most important of which were the depth of the wells and the layers of the ground containing them. The closer the groundwater is to the Earth's surface, the more affected it is by the surrounding climate fluctuations. However, in cases where the wells are deep, the external influence is minimal, but they are nevertheless affected by the interactions that occur between the water layers and the rocks within the Earth's interior [18]. Considering the results in Table (1), they indicate the presence of variations in water temperature ranging between (19-28.5) °C. As for the temperature of the samples taken from the well water, as shown in Table (1), the lowest temperature was recorded in wells (1, and 6), while the highest temperature of the samples was recorded in well (1).

Table 1. Monthly and locational changes in water temperature at the study stations during the study period in units of (ºC).

Sequence	well	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Rate
1	October	27	27	27.5	25	26.5	25	26.3
2	November	28.5	27	27	25.5	27	27.5	27.08
3	December	26	25.5	26	24.5	25.5	24	25.25
4	January	21	20	21	20.5	21.5	20	20.66
5	February	19	20	20	19.5	20	19	19.58
6	March	23	23	24	24	24	25	23.83
	Rate	24.08	23.75	24.25	23.16	24.08	23.41	

Turbidity

Significant significant differences were observed between turbidity values in the wells. The highest turbidity value (20.97) NTU was recorded in Well 1 during January. This is due to the high turbidity level resulting from the presence of algae and inorganic materials such as clay and sand, which leads to varying degrees of turbidity in the well water due to the pollutants that cause it. The lowest value was recorded in Well 4 during October and February, Well 5 during February, and Well 6 during October (0.00) NTU. This may be due to the high rainfall accompanied by sandstorms, which generally characterize the Iraqi climate. These results are consistent with the results of [19].

Table 2: Monthly and locational changes in water turbidity at the study stations during the study period in units of (NTU).

Sequence	well	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Rate
1	October	0.19	0.08	0.25	0.00	0.21	0.00	0.12
2	November	11.92	4.02	4.38	3.22	3.13	4.57	5.20
3	December	4.25	3.63	3.32	1.30	4.44	2.43	3.18
4	January	20.97	1.42	3.4	1.14	0.45	2.4	4.77
5	February	5.07	0.98	0.07	0.00	0.00	4.65	1.79
6	March	6.55	4.96	5.45	3.89	3.52	1.73	4.35
	Rate	8.15	2.51	2.64	1.59	1.95	2.63	

Electrical Conductivity

The data for this study indicated significant differences in electrical conductivity between wells. The highest electrical conductivity values were recorded in Well 6, at 3999 µs/cm in November, and the lowest value, at 1.859 µs/cm in Well 2, during November. This is due to the different salinity levels between the aforementioned wells, as the electrical conductivity value depends on the percentage of ions present in the water. Because the groundwater studied passes through different geological formations, this could be the reason for the high electrical conductivity[20].

Table 3: For monthly and site changes in electrical conductivity at stations in units of (μs/cm).

Sequence	well	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Rate
1	October	4.34	2332	3.91	3.22	3.27	3989	1055
2	November	2.981	1.859	2.708	2.539	2.501	3999	668.598
3	December	3.57	2090	3.28	3.37	2933	5.56	839.7
4	January	2313	1297	2266	1692	1761	2867	2032
5	February	3.59	2143	3.52	2733	2707	4.88	1265
6	March	3.84	2288	3.80	3.24	1.999	4.626	384.2
	Rate	388.5	1691.9	380.5	739.5	1234.7	1811.6	

Total Dissolved Solids (TDS)

The specific results showed significant differences in total dissolved solids between the six wells. The average total dissolved solids concentration ranged from 1.223 mg/L in Well No. 5 for November, which was the lowest value recorded, to 2,000 mg/L in Well No. 6 for November. The significant differences may be due to the different soil characteristics at each station, as the amount of solids at each site depends on the groundwater level in each well. Therefore, solids appear in water samples, and their quantity is directly proportional to the amount of rainfall and groundwater movement within each well. The results of this study are confirmed that the quality of well water depends on the geological differences of each region, especially the presence and concentration of solid materials in groundwater, regardless of the season of the year.

Table (4) Monthly and local changes in total dissolved solids (TDS) at the study stations in units (mg/L).

Sequence	well	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Rate
1	October	2.13	1169	1.96	1.63	1.63	3.16	196.5
2	November	116	953	1.543	1.274	1.223	2000	512.1
3	December	1.76	1.012	1.69	1.59	1487	4.86	249.6
4	January	1156	681	1131	873	878	1480	1033.1
5	February	1.79	1105	1.73	1353	1356	2.46	636.6
6	March	1.93	1.170	1.89	1.63	1.51	2.31	1.74
	Rate	213.2	651.6	189.9	372.0	620.8	582.1	

pH

The process of measuring the alkalinity and acidity achieved by the dissolved substances in water. This is achieved through the balance between carbon dioxide, carbonates, and bicarbonates, in addition to the overall balance, which includes the balance of other dissolved substances in water. These substances are greatly affected by temperature and a direct reaction. As the temperature of pure water increases, the pH decreases by 45% [21]. Looking at Table (3), it becomes clear to us that the results and values of the pH ranged between (8.74-7), where the lowest pH value was recorded in well (6) for the month of March, while the highest value of the acidity function was recorded in well (5) for the month of December. This function depends on the concentration of hydrogen ions that affect many chemical reactions, and the acidity function is also affected by gases dissolved in water, such as ammonia gas, carbon dioxide, and hydrogen sulfide gas, in addition to carbonate and bicarbonate ions.

Table 5. Monthly and local changes in pH at the study stations during the study period

Sequence	well	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Rate
1	October	7.21	7.88	7.09	7.94	7.82	7.31	7.54
2	November	7.64	7.50	7.76	7.78	7.74	7.68	7.68
3	December	8.59	8.66	8.67	8.67	8.74	8.72	8.67
4	January	7.5	7.4	7.6	7.3	7.3	7.6	7.45
5	February	7.5	7.3	7.6	7.3	7.2	7.7	7.43
6	March	7.33	7.34	7.8	7.4	7.6	7	7.41
	Rate	7.62	7.68	7.75	7.73	7.73	7.66	

Dissolved Oxygen (DO)

DO is significantly impacts numerous water indicators, encompassing biochemical factors and aesthetic qualities such as odor, transparency, and flavor. The analysis of water samples indicates that the level of DO is higher than the criteria set by WHO [22] The low level of oxygen in water has a significant negative impact on the aquatic environment. This is caused by a significant increase in the activity of anaerobic microorganisms, which in turn leads to significant changes in the reactions occurring with organic matter. This, in turn, causes significant damage to the water by producing numerous substances harmful to the water and to organisms[23,24]. The results shown in Table (4) show the concentration of dissolved oxygen in water samples, with the results ranging between (7.6-36.3) mg/L. The lowest value was recorded in Well (4) for the month of October, while the highest value of dissolved oxygen was recorded in Well (4) also in the month of February. Some attribute the high concentration of dissolved oxygen to the large openings of some well pipes and the lack of tight covering, which makes them close to their external surroundings, as well as the proximity of the wells to the ground surface, which puts them in almost direct contact with the air outside the well.

Sequence	well	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Rate

1	October	8.3	8.3	8.7	7.6	11.3	8.4	8.7
2	November	11.2	8.9	11.3	9.2	13.2	8.8	10.4
3	December	17.2	10.4	21	23.2	11.2	23.6	17.7
4	January	24.1	17.46	24.4	23.4	21.6	20.53	21.9
5	February	18	22	30	36.3	25	18.7	25
6	March	24.8	16.4	23.3	11.3	26.4	32.2	22.4
	Rate	17.2	13.9	19.7	18.5	18.1	18.7	

TABLE 6. Monthly and local changes in dissolved oxygen in the water of the study stations during the study period in units (mg/L).

Biological Oxygen Demand (BOD)

When examining water quality, calculating the BOD in water is essential [25]. This is because it indicates the amount of oxygen consumed in organic decomposition, in the atmosphere and external conditions, and available at a specific temperature and time period [26]. Upon completion of our BOD tests, the results shown in Table (5) revealed a discrepancy in the final results. The BOD concentration in the water ranged between (2.9-13.2) mg/L, with the lowest value recorded in Well (1) for the month of October, while the highest value was recorded in Well (3) for the month of February. Some believe that the low BOD is due to filtration between the rock layers in these wells, as well as the fact that the water does not stagnate due to repeated use and is not contaminated by organisms, which would lead to a high BOD value.

Table 5. Monthly and local changes in the biological oxygen requirement in the water of the study stations during the study period in units (mg/L).

Sequence	well	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Rate
1	October	2.9	3.7	4.4	3.2	6.24	4.6	4.17
2	November	5.4	4.6	6.3	4.1	7.5	5	5.4
3	December	5.4	5.4	7.9	9.7	7.4	8.9	7.45
4	January	8.8	5.06	9.5	12	11	15	10.22
5	February	7.6	4.3	13.2	11.5	8.4	6.4	8.5
6	March	8.7	6.8	4.8	5.9	3.9	9.6	6.6
	Rate	6.4	4.97	7.68	7.7	7.40	8.25	

Total Hardness

The results shown that the total hardness values of the well water samples ranged between 0.105 and 0.79 mg/L. The lowest value recorded in Well 2 was in November, while the highest value was recorded in Well 2 in December. The variation in total hardness concentration between different areas is likely due to the effects of groundwater extraction and pumping, in addition to its use for domestic purposes, as well as the influence of the geological structure of the area in which the wells are located, which may contain deposits rich in limestone and calcium sulfate.

Table (8) Monthly and locational changes in total hardness at the study stations during the study period in units (L/mg) $CaCO_3$.

Sequence	well	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Rate
1	October	0.25	0.134	0.23	0.241	0.24	0.32	0.23
2	November	0.350	0.105	0.15	0.20	0.196	0.27	0.211
3	December	0.299	0.79	0.209	0.219	0.214	0.26	0.331
4	January	0.37	0.23	0.29	0.34	0.27	0.34	0.29
5	February	0.196	0.65	0.175	0.15	0.151	0.17	0.248
6	March	0.23	0.152	0.177	0.184	0.396	0.23	0.228
	Rate	0.282	0.343	0.205	0.222	0.244	0.265	

Phosphate (PO_4^{-3})

Phosphorus is an essential nutrient that contributes to plant growth, both in dissolved and particulate form[27]. This ion is found in sedimentary and volcanic rocks, and deposits containing animal bones and apatite. When these rocks interact with water, they dissolve, increasing their concentrations in the water, in addition to animal waste seeping into groundwater[28]. Phosphate concentrations in well water samples ranged between 0.226 and 0.549 mg/L. The lowest concentration was recorded in Well. 1 in February, while the highest concentration was recorded in Well. 1 in March. Sedimentary and volcanic rocks, apatite, and decomposed animal bones are the main sources of this ion in groundwater. The use of detergents and powders containing this ion also contributes to increasing its concentration, as it reacts with water to form the phosphate ion, as shown in the following equation:

$P3O10 + 2H2O\ 4H^{+} + 3PO4^{-3}$

Table 9: For monthly and site changes in phosphate at stations in units of (µs/cm).

Sequence	**well**	**Well 1**	**Well 2**	**Well 3**	**Well 4**	**Well 5**	**Well 6**	**Rate**
1	October	0.528	0.540	0.527	0.524	0.518	0.518	0.525
2	November	0.510	0.509	0.510	0.509	0.508	0.509	0.509
3	December	0.508	0.514	0.507	0.502	0.511	0.498	0.506
4	January	0.538	0.504	0.507	0.505	0.506	0.505	0.510
5	February	0.226	0.235	0.241	0.233	0.252	0.230	0.236
6	March	0.549	0.548	0.545	0.542	0.534	0.541	0.543
	Rate	0.476	0.475	0.472	0.469	0.471	0.466	

Nitrite (NO_2)

Nitrite is a naturally occurring ion in the nitrogen cycle, containing nitrogen in an unstable oxidation state[29]. Human waste is a major source of this ion in water[30]. The current results showed variations in nitrite concentration in wells, ranging from 0.156 to 0.293 mg/L. The lowest concentration was recorded in Well 4 in January, while the highest concentration was recorded in Well 3 in March. Nitrite concentrations in water increase as a result of the decomposition of organic matter, agricultural activities, and the use of nitrogen fertilizers. Nitrite is a highly soluble ion that can quickly reach aquifers, making it a potential pollutant of groundwater resources. Its increased concentration in well water is attributed to urban expansion and industrial and agricultural waste, which leads to an increase in its concentration in groundwater [31]

Table 10. For monthly and site changes in nitrate at stations in units of (μs/cm).

Sequence	well	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Rate
1	October	0.220	0.207	0.202	0.198	0.196	0.192	0.202
2	November	0.203	0.289	0.194	0.193	0.192	0.204	0.212
3	December	0.199	0.198	0.200	0.195	0.215	0.205	0.202
4	January	0.205	0.221	0.212	0.156	0.210	0.159	0.193
5	February	0.218	0.206	0.220	0.216	0.218	0.214	0.215
6	March	0.275	0.250	0.293	0.235	0.250	0.251	0.259
	Rate	0.22	0.228	0.220	0.198	0.213	0.204	

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تقييم نوعية مياه بعض الابار في قرية شميط - ناحية الزاب

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معلومات البحث:
تأريخ الاستلام:
تاريخ التعديل:
تأريخ القبـــول:
تاريخ الــنشر:
الكلمات المفتاحية:
نوعية المياه، ناحية الزاب، العكورة،
معلومات المؤلف
الايميل:
الموبايل:

الخلاصة:

شملت الدراسة الحالية إجراء مسح ميداني لخصائص المياه الجوفية في ناحية الزاب، حيث تم فحص الجانب البكتريولوجي لهذه المياه بهدف تحديد جودتها. وبدأت الدراسة في شهر تشرين الأول 2024 واستمرت حتى شهر اذار2025، حيث تم اختيار ستة آبار في المنطقة لجمع عينات من المياه وتحليل بعض خصائصها. أظهرت نتائج الدراسة أن درجة حرارة الهواء في المنطقة محل الدراسة قد تباينت بشكل ملحوظ بين (15º و38º) درجة مئوية خلال تشرين الأول واذار، في حين تراوحت درجة حرارة عينات المياه بين (19º و28.5º) درجة مئوية. كما تراوحت قيم الرقم الهيدروجيني (PH) بين (7 و8.74) وكانت قيم الأوكسجين المذاب تتراوح بين (7.6و 36.3) ملغم/لتر، بينما تراوحت قيم المتطلب الحيوي للأوكسجين بين (3.2 و13.2) ملغم/لتر. تراوحت قيم العكورة في مياه الآبار بين 0.00 و20.97 NTU، بينما كانت قيم التوصيلة الكهربائية تتراوح بين (1.859 و3999) مايكروسيمنز/سم. في حين كانت قيم العسرة الكلية في المياه تتراوح بين (0.105 و0.79) ملغم/لتر. اما بالنسبة لقيم المواد الصلبة الذائبة الكلية (TDS) فقد تراوحت بين 1.012 و2000. أما قيم الفوسفات فقد تراوحت بين (0.226 و0.549) ملغم/لتر، بينما تراوحت قيم النتريت بين 0.156 و0.293 مايكرو غرام/لتر.