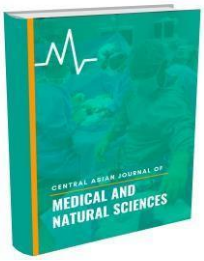

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Article

Study of Some Physical and Chemical Properties of Drinking Water at Several Stations in Kirkuk City and Determination of Their Potability

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Abstract: This study investigated some physical and chemical properties of drinking water in Kirkuk Governorate from January 2024 to June 2024. Five stations were selected for the study. The first station was Reservoir No. 1, which is the initial station after water purification in the Unified Kirkuk Water Project. Stations were also selected from the north, south, east, and west of Kirkuk City. The results indicated that the pH values of the water were on the weak alkaline side throughout the study period for all stations. The results also showed that the water samples contained salinity levels within the permissible limits for potable water. Additionally, the study revealed that the electrical conductivity increased with higher total dissolved solids in the water. The turbidity of the water remained within the required specifications for drinking water throughout the study period. Statistical analysis did not show any significant differences in the physical and chemical properties of the studied stations during the study period.

Keywords: Aquatic Environment, Water Purification Plants, Drinking Water, Physical and Chemical Properties

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1. Introduction

Water is one of the essential elements present on Earth and is one of the most crucial resources needed by humans in daily life. All living organisms require water to survive, and all the vital processes occurring within the bodies of various organisms, from food consumption to waste disposal, depend on water [1]. Water is a major component in the structure of most living organisms; the human body is composed of 65% water. The water content in human blood ranges from 80% to 90%, while the water content in plant leaves is between 65% and 85%, and in the stem, it is 50%. Water plays a fundamental role in the process of photosynthesis in plants [2]. Historically, water has played a vital role in the advancement and survival of human civilization. Early civilizations flourished along riverbanks, with the most significant civilizations emerging on the banks of the Nile, Tigris, and Euphrates rivers [3]. The demand for water is continuously increasing. Each year, the global population grows, and industries are producing more, which increases the demand for water. However, approximately 97% of the world's water is contained in oceans, and it is highly saline, making it unsuitable for drinking, agriculture, or industry. Only 3% of the world's water is freshwater, which can be utilized by humans. The study of drinking water is of paramount importance due to its direct connection to the spread and transmission of diseases if it fails to meet the required standards [4].

Study Objective

The primary goal of this study is to examine the key physical and chemical properties of household drinking water in Kirkuk City, assess its quality and suitability for human consumption, and compare it with the Iraqi standards and those of the World Health Organization (WHO).

Description of the Study Stations

Table 1. Names and Locations of the Stations Included in the Study.

Station	Station Location	Description Of Study Area
Station 1	Reservoir No. 1 in the Unified Kirkuk Water Project	The first station after water treatment in the Unified Kirkuk Water Project, located in Koyan area, northwest of Kirkuk City.
Station 2	Residential Area	Located in the northern part of Kirkuk City.
Station 3	Al-Asra Neighborhood	Located in the eastern part of Kirkuk City.
Station 4	Ras Dumiz Neighborhood	Located in the western part of Kirkuk City.
Station 5	Al-Nidaa Neighborhood	Located in the southern part of Kirkuk City.

2. Materials and Methods

Water samples were collected from the studied stations starting from January 2024 to June 2024. A total of 90 samples were collected, with an average of 15 samples per month. Laboratory analyses were conducted at the Kirkuk Water Directorate. The results presented here represent the monthly averages in polyethylene containers after washing them. Mercury thermometers were used to measure the air and water temperature. The pH was measured using a pH-meter, and electrical conductivity was determined using a conductivity meter from WTW by immersing the device's electrode into the sample for five minutes, after which the reading was recorded in μS/cm (micro Siemens/cm) [5]. Total hardness, and the concentrations of calcium and magnesium ions, were measured according to the method [6]. Alkalinity was measured using the method [5]. Statistical analysis of the results was performed using Two-Way ANOVA at a significance level of $0.01 \leq P$ [7].

3. Results and Discussion

Water Temperature

The results shown in Table (1) indicate that water temperature gradually increases from January to June at all stations. It starts from around 16.6-19.0°C in January and reaches 27-28°C in June. This expected rise in temperature is linked to the seasonal change from winter to summer, where higher temperatures contribute to increased water temperatures. This increase may affect water quality and aquatic organisms, as well as potentially accelerate chemical and biological reactions within the water [8].

Table 1. Water Temperature (°C) at the Stations.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
January	18.1	18.5	18.8	19.0	16.6
February	19.0	19.3	19.6	20.0	17.0
March	20.5	20.8	21.0	21.3	18.2
April	22.0	22.3	22.6	23.0	19.5

May	24.0	24.5	25.0	25.3	20.8
June	26.0	26.5	27.0	27.5	28.1

pH (Hydrogen Ion Concentration)

The results of the pH measurements, shown in Table (2), indicate that the pH values range from 7 to 7.3. These values suggest that the water is weakly alkaline, which can be attributed to the calcareous nature of the Tigris River's deposits as it flows through numerous mountainous regions [9]. These pH values are within the acceptable range for drinking water quality according to the World Health Organization (WHO), which recommends a pH range between 6.5 and 8.5.

Table 2. pH Concentration at the Stations.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
January	7.0	7.1	7.2	7.3	7.0
February	7.0	7.1	7.2	7.3	7.1
March	7.0	7.1	7.2	7.3	7.1
April	7.0	7.1	7.2	7.3	7.2
May	7.0	7.1	7.2	7.3	7.2
June	7.0	7.1	7.2	7.3	7.3

Turbidity

Turbidity is a measure of water clarity, affected by suspended solids or high concentrations of disease-causing microorganisms. High turbidity levels can protect microorganisms from the effects of disinfection; therefore, the treatment and disinfection processes must be effective enough to maintain water turbidity at the lowest possible level [10]. The results showed a close range of turbidity values, which varied between 3.8 and 4.7 Nephelometric Turbidity Units (NTU), as shown in Figure 3. These values fall within the global standards for drinking water quality.

Table 3. Turbidity (NTU) at the Stations.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
January	4.1	4.2	4.0	4.3	3.8
February	4.1	4.3	4.0	4.4	4.0
March	4.2	4.3	4.1	4.5	4.2
April	4.3	4.4	4.2	4.6	4.4
May	4.4	4.5	4.3	4.7	4.6
June	4.5	4.6	4.4	4.7	4.7

Electrical Conductivity

Table (4) indicates an increase in electrical conductivity values during the spring season, which can be attributed to the rainwater washing process, which carries salts from surrounding lands. The results of electrical conductivity in this study are consistent with the study by [11] and lower than those in the study by [10]. The electrical conductivity of water depends on the dissolved substances (primarily electrolytes) and is influenced by the concentration of salts present as ions [5]. The electrical conductivity ranged from 399 to 429 microsiemens/cm.

Table 4. Electrical Conductivity (Micro Siemens/cm) at the Stations.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
January	399	400	401	402	403
February	405	406	407	408	409
March	410	411	412	413	414

April	415	416	417	418	419
May	420	421	422	423	424
June	425	426	427	428	429

Total Alkalinity

Total alkalinity in surface water is influenced by the negative ions that affect pH values, usually including carbonate, bicarbonate, and hydroxide ions. The alkalinity of natural waters is attributed to the presence of salts of weak acids, weak bases, silicates, and phosphates, which make up a small proportion, as well as other organic acids such as humic acid, which increase the alkalinity of the water [12]. The alkalinity values ranged from 142 mg/L at Station 3 in June to 148 mg/L at Station 3 and Station 2 in March and February, as shown in Figure (5). All values were below the Iraqi standards and the World Health Organization's (WHO) threshold of 200 mg/L. This decrease is attributed to the consumption of CO2 by phytoplankton, and the precipitation of carbonates at higher temperatures, which in turn reduces alkalinity [9].

Table 5. Total Alkalinity (mg/L) at the Stations.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
January	145	146	148	147	145
February	144	148	146	145	144
March	143	147	148	145	143
April	142	146	147	144	142
May	143	145	144	143	141
June	144	143	142	141	140

Total Hardness

Water hardness varies depending on the water source, with surface water being less hard than groundwater. This is influenced by the geological characteristics of the land through which the water flows or passes [13]. The total hardness values for all stations were below the permissible limit of 500 mg/L according to both Iraqi and global standards. The lowest value was recorded at Station 5 in May, at 181 mg/L, while the highest value was observed at Station 3 in April, at 187 mg/L, as shown in Figure (6). Total hardness values for drinking water may fluctuate, sometimes decreasing and at other times increasing. This variation is attributed to the high concentration of salts in the sedimentation basins and the lack of scheduled maintenance or cleaning of water reservoirs from time to time [14].

Table 6. Total Hardness (mg/L) at the Stations.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
January	185	186	187	186	185
February	184	185	186	185	184
March	183	184	185	184	183
April	182	183	184	183	182
May	181	182	183	182	181
June	180	181	182	181	180

Calcium

Calcium and magnesium are among the most common ions responsible for water hardness in nature. The concentration of calcium ions is generally higher than that of magnesium ions in natural water systems [10]. The calcium concentrations in drinking water at all stations ranged from the highest value of 43 mg/L at Station 5 in January to the lowest value of 40 mg/L at Station 1 in June, as shown in Table (7). All values were well below the permissible limit of 200 mg/L according to Iraqi standards and 100 mg/L according to the World Health Organization's (WHO) guidelines. This can be attributed to the cleanliness of sedimentation basins, filters, and water reservoirs [14].

Table 7. Calcium Concentration (mg/L) at the Stations.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
January	43	42	41	41	43
February	42	42	41	41	42
March	41	41	41	40	42
April	41	41	40	40	41
May	40	40	40	40	41
June	40	40	40	40	40

Magnesium

Table (8) shows the magnesium values at all stations, indicating that the values are closely similar across the stations. The lowest value was recorded at Station 3 in May, at 18 mg/L, while the highest value was recorded at Station 3 in April, at 20.5 mg/L. These values remained well below the permissible limit set by the World Health Organization (WHO) at 150 mg/L and the Iraqi standards at 50 mg/L [10].

Table 8. Magnesium Concentration (mg/L) at the Stations.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
January	20.0	20.0	19.0	19.0	18.0
February	20.0	20.0	19.5	19.0	18.5
March	20.0	20.0	20.0	19.5	19.0
April	20.5	20.5	20.0	19.5	19.5
May	20.0	20.0	19.5	19.0	18.5
June	19.5	19.5	19.0	18.5	18.0

Sodium

The sodium values at all stations were recorded below the permissible limit set by both the Iraqi standards and the World Health Organization (WHO). These values ranged from the lowest value of 8 mg/L at Station 2 in May to the highest value of 10 mg/L at Station 3 in February, as shown in Table (9).

Table 9. Sodium Concentrations (mg/L) at the Stations.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
January	9.0	9.0	10.0	9.0	9.0
February	9.0	8.5	9.5	8.5	9.0
March	9.0	8.5	9.5	8.5	8.5
April	9.0	8.5	9.0	8.5	8.5
May	9.0	8.0	9.0	8.5	8.5
June	8.5	8.0	8.5	8.5	8.5

Potassium

Potassium content were within permissible limit according to both the Iraqi standard and world health organization (WHO). These values varied from Station 4 in January the highest value of 1.7 mg/L to Station 2, this was the lowest value of 1.3 mg/L (Table 10). Sodium concentration was low in all the stations with no station exceeding the WHO permissible limits. Potassium values were similar low to that of potassium that is useful in the stability of drinking water any also helps to minimize the possibility of torsive effect to human health. [15] [16].

Table 10. Potassium Concentrations (mg/L) at the Stations.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
January	1.6	1.5	1.4	1.7	1.6
February	1.5	1.5	1.4	1.6	1.5
March	1.5	1.4	1.4	1.6	1.4
April	1.4	1.4	1.3	1.5	1.4
May	1.4	1.3	1.3	1.4	1.3
June	1.3	1.3	1.3	1.3	1.3

4. Conclusion

The latter study gives very valuable data about the quality of drinking water at various stations in Kirkuk City and this is one of the key findings. The outcome shows the water quality is overall at an acceptable level for drinking, with some seasonal fluctuations that are characteristic to surface water regimes. Based on the results of the water quality analysis, the physical and chemical (pH, turbidity, electrical conductivity and hardness) parameters of the water fall within the acceptable limits of drinking water quality recommended by both local and international standards. Nevertheless, monitoring should be sustained to keep these values in safe ranges and particularly during extreme conditions such as those with the possibility to affect water quality.

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