Research Paper

Evaluation of some chemical and physical properties of the liquefaction plant in al-dibs district - kirkuk governorate

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ABSTRACT

This research to evaluate some chemical and physical characteristics of water in Al-Dibs district located in Kirkuk governorate, Iraq, from October 2023 to March 2024. Samples were collected from different water sources including the Zab River, Dibs Liquefaction Plant and public supply networks during different seasons to ensure accurate representation of seasonal conditions. Total Suspended Substances (TSS) values in drinking water were recorded within a range of 0.22-1.42ppm. Total alkalinity (TA) - ranged from 100 to 140 ppm. The results for total hardness (TH) showed variation between 120 and 230 ppm. The calcium (CaH) and magnesium (MgH) hardnesses were recorded in the range of 85-165 and 25-65 ppm, respectively. Chloride ion (Cl) concentrations ranged between 5.68 and 31.24 ppm. As for nutrients, the total nitrogen (TN) concentration was between 0.1% and 0.2%, while the available phosphorus (TP) concentrations were very low and ranged from insignificant values to 0.11 ppm. The results of analysing the drinking water in Dibs district showed that the water is generally fit for use, but contains some high values in hardness and nutrients, indicating the need for continuous monitoring and simple improvement in treatment to ensure its quality and safety.

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1. INTRODUCTION

Although water is essential for life, contaminated water leads to the deterioration of people's health. Drinking water is mainly obtained from three main sources: Surface water, groundwater, and rainwater, Water is one of the most abundant and widespread compounds on the surface of the earth, covering the largest part of the water areas and representing an essential element in various ecosystems, and it exists in three different states of matter: Liquid, solid and gaseous. However, the provision of safe drinking water is critical for sustaining life and promoting human well-being [1]. Water is fundamental to the sustainability of life on the planet and is a pivotal factor in the development of cities and the growth and prosperity of in dustrie, the management of freshwater resources is important for policymakers under the influence of climatic, social and economic factors [2]. It is estimated that 71 per cent of the earth's surface is either saline or fresh water, including oceans, seas, rivers, groundwater, snow and ice [3]. The shortage of potable water is increasing as a result of increasing demand, which may lead to future issues in many countries of the world, especially in arid and semi-arid regions, due to its frequent use in agriculture and industry. In agriculture and industry, more than half of the world's population suffers from a lack of potable water, especially in third world countries, which leads to the spread of portable waterborne pathogens, Water pollution is a major environmental concern that poses economic and health risks to both humans and other organisms. In many developing countries, there is an urgent issue of contamination of drinking water supplies, leading to a significant reduction in surface water quality [4].

The World Health Organisation (WHO) has established exposure standards or safe limits for contaminants of all types in drinking water [5]. National and international organisations in different countries have developed additional types of water quality indicators based on their need to assess the level of water quality in a particular area of interest. To date, specialists have not proposed a consistent method for assessing water quality that can be used worldwide to provide drinking water with objectivity and accuracy [5]. This leads to an increase in the number of people suffering from water issues, which poses an increased risk to children, causing significant numbers of deaths, Consumption of contaminated water as a source of drinking water increases the risk of disease outbreaks, including diarrhoea, which kills children in vulnerable communities , Water has distinctive physical and chemical properties, which has made it important in its uses for various purposes, and the organisms living in it are highly sensitive to changes in its physical and chemical properties. These factors affect the quality of life of the organisms living in it [6]. Analysing the physical, chemical and biological properties of water from filtering stations is vital to ensure the quality of water and its suitability for different uses, and scientific studies, including, indicate that the increase in bacterial pollution is related to the high level of chlorination, especially in the winter and spring seasons due to heavy rains that cause soil erosion and reach surface water. Given the importance of drinking water quality and safety for humans, periodic tests of drinking water must be conducted and evaluated with modern techniques, such as the use of mathematical models as one of the good and easy ways to know the interactive effects of the studied factors, and then finding a single means of value that describes water quality instead of the huge amount of data that not everyone understands [7].

2. RELATED WORK

[8] In their study, evaluated the water quality of the Debs Water Treatment Plant ,The results indicated unsatisfactory water quality at the raw water collection point, while excellent quality was observed at the other sites (2, 3, 4, and 5). The study conducted by [9] assessed the Drinking Water Quality Index (DWQI) in Kirkuk Governorate These results indicate the high efficiency of the water treatment plant in producing water suitable for daily sanitary uses, ensuring the safety and quality of drinking water for the residents of Kirkuk city. [10] Research focused on determining the physical and chemical characteristics of drinking water in the city of Samawah, Iraq Conclusion The drinking water in Al-Samawah city is acceptable in terms of physical, chemical, and biological properties. Most of its characteristics fall within the permissible limits according to Iraqi standards and the World Health Organization (WHO), making it suitable for human consumption and domestic use. [11] Evaluated water quality by analyzing the physical

and chemical properties in the water treatment stations of Basra city the result showed that some of the chemical parameters were within the acceptable limits set by the World Health Organization, except for water turbidity and lead levels. The study by [12] measured the qualitative properties of the Tigris River water at two locations in the city of Mosul The results indicate an increase in most of the studied parameters in the summer and autumn seasons compared to the winter and spring seasons. The study by [13] indicated the measurement of the physical, chemical, and mineral properties of suspended sediments in the Tigris and Euphrates rivers in the Ma region the results show a predominance of silt particles, followed by clay, then sand. The presence of clay particles increased, while the presence of silt and sand decreased with their increased transport to the two rivers. The study by [14] showed the impact of the Tharthar-Dijla Canal on the environmental characteristics of the Tigris River north of Baghdad, IraqThe study's conclusions indicate that the water quality in the Tigris River after the confluence with the Tharthar Canal was acceptable within environmental standards, especially regarding the biological oxygen demand, which did not exceed 5 mg/L, and good water aeration, along with some chemical changes that do not indicate severe pollution.

3. METHODOLOGY

Description of the Study Area

The study area is located in Al-Dibs district in Kirkuk governorate, north of Baghdad on longitude (44-23) and latitude (35-28), about 40 km from Kirkuk city and about 240 km from Baghdad. The source of water in this project is the Lower Zab River, where water is withdrawn from the river through intake pumps and then the water is pushed to reach the project where it is treated inside the project by sedimentation and filtration processes as well as sterilization using aluminum sulphate and chlorine, Where the water is sterilized to kill harmful microorganisms using chemicals such as chlorine or other techniques such as ultraviolet rays or ozone, the project feeds all areas of Dibs district, the project area is 3 km2 and consists of three main basins, the collection basin has an area of 5000 cubic meters, the sedimentation basin has a storage capacity of about 5000 cubic meters, and the payment basin has a depth of 7 meters and 20 cm, length 30 meters and width 25 meters and the water is used for drinking Five sites were selected within the study area of Dibs district / Kirkuk governorate, where a number of physical, chemical and bacteriological properties of the drinking water supplied by the plant were studied. The selection of sites for this study was to assess the characteristics of drinking water in general and for the study area in particular through its impact on the health, economic and social life of the region as shown in the Figure 1.

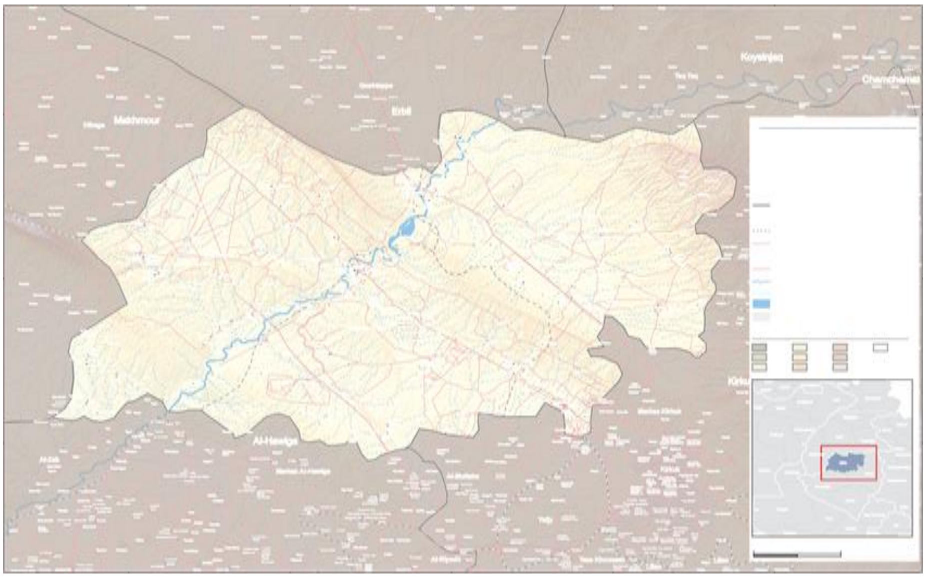

Figure 1. Distribution of Sampling Areas within the Dibis District

Sample Collection

Samples were collected for the five sites producing the physical, chemical and biological properties of the study areas for a period of six months from October 2023 to March 2024. The study samples were collected using polyethylene pots in the early morning of the sample collection times to ensure timely access to the laboratory, and the samples were collected after letting the water about 10 minutes flow from the tap to obtain water free of calcification and pipe residues, and the samples were transported to the laboratory in a special container. Physical, Chemical and Biological Parameters Measurement Method. The methods mentioned [15] were used to measure the physical, chemical and biological properties of the samples collected at the study sites which were used to assess the drinking water quality index of the studied sites

Statistical Analysis

Significance differences were extracted using the ANOVA-one way test. These differences were confirmed by the standard error. The differences were determined by Duncan's multiple ranges and at a significant level (P< 0.01).

4. RESULTS AND DISCUSSION

Table 1. Shows the Values of the Physical and Chemical Elements

Factors	The first site	Second site	Third site	Fourth site	Fifth site
Tur N.T. U	0- 0.77)) 0.162a	0-0.026)) 0.089 a	0.22-0)) 0.074a	0.332-0.004 a 0.071	0.11-0)) 0.62 a
Tss PPm	(1.02-0.5) 0.77a	1.04-0.22) 0.71a	1.04-0.5 0.803a	1.42-0.6)) 0.83a	1-0.3)) 0.666a
Alk PPm	(100-140) 122.33a	(112-136) 121.00a	(112-140) 127.22a	(108-140) 121.00a	(108-140) 121.66a
TH PPm	(120-190) 152.5a	(120-190) 154.16a	(135-230) 167.5a	(120-180) 152.5a	(120-180) 154.15a
CaH PPm	(125-95) 105.833a	(130-85) 110.833a	(165-98.75) 120.625a	(125-85) 108.333a	(125-85) 108.333a
MgH PPm	(65-25) 46.666a	(60-30) 43.333a	(65-30) 46.875a	(55-30) 44.166a	(65-30) 45.833a
Cl PPm	(11.36-5.68 8.756a	(11.36-5.68) 9.23a	31.24-8.5 14.97c	(11.36-8.52 9.94b	(11.36-8.52 9.94b
TN%	(0.1-0.2) 0.15a	(0.1-0.2) 0.133a	(0.1-0.2) 0.15a	(0.1-0.2) 0.15a	(0.1-0.2) 0.15a
TP PPm	(0-0.033) 0.0081a	(0-0.022) 0.006a	(0-0.011) 0.0058a	(0.011-0) 0.004167a	(0.011-0 0.006a

As shown in the Table 1 and Figure 2, the results indicate the first site recorded the highest average values of turbidity, which is caused by rainfall in some months of sampling, which leads to soil erosion and the increase of suspended and dissolved substances in the water, in addition to the spread of algae and organic matter in the riverbed, and turbidity increases due to the occurrence of soil runoff and its access to the river [5].

The second, third, fourth and fifth sites, which recorded lower values of turbidity, may be due to the water treatment process at the plant. The negative significant correlation coefficient ($P \leq 0.05$) between the values of turbidity and total hardness (r=0.362). The results of our study did not agree with the results of [6], as they recorded lower chloride values (40.1-25.4 naphthalene turbidity units) in the Lower Zab River water

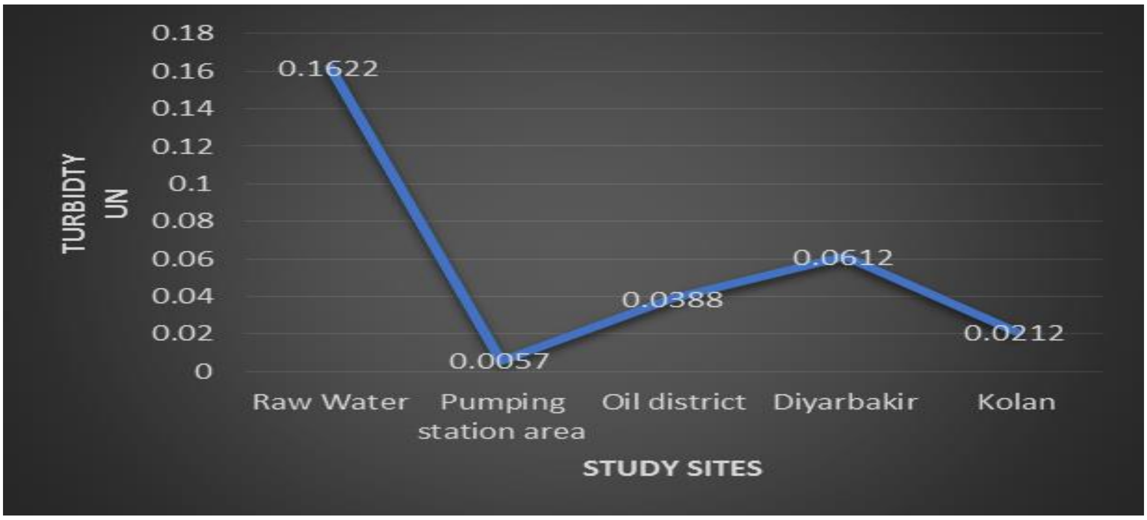

Figure 2. Turbidity Levels at the Study Sites

Total Solids

The results of our study as shown in the Table 1 and Figure 3, the results indicate documented varying values at the sampling sites, and the results of the statistical analysis documented that there were no significant differences (P≤0). The results were consistent with both [16]. The presence of significant differences in the concentrations of suspended matter at the sampling site may be due to the fact that the proportion of suspended matter in river water is affected by a range of factors, including the distance between the site and the previous site, as suspended particles, including clay, increase directly with the increase in the length of the riverbed, and the nature of these substances is affected by distance as well as by the speed of the river flow and hydrological conditions represented by the meandering of the riverbed, changes in cross sections and engineering constructions (dams and reservoirs) along the riverbed [17]. The correlation coefficient recorded a negative correlation between suspended matter and pH (0.414-r=), which may be attributed to the fact that some of the total suspended matter is organic matter resulting from the activity of organisms such as fish, algae and bacteria, which can be decomposed in the presence of dissolved oxygen.

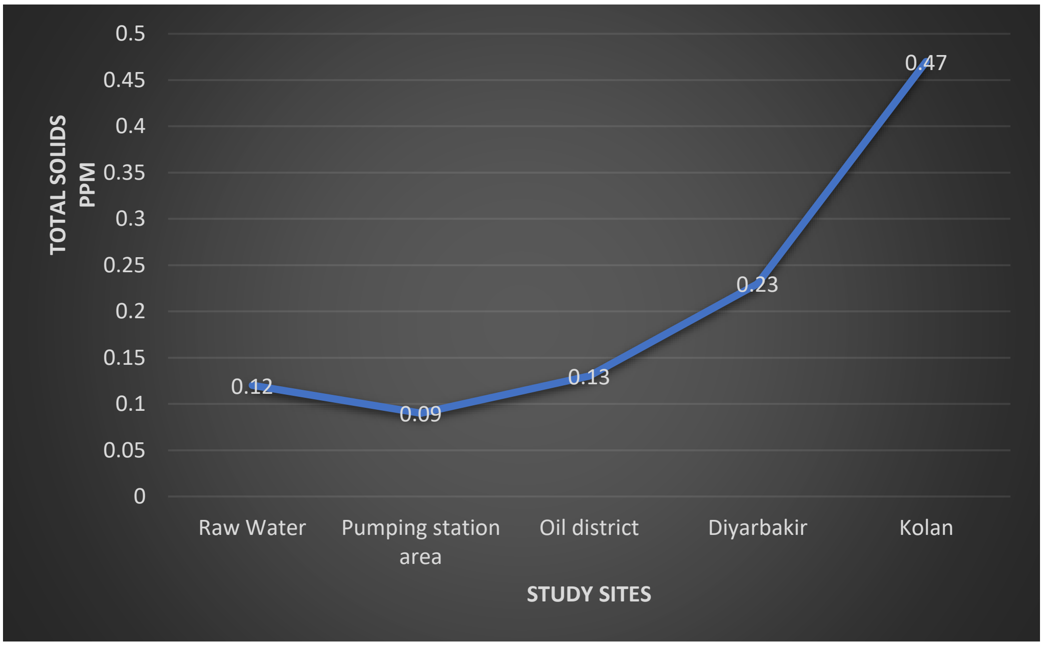

Figure 3. Total Dissolved Solids Levels at the Study Sites

Total Basal Area

The results of the statistical analysis as shown in the Table 1 and Figure 4, the results indicate documented that there were no significant differences ($P \leq 0.05$) between the means of total base relative to the sampling locations, while significant differences ($P \leq 0.05$) were recorded relative to the sampling dates. The range was in accordance with the Iraqi standards as well as the World Health Organization (WHO) standards (Appendix 1 Iraqi or WHO standards for drinking water). Our study came in conflict with the study of [18]. Where the range of basicity ranged between (240-145 mg/L) for the Tigris River in the city of Mosul. The reason for the high basicity is the high concentration of organic matter consumed by microorganisms in aerobic decomposition and results in carbon dioxide gas that changes the properties of the water medium that results in dissolved carbonic acid as well as bicarbonate and carbonate ions, as in the following equations:

$CO_2 + H_2O$

$CO_2 + H_2O \rightleftharpoons H_2CO_3$

$HCO_3 + CaCO_3 \rightleftharpoons Ca\,(HCO_3)_2$

H2CO3 dissolves CaCO3 from the basal deposits of the source and converts it into less water-soluble bicarbonate compounds. The correlation coefficient recorded a significant positive correlation at a significant level ($P \leq 0.01$) between the averages of total basicity and electrical conductivity values (r = 0.589), total hardness values (r = 0.527) and calcium hardness (r = 0.579) and with chloride values (r = 0. 565) The correlation coefficient documented a significant positive correlation at a significant level ($P \leq 0.05$) between the averages of total basicity and chloride (r=0.362) and pH (r=0.458) and a negative correlation was observed between total basicity and total nitrogen (r=0.386).

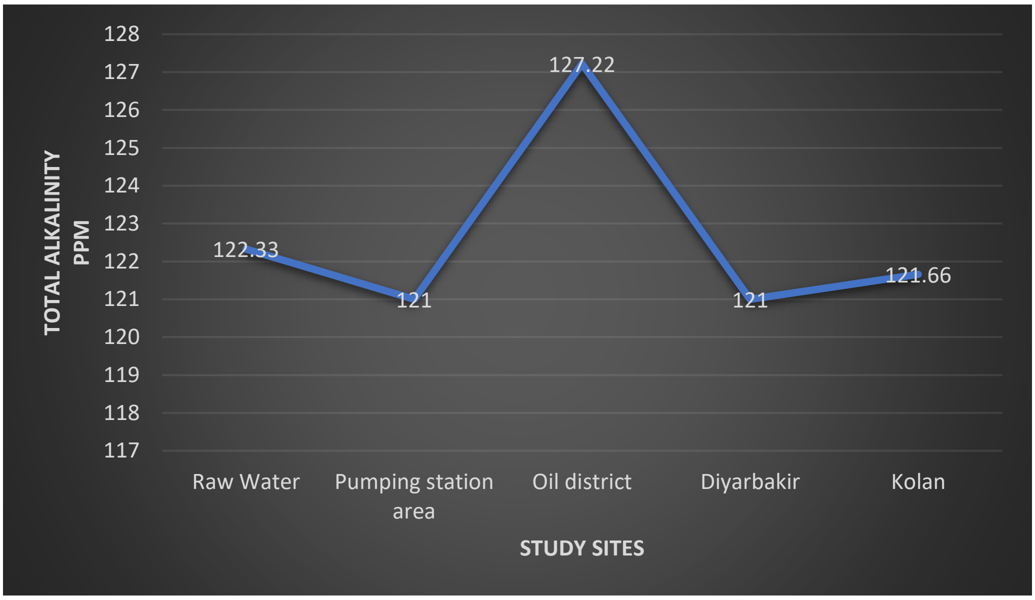

Figure 4. Total Alkalinity Levels at the Study Sites

Total Hardness

The results of the statistical analysis documented that the mean values of the total hardness of water in all sites did not register no significant differences (at a significant level $P \leq 0.05$), while significant differences were recorded relative to the dates of sample collection as shown in the Table 1 and Figure 5, the results indicate The reason for the increase in hardness at some sampling times may be attributed to the fact that the water in the Zab River was affected by rainfall, especially in March, where the Upper Zab areas experienced large amounts of rainfall in this month.

The correlation coefficient recorded a negative correlation at a significant level ($P>0.01$) with the averages of total hardness and total base (r=-0.527), calcium hardness (r=-0.579) and magnesium (r=-0.834). 834) The reason for the increased levels of total hardness in water may be due to the presence of calcium ions and magnesium ions in large quantities as a result or due to the nature of the lands that make up the river basin, which are of a calcareous nature when water hardness is formed [19] and the correlation coefficient recorded a significant correlation at a significant level (P≤ 0.01) between total hardness and chloride (r = 0.711) and a negative correlation was observed between total hardness and total nitrogen (r = 0.655). The results of our study were lower than those recorded by [10], which ranged between (310-235) mg/liter in Ninewa.

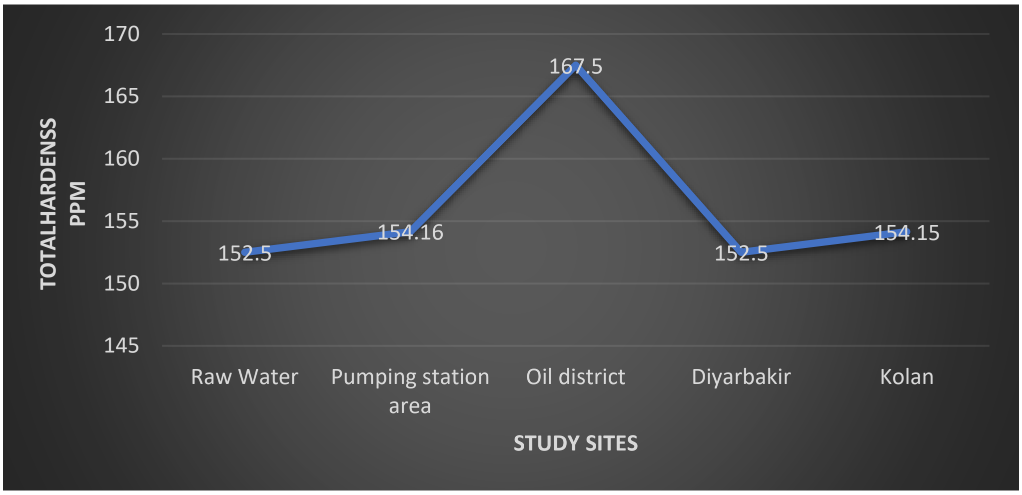

Figure 5. Total Hardness Levels at the Study Sites

Calcium Hardness

The results of the statistical analysis showed that there were no significant differences (P≤ 0.05) between the mean values of calcium hardness relative to the areas of sample collection and the dates of sample collection as show in the Table 1 and Figure 6, the results indicate. The values of calcium hardness were within the permissible limit according to international and Iraqi water standards. The nature of the recorded values may be attributed to the geological nature of the land and the riverbed, which is a major source of calcium ions in the river water used to produce potable water [20]. The correlation coefficient recorded a significant correlation (P ≤ 0.01) between calcium hardness and total base averages (r = 0.579) with total hardness values (r = 0.909) and magnesium hardness (r = 0.527) as well as with chloride values (r = 0. 738) and negatively correlated with total nitrogen values (r=0.678). This may be attributed to the competition of nitrate ions with other negative ions to form stable salts with calcium ions available in the Zab River water. The results of our study recorded lower values than those of [21] in the Tigris River in the city of Tikrit in Salahuddin Governorate, which ranged between (280-218.5 mg/L.

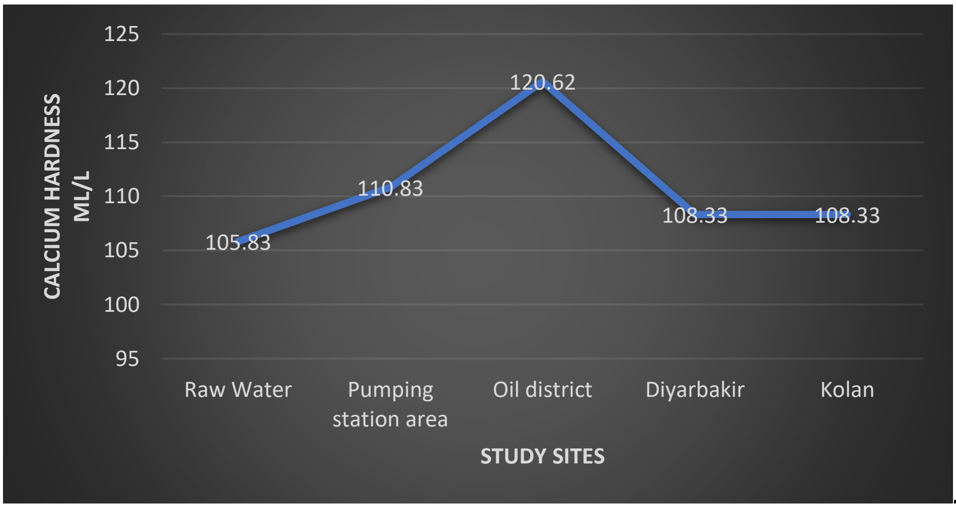

Figure 6. Calcium Hardness Levels at the Study Sites

Magnesium Hardness

The results of the statistical analysis as shown in the Table 1 and Figure 7, the results indicate documented that there were no significant differences (P≤ 0. 05) between the magnesium hardness averages relative to the sample collection areas, while significant differences were documented relative to the dates of sample collection. Upon observation, we find that magnesium values were not affected by the filtration stages, on the contrary, they were increased in some sites, and this may be due to the age of water distribution networks, some of which may reach 60 years old, which causes the accumulation of large amounts of sediment in them, which may increase magnesium hardness values in addition to other ion values, and this is clear when comparing magnesium hardness values in the first site with its value in the second site (sedimentation basins), The reason for this increase may be the impurities that formed with chloride and showed that the traditional filtration stage of drinking water is unable to remove the amount of salts from the water, including magnesium [20].

The correlation coefficient recorded a significant correlation at a significant level (P>0.01) between the average magnesium hardness values and total hardness values (r=0.834) and calcium hardness values (r=0.527) and calcium hardness values (r=0.471). 471) the correlation coefficient recorded a positive significant correlation at the 0.05 level (P ≤ 0. (r=0.365) and pH (P≤0.404) and the correlation coefficient recorded a negative correlation at a significant level (P>0.05). The results of our study were close to the results of (29), which r=-0.437.) Within the Iraqi specifications for drinking water No. 417 in 1989, which ranged between (50-25) mg/liter. In Zab River in Hawija district of Kirkuk governorate and lower than [22] which ranged between (112-12) mg/L in Tigris River in Salah al-Din governorate.

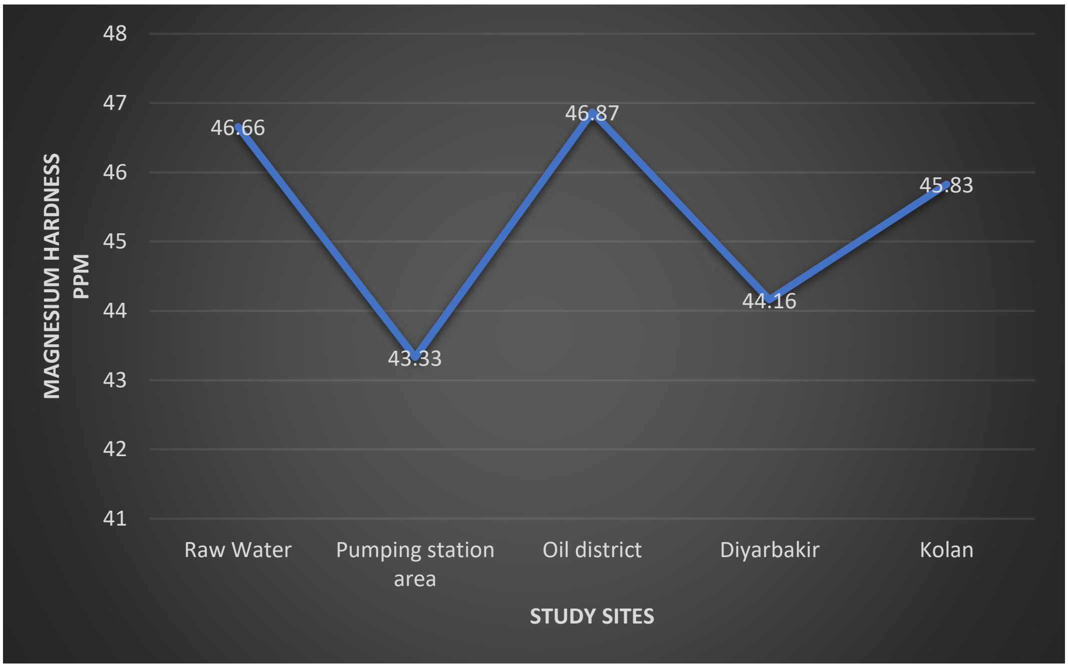

Figure 7. Magnesium Hardness Levels at the Study Sites

Chloride

The results of the statistical analysis as shown in the Table 1 and Figure 8, the results indicatedocumented the existence of significant differences (P≤0.05) between the chloride averages relative to the sample collection sites, where the first and second sites are the lowest sites containing chloride values, while the fourth, fifth and third sites are the highest sites due to the chlorine gas to the water after treatment with alum. The difference in the concentrations of chloride values at the sampling sites may be due to the deposition of chlorine in the collection basin and also due to the age of the distribution network, which may increase chloride in the form of potassium salts [11]. The results documented that chloride values increase at the third site where chloride is added at the third site, as chloride is used as it is known to disinfect and purify water from algae, plankton, bacteria and other microscopic microorganisms.

The correlation coefficient recorded a positive significant correlation at a significant level ($P \leq 0.01$) between chloride and total basicity values ($r = 0.565$) and total hardness values ($r = 0.711$) and calcium hardness ($r = 0.738$) and a positive correlation between chloride and magnesium hardness ($r = 0.471$) and a negative correlation with total nitrogen ($r = 0.381$), which may be attributed to the competition of nitrate ions with other toxic ions.

This may be attributed to the competition of nitrate ions with other negative ions (bicarbonate _ carbonate) to form stable salts with calcium ions available in the Zab River water which is documented by the correlation coefficient with its negative value of 0.471 _ at a significant level $P \leq 0.05$. The results of our study are close to the study of [23], which ranged between (39.9-5.9) mg/l. It is lower than the study of (38), which ranged between (39.9-5.9) mg/l. and [10] in Aysar Al-Qadim of Mosul city (30.0-60.0 mg/liter).

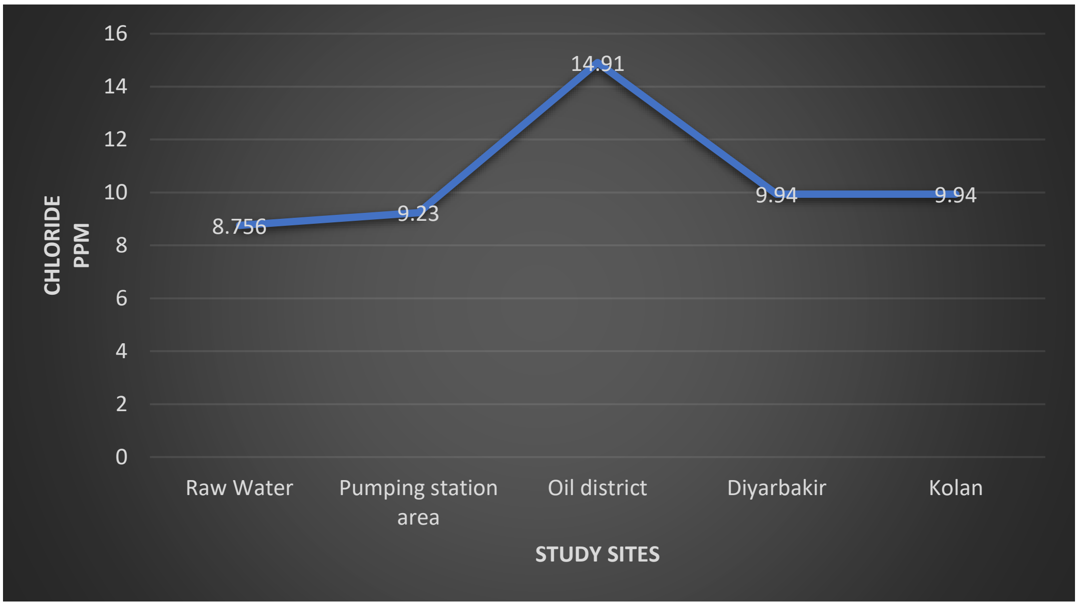

Figure 8. Chloride Levels at the Study Sites

Total Nitrogen

The results of the statistical analysis as shown in the Table 1 and Figure 9, the results indicate documented that there were no significant differences between the mean values of total nitrogen at the level of ($P \leq 0.05$) relative to the sampling locations, while it was documented relative to the dates of collection samples. The change in total nitrogen levels in the water may be attributed to the rains that wash away the soil containing fertilizer residues and thus increase the level of total nitrogen in the water as well as the lack of nitrogen consumption by plant organisms in the winter season may lead to an increase in total nitrogen levels in the water [4].

The correlation coefficient recorded a negative correlation between total nitrogen values at a standardized level ($P \leq 0.01$) and total hardness values ($r = 0.655$) and calcium hardness ($r = 0.678$) and a positive correlation was observed between its values and total phosphorus values ($r = 0.519$) and a positive correlation was observed between its values and total phosphorus values (r = 0. The correlation coefficient recorded a negative significant correlation at a significant level ($P \leq 0.05$) between total nitrogen values and total base values ($r = 0.386$) and magnesium hardness ($r = 0.437$) and with chloride values ($r = 0.381$). The results of our study were lower than that of [24] between 1.01-0.24 mg/liter in the Lower Zab River in Hawija district of Kirkuk city.

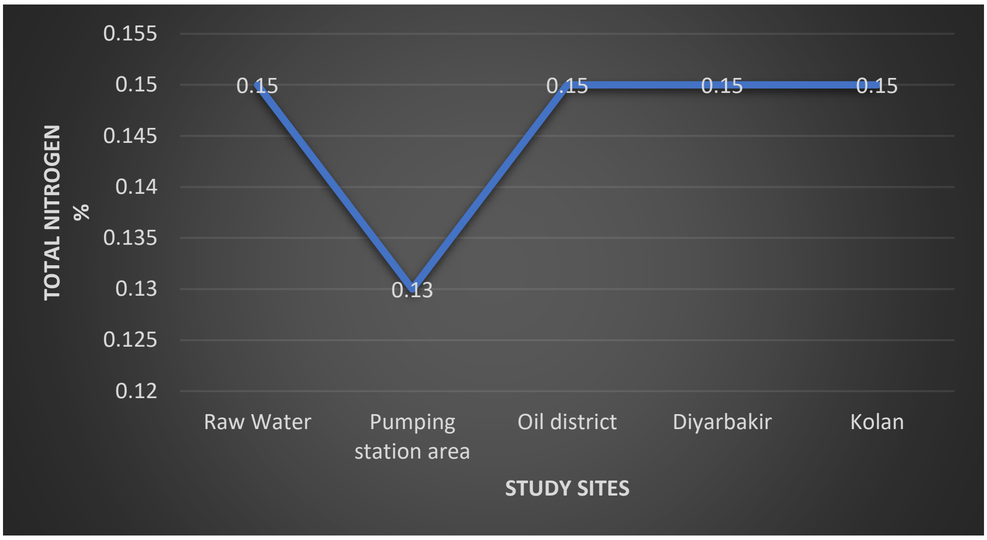

Figure 9. Total Nitrogen Levels at the Study Sites

Total Phosphorus

The results of the statistical analysis as shown in the Table 1 and Figure 10, the results indicate documented that there were no significant differences at a significant level ($P \leq 0.05$) for sample collection sites and sample collection dates. Correlation coefficient. There was a significant positive correlation at ($P \leq 0.01$) between the average values of available phosphorus and total nitrogen ($r = 0.519$), and the results of our study were lower than those of [24], which ranged between 0.27-0.4 mg/liter in the influence of physical and chemical properties of the lower Zab River water in the Tigris River.

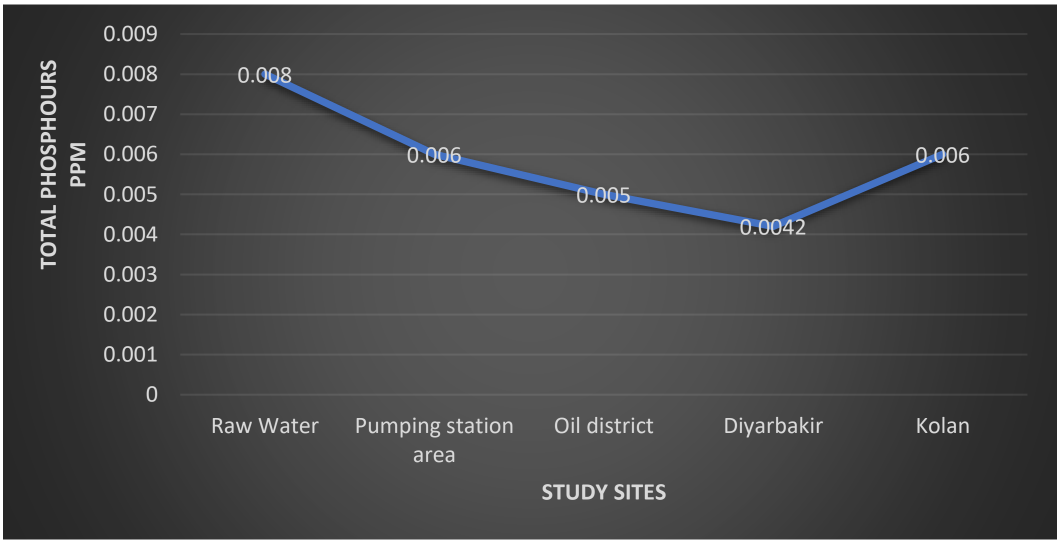

Figure 10. Total Phosphorus Levels at the Study Sites

5. CONCLUSION

We conclude that most of the physical properties fall within the permissible limits in accordance with the Iraqi and international specifications of drinking water, which indicates an initial efficiency in physical therapy operations at the liqueum station. The chemical analyzes of the plant water showed that the concentrations of elements such as chlorine, calcium, and magnesium were within the standard limits, indicating the effectiveness of chemical treatments at the station. The results indicate that the efficiency of the treatment at the molasses station is generally acceptable, but it may need to develop or maintain some processing units to maintain water quality continuously. The study recommends the need to enhance technical control, and to update filtration and sterilization systems in line with environmental and seasonal changes that may affect water quality.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Omar Taha Mahmoud Altaie		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓
Rushdi Sabah Abdul Qader	✓	✓		✓		✓		✓	✓	✓	✓	✓	✓	✓
Ahmed Abdulnaser Abdulla	✓		✓	✓		✓			✓		✓		✓	✓

C : **C**onceptualization	I : **I**nvestigation	Vi : **Vi**sualization
M : **M**ethodology	R : **R**esources	Su : **Su**pervision
So : **So**ftware	D : **D**ata Curation	P : **P**roject administration
Va : **Va**lidation	O : Writing - **O**riginal Draft	Fu : **Fu**nding acquisition
Fo : **Fo**rmal analysis	E : Writing - Review & **E**diting	

Conflict of Interest Statement

The authors confirm that there are no conflicts of interest associated with this research, its results, or its publication in any form.

Informed Consent

Official approvals were obtained from the relevant authorities prior to conducting the study, which aimed to assess the physical and chemical properties of drinking water in the Dibis District. All research procedures were carried out in accordance with the ethical and professional standards approved for environmental studies, and in compliance with national and international guidelines related to the collection and analysis of water samples.

Ethical Approval

Ethical approval was obtained from the Ethics Committee at the University of Kirkuk to conduct this study, which aims to assess the physical and chemical properties of drinking water in the Dibis District. All ethical guidelines and approved scientific standards were followed to ensure the accuracy of the results and the integrity of the procedures used in the collection and analysis of water samples.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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