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Research Article

# Temporal And Spatial Changes of Some Indicators of The Water Quality of The Tigris Within Nineveh Governorate/ Iraq

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**Abstract**

Three sites along the Tigris, stretching from the Mosul Dam Lake to the Qayyarah neighborhood, were chosen to collect water samples in order to determine the Tigris' water quality. The research lasted six months (September 2020-February 2021). Physical and chemical parameters exhibited local and temporal alterations, but they were consistent with all previous studies findings, that the Tigris water is alkaline, with the exception of a value of (171) NTU reported in November, when the turbidity ranged between (0.54) and (9.6), putting it in the category of excellent water in terms of suspended matter. The total dissolved solids findings revealed an increase in value as moving south. The water of the Tigris River, on the other hand, is classified as extremely hard, with total hardness ratings higher than those reported prior to the dam's construction in the early 1980s. In terms of plant nutrients, the current study found that sulfate, nitrate, and orthophosphate levels fluctuated due to pressure from a variety of domestic, agricultural, and industrial sources, as well as seasonal variations.

**Keywords**

Tigris, Water Quality, Mosul Dam Lake, Plant Nutrients.

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# Introduction

The Tigris' poor water quality, both quantitatively and qualitatively, is due to a number of factors, including the impact of development projects in the river basin, sewage water, drought, a large number of household pollutants along the river's course, and an increase in salinity, which was observed to rise from (0.5) decimens in Mosul to (5.0) decimens at Qurna (Mohammed & Iktami, 2016).
It is worth mentioning that Salinity is increasing in southern Iraq, according to (S. O. Hamad, 2015), who also stated that Tigris water is better than Euphrates water due to the presence of a group of tributaries that feed the Tigris inside Iraqi territory, such as the Upper and Lower Zab, and the Khazir River., on the other hand, The geological nature of the basin and valley of the river on which the water runs has an impact on the Tigris' water. This was reflected in a variety of parameters, including hardness, which ranged from (94 to 284) mg/liter, (Mahmood, Abudl-Jabar, & Kharnob, 2018) Many studies have found that the Tigris River's water is classed as very hard, such as the study (Yasin, 2018), which also found that turbidity produced primarily by contaminants that enter the river channel with heavy rainwater can exceed (31.5) turbidity unit during the rainy season. In the same way, the geology of the Tigris has an impact on the value of the river water's acidity function. The water of the Tigris, according to most research, is close to alkaline (Basat and Hassan, 2016;) (Alkam & Yassir, 2015)
One of the most important factors for the variation of dissolved oxygen in the Tigris water is the large volume of organic matter and the high-water temperature, especially in the summer. The dissolved oxygen levels dropped to (0.0) mg/liter, according to Abdul-Aziz Y Al-Saffawi and Talat (2018).
It was discovered that the value of plant nutrients is influenced by a variety of factors, some of which are natural and others which are produced by human activity. It was discovered that nitrate concentrations in the winter are higher than in the other seasons. This is due to the fact that it is not reduced to nitrite, as well as low temperatures, sufficient ventilation, and low phytoplankton consumption. (Jabbar & Al-Hassany, 2018) Phosphate concentrations climbed to (5.11) mg/liter. In the waste delivered by the Qara Saray estuary to the Tigris River, the concentration of sulfate ions reached (245) mg/liter. (Abdul-Aziz Y Al-Saffawi & Talat, 2018).
The elements that influence Tigris water quality, as is widely known, are also subject to seasonal fluctuations. The dry season had the lowest pH, nitrite, and dissolved oxygen values, according to (Al-Ani, Al Obaidy, & Hassan, 2019). While the values of a number of other parameters, such as turbidity, total dissolved salts, total and basic hardness, increased during the rainy season, turbidity, total dissolved salts, total and basic hardness, and dissolved oxygen are only a few examples. (Alkam & Yassir, 2015; Hassan, Al-Zubaidi, & Youssef, 2018) The study's goal is to determine the water quality of the Tigris River in the area stretching from the Mosul Dam Lake to the Qayyarah neighborhood.

# Materials And Working Methods:

## Sample Collection:

Water samples were collected for six months (September 2020-February 2021) from three places along the Tigris River, as illustrated in Figure (1), in the section spanning from Mosul Dam Lake to Qayyarah District:

1. The first location is the Mosul Dam's main lake.
2. Second location: within Mosul, near the old bridge.
3. Third location: At Qayyarah, near Qayyarah Water Station, Al-Shura, Tel Abtah Al-Muwahed.

Following the transfer of the water samples to the laboratory in two-liter plastic bottles, a number of physical and chemical tests were performed on them using the standard methods indicated by Snowden (2003), including: Cl-chlorides, T.D.S., total hardness (TH), Calcium hardness (Ca Hard), magnesium hardness (Mg Hard), turbidity, dissolved oxygen (Do), sulfate (So4), and nitrate (Nit) are some of the parameters that can be measured (No3). -) phosphorus, and (Po4) The pH function of water, as well as the temperature of air and water, were all measured in the field.

# Results and Discussion

## Water Temperature

Temperature affects all physical and chemical processes and transformations in the aquatic environment, including the dissolution of oxygen and carbon dioxide, as well as the toxicity of some compounds. (de Oliveira, de Rezende, de Fonseca, & Libanio, 2019).

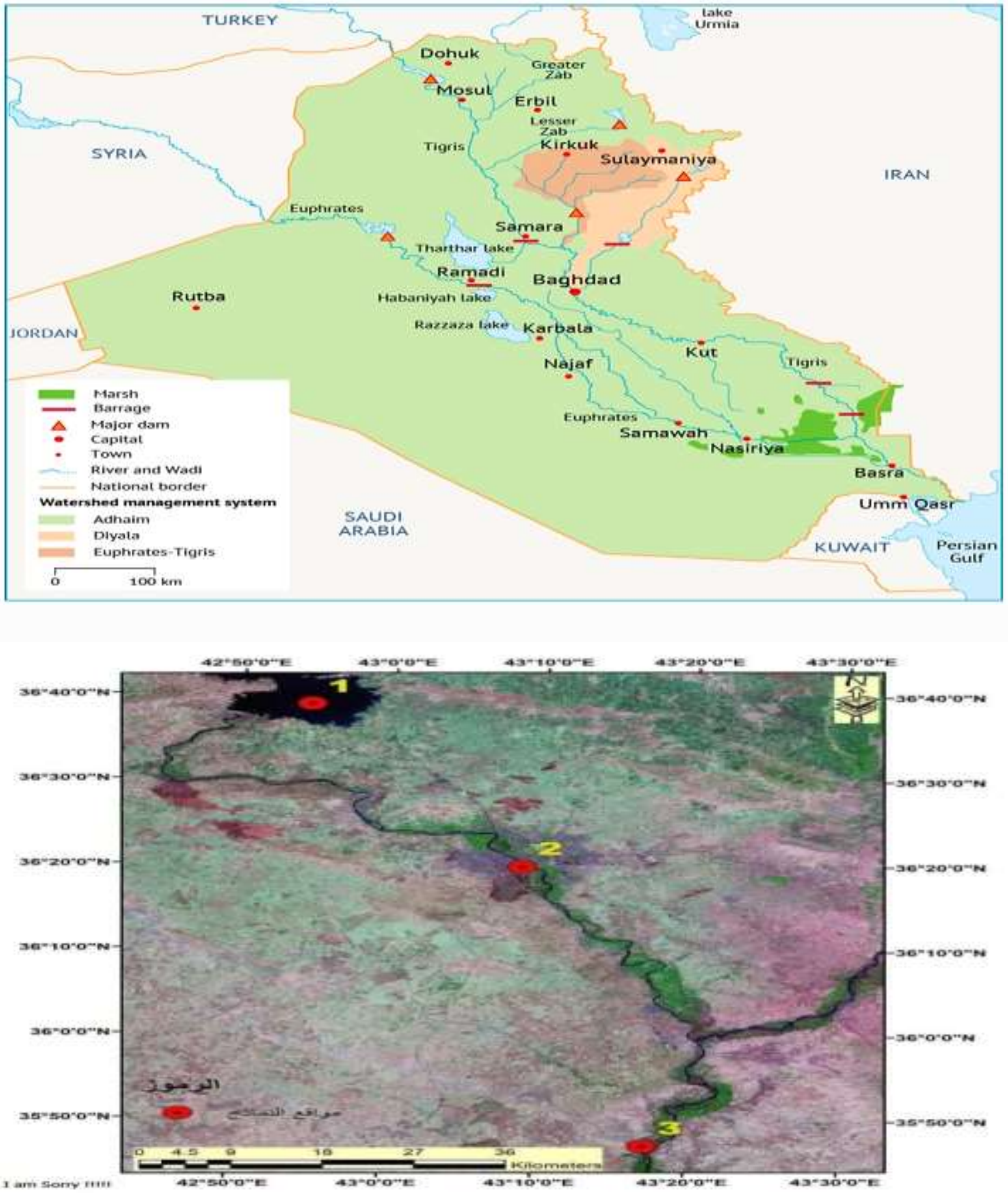


**Figure (1)** A- Map, B- Aerial: The Study Area and The Sampling Site

Tables (1) and (2) show that the water temperature at the study sites varied between 12.5 and 15.2 degrees Celsius. The lowest temperature (12.5 degrees Celsius) was recorded at the first site in January, while the highest temperature (25.2 degrees Celsius) was recorded at the first site in September. It is worth noting that for the same geographical location, the temperature of still water is higher than the temperature of running water (Abdul-Aziz YT Al-Saffawi & Al-Maathi, 2017), and this is what was observed in the current study, where the current water temperature at the first site was higher than those at the second and third stations. In general, the current study's findings are consistent with many other studies on the Tigris River's cross-section in Nineveh Governorate, including as (Abdul-Aziz Y Al-Saffawi & Talat, 2018).

## Acidity Function: pH

During the current investigation, the maximum value of the pH function was recorded at the first site, which reached (8.8) in Table (1) in October, whereas the lowest value (8) was observed at the second site in September and October. With regard to the low pH values recorded throughout this study, it should be noted that the acid function values are related to the water temperature, as high temperatures increase the effectiveness of microorganisms decomposing organic materials, lowering the value of the acidic function as a result of the liberation of some acidic nitrate compounds. (AL-Mashhadany, 2019). In light of the foregoing, the lower pH values reported at the second site compared to the first site could be the result of the massive volume of household and industrial waste discharged in the river nearby.
The current study's findings are similar to previous ones in that the presence of carbonate and bicarbonate ions affects the basic nature of Tigris water, although the pH levels do not exceed the minimum value. According to Sissakian, Al-Ansari, Adamo, Knutsson, and Laue (2018) in a study on the Tigris between Mosul Dam and Qayyarah, the river water varies between neutral and alkaline, with pH levels ranging between 7.0 and 8.0. (8.12-7.33).

## Dissolved Oxygen

Throughout the current study, the third site had the highest value of dissolved oxygen, reaching (9) mg/liter (table 2), and this was in January, which, as is well known, has cold temperatures, which helped increase the ability of water to carry oxygen in addition to the lack of biological activity that consumes oxygen, and this is what observed by Sissakian et al. (2018) on the section of Tigris under study, and although the increase in temperature contributes to increasing the dissolution of oxygen, it works in turn to reduce the ability of water to carry oxygen as well as increase the rate of respiration of living organisms. As a result, it's reasonable to assume that this factor is one of the explanations for the drop in dissolved oxygen to (6.8) mg/liter seen in this study. It's worth noting that the drop in dissolved oxygen values could be related to an increase in organic matter decomposition processes, resulting in increased oxygen demand by the studied species (Chourasia, 2018). The range (9-6.8) mg/l that was observed on the study sites, tables (1) and (2) indicates that the dissolved oxygen was greater than the value (5) mg/l determined by the World Health Organization. Besides, the results of the current study are close to (9.5-7.1) mg/L that was observed by N Fadhel (2013), but they differed from the results of the study by Karimzadeh and Matsuoka (2021), which indicated that the concentration of dissolved oxygen in the Tigris ranged between (7.7-4.5) mg/L.

## Turbidity:

As a result, it's reasonable to assume that this factor is one of the explanations for the drop in dissolved oxygen to (6.8) mg/liter seen in this study. It's worth noting that the drop in dissolved oxygen values could be related to an increase in organic matter decomposition processes, resulting in increased oxygen demand by the studied species, as well as the torrential rains that contribute to bringing large quantities of clay particles, thus raising the turbidity values of the river water during the rainy season. It should be mentioned that the low Tigris turbidity values in Nineveh Governorate are frequently influenced by the presence of the Mosul Dam lake, which plays a significant role in the sedimentation of suspended material (Al-Mandel, 2005), in addition to the

decrease in water flow velocity during the summer as a result of the low water levels of the Tigris, the results of the turbidity recorded during the current study are much higher than the range ( 10.1-2.92) NTU observed (Karimzadeh & Matsuoka, 2021).
Except for the value of 171 NTU which was observed at the third site during November and caused by rainfall before the day of sampling in that month, it was noted that the turbidity range of the water of the Tigris is (0.54 - 9.6) NTU, and accordingly, the water of the Tigris under study can be described as being within the category of excellent water in terms of turbidity values, according to (Li et al., 2021).

## Total Dissolved Solid TDS

TDS values increased southward throughout the entire investigation, with the highest values rising from 305 mg/liter at the first site in September 2020 to (741) mg/liter at the third site, as shown in Tables (1) and (2). (2). (Vanderploeg et al., 2009) detected a rise in total dissolved salts in the river as it moved south, indicating that this is related to soil qualities as well as the cumulative influence of agricultural, industrial, and domestic wastes deposited into the river.
The lowest total dissolved salts concentration was (240) mg/L at the first site in January, and this result can be explained by Laskar and Gupta (2009), who concluded that the decrease in TDS concentration is due to dilution caused by rising water levels due to rainfall and an increase in flow speed, which leads to mixing water and the occurrence of dilution operations.

## Total Hardness TH

Table shows that the third site had the highest hardness values (2). During November, total hardness, calcium hardness, and magnesium hardness all reached (360, 192, 168, respectively). It is noted that these results agree with some previous studies that were conducted on the Tigris more than (15) years ago, such as the study of (H Jankeer & H Mustafa, 2007) and (A. Y. Al-Saffawi, Al-Shanoona, & Alobidy, 2021). The values of total hardship are higher than those obtained prior to the dam's completion, which varied between (198 and 206) mg / liter (Mustafa, 2000). Evaporation processes may play a role in enhancing the hardness values by confining water behind the dam's body. In addition to that, the increase in civil and agricultural activity and its consequences of dumping liquid wastes into the river and the dissolution of gypsum and limestone rocks by the action of river water or by rain are among the most important factors for increasing water hardness in the Tigris River (N Fadhel, 2013). During October, the lowest hardness concentration was (120) mg/l at the first site. The union of hardness-causing ions such as calcium with phosphorous ions dissolved in water, generating stable compounds, may be responsible for the decrease in hardness levels in water. (A. I. Hamad & Abduljabar).
The findings of the study agree with the findings of (S Al-Sarraj, H Jankeer, & M Al-Rawi, 2014) in their study of some indicators of Tigris water quality in Mosul, where average total hardness values ranged between (192 and 294) mg / liter, and the waters of the Tigris River are classified as very hard according to (Skalny, Salnikova, Burtseva, Skalnaya, & Tinkov, 2019).

## Chloride $Cl^-$

Tables (1) and (2) reveal that chloride values in the three sites ranged from (39.9-5.9) mg/L, with the greatest value recorded in November at the third site and the lowest value reported in October at the first site. Tables (1) and (2) reveal that chloride values in the three sites ranged from (39.9-5.9) mg/L, with the greatest value recorded in November at the third site and the lowest value reported in October at the first site. The results of the current study are close to the range (33-13.8) mg / liter which was observed by Sissakian et al. (2018) when studying the water of the Tigris within Nineveh Governorate. It's worth mentioning that the highest figure found in this study is twice the amount of chloride found on the Tigris in the early 1970s, when (H Jankeer & H Mustafa, 2007) reported that chloride concentrations on the Tigris didn't surpass (20) mg/liter.

## Sulfates SO4

Throughout the current study, the concentrations of sulfate changed in space and time, as shown in tables (1) and (2). (2). The highest concentration (97 mg/liter) was found at the third location in

September, while the lowest (46.7 mg/liter) was found at the first site in December. First, the results of sulfates indicate an increase in their values towards the south, as the values ranged (79.7,46.7) mg/L in the first site, while its range reached (92-55.7) mg/L in the second site and (97-69.2) mg/L in the third site. The readings rate was also an indication of that increase, as it reached a range of (85.1-78.7) mg/L in the sites under study, respectively.

The amount of sulfate in the Tigris has increased during the last four decades, according to prior studies. The increase in sulfate values may be attributable to the usage of sulfuric acid in reactivating batteries, according to a study by H Jankeer and H Mustafa (2007) on the water of the Tigris in Mosul, and also due to the nature the geology of the riverbed (M Ezzat, M Mahdy, H Abd El Shakour, & A El-Bahnasawy, 2012) and the increase in the amount of industrial and agricultural wastes that reach the riverbed either by rain water or through wastewater carrying channels (Al-Sarraj, 2019).

**Table (1)**

Physical and Chemical Factors in The First and Second Sites During the Period of Study

| First Site | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Phosphorous mg/l | Nitrates mg/l | Sulfate mg/l | Magnesium Hardness mg/l | Calcium Hardness mg/l | Total Hardness mg/l | Dissolved Oxygen mg/l | Turbidity NTU | mg/l Chlorides | T.D.s mg/l | PH | Temperature | Period of Study | |
| | | | | | | | | | | | | Months of Sample Collection | Year |
| 1.7 | 0.02 | 58 | 51 | 115 | 166 | 7.2 | 1.32 | 10 | 305 | 8.5 | 25.2 | September | |
| 1.4 | 0.045 | 79.74 | 16 | 104 | 120 | 8.4 | 4.7 | 5.99 | 266 | 8.8 | 24 | October | 2020 |
| 1.25 | 0.046 | 55.73 | 40 | 120 | 160 | 8.2 | 1.21 | 7.99 | 268 | 8.1 | 18.5 | December | |
| 0.054 | 0.022 | 46.7 | 20 | 120 | 140 | 8.8 | 1.8 | 7.99 | 273 | 8.5 | 15.6 | November | |
| 0.119 | 0.004 | 63.88 | 12 | 120 | 132 | 7.6 | 1.14 | 11.9 | 240 | 8.5 | 12.5 | January | 2021 |
| 0.05 | 0.018 | 67.4 | 20 | 132 | 152 | 7.5 | 0.45 | 8.99 | 273 | 8.5 | 13 | Fabruary | |
| 0.05 | 0.004 | 46.7 | 12 | 104 | 120 | 7.2 | 0.45 | 5.99 | 240 | 8.1 | 12.5 | min | |
| 1.7 | 0.046 | 79.74 | 51 | 132 | 166 | 8.8 | 4.7 | 11.9 | 305 | 8.8 | 25.2 | max | |
| 0.762167 | 0.0258 | 61.91 | 26.50 | 118.50 | 145 | 7.95 | 1.77 | 8.83 | 270.83 | 8.48 | 18.13333 | mean | |
| Second Site | | | | | | | | | | | | | |
| Phosphorous mg/l | Nitrates mg/l | Sulfate mg/l | Magnesium Hardness mg/l | Calcium Hardness mg/l | Total Hardness mg/l | Dissolved Oxygen mg/l | Turbidity NTU | mg/l Chlorides | T.D.s mg/l | PH | Temperature | Period of Study | |
| | | | | | | | | | | | | Months of Sample Collection | Year |
| 1.6 | 0.03 | 92 | 40 | 140 | 180 | 6.8 | 2.15 | 12 | 306 | 8.1 | 23 | September | 2020 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.35 | 0.041 | 74.23 | 42 | 114 | 156 | 8 | 0.93 | 9.99 | 272 | 8.1 | 20 | October | |
| 2.142 | 0.023 | 55.73 | 104 | 108 | 212 | 8.4 | 3.72 | 23.99 | 308 | 8.1 | 18 | December | |
| 0.041 | 0.02 | 68.73 | 72 | 128 | 192 | 8.4 | 0.85 | 9.99 | 324 | 8.2 | 13.8 | November | |
| 0.0353 | 0.041 | 91.86 | 22 | 142 | 164 | 8.4 | 1.6 | 14.99 | 309 | 8.4 | 12.5 | January | 2021 |
| 0.03 | 0.015 | 89.65 | 14 | 142 | 156 | 8.4 | 2.61 | 15.99 | 319 | 8.4 | 12 | Fabruary | |
| 0.03 | 0.015 | 55.73 | 14 | 108 | 156 | 6.8 | 0.85 | 9.99 | 272 | 8.1 | 12 | min | |
| 2.142 | 0.041 | 92 | 104 | 142 | 212 | 8.4 | 3.72 | 23.99 | 324 | 8.4 | 23 | max | |
| 0.87 | 0.03 | 78.70 | 49.00 | 129.00 | 176.67 | 8.07 | 1.98 | 14.49 | 306.33 | 8.22 | 16.55 | mean | |

Third Site

| Phosphorous mg/l | Nitrates mg/l | Sulfate mg/l | Magnesium | Calcium Hardness mg/l | Total Hardness mg/l | Dissolved Oxygen mg/l | Turbidity NTU | Chlorides mg/l | T.D.s mg/l | PH | Temperature | Period of Study | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Months of Sample Collection | Year |
| 1.1 | 0.021 | 97 | 80 | 90.00 | 170 | 7 | 1.66 | 12 | 319 | 8.4 | 23 | September | |
| 1.03 | 0.064 | 89.9 | 65 | 130 | 195 | 7.4 | 3.52 | 13.99 | 333 | 8.4 | 20 | October | 2020 |
| 1.428 | 0.009 | 87.23 | 168 | 192 | 360 | 8 | 171 | 39.98 | 741 | 8.4 | 15 | December | |
| 0.033 | 0.027 | 77.54 | 76 | 140 | 216 | 8.6 | 1.73 | 17.99 | 315 | 8.4 | 11.5 | November | |
| 0.0707 | 0.012 | 89.65 | 48 | 148 | 196 | 9 | 9.6 | 18.99 | 319 | 8.5 | 10.5 | January | 2021 |
| 0.06 | 0.024 | 69.17 | 26 | 138 | 164 | 8.6 | 7.75 | 13.99 | 298 | 8.4 | 12.1 | Fabruary | |
| 0.033 | 0.009 | 69.17 | 26 | 90 | 164 | 7 | 1.66 | 12 | 298 | 8.4 | 10.5 | min | |
| 1.428 | 0.064 | 97 | 168 | 192 | 360 | 9 | 171 | 39.98 | 741 | 8.5 | 23 | max | |
| 0.62 | 0.03 | 85.08 | 77.17 | 139.67 | 216.83 | 8.10 | 32.54 | 19.49 | 387.50 | 8.42 | 15.35 | mean | |

**Table (1)** Physical and Chemical Factors in The First and Second Sites During the Period of Study

## NO3 Nitrate

Nitrate values in the current investigation ranged from (0.004-0.064) mg/L. The maximum nitrate content (0.064 mg/L) was found at the third location in October, while the lowest was found at the first site in January. The effect of nitrate concentrations on sewage water from the city, agricultural fertilizers, and container fertilizers may be causing this volatility in nitrate readings. The more of these compounds there are, the higher the level of nitrates in the water. (Al-Shanona, Al-Assaf, & Al-Saffawi, 2020), although (D Meshhadani & Jassim, 2012) have indicated that the concentration of nitrates increases with the flow of the river southwards. The average readings in this study ranged from 0.026 to 0.028 mg/liter, with the highest concentrations observed in October and November 2020. Then it began to decline in the study areas, which could be attributed to a lack of rainfall in 2021, and thus a lack of nitrogen compounds from nearby agricultural fields reaching the river's path, as determined by the researchers (Sissakian et al., 2018), who noticed an increase in nitrate concentration rates with the high flow of the river during spring and its decrease during the summer season.

Tables (1) and (2) show that the highest value of phosphate reached (2.142) mg/l during November at the second site, which is under effect a group of estuaries which are contaminated by domestic, agricultural and industrial pollutants especially, washing powder and detergents that contain multi-phosphorous compounds such as Tripolyphosphate which interacts with water forming phosphate ions (Abdul-Aziz Y Al-Saffawi & Talat, 2018).

The lowest concentration of phosphate (0.03) mg/L, was recorded in the second site during February. Phosphorous values decrease in Tigris can be attributed to various factors such as the tendency of phosphate to precipitate forming calcium phosphate, in addition to aquatic plants consumption, such as phytoplankton, which absorbs large amounts of phosphorous in their bodies. As a result, it is found that phosphate concentrations often range between (0.005 and 0.02) mg. / L. The range (0.03-2.142) mg / L that was recorded through the current study is higher than the range (0.0519-0.027) that was observed by Sissakian et al. (2018) while it was nearly two times lower than the range (1.41-5.11) recorded by Abdul-Aziz Y Al-Saffawi and Talat (2018) in their study on the Qara Saray estuary in Mosul.

# Conclusions

1- Tigris water can be classified among the excellent water in terms of turbidity values, with the exception of some cases that deal with torrential rain and rain.
2- Tigris water values are very hard to the extent that its hardness values are higher than those recorded before the construction of the Mosul Dam in the eighties of the last century.
3- The values of plant nutrients are not subjected to a certain pattern of changes, as they fluctuate due to their influence by a group of factors resulting from human activity.
4- The water is of alkaline nature and well aerated, where the dissolved oxygen values did not reach to the critical level specified by the World Health Organization.
5- The concentration of total salt increases towards the south of Mosul due to the cumulative effect of agricultural, industrial and domestic residues that were dumped into the river without treatment.

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