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Study of The Physical and Chemical Properties of The Waters of The Tigris and Lower Zab Rivers and Their Pollution With Heavy Elements

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Abstract: The study was carried out during the period between September 2024 and February 2025 in four stations and at a rate of once a month by three repeaters for each station, and the results of the average values of air temperature, water temperature, electrical conductivity, dissolved oxygen, vital requirement for oxygen, total hardness, calcium hardness, magnesium hardness, sulfate, chloride, magnesium, sodium, copper, zinc, lead and iron ranged between (18.83-24.55), (16.16-18.3), (345.3- 277.16), (7.461 - 12.443), (7.461-12.443), (3.04- 4.4383), (137.986 - 227.386), (74.3388 - 147.28716), (84.7445-64.563), (36.54-220.66), (25.1965 - 29.2215), (26.7141- 42.2178), (26.105 -32.7173), (0.115783_0.1587906),(0.08913- 0.1476), (0.0511 - 0.1230) , (0.0906 - 0.1463) respectively.

Keywords: Water, Quality, Parameter

1. Introduction

Water is the secret of life, and it is an essential element for all living organisms, and the importance of water lies in the fact that it enters the synthesis of living cells by 75-95% of the protoplasmic mass of each cell, and also enters the composition of various tissues of the human and animal body and plant components as none of the digestion and absorption processes take place without the aquatic medium (1) Waterborne diseases are widespread, with (2.5) billion people not receiving improved sanitation and more have died(3). of (1.5) million children each year as a result of diarrhea (2) and has been measured a set of physical and chemical properties in the waters of the Tigris and Lower Zab rivers, and explained (4) the effect of the Lower Zab River on the environment of the Tigris River in some physical and chemical qualities, which are of great importance in prosperity and biodiversity and properties with a high impact on water temperature as the temperature difference is caused by the difference in the seasons of the year And the difference in continental climate between summer and winter (5), and that the temperature of the water follows changes in air temperature and this is a natural phenomenon in an area located within a climate characterized by high temperature in .. (6) . Since water is a natural habitat for fish, it places great emphasis on its quality on the growth and presence of fish and assessing their impact on the environment(7). The term "water quality" is associated with the elements in water that play a crucial role in achieving the optimal growth of aquatic

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organisms. The level of water quality is affected by physical and chemical factors and the presence of heavy elements in the water, which also affects the presence, growth and reproduction of fish (8) as well as some heavy elements whose presence in the water is one of the dangerous indicators of water pollution and unsuitability for human use (9). As shown in the Hendron-River in India, the proportion of heavy elements in the water as a result of the discharge of large quantities of pesticides and chemicals in large quantities (10) Heavy metals include the basic elements of the needs of the human body, and include about thirteen elements, namely: silicon, vanadium, chromium, manganese, iron, cobalt, nickel, copper, zinc, arsenic, selenium, molybdenum, and iodine. These elements are necessary to meet the requirements of the chemical environment (11) and one of the advantages of heavy elements is that they are slow to decompose unlike the rest of the elements(12).

Some previous studies :(13) He pointed out that optimal fish production depends largely on the physical and chemical properties of the water available in Kirkuk. He also stressed (14) the importance of assessing the quality of water in wells in the Taza/Kirkuk area for drinking and human use. They pointed out that water should be hygienic and unpolluted.(15) evaluated the quality of drinking water in Dibs-Kirkuk district, and found that the plant produces high quality water suitable for various human uses, including drinking. On the other hand, (16) studied the monthly and spatial variation in water temperature and pH levels at water sites from different areas of Kirkuk. The results of their study showed monthly and spatial differences in these environmental factors, which allowed to understand their impact on the aquatic environment and on human health.

Objective of the study:

1. Measurement of some physical and chemical properties of the waters of the Tigris and Lower Zab rivers
2. Estimation of some heavy elements in the waters of the Tigris and Lower Zab rivers

2. Materials and Methods

2.1 Description of the study area:

Samples were collected from the study stations within the boundaries of Kirkuk Governorate, Hawija district, the lower Zab district, within four different stations and include three repeaters for each station, and these stations are

- 1- The first station is the lower Zab River (the village of Shamit)
- 2- The second station is the lower Zab River (the village of alshq)
- 3- The third station mixed (the mouth of the Zab River below the Tigris)
- 4- The fourth station is the Tigris River (the area of the water project of the lower Zab district)

The samples were collected on a monthly basis from the surface layer of the Tigris Lower Zab rivers by three repeaters using polyethylene pots with a size of 2.25l to measure some physical and chemical properties, either DO and BOD were used opaque pots and the aim is not to reach the light important for the growth of bacteria and microalgae and was measured.

2.2 Water and air temperature:

The temperature of the water and air was measured directly through the use of a mercury thermometer graduated from (0-100) °C, as the temperature of the air surrounding the site to be studied was measured in the shade at a height of one meter from the surface of the earth, either the temperature of the water was measured by placing the tip of the thermometer in the water directly for a period ranging from one to two minutes until it settled and then the reading was recorded.

2.3 Electrical conductivity:

As for the electrical conductivity of water, it was recorded using a device (Conductivity Multi-meter) type to measure the electrical conductivity of the samples,

after calibrating it before use and at a rate of three readings in terms of microcemins / cm, and it was corrected at a temperature of 25 ° C.

2.4 Dissolved Oxygen measurement:

Using the Winkler method, dissolved oxygen was measured according to (17), as transparent glass Winkler bottles with a capacity of 250 ml were used, as the bottles were filled with sample water while ensuring that there were no air bubbles. It is installed in the field by adding 2 ml of aqueous manganese sulfate $MnSO_4 \cdot 2H_2O$, then shake well and after a period ranging from two to three minutes, then add 2 ml of basic iodide KOH-KI, then shake the sample and leave 10 minutes, then add concentrated sulfuric acid H_2SO_4 and shake the sample also several times. The samples are transferred to the laboratory for testing by taking 100 ml and are powdered with sodium thiosulfate and then a small amount of starch reagent is added and the result is expressed in mg/L (18).

2.5 Biological Oxygen Demand (BOD5):

In the same way as in (18) opaque bottles of 250 ml were filled and incubated in a water bath for 5 days at a temperature of 20 m, and then perform the steps described in the method of measuring dissolved oxygen itself and using the following equation, and the results are expressed in mg / liter: $BOD_5 = DO_1 - DO_5$

DO1 : amount of oxygen measured on the first day.

DO5: amount of oxygen measured after 5 days.

Total Hardness The method that was adopted (18) was used within the water tests, where 50 ml of sample water was placed in a glass flask of 250 ml and then 1 ml of ammonia buffer solution was added for the purpose of organizing the pH solution, then a little Erichrom Black T guide was added to the hardness guide as a solid until the color of the sample water becomes purple, then it is washed with the standard Na_2EDTA solution Ethylene Diamine Tetra Acetic Acid Disodium salt Standard 0.01 N until the color of the solution turns from violet to blue, and then the total hardness was calculated using the following equation and expressed in terms of units mg calcium carbonate / l, equivalent to three readings for each sample.

$$\text{Total Hardness} = \frac{V Na_2EDTA \times N Na_2EDTA \times 1000 \times \text{Equ.wt.as } CaCO_3}{v \text{ sample}}$$

2.6 Calcium Hardness:

The method used in (18) was adopted to calculate the hardness of calcium, where 50 ml of sample water is placed in a 250 ml glass flask and then 2 ml of NaOH is added. 2.5 N stirring then add 0.2 g of Murexide calcium guide mix and powder with standard Na_2EDTA at 0.01 N Until the color changes from pink to purple, then the calcium hardness is calculated using the following equation and expressed in terms of units of mg calcium carbonate / liter, at the rate of three readings for each sample.

$$\text{Ca Hardness} = \frac{V Na_2EDTA \times N Na_2EDTA \times 1000 \times \text{Equ.wt.as } CaCO_3}{v \text{ sample}}$$

2.7 Magnesium Hardness:

Magnesium hardness was measured by the following equation and is expressed in terms of units mg calcium carbonate / l (18) : $Mg \text{ Hardness as } CaCO_3(\text{mg/L}) = \text{Total Hardness}(\text{mg/L}) - \text{Ca Hardness}(\text{mg/L})$

2.8 Sulfate SO_4 :

100 ml of sample water was taken and 5 ml of conditioning reagent was added, then barium chloride $BaCl_2$ 0.15 g was added to the sample and placed on the magnetic motor device at a constant speed of less than a minute to precipitate the sulfate ion SO_4 in the acidic ocean in combination with the conditioned material to form irregularly sized crystals, and then the absorption of the product was measured by the spectrophotometer - U .v at a wavelength of 420 nm, and according to the sulfate concentration after preparing solutions Standard approximates the expected concentrations in water models and expresses the result in mg/L. (18).

$$\text{Sulfate} = \text{ABS sample} \times 1000 / V \text{ sample}$$

2.9 Chloride:

Chloride was recorded according to Mohr method as in (19) by taking 50 ml of water sample, then adding some drops of potassium dichromate reagent K_2CrO_4 , and rubbing with the standard silver nitrate solution $AgNO_3$ at a concentration of (N 0.025) until the color changes from yellow to fleshy red.. As for the nutrients represented by sodium, magnesium and heavy, which include copper, zinc, lead and iron, they were measured in the laboratories of the University of Tikrit, Faculty of Engineering, Department of Chemical Engineering - Instrumental Analysis Laboratory using the atomic absorption spectrometer type SHIMADZA AA-6200 (20). And under operational conditions

Na = λ_{max} = 589.0 lamp current = 12 mA slit = 0.2 ,Mg = λ_{max} = 766.5 lamp current = 8 mA slit = 0.2

Pb = λ_{max} = 283.3 lamp current = 10 mA slit = 0.7, Zn = λ_{max} = 213.9 lamp current = 8 mA slit = 0.7

Cu = λ_{max} = 324.8 lamp current = 6 mA slit = 0.7, Fe = λ_{max} = 248.3 lamp current =8 mA slit = 0.7

3. Results and Discussion

3.1 Air temperature: The results of the study showed that the average air temperature values ranged between (24.55-18.83) °C, which is higher than the results of (21) ranged between (11.1-18.3). °C, The Impact of Seasons on Temperature The difference in temperatures is due to the variation in seasons and the continental climate difference between summer and winter (22). The results of the statistical analysis of the Pearson correlation coefficient showed that there is a positive correlation between air temperature and water temperature amounting to ($r = 0.794$) at a significant level ($P \leq 0.01$) and the results of Dunkin' test showed that there are no spatial significant differences at the level of significance ($P \leq 0.05$) . Table No. (1)

3.2 Water temperature: The results of the study showed that the average water temperature values ranged between (16.16-18.3) ° C, which is higher than the results of (21) ranged between (8.0-17.6) ° C, The variation in water temperatures is attributed to the influence of air temperatures on water, as well as the variation in temperatures between day and night (23). The results of the statistical analysis using Pearson's correlation coefficient confirmed the existence of a negative significant correlation between water temperature and electrical conductivity reached ($r = -0.727$) at a significant level ($P \leq 0.01$) ,The Dunkin' test showed spatial significant differences at a significant level ($P \leq 0.05$). Table No. (1)

3.3 Electrical conductivity: The results of the study showed that the average values of electrical conductivity range between (277.483-345.3) microsemins / cm, which is close to the results of (21) which ranged between (189.0- 340.0) microsemins / cm, Electrical conductivity expresses the number of positive and negative ions present in water, indicating the water's ability to carry electric current and serving as an indicator of salts (24). The results of the Pearson correlation coefficient showed a positive significant correlation between electrical conductivity and pH reached ($r = 0.658$) at a significant level ($P \leq 0.01$) and the results of the Dunkin' test showed that there are no spatial significant differences at the level of Moral ($P \leq 0.05$). Table No. (1)

3.4 Dissolved oxygen: The results showed that the average values of dissolved oxygen ranged between (7.461 - 12.443) mg / liter , which is higher than the results of (21) as they ranged between (7.14 - 9.97) mg / liter, Oxygen is generally a product of photosynthesis carried out by plants. Dissolved oxygen results from aquatic plants and algae performing photosynthesis, as well as being transferred to water by wind (25). The results of the Pearson correlation coefficient showed a positive significant correlation between dissolved oxygen and the Biological Oxygen Demand ($r = 0.425$) at a significant level ($P \leq 0.05$) The results of the Duncan test showed that there are spatial significant differences at a significant level ($P \leq 0.05$). Table No. (1)

- 3.5 (BOD₅) Biological Oxygen Demand:** The results during the study period showed that the average values of the (BOD₅) Biological Oxygen Demand ranged between (3.04 - 4.4383) mg / liter ,which is higher than the results (21) as they ranged between (1.18 - 2.87) mg / liter Biological oxygen demand is an important indicator for measuring water quality, indicating the amount of oxygen consumed by microorganisms during the decomposition of organic matter in water (26),The results of Pearson's correlation coefficient showed a positive significant correlation between the (BOD₅) Biological Oxygen Demand and sulfate ($r = 0.476$) at a significant level ($P \leq 0.05$) The results of the Duncan test showed that there are spatial significant differences at a significant level ($P \leq 0.05$). Table No. (1)
- 3.6 Total hardness:** The results during the study period showed that the average values of total hardness ranged between (137.986 - 227.386) mg / liter, which is close to the results of (15) which ranged between (120-230) mg / liter Total hardness is an important determinant in determining water quality, and its main causes are the positive ions of calcium and magnesium, as well as other ions but in very small amounts such as iron, barium, and zinc (28), The results of the Pearson correlation coefficient showed a negative significant correlation between total hardness and potassium amounting to ($r = -0.481$) at a significant level ($P \leq 0.05$),The results of the Dunkin' test showed that there were no spatial significant differences at the level of significance ($P \leq 0.05$). Table No. (1)
- 3.7 Calcium hardness:** The results of the statistical analysis showed that the average values of calcium hardness ranged between (74.3388 - 147.28716) mg / liter , which is lower than the results of (15) as it ranged between (85-165) mg / liter, Calcium hardness is one form of hardness, as it is considered an essential part of total hardness if present in large quantities in water. The source of calcium is considered to be calcite stone and also gypsum (29). The results of the Pearson correlation coefficient showed a positive significant correlation between calcium hardness and magnesium hardness ($r = 0.449$) at a significant level ($P \leq 0.05$).The results of the Dunkin' test showed that there were no spatial significant differences at the level of significance ($P \leq 0.05$). Table No. (1)
- 3.8 Magnesium hardness:** The results of the statistical analysis showed that the average values of magnesium hardness ranged between (64.563-84.7445) mg / liter, which is higher than the results of (15) which ranged between (25-65) mg /Liter, The reason for the relative increase in magnesium hardness is attributed to the rock formations and geological nature of the area, which contains dolomite rocks and limestone rocks, as well as when rainfall occurs and riverbank erosion and soil and rock weathering (30). The results of Pearson's correlation coefficient showed a positive significant correlation between magnesium hardness and electrical conductivity ($r = 0.566$) at a significant level ($P \leq 0.01$) The results of the Dunkin' test showed that there were no spatial significant differences at the level of significance ($P \leq 0.05$). Table No. (1)
- 3.9 Sulfate:** The results of the statistical analysis showed that the average sulfate values during the study period that the average sulfate values ranged between (36.54-220.66) mg / liter, which is lower than the results (21), which ranged between (133.2-318.8) mg / liter, The presence of sulfates in water is due to pollutants added to the soil in the form of fertilizers, which are washed away by rainwater and floods into rivers, as well as from industrial and domestic waste into oxides that fall on water in the form of acid rain(31). The results of the Pearson correlation coefficient showed that there is a positive correlation between phosphates and nitrates amounting to ($r = 0.547$) at a significant level ($P \leq 0.01$),The results of the Dunkin' test showed that there were no spatial significant differences at the level of significance ($P \leq 0.05$). Table No. (1)
- 3.10 Chloride:** The results of the statistical analysis showed that the average values of chloride ranged between (25.1965 _ 29.2215) mg / liter, which is higher than the results of (15) which ranged between (5.68-31.24) mg / liter, Chloride is an important factor

in determining water quality, as it is present in relatively low amounts but increases with increased rainfall, which leads to erosion of the soil near the river (32). and the results of the Pearson correlation coefficient showed that there is a negative correlation between chloride and magnesium amounting to ($r = -0.641$) at a significant level ($P \leq 0.01$), The results of the Duncan test showed that there are spatial significant differences at the level of significance ($P \leq 0.05$). Table No. (1)

- 3.11 Magnesium:** The results of the statistical analysis showed that the average magnesium values in the study sites that the average magnesium values ranged between (26.7141-42.2178) mg / liter, which is higher than the results of (33) as it ranged between (2-2.7) mg / liter, Magnesium is the fourth most abundant cation in the body and the second most abundant enzyme in intracellular fluid. It is a cofactor for approximately 350 cellular enzymes, many of which are involved in energy metabolism. It also participates in protein synthesis and DNA synthesis. It is essential for normal vascular tone. Low magnesium levels are associated with endothelial dysfunction, increased vascular reactivity, and elevated levels of C-reactive protein in the circulation (34). The results of the Pearson correlation coefficient showed that there is a positive correlation between magnesium and the vital requirement of oxygen amounting to ($r = 0.400$) at a significant level ($P \leq 0.05$). The results of the Dunkin' test showed that there were no spatial significant differences at the level of significance ($P \leq 0.05$). Table No. (1)
- 3.12 Sodium:** The results of the statistical analysis showed that the average sodium values in water during the study period ranged between (26.105-32.7173) mg / liter, which is higher than the results of (21) as it ranged between (0.17-16.13) mg / liter, The presence of sodium in the study sites is attributed to its high solubility. High concentrations of sodium can cause harm to human, animal, and plant health. The relative increase in some sodium values may be due to differences in sodium concentrations discharged into the water due to irrigation activities and runoff from adjacent lands, as well as rainfall or domestic waste (35). and the results of the Pearson correlation coefficient showed that there is no correlation between sodium and any other physical and chemical properties of water during the study period and in the study sites and the results of the Dunkin' test showed that there are no significant differences in time and there are no significant differences Spatial at a significant level ($P \leq 0.05$). Table No. (1)
- 3.13 Copper:** The results of the study showed that the values of copper ranged between (0.115783_0.1587906) mg / liter, which is less than the results of (33) as it ranged between (0.2129-0.4012) mg / liter, Copper exists in low concentrations in nature (less than 0.05 mg/L) and reaches the environment through mining, electrical, and textile industries via wastewater (36). The results of the Pearson correlation coefficient showed that there is a positive correlation between copper and turbidity amounted to ($r = 0.521$) and a negative correlation between copper and pH and has reached ($r = -0.540$) at the level of significance ($P \leq 0.01$) and the results of the Dunkin' test showed no spatial significant differences at the level of significance ($P \leq 0.05$). Table No. (1)
- 3.14 Zinc:** The results of the statistical analysis showed that the average values of zinc in the study sites ranged between (0.08913 _ 0.1476) mg / liter, which is less than the results of (33) as it ranged between (0.2129-0.4012) mg / liter, The increase in zinc levels is due to the discharge of untreated pollutants into the river (37). and the results of the Pearson correlation coefficient showed that there is a negative correlation between zinc and electrical conductivity amounted to ($r = -0.510$) at the level of significance ($P \leq 0.05$) and the results of the Duncan test showed that there are spatial significant differences at the level of significance ($P \leq 0.05$) and has reached (0.000). Table No. (1)
- 3.15 Lead:** The results of the statistical analysis showed that the average values of lead, which ranged between (0.0511 - 0.1230) mg / liter, which is higher than the results of (37), which ranged between (0.035-0.01) mg / liter, The increase in lead concentration

is due to the discharge of large amounts of liquid waste from factories and industries into the river(38), The results of the statistical analysis of the Pearson correlation coefficient showed that there is a positive correlation between lead and zinc amounted to ($r = 0.528$) at the level of significance ($p \leq 0.01$) and the results of the Dunkin' test showed that there are spatial significant differences at the level of significance ($P \leq 0.05$) and amounted to (0.044). Table No. (1)

3.16 Iron: The results of the statistical analysis showed that the average values of iron in the study sites ranged between (0.0906 - 0.1463) mg / liter, which is lower than the results of(38) as the values of iron in the waters of the Tigris River ranged between(N. D. -4825.5) mg / liter, The increase in iron during winter is due to theerosion of lands adjacent to the river due to rainfall and the geological nature of the area(39) . The results of the Pearson correlation coefficient showed that there is a positive correlation between iron and turbidity ($r = 0.434$) at a significant level ($P \leq 0.05$) and the results of the Dunkin' test showed that there are spatial significant differences at a significant level ($P \leq 0.05$) and it reached (0.024). Table No. (1)

Table 1. Average of Air Temperature, Water Temperature, Electrical Conductivity, Dissolved Oxygen, (BOD5) Biological Oxygen Demand, Total hardness, Calcium hardness, Magnesium Hardness, Sulfate, Chloride, Magnesium, Sodium, copper, zinc, Lead and Iron. , the same letter are not significantly different while the different letters are significantly different according to Duncan's test.

Sites	First Site	Second site	Third site	Fourth site
Air Temperature	24.55a	23.67a	21.83a	18.83a
Water Temperature	17.43a	18.3a	16.16a	16.5a
Electrical Conductivity	345.3a	329.16a	317.16a	277.483a
Dissolved Oxygen	8.653a	12.443b	12.03b	7.461b
(BOD ₅) Biological Oxygen Demand	3.04a	3.873a	3.675a	4.4383b
Total hardness	207.1483a	227.386a	137.986a	149.576a
Calcium hardness	127.7835a	147.28716a	74.3388a	85.01a
Magnesium Hardness	79.3643a	84.7445a	65.041a	64.563a
Sulfate	118.9183a	93.1816a	87.335a	95.385a
Chloride	29.2215b	28.2611b	25.1965a	27.07583a
Magnesium	29.037a	26.7141a	42.2178a	33.4826a
Sodium	26.105a	28.8546a	29.716a	32.7173 a
copper	0.115783a	0.1587906a	0.1538a	0.1585a
zinc	0.08913a	0.0923a	0.08948a	0.1476b
Lead	0.0616a	0.0511a	0.0518a	0.1230b
Iron	0.0906a	0.10683a	0.132b	0.1463b

4. Conclusion

The difference in the proportions of physical and chemical properties and heavy elements is a result of the difference in temperature and the change in rainfall rates, as the highest rainfall rates were in February, as well as the impact of the lower Zab River on the Tigris River in that region, because the lower Zab River flows into the Tigris River in that region and the wrong use by farmers and the throwing of agricultural pesticides in the water led to an increase in the proportions of heavy elements.

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