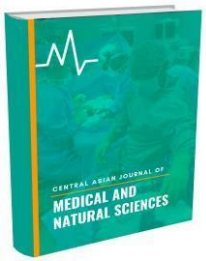

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Article

Physical and Chemical Characteristics of Tigris River Water in the Cities of Essaouira and Numaniyah - Southern Iraq

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Abstract: The physical and chemical properties of the Tigris River water were studied in Wasit province at the cities of Essaouira and Numaniyah and two stations were selected. The sampling study was monthly from Jan2018 to July 2018 . The effect of the dropping in water levels in the Tigris River and the lack of rainfall for 2018 with the rise of most property values in the winter of 2018 and the decrease in April 2018 to increase rainfall this month, as most values showed a marked rise at the Numaniyah station, while the vital requirement for BOD5 oxygen and phosphates increased at Essaouira station, the electrical conductivity rate was recorded at (1798micro cm/cm) at Numaniyah which is reflected in the presence of contaminated elements, as the results showed a rise in the values of total hardness at a rate of (400 mg/l) and that calcium and magnesium elements are the causes of the hardness and the baseband was mostly due to the presence of carbon ions and biacarpones. Sulfate increased by (484 mg/L) and phosphates and nitrate exceeded surface water courses by(0.46-9.4 **mg/L).**

Keywords: Tigris River, physical and chemical properties, Wasit province, Essaouira and Numaniyah.

1. Introduction

Water is essential to life on Earth and is becoming more so than many other natural resources. It has negative effects on the economy, society, and environment and is an engine of economic growth. It also plays a key role in the preservation of many living things and the preservation of life itself. Finally, water helps societies evolve and develop by preventing pollution [1]. Ecosystems face many challenges arising from the development of the world, including aquatic ecosystems, because of the pollution caused by the throwing of industrial, agricultural and civil waste, as water pollution in its various forms is one of the main problems at the global level.

The process of throwing residential waste and industrial into the Tigris river stream through several estuaries distributed along the river path and increasing the population as well as the decrease in the amount of water running across the Tigris River in these years can no longer be absorbed by the river for its ecosystem, and this reflects negatively on the quality of water and its suitability for use .The process of throwing these waste directly into water sources is a serious breach of the natural and a threating to human life for the possibility of epidemics and diseases spreading at any time. Water resources need to be taken care of and utilized in the development process in terms of management, treatment, rational investment and reducing the risk of contamination. Surface water is one of the main water resources in Iraq and its quantity changes from season to season

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and varies from year to year depending on the varying amounts of rain and snow falling in the two rivers basins, Iraq has long faced the challenges of reducing water imports due to the construction of dams and tropical projects in upstream countries and the climatic changes represented by high temperatures, low rainfall from rain and snow and numerous excesses on water resources consumption or pollution and thus deteriorating quality and high concentration of salts. It has a negative effect on food and water security and threatens the national economy and development plans, and water issues in Iraq are the scarcity of resources and their low quality [2], [3]. The current research aims to study the physical and chemical properties of the Tigris River water for the passage through the cities of Essaouira and Numaniyah if such studies are important for monitoring the effect of city pollutants as the river passes [4].

2. Materials and Methods

Study Area:

A. Al-Suwera District

Essaouira district is one of the districts of Wasit province in Iraq and is famous for its agricultural areas and fruit and palm groves, and is located in Essaouira district north of Kut city about 135 km away from Baghdad city about 55 km south, The city of Essaouira belongs to both Zubeidia and Al-Shehimiya, Essaouira district consists from 19 districts with a total area of about 235593 dunums equivalent to 588.9 km^2 and the arable area is about 232682 dunums. The district border from the north of Diyala province and from the south and southeast of Numaniyah district and kut city and to the west the Salt River to separate it from the administrative border of Babil province and bordered to the east and north-east district of Badra district and part of Diyala province and penetrated by the Tigris River from the northwest to the southeast, astronomically the district is located east between the lines of length (44° and 45°) and between two districts of width (32°-18°) north.

B. Numaniyah District

Numaniyah district is located in the center of Wasit province and serves as its administrative center, more than 40 km away from the center of Kut city , its area is about 946 km^2 and is located in this district the tomb of the poet Abu Tayeb al-Mutanabbi, its follows by one area is Al-Ahrar district. Numaniyah district is famous by agriculture and industry where it includes a factor for the manufacture of tomato paste as well as a natural gas plant.is located to the northwest of Kut city , located in the southwest of AL- Azizyia city 60 km from the north, which is bordered to the north by Zubaidia and Dabboni, and to the south, to the Al-Ahrar side and the shrine of Imam Mahdi (Aj) but to the west, the Salt River separates it from Babil province, this site is very important because it represents a major transport complex linking Baghdad, the capital, to the southern provinces.

Water samples were collected monthly from study stations for six months from December 2017 to June 2018. The samples of water collected from the surface layer in a depth of 30 cm underwater using three replicates from the center and sides of the river and were used for physical and chemical analysis of 5-liters polyethylene containers that were washed by the water sample twice before the filling.Several measurements were made directly at the study stations when the temperature of water and PH was measured used a temperature meter, and electrical conductivity, total dissolved solids, and dissolved oxygen were measured using a multiparameter device (YSI Incorporated) while winkler's bottles dark were water sample collection to measure the biochemical oxygen demand.

3. Results

Nitrate and phosphate concentrations were identified using a UV spectrophotometer following methods described in APHA and Total suspended solids (TSS) were measured using the Buchner system as per the American Public Health Association and measured hardness and sulfate by English-device (Turbid Meter) and the total basal, total turbid, calcium and magnesium insatiable have been quantized in the methods described in Lind,

all the devices above have been calibrated laboratory and field before the measurements are initiated [5].(Figure 1).

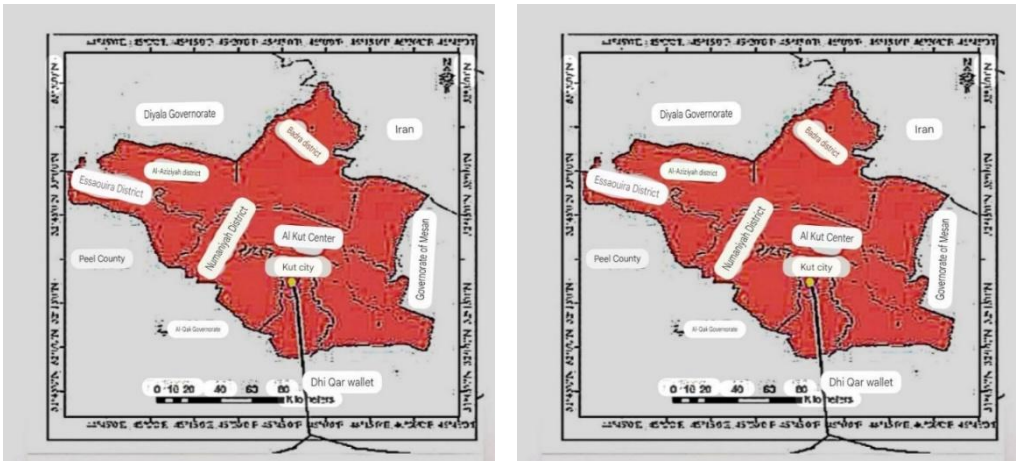


Figure 1. Monthly changes in air temperature values at Tigris River study stations from January 2018 to July 2018

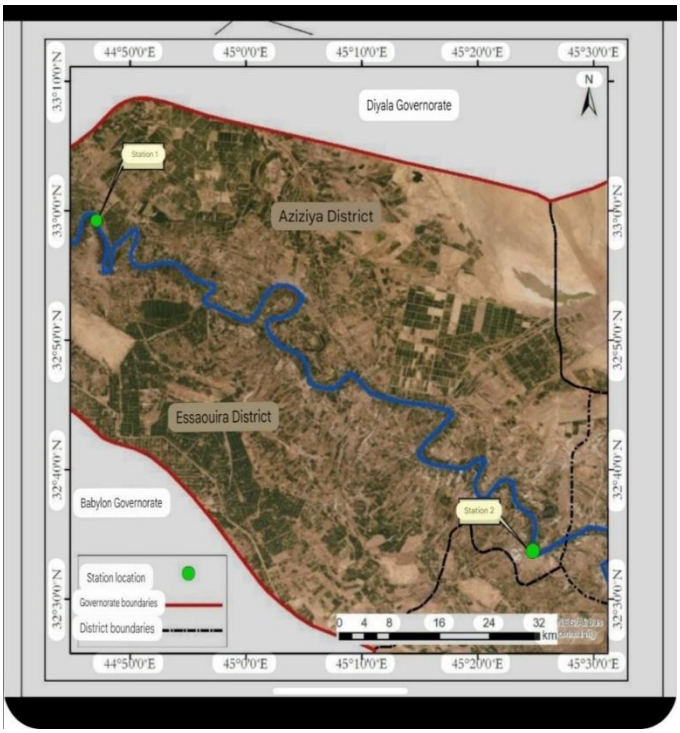


Figure 2. Monthly changes in pH values at Tigris River study stations from January 2018 to July 2018.

Table 1. Standard ranges, rates and deviations of the values of physical and chemical properties of water at the two sites of the Tigris River for the period from January 2018 to July 2018.

Parameters	Essaouira Station 1	Numaniyah Station 2
Water Temp. °C	10.6-21.5 15 ±3.38	11.2-21.2 15.31 ±3.33
PH	7.2-8 7.62 ± 0.305	7.5-8 7.79 ± 0.19
EC µS/cm	997-1798	1162-1968

	1252.5 ± 267.21	1402.16 ± 284.66
TDS(g/L)	652 -1024 837.33 ± 127.87	706-1160 903 ± 144.06
DO (mg/L)	7.42 - 9.84 8.37 ± 0.77	7.89 -10.51 8.913 ± 0.88
BOD_5 (mg/L)	1.35 -4.7 3.195 ± 0.033	2.27 -4.12 3.04± 0.70
Nitrate- Nitrogen ($mgNO_3$- N/L)	3.4 -7.8 5.8 ± 1.42	4.8 -9.4 6.8 ± 1.64
Phosphate $PO4^{-2}$ (mg/L)	0.28- 0.46 0.33 ± 0.06	0.26 - 0.34 0.31± 0.03
TSS(mg/L)	8.86 - 42.36 19.35± 12.09	11.46 -18.22 15.55 ± 2.603
Sulfate SO_4^{+4} (mg/L)	228-409 273.83 ± 64.08	248-483 304.66 ± 83.005
Turbidity NTU	18.2-58.5 31.85 ±15.06	21.8-27.8 25.85 ±1.94
Total Hardness as ($mgCaCo_3$/L)	286-386 336.66 ± 35.52	280-400 348.66 ± 42.60
Ca^{+2} (mg/L)	76.4 -92.6 85.43 ± 6.88	80.2 -96.4 89.1 ± 7.04
Mg^{+2} (mg/L)	20.2 -35.6 28.53 ± 5.16	21.3 -40.2 30.51 ± 6.45
T. Alkalinity (mg/L)	128-190 161 ± 19.65	138 -287 192.5 ± 47.56

Table 1 shows the standard ranges, rates and deviation of the values of the physical and chemical properties of water at the two sites of the Tigris River. Temperatures ranged from the lowest value to (10.6 C°) during December 2018 and the highest value during May 2018 and (21°C) at Essaouira station figure (2) the results of the study showed monthly changes in water temperatures where the lowest temperatures were recorded during the winter and the highest grades during the summer due to the difference in climatic conditions in terms of the intensity of sunshine and the length of the day [6]. While the results of PH values ranged from (8.08-7.21) if the lowest value was recorded in the current study at Essaouira station during April and the highest value at Numaniyah station during May 2018 form(2) .PH values were within the light baseband side throughout the study and for all sites as PH values in winter are higher than the rest of the months, and this may be due to the high density of planktons resulting in an increase in the effectiveness of construction Photosynthesis has therefore led to the consumption of carbon dioxide in water, which increases the values of PH or may be due to water dilution

, which explains the fluctuation of PH values in winter, that the relatively high PH values during the winter months are due to the discharge of large quantities of fertilizers, pesticides and household waste by the agricultural area, all of which contain nitrogen, organic and phosphate material that affect PH values [7], [8]. The decline in PH values may explain the rise in water levels and the increase in rainfall in April 2018 and the reduction in the winter months of 2018, which reduces the amount of sewage and pesticides and then resumed to rise at the beginning of the summer months with a reduced water level, see Figure 3.

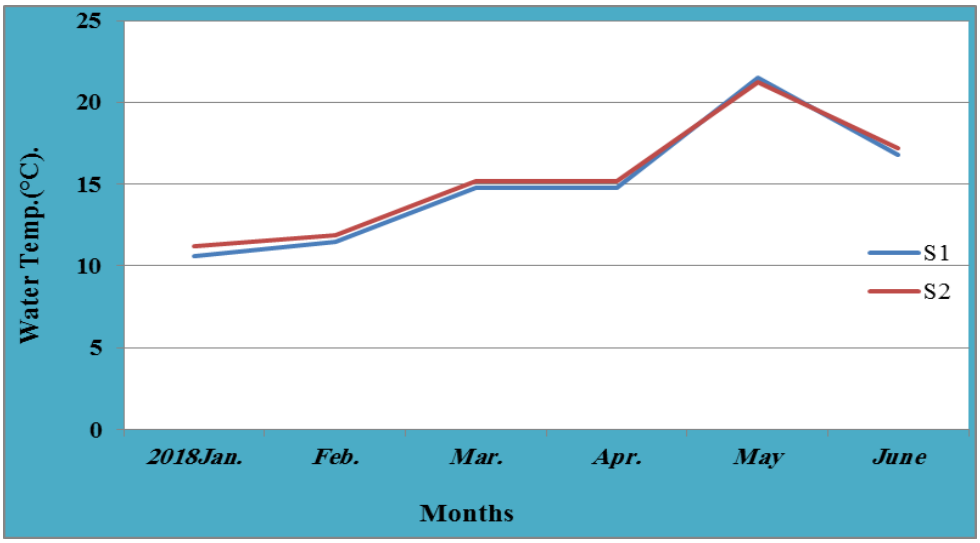


Figure 3. Monthly changes in air temperature values at Tigris river study stations from January 2018 to July 2018.

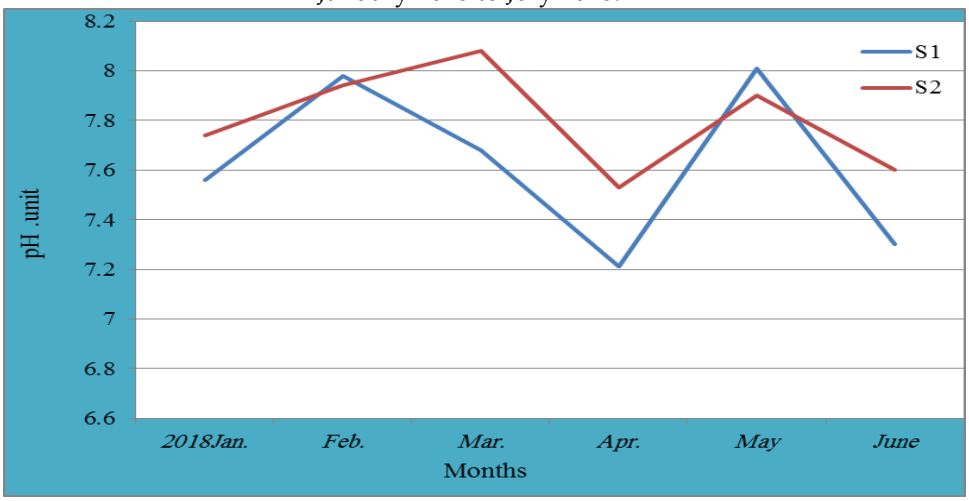


Figure 4. Monthly changes in PH values in Tigris river study stations from January 2018 to July 2018

The electrical conductivity values of the Tigris River water varied between the maximum value of (1798 micro cm/cm) and a higher value of total dissolved solids of (1160g/L) during February 2018 at Numaniyah station and the lowest value was (997 micro cm/cm) during April 2018 at Essaouira station and total dissolved solids, the value was at least (652 g/L) during June 2018 at Essaouira Station figure 3 and 4. The results of the current study showed the recording of the highest values of electrical connectivity and total dissolved solidity(TDS) at Numaniyah station which may be due to the process of throwing household waste water directly into the river and the effect of river water on the distinctive agricultural activity in the areas near the river, and noted Electrical conductivity increases in general as we head south, which may be due to the different characteristics of the soil that the river passes through, as well as the different uses of water along the riverbed, which corresponds to what pointed out to increase the values of electrical

conduction of the Tigris and Euphrates rivers as the direction to the south increases [9], [10]. For monthly changes, the highest electrical conductivity values were recorded in February 2018 and may be due to low water levels and rising temperatures, leading to increased evaporation processes and thus increased concentration of dissolved salts the lowest values for electrical connectivity recorded during April and for total melted solids during June 2018 due to increased rainfall and rising water levels, leading to further dilution of dissolved salts in water [11], [12].

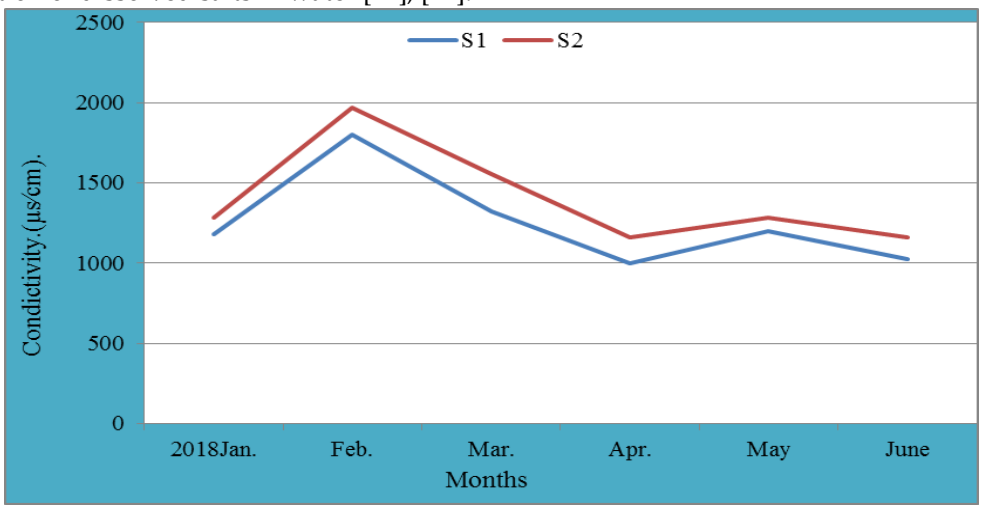


Figure 5. Monthly changes in connectivity and electrical values at Tigris river study stations from January 2018 to July 2018

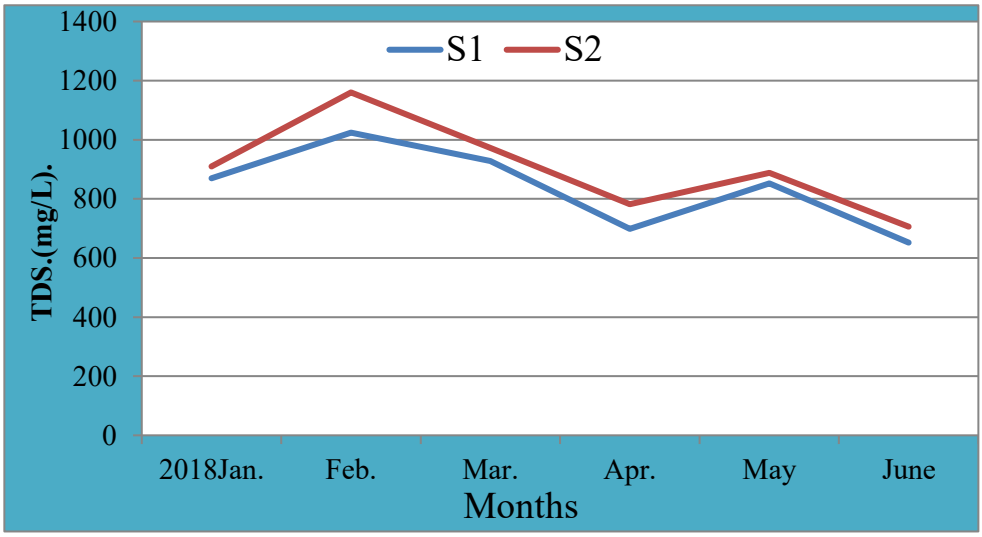


Figure 6. Monthly changes in TDS values at Tigris River study stations from January 2018 to July 2018

Dissolved oxygen is a specific environmental factor for describing ecosystem health and water quality and reflects the physical and biological processes prevailing in water highest reading of dissolved oxygen was (10.51 mg/L) during December 2018 at Numaniyah station and lowest reading of (7.42 mg/L) during April at Essaouira Station figure 5 and 6. During the current study, it was not observed that dissolved oxygen concentrations have decreased to critical levels and may be due to the production of dissolved oxygen gas by plant planktons and aquatic plants in the process of photosynthesis in addition to continuous mixing processes that increase the melting of oxygen in water [13].The dissolved oxygen at Numaniyah station may be due to the density of plant planktons and aquatic plants, as well as the movement of water currents and limited depth, which help to increase ventilation. While the lowest concentrations of dissolved oxygen were recorded at Essaouira station, the reason may be due to the direct release of Sewage household waste water to the river, which contains large amounts of organic matter, where its degradation leads to the consumption of dissolved oxygen [14],

[15]. Monthly changes in dissolved oxygen values showed a clear increase in the concentration of dissolved oxygen during the winter and spring months and may be due to lower temperatures, which leads to increased mutability of gases as well as reduced oxygen gas consumption. In the spring months the efficiency of photosynthesis by algae and aquatic plants was increased by the increase in the concentration of dissolved oxygen, while the lowest concentrations of dissolved oxygen were recorded during April at Essaouira station, as high temperatures led to a decrease in the melting of gases and increased decomposition of organic matter by dissolved organisms that consume dissolved oxygen [16], [17].

Figure 7. Monthly changes in dissolved oxygen values at Tigris river study stations from January 2018 to July 2018

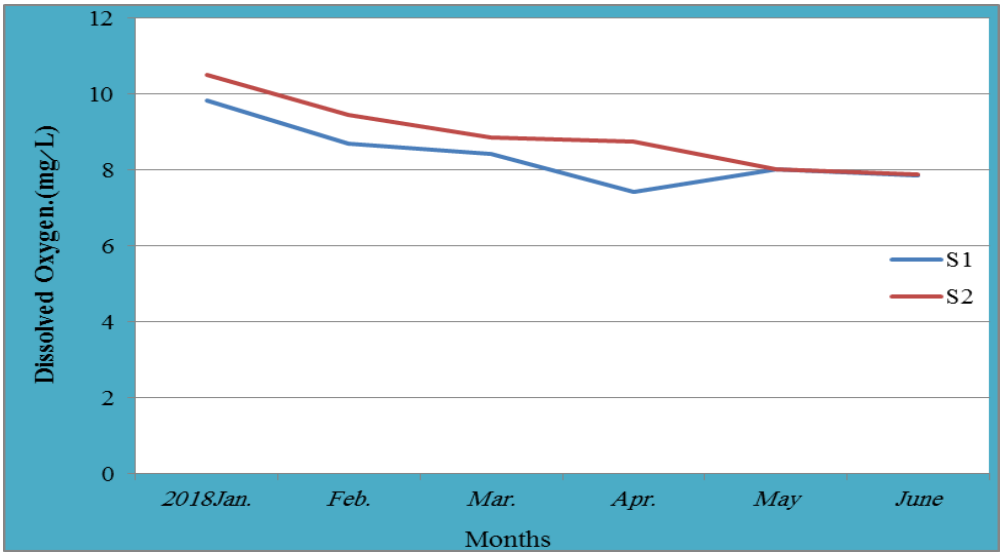
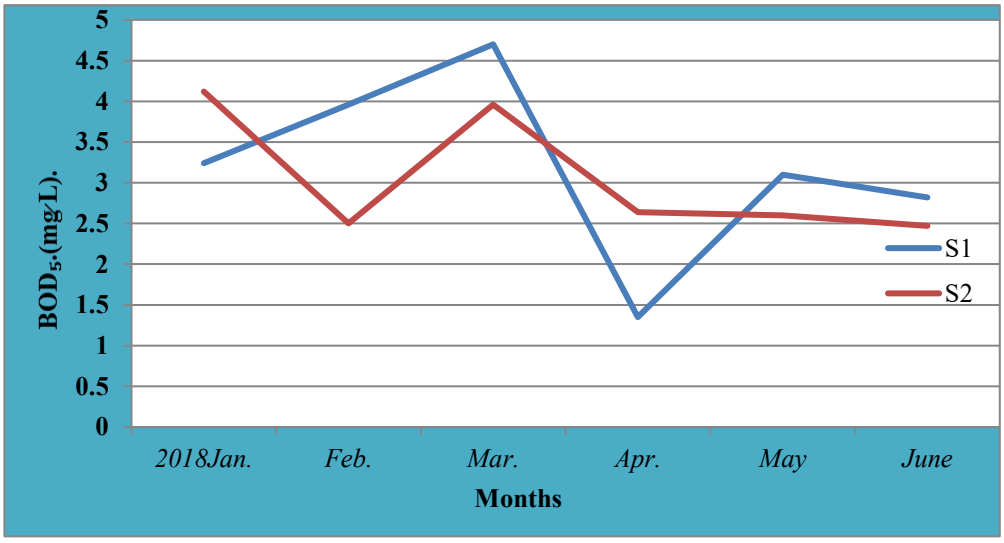


Figure 8. Monthly changes in BOD5 values at Tigris River study stations from January 2018 to July 2018



The vital requirement of BOD5 oxygen is a measure of the amount of oxygen required or consumed by bacteria and microbiology under aerobic conditions during the biological oxidation of organic matter in the waterway, giving an indication of the amount of oxygen likely to be consumed by these organisms, which live on organic matter in the water body, when the BOD5 values is lower the quality of water is good its express the organic pollution in the aquatic environment.The values of the bio-oxygen requirement ranged from (1.35-4.7) mg/L during April and March 2018 respectively, at Essaouira station form (6).BOD5 values increased significantly in the current study but did not exceed the international permissible limit of (5 mg/L) and the highest bio-oxygen requirement values were recorded at Essaouira station due to the direct release of organic waste into river

water, where decomposition by micro-revival leads to the consumption of dissolved oxygen and the rising of BOD5 [18], [19], [20]. The decrease in the values of the bio-oxygen requirement observed at Numaniyah station also confirms the river's self-purification susceptibility by dilution and propagation and ventilation. For monthly changes, the lowest values of the bio-oxygen requirement were recorded in April, while dissolved oxygen was high, while the highest values were recorded in March, because throwing organic waste into the river directly, whose requires analysis the consumption of large amounts of dissolved oxygen, so high temperatures lead to increased degradation of organic matter due to oxidation resulting from micro-revival activity. The high values of BOD5 may also be due to the presence of agricultural land on both sides of the river and the accompanying use of pesticides and organic fertilizers and their entry into the riverbed. The results of the current study recorded the highest nitrates values during February 2018 at Numaniyah station and were (9.4 mg/L) and the lowest nitrate values in Essaouira station and were (3.4 mg/L)during April 2018. Phosphorus recorded the highest values during the month of March 2018 for Essaouira station was (0.46 mg/L) with the lowest values of (0.26 mg/L) during February 2018 at Numaniyah Figure 7 and 8. The results of the current study showed rising in nitrates during February and the beginning of the summer months, and may be due to the availability of high oxygen content of nitrite oxidation to nitrate or may be due to the decrease in the numbers of algae where nitrate ion is a specific and important factor for its growth. It may also be due to the process of nitrogenization and nitrogen sources from agricultural land also contribute to increasing their water concentrations as well as household water and sanitation. Either the apparent decrease in nitrate concentrations during April may be due to increased consumption by plant phytoplankton and further dilution of rising water levels due to the rains of April. Monthly changes also showed that effective phosphate values increased during March at both Stations, possibly due to the use of phosphate fertilizers by farmers in fertilizing agricultural land around the river and drifting into the riverbed, while effective phosphate concentrations decreased during the months of February and April, possibly due to their consumption by phytoplankton and aquatic plants or the tendency of phosphates to collect in sediments or dilution because the rains in April. Through the results of the study, it was found that the highest rates of effective phosphate were recorded at Essaouira station, possibly due to household waste water received by the station, agricultural land waste and residues of nitrogen and phosphate fertilizers, as well as waste directly discharged into river water from animal husbandry.

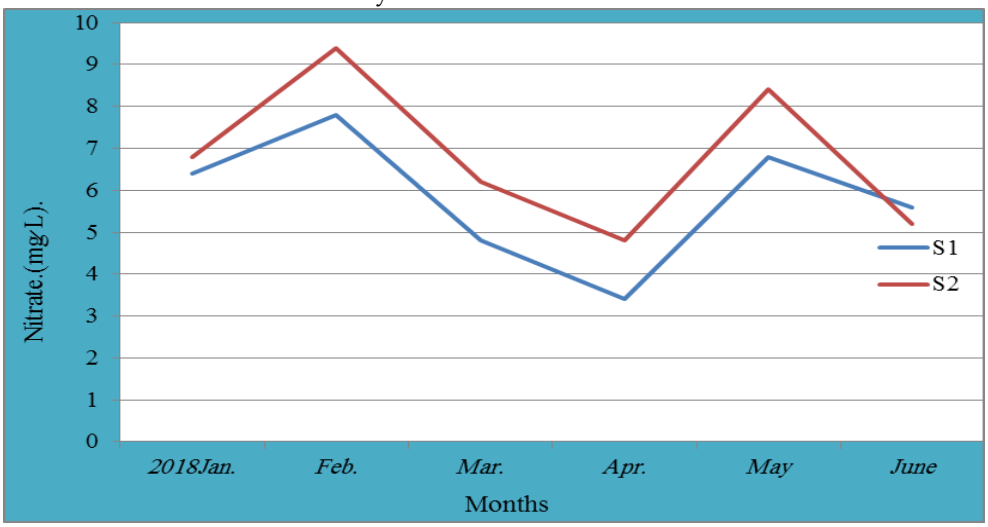


Figure 9. Monthly changes in nitrates values in Tigris river study stations from January 2018 to July 2018

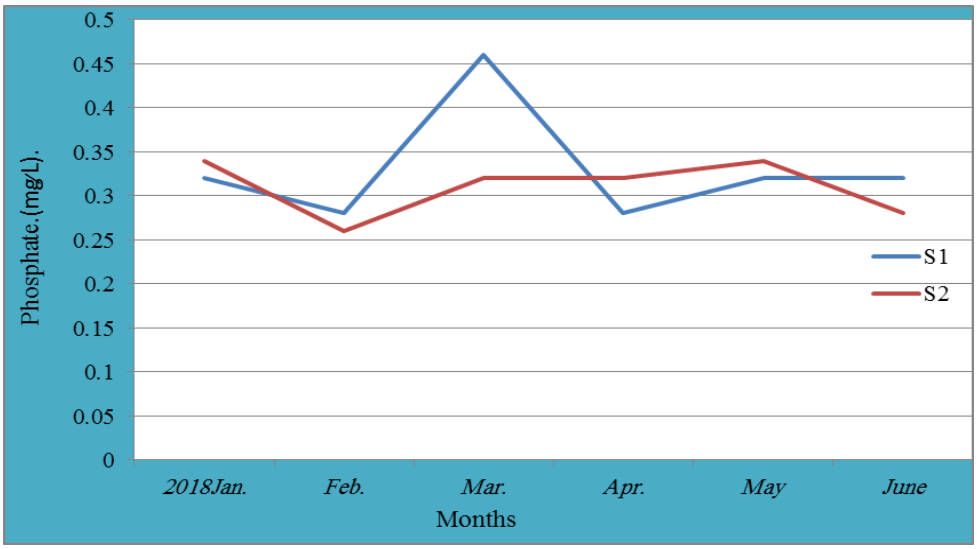


Figure 10. Monthly changes in phosphate values at Tigris river study stations from January 2018 to July 2018

The value of total suspended soiled (TSS) were recorded at a high value in February 2018 (42.36 mg/L) at Essaouira station and the low value during April was (8.86) .The values of the hardness samples from Tigris River showed highest values at Essaouira station were (58.5 units) of NTU during February 2018.The low values at Essaouira station were (18.2 units) of NTU during the month of April 2018 form Figure 9 and 10. The results of the current study showed that the highest values of turbid and TSS were recorded at Essaouira station due to the throwing of wastewater to the river directly, which contain large amounts of organic and inorganic material, bits of dust, sand and microscopic revival that increase the hardness and TSS, and the length of distance pass by the riverbed is a factor that helps to increase the hardness and TSS due to erosion factors and the nature of the bottom. For monthly changes, the values of hardness and total suspended solids decreased at the beginning of the spring and summer months, which may be due to the high water levels and thus dilution, while the highest values of turbid and TSS were recorded during February and July at Essaouira station due to the low water level and this increase and decrease in the values of the turbid coincided with the decline and rise of TSS values. In addition, the dryness of the area in the summer leads to an increase in soil and dust fall carried by wind from roads on both sides of the river and thus increase the turbid and TSS in the water.Water containing solid concentration of less than (20 mg/L) has been classified as pure water, while those containing concentrations between (80-20) mg/L are low-turbid water, which contains more than (150 mg/L) of turbid water, according to the current study the waters of the Tigris River are low-turbid.

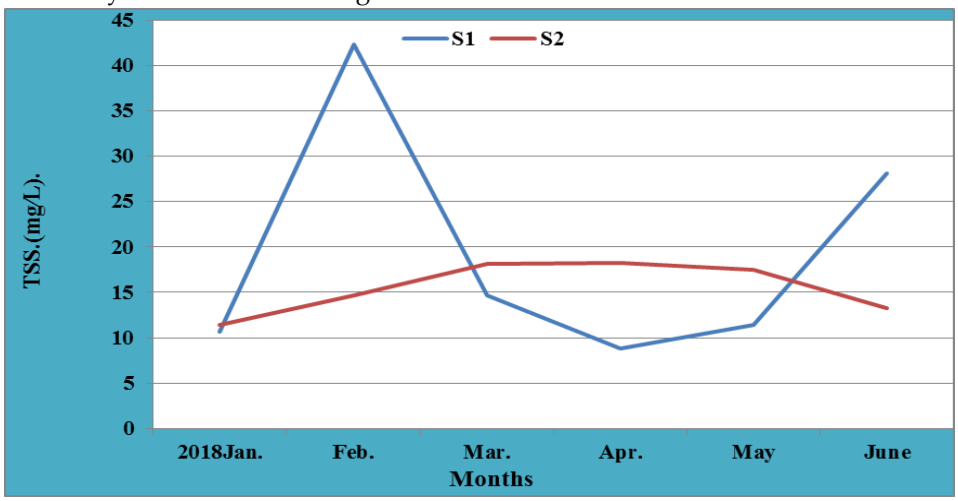


Figure 11. Monthly changes in TSS values at Tigris River study stations from January 2018 to July 2018

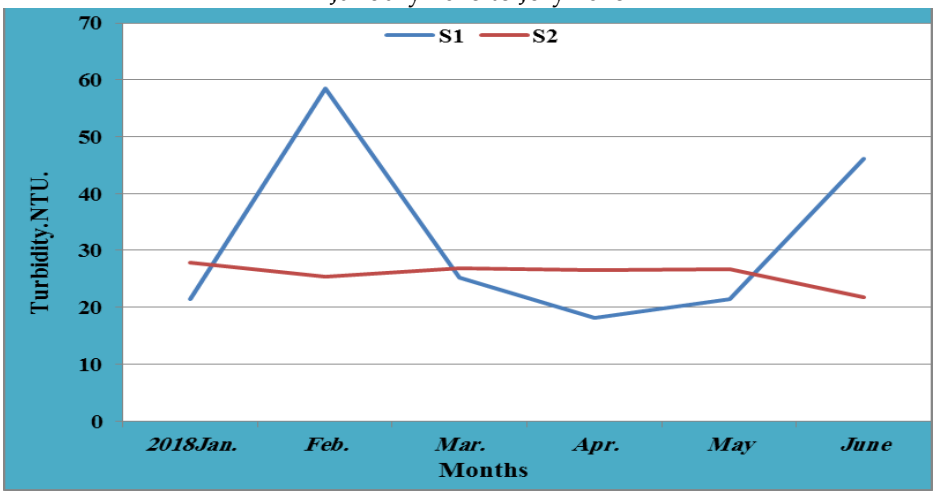


Figure 12. Monthly changes in the values of turbid in the study stations of the Tigris River from January 2018 to July 2018

Sulfate values in the current study varied to the highest value during February 2018 were (483 mg/L) at Numaniyah station and the lowest value was (228 mg/L) during June 2018 at Essaouira Station figure 11. The current study recorded high sulfate concentrations due to the gypsum nature of sedimentary soil, which is a direct source of dissolved sulfates in natural water or because of the passage of the river in agricultural land where fertilizers containing Sulfate, especially in the planting season to increase productivity, as well as due to the high percentage of Sulfate dioxide in the atmosphere caused by fuel combustion, which may reach the water area through rain or fall dry bits, in addition to erosion rocks and soils. For monthly changes, the highest Sulfate values were recorded during February in all study stations and this increase may be due to a decrease water levels and the high proportion of organic pollutants resulting from human activities that are released to the river directly through sewage especially in Numaniyah station, these wastes contain organic material carrying-Sulfate, which add high concentrations of sulfur element when decomposed by micro-revival, and Sulfate concentrations recorded a decrease at the beginning of the spring and summer months at all stations, due to the dilution factor resulting from the rise in water levels and increased discharge rate, see Figure 12.

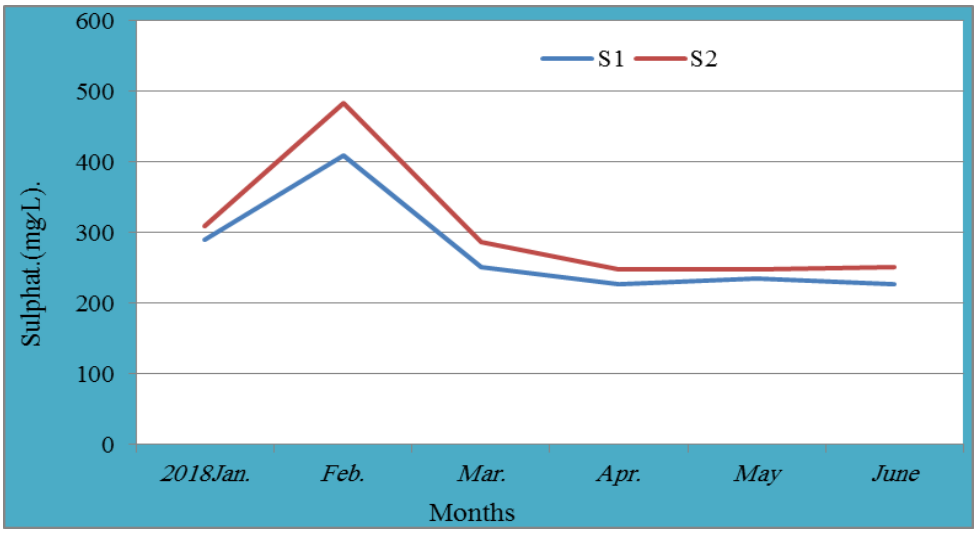


Figure 13. Monthly changes in sulfate values at Tigris river study stations from January 2018 to July 2018

The results of the total hardness of the Tigris River water showed a maximum value of (400 mg/L) during February 2018 at Numaniyah station and the lowest value was (280 mg/L) during April 2018 at Numaniyah station form (12). In the current study the values

of Calcium and magnesium reached highest values were recorded (96.4 mg/L) and (40.2 mg/L) during December 2018 and February 2018 respectively at Numaniyah Station and the lowest value was (76.4 mg/L) and (20.2 mg/L) during April 2018 respectively, for both values at Essaouira station figure 13 and 14. The results of the current study showed that the values of total hardness exceeded the total baseband values in all stations during the study months, indicating that the total hardness in the study area is due to the presence of ions other than calcium and magnesium ions that contribute to the formation of non-carbon hardness. The monthly changes were evident in the values of total hardness, calcium and magnesium hardness, if the highest total hardness values were observed during the winter months at all stations, and may be due to a decrease in water levels, thereby increasing the concentration of dissolved salts while the reason for the high values of total hardness in Numaniyah and Essaouira stations during the winter months may be due to increased pollution resulting from the throwing of household waste and agricultural land waste .The decline in total hardness values during April at all stations may be due to the dilution factor resulting from higher water levels and increased discharge rate. The waters of the Tigris River were classified as very hardness according to, when the value of hardness were exceeded of 300 mg/L, it considered as very hardness, although it did not exceed the Iraqi determinants of (500 mg/L).

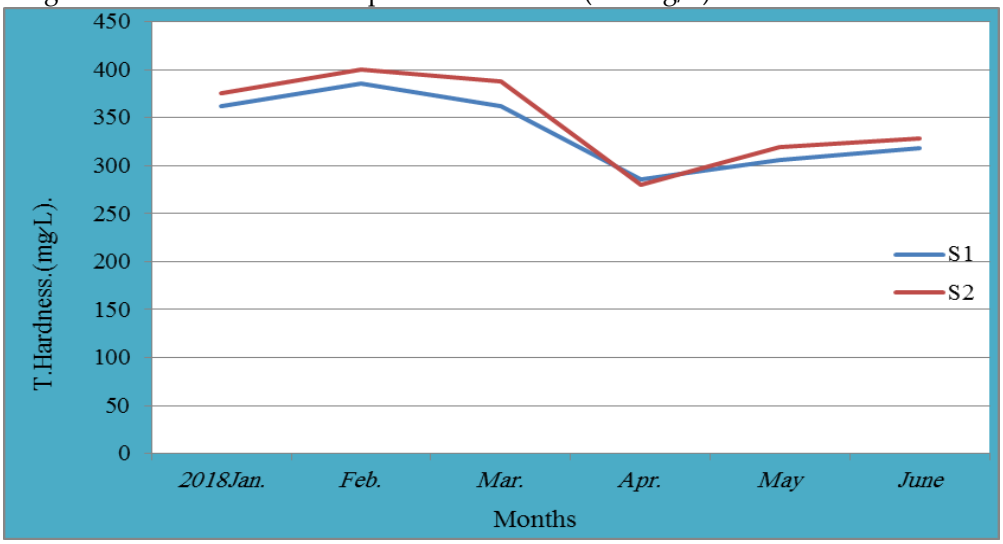


Figure 14. Monthly changes in the values of total hardness in the study stations of the Tigris River from January 2018 to July 2018

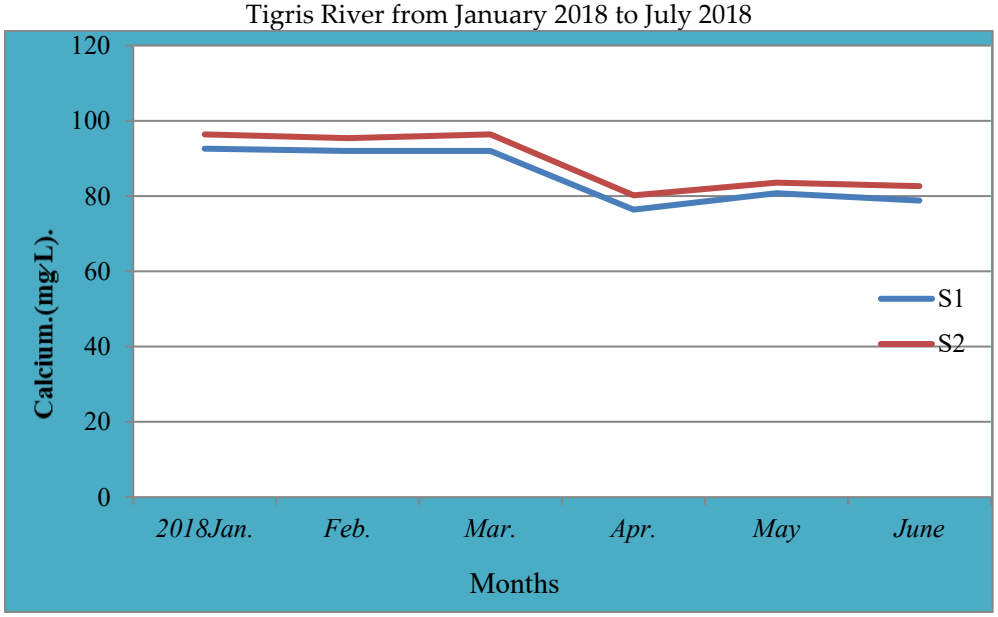


Figure 15. Monthly changes in calcium hardness values in Tigris river study stations from January 2018 to July 2018

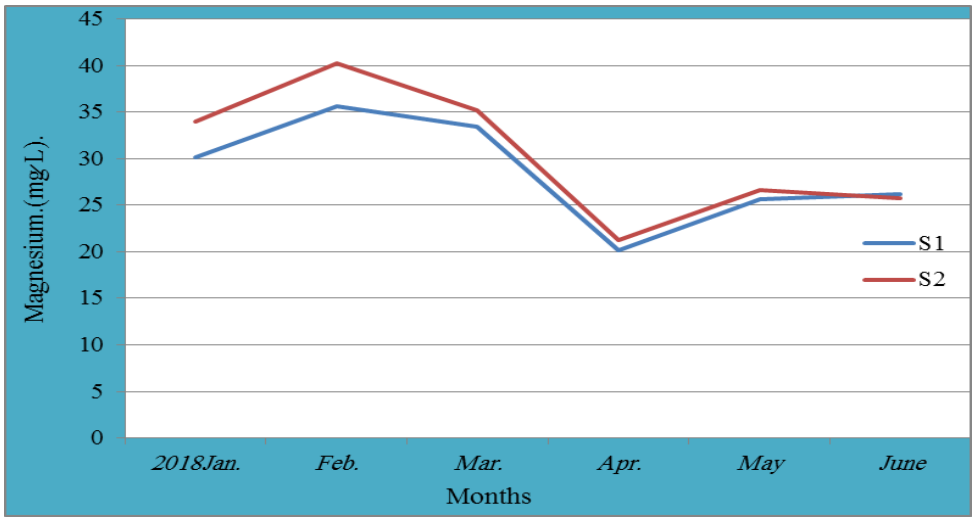


Figure 16. Monthly changes in magnesium hardness values at Tigris river study stations from January 2018 to July 2018

The results showed the total baseband of the Tigris River water between the maximum value about (287 mg/L) during the month of March 2018 at Nomaniyah station the lowest value and was (128mg/L) during April 2018 at Essaouira station figure 16. The rising in the baseband in some winter months may be due to factors related to low discharge and high plant density, especially at Nomaniyah station, but the direct decline in April may be due to the high water levels of rainfall in this month of 2018 compared to the winter months of 2018, which were characterized by low or no rainfall in this year, see Figure 17.

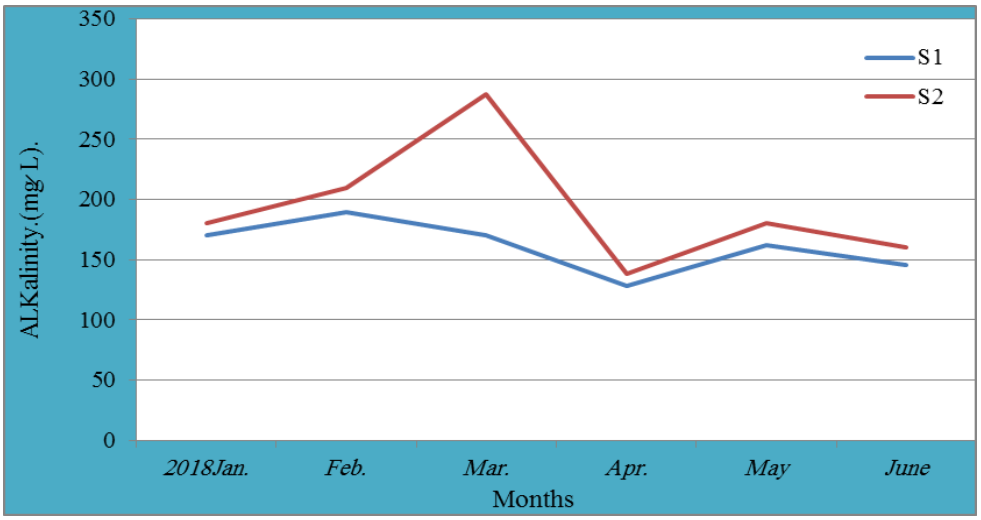


Figure 17. Monthly changes in total baseband values at Tigris river study stations from January 2018 to July 2018

4. Conclusion

This study highlights the importance of integrating environmental data, spatial analysis, and ecological indicators to understand the complex dynamics of Iraq's water systems. Drawing from a diverse set of theses, academic articles, and governmental reports, it becomes evident that anthropogenic activities, including industrial waste, residential pollution, and unregulated agricultural expansion, have contributed significantly to the degradation of river ecosystems such as the Tigris, Euphrates, and Shatt al-Arab. The reviewed literature emphasizes the need for continuous monitoring of water quality parameters—such as chemical, physical, and biological indicators—as well as the spatial distribution of land use and pollution sources. The findings underline the urgency of adopting more sustainable water management strategies, enhancing regulatory oversight, and investing in public awareness campaigns to mitigate future environmental damage.Furthermore, the use of geographic information systems (GIS)

and remote sensing technologies, as demonstrated in several academic studies, provides a reliable and practical tool for visualizing and predicting environmental change. Policymakers and environmental agencies are encouraged to incorporate these scientific tools and data into their planning frameworks to ensure the long-term sustainability of Iraq's freshwater resources.

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