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Article

Impact of Wasit Power Plant effluents on the Physico-chemical Characteristics of water from Tigris River.Wasit, Iraq

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ABSTRACT

The current study aims to know the WasitPower Planteffluents (WPP) effect on the Tigris River's physical and chemical factors. Samples were collected monthly for the period from January to December 2021. The water temperature ranges from 1.4-6.1°C compared with the high temperature at WPP. The water was classified as low salinity, oligohaline, low turbidity, very hard and high alkalinity, with an increased pH value of approximately 0.8-0.9 compared with the first site. The study also showed that high conductivity values, salinity, turbidity, total hardness, calcium, magnesium, nitrate and phosphate increased near WPPefflunts. The results showed a negative effect of WPP on the physicochemical properties, especially on the site near WPP effluent.

Keywords: - Physico-chemical parameters, Tigris River, ThermalPower Plant.

INTRODUCTION

Water is the origin of life on our planet. It is an important factor in all biochemical reactions in living organisms. Also, the survival of ecosystems depends on the presence of water, so its presence is important for the growth of plants and a permanent or temporary habitat for many organisms such as fish, amphibians, and reptiles[1]. The pollution of the aquatic environment is one of the major global problems that concern governments and people worldwide. Hence, the pollution endangers human health, threatens aquatic life, and hinders industrial, agricultural and urban development [2.] Water pollution changes the physical and chemical properties of water and, as a result, endangers the amount of suitable water for human use. [3]. It is known that the amount of fresh water is limited and constitutes only 2% of the total water, which constitutes 71% of the surface waterbodies 2.

The limnology of Iraqi water bodies has received considerable attention in the last four decades. Many studies have been conducted on parts of Iraqi water bodies, such as [4-5]. Establishing electric power plants near waterbodies is one of the most important human activities that directly impact the ecosystem in different ways [6]. At present, monitoring the quality and quality of the water of the Tigris River has become an important topic to identify its suitability for human use, so the idea of the current study came that included the study of the environmental factors of the Tigris River and the impact of the WasitPower Plant (WPP) on it. Thus, it is a database for future studies on the impact of the electrical power plant on any waterbodies near it.

MATERIALS AND METHODS

Study Area

WasitPower Plant is located on the right side of the Tigris River, with an area of 800 acres in Zubaidi City, about 80 Km north of KutGovvernotate. The Wasit Thermal Power Plant consists of two phases. The first phase consists of four generating units and produces the equivalent of 1320 MW each. Those units are complete and are now in service. The second phase consists of two generating units, each with a capacity of 660 MW. The first unit of this stage was supposed to operate in 2015, and the second unit in 2016, according to the schedule set by the company executing this site. However, the company reduced the period and began the trial operation of the first unit of This plant in October 2014. The estimated quantity of the operational water needs of the project ranges around 16,320 m2/ day. Refining and filtration operations are carried out so that it becomes free of all impurities before entering the generation engines. The power plant operates on natural gas, crude oil, heavy fuels, and water. There are three drainage tubes. The first tube represents the industrial water tube, and the amount of water released through it ranges from 450-400 m3/ hour, and the second tube represents the cooling water tube, as the amount of water released through it ranges from 650-600 m3/ hour. In contrast, the third tube represents the desalination tube. The amount of water released through it ranges from 150-200 m3/ hour, where the water discharge is according to the site's operation, and the main effects are confined to the water environment. and measuring the concentration of suspended pollutants in the air [7].

Sample Collection

Water samples were collected monthly from five studies on the Tigris River within Wasit Governorate for the period from January to December 2021 (Fig. 1). The first site is located at the end of AziziyahDistrict, about 1 Km before WPP at 3627194.008 N, 508153.0982 E, and Tigris River350 m width, 4 m depth on this site. The second site is about 50 m near WPP at 3626575.886 N, 508268.2392 E, and Tigris River. This site is 475 m in width and 4 m in depth. The third site is located approximately 500 m away from the second site.

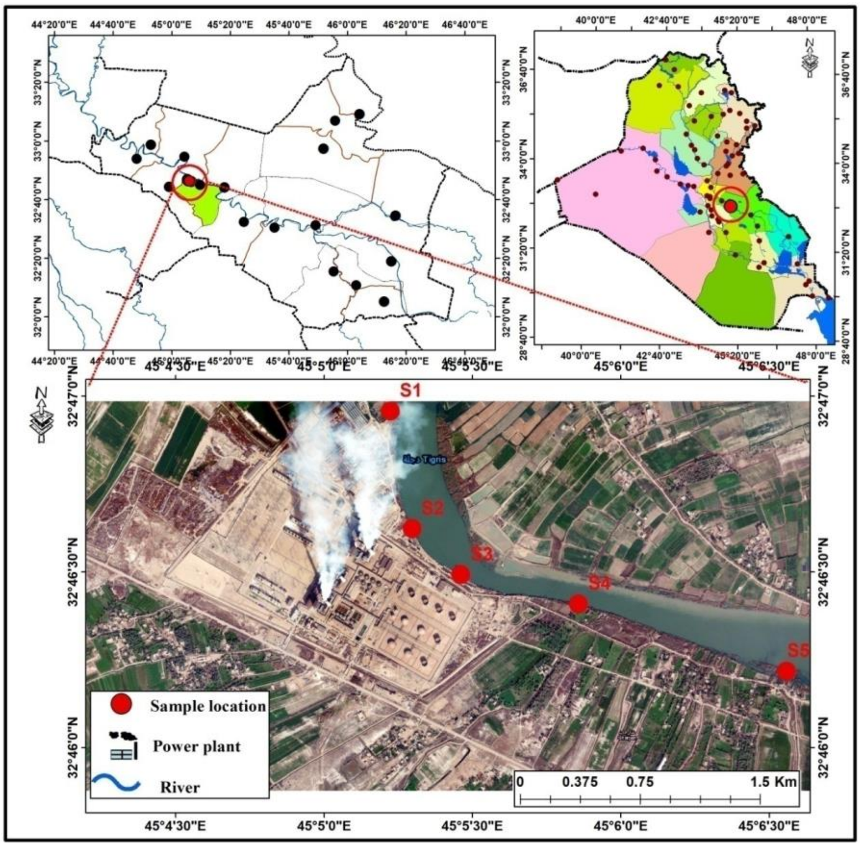

Figure (1) Study sites on the Tigris River within Wasit Governorate (Source: Ministry of Water Resources, Baghdad, 2021at a scale of 1:1000000 and the map of Wasit Governorate, at a scale of 1:250,000, using the 10.8 Arc Map (2021) program, Personal communication).

It is located after the WPP effluents, below 3626334.594 N,508525.2014 Eand300 m width, 4 m depth. The fourth site is approximately 1 Km away from the third site, at below latitude 3625828.245 N, 510238.8 E, and 350 m width, 4 m depth. The fifth site is about 2 Km away from the fourth site at 3626180,887 N, 509144.3742 E and width350 m, depth 4 m. The monthly variation of water discharge of the Tigris River water during the study period ranged from 659.196 - 397,164 m3/s, while the water current ranged from 0.7742 - 0.6326 m/s during the study period (Table 1).

All samples were taken from the surface layer at a depth of about 30-50 cm, taking into account not to take samples from lentic water [8]. Polyethylene-locked containers with a capacity of 2,250 L were used after being washed well with river water. Some characteristics were conducted at the study site directly, such as air and water temperature, electrical conductivity, total dissolved solids, and pH. The temperature was measured in the field using a digital thermometer in all study sites by placing it in the shade until the reading was stable. At the same time, the temperature of water, electrical conductivity and dissolved solids were measured using an Electrical Conductivity Meter of MARTINI Instruments [9]. The pH was measured by using HANNA (H19811) [27]. Turbidity was measured with a Jenwaw Model 6035 turbidity meter.

Months	Water discharge (m^3/s)	water current (m/s)
January 2021	592.134	**0.7382**
February	517.005	**0.6768**
March	659.196	**0.7369**
April	519.773	**0.6886**
May	397.164	**0.6326**
June	472.173	**0.7058**
July	525.461	**0.7523**
August	536.726	**0.7624**
September	455.945	**0.7284**
October	416.856	**0.6992**
November	436.475	**0.7082**
December	498.341	**0.7742**

Table (1): Average monthly water discharge (m^3/sec) and water current (m/sec) of the Tigris River during the study period 2021 (Department of Water Signals - Ministry of Irrigation, Personal communication)

Modification Azid Winkler's method8 measured the dissolved oxygen and the BiologicalOxygen Demand. The percentage oxygen saturation was calculated based on [10]. Total suspended solids were measured according to the procedure mentioned by Spellman [8]. The total hardness, calcium and magnesium were measured according to standard methods [11]. The sulfate ion was measured according to the Brands and Tripke [12] procedure. Phosphates were measured using ascorbic acid. A UV-spectrophotometer was used to measure nitrate as described by the standard method by 11. Finally, the titration method of sulfuric acid was used to determine the total alkalinity as described by Spellman [8].

Statistical analysis

The data were analyzed by using the statistical program SAS-Statistical Analysis system (2012) to find the significant differences between the sites according to the results of the analysis of variance Duncan [31], and this test was conducted at a significant level of 0.05 [31].

RESULTS

The results showed that the air temperature fluctuates seasonally. The highest air temperature values were recorded during the summer. In contrast, the lowest values were recorded during the winter (Fig. 2). This may be related to Iraq's climate, with hot, dry summers and cold and rainy winters [32]. The statistical analysis found no significant differences at $P \leq 0.05$ among the studied sites (Table 2).

The water temperature also increased in the summer, especially in August. It decreased in the winter season (Fig. 3). Through the results of the statistical analysis, it was found that there were no significant differences at $P>0.05$ among sites 3, 4 and 5, with significant differences at $P \leq 0.05$ with the rest of the studied sites (Table 2). The hot effluents cause the rise in water temperature near the WPP, as the cooling water that enters the WPP rises in temperature and is then returned to the river.

Table (2) and Figure (4) show the turbidity values in Site 1, up ofWPPeffluents. The values ranged from 27.03 NTU in April to 3.27 NTU in January, while the turbidity values at site 2 near WPP effluents recorded the highest value of 43.07 NTU in March, while the lowest value was 11.78 NTU recorded in August. As for the down of WPP, the highest values were 37.51 NTU recorded at site 3 in April, and the lowest was 9.85 NTU recorded at site 4 in January.

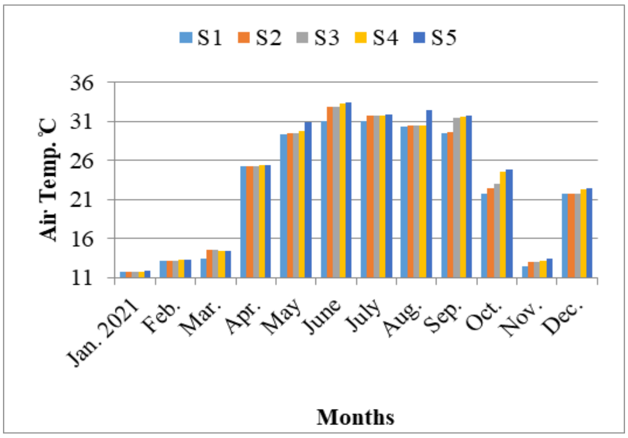

Figure 3. Variations of Air temperature value during the study period.

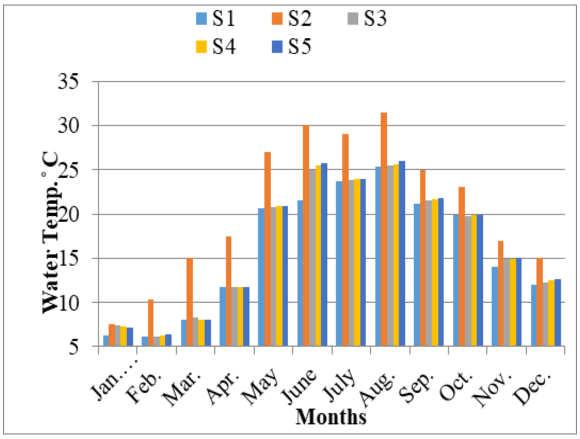

Figure 2. Variations of Water temperature value during the study period

The statistical analysis results found no significant differences at P>0.05 among sites 3, 4 and 5, which differed significantly from P<0.05 with the rest of the sites (Table 2). Regarding the spatial changes, the turbidity values increased in site 2 near the WPP effluents and reached 43.07 NTU, while the lowest value was 3.27 NTU recorded at site 1 (Table 2).

The electrical conductivity and salinity in site 1 up of WPP ranged from 620-1240 µs/cm (0.79-0.39‰), with the highest value in September and the lowest in August. As for site 2 near WPP, the electrical conductivity and salinity values reached 1510-1110 µs/cm (0.71-0.96‰), where the highest value was in March, and the lowest value was in January. At sites down of the effluents, the values of electrical conductivity and salinity ranged from 1020-1260 µs/cm(0.65 -0.80 ‰), the highest values in sites 3 and 5 during September, and the lowest values in sites 3, 4 and 5 during May. (Table 2 and Figure 5-6)

The statistical electrical conductivity and salinity analysis showed no significant differences at P>0.05 among the studied sites (Table 2).

As for the total dissolved solids, in site 1 up of WPP effluents, the highest value was 0.62 g/L during September, and the lowest value was 0.31 g/L during August, while the values in Site 2 near WPP effluents ranged from 0.75 g/L during August to 0.55 g/L during January. At sites down of the WPP effluents, the highest value was 0.63 g/Latsites 3 and 5 during September, and the lowest value was 0.51 g/Latsites 3, 4 and 5 during May (Table 2 and Figure 7).

Statistically, it was found that there were no significant differences at P>0.05 among the studied sites (Table 2).

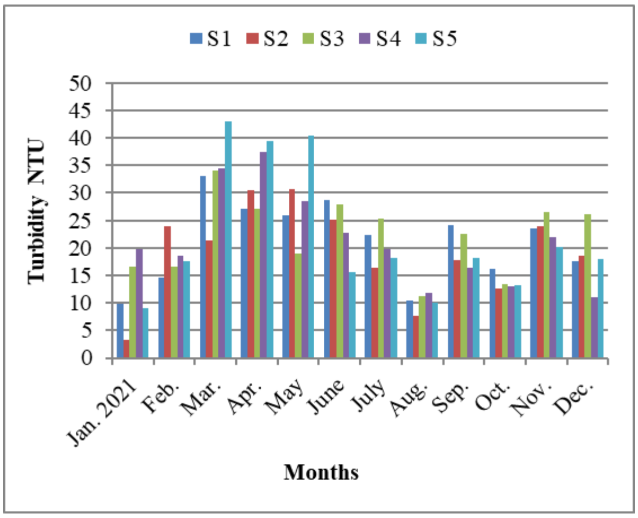

Figure 4. Variations of turbidity value during the study period.

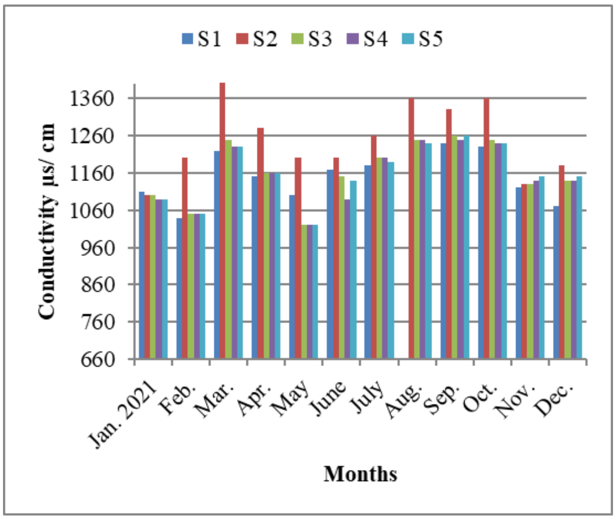

Figure 5. Variations of conductivity value during the study period.

As for the temporal changes, the highest values were recorded during the spring and autumn seasons, especially near WPP effluents, which may be due to the increase of effluents due to the increase in the electricity demand.

As for the pH, in Site 1 up of WPP effluents, the maximum value was 7.6 during September, and the minimum value was 7 during January, March, August, October and December, while in the 2nd site near WPP effluents, the highest value 7.9 during February, March, September and November and the lowest value was 7.5 January and August. As for sites down of the WPP effluents, the highest values were 7.9 at sites 3 in November, and the lowest was 7 at sites 4 and 5 in October (Table 2 and Figure 8). The statistical analysis results recorded no significant differences P> 0.05 among the studied sites (Table 2).

As for the temporal changes, a slight rise in the values appeared in the waters of sites 2 and 3 during winter. This may be due to their being affected by the hot effluents that provide a suitable temperature for photosynthesis during the cold season. The opposite occurs during summer's hot season [42]. The highest value of total suspended solids recorded in Site 1 up of WPP effluents was 64 mg/L during August.

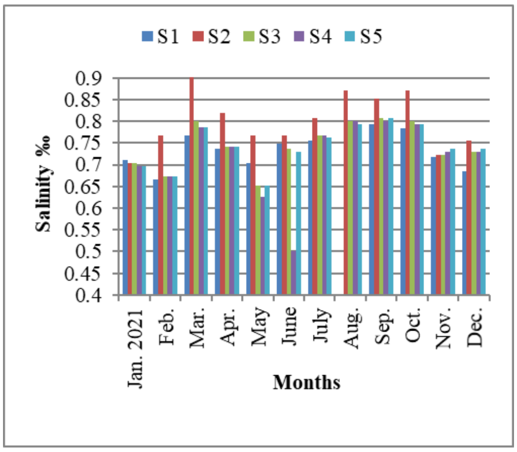

Figure 6. Variations of salinity value during the study period.

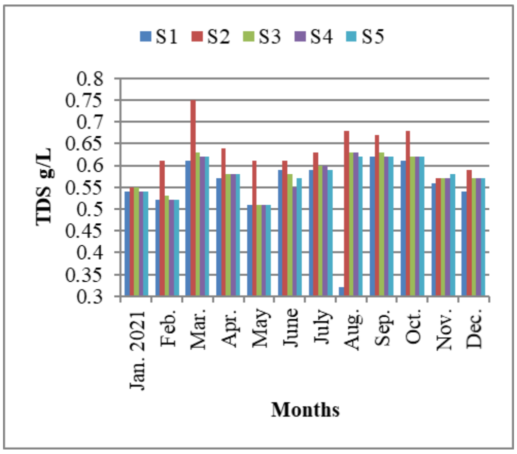

Figure 7. Variations of total dissolved solids value during the study period

The lowest value was 1 mg/L during January, while the values in Site 2 near WPP effluents ranged between the highest value of 48 mg/L during July. The lowest value was 2 mg/L during January and February. As for the sites down WPP effluents, the highest value recorded was 63 mg/L at site 3 during August, and the lowest value was 1mg/L at site 3 during June and 1 mg/Latsite 4 on January and May and 1mg /L at site 5 on January, March and May (Fig. 9). Through the results of the statistical analysis, it was found that there were no significant differences at P>0.05 among the studied sites (Table 2).

As for the temporal variation, the concentrations of total suspended solids increased during the summer and autumn seasons (Fig. 9). This may be related to the variation of water discharged quantities to the Tigris River and WPP effluents (Table 1).

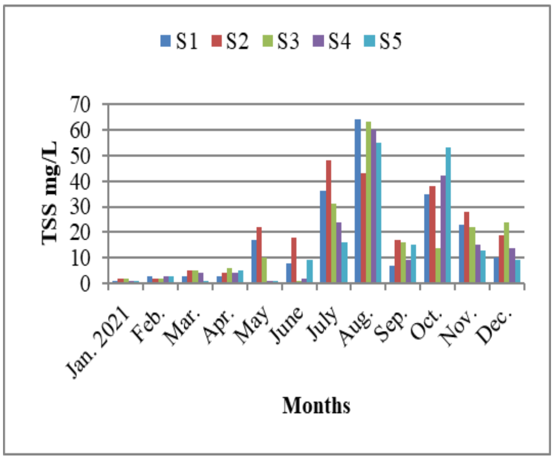

Figure 9. Variations of total suspended solids value during the study period.

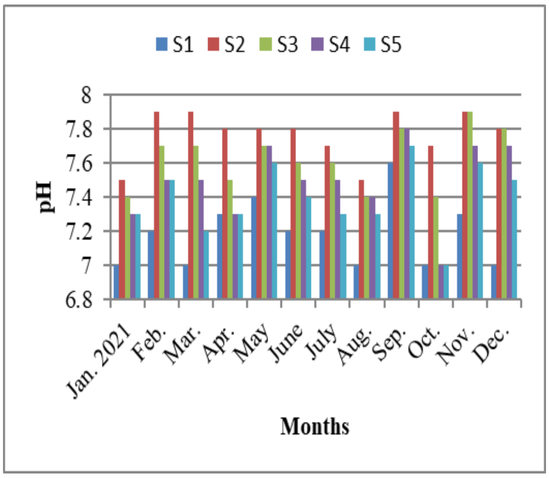

Figure 8. Variations of pH value during the study period.

As for dissolved oxygen, it was recorded in Site 1 up of WPP effluents. The highest value was 11.5 mg/L during January. The lowest value was 6.7 mg/L during September, while in Site 2, near WPP effluents, the highest value ranged from 7.7 mg /L during January, the lowest value was 4.2 mg/L during May, while the values of dissolved oxygen down WPP effluents recorded the highest value of 8.5 mg/Latsite 5 on December. The lowest value was 4.2 mg/Latsite 3 in May (Fig. 10).

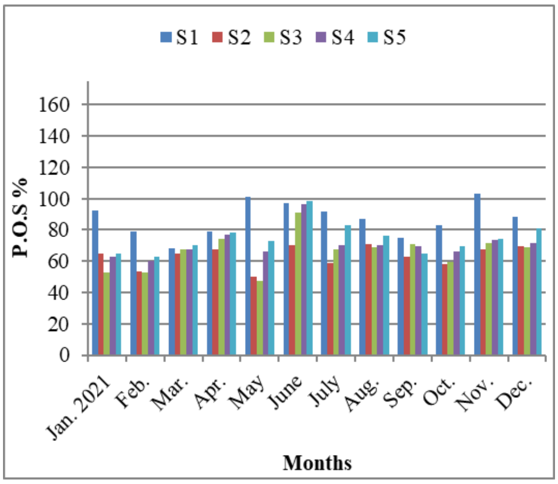

Figure 11. Variations of the percentage of oxygen saturation value during the study.

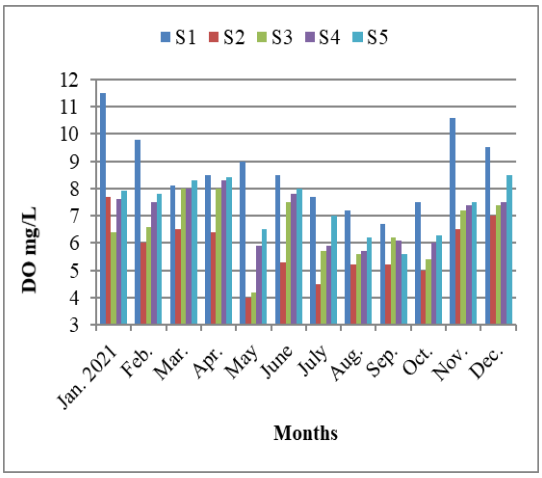

Figure 10. Variations of dissolved oxygen value during the study period.

The values of the percentage of oxygen saturation site 1 up of WPP effluents, where the highest value was recorded at 103.0126 % during November, and the lowest value was 68.4121% during March, while in site 2 near WPP effluents, the highest values were ranged between 70.9413% during August and the lowest values were 50.1882 % on May, while the values of the percentage of oxygen saturation at the down WPP effluents recorded the highest value of 98.5221% at site 5 during June. The lowest value was 47.138 % atsite 3 in May (Figure 11).

Through the results of the statistical analysis of dissolved oxygen and the percentage of oxygen saturation, it was found that there were no significant differences at $P>0.05$ among sites 2 and 3, which differed significantly from $P<0.05$ with the rest of the sites (Table 2).

Figure (13) and Table (2) show total hardness values in the study sites. In site 1, up of WPP effluents, the highest value was 660 mg/L in December, and the lowest was 100 mg/L during May. As for site 2, near WPP effluents, the values ranged from 720 mg/L in December to 140 mg/L, recorded during May. While the values on sites down of WPP effluents, the highest value was 700 mg/L at site 3 during December, while the lowest value was 120 mg/L at site 3 during May. The statistical analysis results found that there were no significant differences at $P>0.05$ among the studied sites (Table 2).

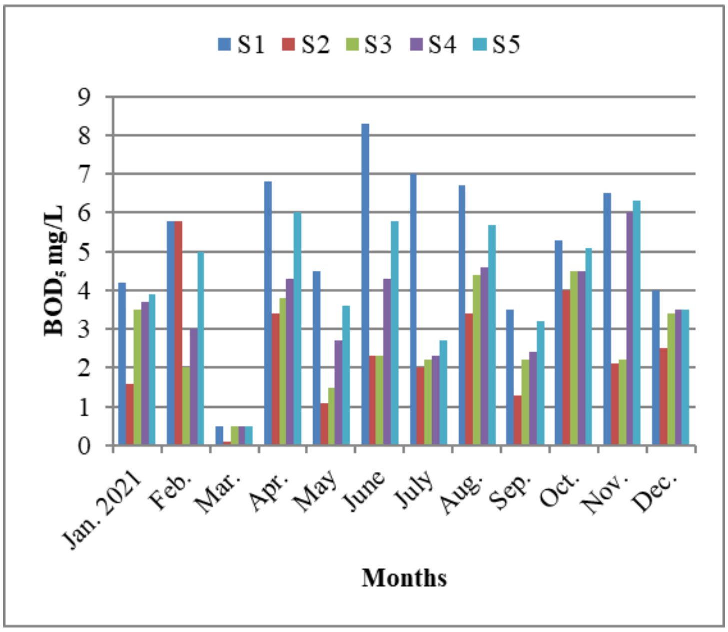

Figure 13. Variations of the BOD_5 value during the study period.

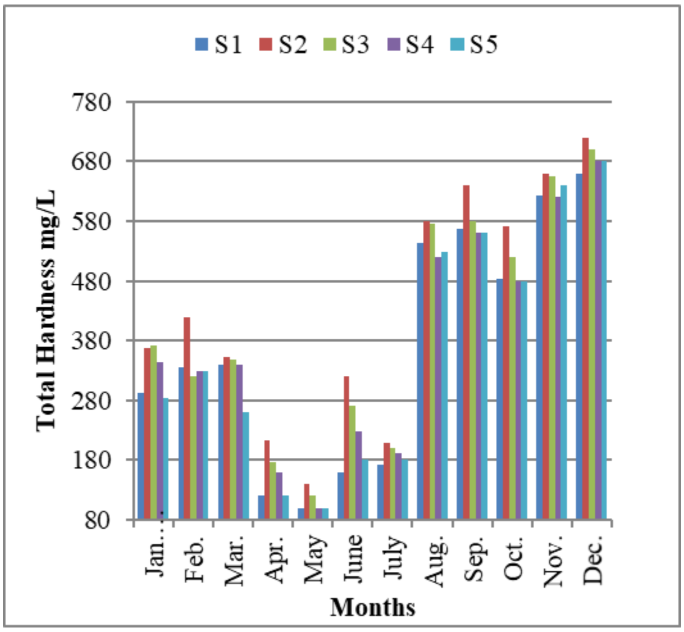

Figure 12. Variations of total hardness value during the study period.

Calcium values showed a clear variation in the current study sites (Fig. 14). In site 1, up of WPP effluents, the values ranged from 350.7 mg/L during September to 52.10 mg/L during July, while in site 2 near WPP effluents the highest value was recorded. 400.8 mg/L during September, and the lowest value was 80.16 mg/L during July. As for sites down WPP effluents, the highest values were 350.76 mg/L at sites 3 and 4 during September, and the lowest values were 60.12 mg/L at site 5 during July.

The statistical analysis showed no significant differences at P>0.05 among the studied sites (Table 2).

Figure (15) and Table (2) show the magnesium ion values for the study sites. In site up of WPP effluents, the highest value was 79.62 mg/L during February, and the lowest value was 10.18 mg/L during July, while the values in site 2 near WPP effluents were recorded the highest value of 100 mg/L during February. The lowest value was 10.85 mg/L during July, while the sites down of WPP effluents, the highest value was 87.77 mg/L at site 3 during January, and the lowest value was 4.79 mg/L at site 3 during July.

The statistical analysis found no significant differences at P>0.05 for sites 1, 3 and 4, which differed significantly at P>0.05 with the rest of the sites (Table 2).

As for spatial variation, the highest values were recorded in site 2 near WPP effluents, which may be attributed to its significant increase due to industrial waste and sewage water of the WPP, while the lowest values in site 3 may be attributed to the decomposition of algae and aquatic plants or the return of magnesium to the water or it may be due to leakage from the land neighboring as a sulfate magnesium [47]

As for the temporal variation, the values of magnesium concentrations recorded a clear variation during the summer due to its consumption by plankton and plants in the river water.

Figure (16) and Table (2) show the sulfate values. In site 1 up of WPP effluents, the highest value was recorded at 180 mg/L during June and December, and the lowest value was 40 mg/L during January, while the values in site 2 near WPP effluents ranged from 500 mg/L during June to 90 mg/L during January. As for the sites down of WPP effluents, the highest value was 300 mg/L at site 3 during June, and the lowest was 50 mg/L at site 5 during January.

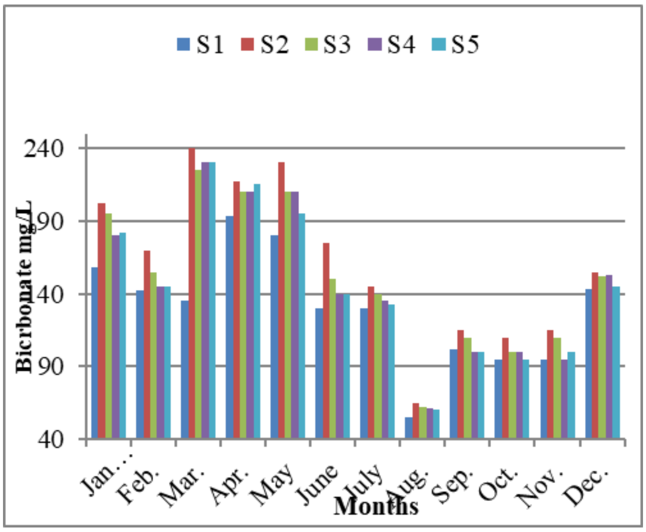

Figure 15. Variations of bicarbonate value during the study period.

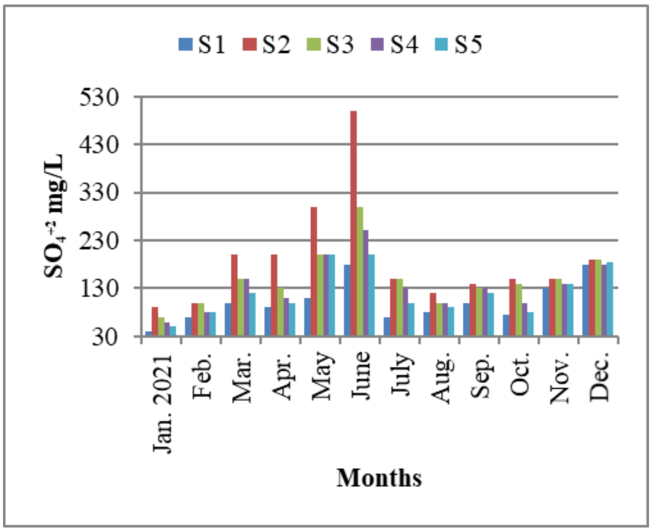

Figure 14. Variations of sulfate value during the study period .

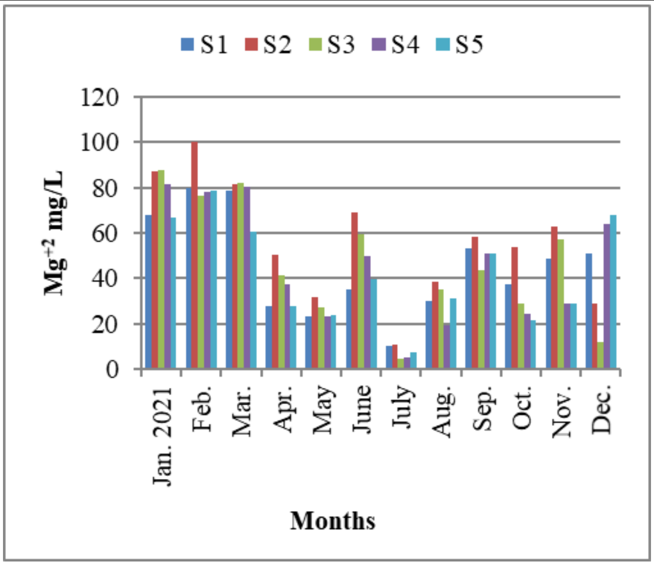

Figure 17. Variations of magnesium value during the study period.

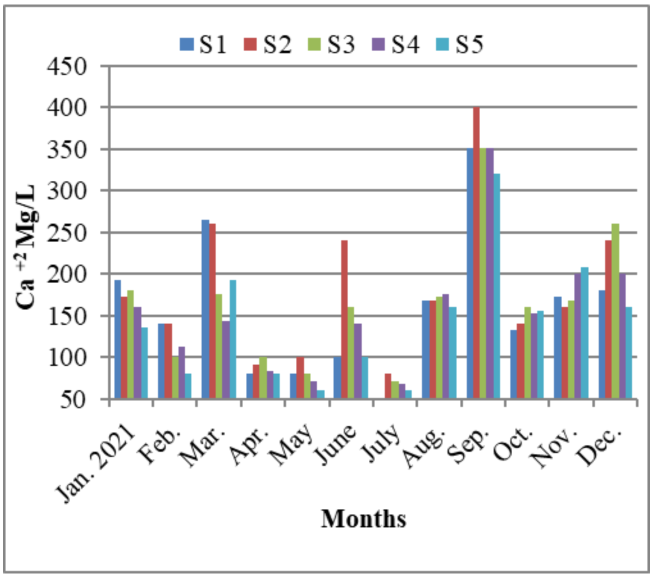

Figure 16. Variations of calcium value during the study period.

As for bicarbonate, in site 1 up of WPP effluents, the values ranged from 193 mg/L during April to 55 mg/L during August, while in site 2, near WPP effluents, the highest value was recorded 240 mg/L during March and the lowest value was 65 mg/L during August, while the lowest values of the sites down of WPP effluents were recorded, the highest was 230 mg/L at sites 3 and 4 during March, and the lowest was 60 mg/Lat site 5 during August. (Table 2 and Figure 17).

The results of the statistical analysis showed that there were no significant differences at P>0.05 among the studied sites (Table 2)

As for nitrates, in site 1, up of WPP effluents, the highest value of nitrate was2.71 mg/L during January, and the lowest value was 0.15 mg/L during August, while in site2 near WPP effluents, the highest values were ranged from 4.65 mg/L during May, and the lowest was 0.71 mg/L during July. In the sites down of WPP effluents, the highest value was 4.2 mg/L at site 3 during May, and the lowest value was 0.44 mg/L at site 5 during August (Table 2 and Figure 18)

The statistical analysis results found that there were no significant differences at P>0.05 among the studied sites (Table 2).

As for phosphate, in site 1, WPP effluents, the highest value ranged from 0.056 mg/L during June, and the lowest value was 0.0019 mg/L during August, while in site 2, near the WPP effluents, the highest value was recorded 0.066 mg/L during the March and the lowest value was 0.0036 mg/L during August, while at sites down of WPP effluents, the highest value was 0.066 mg/L at site 3 during March and the lowest value was 0.0029 mg/L at site5 during August (Table 2 and Figure 19). The results of the statistical analysis showed that there were no significant differences at P>0.05 among the studied sites (Table 2)

As for the temporal variation, the highest phosphate values were recorded during spring and the lowest in summer. This may be due to industrial water, sewage water, and detergents containing phosphate compounds, which are discharged from WPP and dumped into the river without treatment. At the same time, the reasons for the decrease in phosphate concentrations in the summer, in general, are the rise in the water discharge during August 536.72 m^3/S (Table 1) and the increase in the number of plankton and aquatic plants that consume phosphate in large quantities [42].

As for the total alkalinity, the highest value was recorded in site 1 up of WPP effluents, which reached 244 mg/L during July, and the lowest value was 122 mg/L during August, while in site 2, near WPP effluents, the highest value ranged from 268.4 mg/L during July. The lowest value was 134.2 mg/l during November, while in the sites down of WPP effluents, the highest value was 250.1 mg/L at site 3 during July, and the lowest value was 103.7 mg/L at site 5 during August (Table 2 and Figure 19)

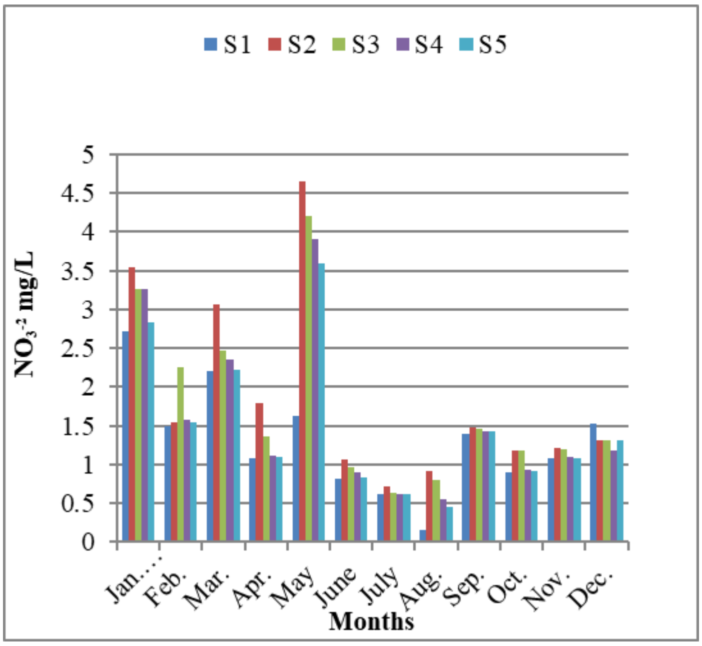

Figure 18. Variations of Nitrate value during the study period.

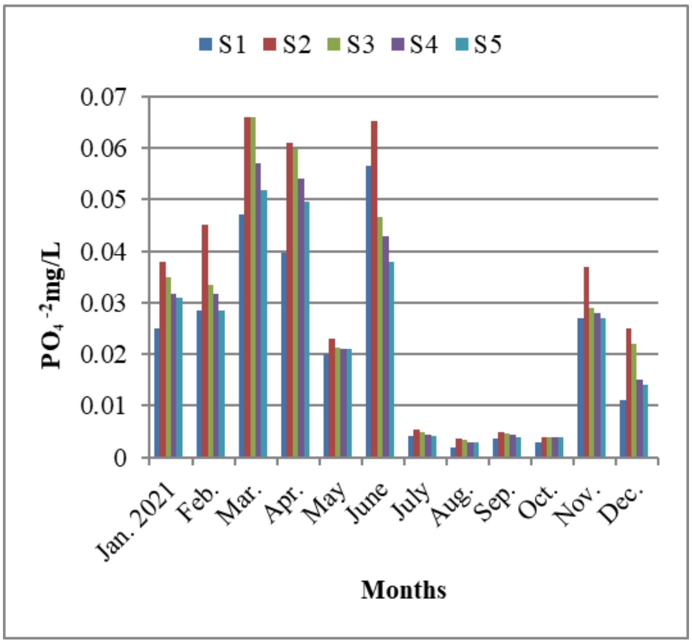

Figure 19. Variations of Phosphate value during the study period.

As for the total alkalinity, the highest value was recorded in site 1 up of WPP effluents, which reached 244 mg/L during July, and the lowest value was 122 mg/L during August, while in site 2, near WPP effluents, the highest value ranged from 268.4 mg/L during July. The lowest value was 134.2 mg/l during November, while in the sites down of WPP effluents, the highest value was 250.1 mg/L at site 3 during July, and the lowest value was 103.7 mg/L at site 5 during August (Table 2 and Figure 19)

The statistical analysis results found that there were no significant differences at P>0.05 among the studied sites (Table 2).

The current study showed that the total alkalinity values are higher than the normal permissible limit for the standard specifications of Iraqi and international waters, which are 20-200 mg/L[56].

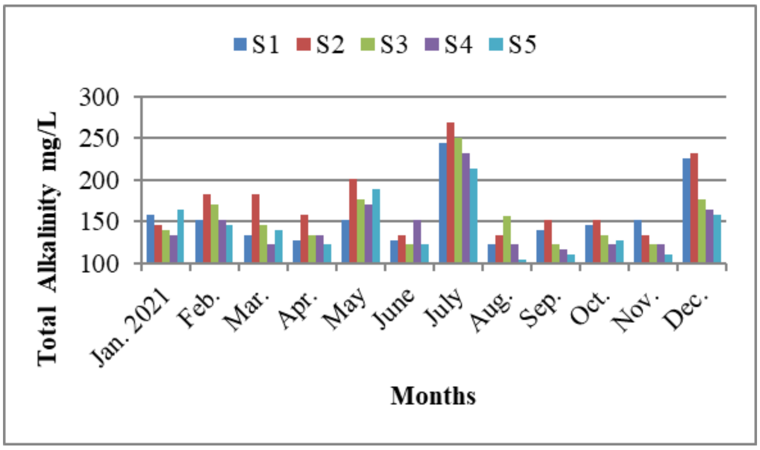

Figure 20. Variations of total Alkalinity value during the study period.

Site Parameters	1	2	3	4	5	LSD value
Air Temp. ˚C	11.7-31 22.55833.±2.29675	11.7-32.9 23.0166.±2.3311	11.8-32.8 23.225.±2.3688	11.8-33.3 23.4833.±2.3898	11.9-33.4 23.85±2.4585	3.04 NS
Water Temp. ˚C	6.1-25.4 15.8666.±2.0143 b	7.5-31.5 20.65±2.3140 a	6.2-25.5 16.4333±2.0602ab	6.3-25.6 16.525±2.0928ab	6.4-26 16.6083±2.1147ab	5.07 *
Turbidity NTU	3.27-27.03 15.4383±1.8291 b	11.78-43.07 26.5358±2.9047 a	11.18-37.51 23.5808±2.3269ab	9.85-34.04 20.8116±2.234 ab	8.99-32.98 19.4975±2.0423ab	8.91 *
EC µS/cm	620-1240 1100.833±47.4109	1110-1510 1261.667±32.5174	1020-1260 1168.333±23.3177	1020-1250 1160.833±22.5455	1020-1260 1158.333±22.4571	168.43 NS
Salinity ‰	0.3968-0.7963 0.7045±0.0303	0.7104-0.9664 0.8074.±0.02081	0.6528-0.8064 0.7477±0.01492	0.6558-0.8 0.7406±0.01581	0.6528-0.8064 0.74133±0.01437	0.208 NS
pH	7-7.6 7.1833±0.0561	7.5-7.9 7.7666±0.0414	7.4-7.9 7.625±0.04943	7-7.8 7.4916±0.06645	7-7.7 7.3916±0.0570	0.772 NS
DO mg/ L	6.7-11.5 8.7166±0.4130 a	4-7.7 5.775±0.3133 b	4.2-8 6.5166±0.3354ab	5.7-8.3 6.975±0.2788ab	5.6-8.5 7.333±0.2834ab	2.61 *
BOD_5 mg/ L	0.5-8.3 5.2583±0.6004 a	0.1-5.8 2.4666±0.4366 c	0.5-4.5 2.7083±0.3497bc	0.5-6 3.4833±0.4111 b	0.5-6.3 4.275±0.4902ab	1.782 *
Oxygen Saturation (POS) %	68.4121-103.0126 87.0262±3.0724 a	50.1882-70.9413 63.1815±1.9546 c	47.138-90.799 66.0698±3.3732 c	60.2409-96.0591 70.8881±2.637 bc	62.6506-98.5221 74.6808±2.8562 b	8.05 *
T.H mg/ L	100-660 366.583±58.8601	140-720 432.666±56.8583	72.144-350.76 165.1672±22.7513	100-680 379.333±55.0802	100-680 361.666±59.6846	94.38 NS
Ca^{+2} mg/L	52.104-350.7 159.4802±24.3241	80.16-400.8 183.0814±26.1309	4.79-87.773 46.3628±7.7403ab	68.13-350.7 155.1419±22.1061	60.12-320.64 142.9513±21.7713	61.77 NS
Mg^{+2} mg/ L	10.18-79.622 45.2381±6.3659ab	10.85-100 56.1738±7.524 a	70-300 150.833±17.165 ab	5.282-81.265 45.2950±7.567ab	7.24-78.588 42.0555±6.4575 b	11.59 *
SO^{+4} mg/ L	40-180 102.0833±12.393 b	90-500 190.8333±32.41 a	62-225 151.5833±14.6666	60-250 135.833±15.44 ab	50-200 122.083±14.3480 b	59.74 *
$HCO_3^{=}$ mg/ L	55-193 129.8333±11.1636	65-240 161.5833±15.6754	0.51-0.63 0.5841±0.0116	61-230 146.5833±15.2421	60-230 145±15.0604	45.89 NS
TDS g/L	0.31-0.62 0.5504±0.0237	0.555-0.755 0.6308±0.0162	0.628-4.2 1.7573±0.3125	0.51-0.625 0.5804±0.0112	0.51-0.63 0.5791±0.0112	0.172 NS
NO_3^{-2} mg/L	0.155-2.71 1.2997±0.2001	0.71-4.657 1.872±0.3524	0.0035-0.066 0.0275±0.0062	0.545-3.914 1.5761±0.3063	0.446-3.6 1.4932±0.2718	0.604 NS
PO_4^{-2} mg/L	0.0019-0.0566	0.0036-0.066	0.0035-0.066	0.003-0.057	0.0029-0.0517	0.0166

	0.0222±0.0053	0.0315±0.0070	0.0275±0.0062	0.0247±0.0056	0.0229±0.0051	NS
TSS mg/L	1-64 17.5±5.5056	2-48 20.5±4.6426	1-63 16.3333±5.0832	1-60 14.9166.±5.3789	1-55 15.083±5.4724	7.027 NS
Total Alkalinity mg/L	122-244 157.075±11.0643	134.2-268.4 173.3417±12.2570	122-250.1 154.3083±10.5425	115.9-231.8 145.3833±9.4930	103.7-213.5 142.333±9.7998	36.823 NS

Table 2. Averages, ranges and standard error of physical and chemical parameters of Tigris River before and after the WPPSites for the study sites during 2021.

DISCUSSION

Regarding the temporal changes, the turbidity values increased in the spring, especially in March, near WPP effluents, and decreased in the rest of the sites of the Tigris River during the summer and winter seasons (Fig. 4). There is a clear effect of the power plant in the high values of turbidity as it is affected by hot effluents, especially during the spring, maybe due to the changes in the quantities of water discharged from power plants and river current water as well as the location of the sampling point [33,34]. As for the low values of turbidity in January and August, it may be due to the difference in the amounts of rain, river current water and water discharges, as well as the amount of river total suspended matter, or it may be due to the difference in the organic and inorganic wastes that contribute to adding significant amounts of particulate matter. [35]. The US Environmental Protection Agency [36] divided water into three types depending on the value of the total suspended solids, as the concentration of less than 20 mg/L is pure, and water with total suspended solids value ranges from 20-80 mg/L is considered low turbidity. In contrast, values higher than 150 mg/L are considered turbid. Depending on the values of total suspended solids recorded during the current study, the waters of the Tigris River are considered low turbidity.

Regarding the spatial changes, the highest values of electrical conductivity and salinity were recorded in Site 2, affected by the heat WPP effluents, due to the high temperature, which increases the water evaporation rate near the hot effluents and an increase in the concentration of salts in them [37;38].

As for the temporal changes, the highest values were recorded in spring and autumn, and the lowest was in the other seasons. This is due to the increase in the evaporation rate due to the high temperature of the heat WPP effluents and the energy of some of the ions present due to the increase in the movement of dissolved substances [39]. The river water was classified as oligohaline according to the classification mentioned by the EPA [40], as it is within the salinity ranges from 0.5-5‰.

For the spatial changes of the dissolved solids in the study sites, the highest value was shown near the WPP effluents, which amounted to 0.75 g/L, and the lowest value was 0.31 g/Latsite 1. The dissolved solids consist of an anion and a cation. The chemical composition of the solids in the water depends on the nature of the land and the special interaction between rocks, rain, soil and plants that live in the neighboring areas, so when the river flow rate was higher, it led to the increase the in the total dissolved solids concentration in the water [41].

Regarding the spatial changes, the highest values were recorded at sites 2 and 3, and the lowest values were recorded at the rest of the sites (Table 2). The high pH values near and down WPP effluents can be attributed to the high content of ammonia that is discharged close to the river [37].

As for Spatial variation of the total suspended solids in the study sites. The highest value of total suspended solids was recorded at 64 mg/L at site 1 up of WPP effluents, and this may be due to the presence of plants in this site that work plankton inactive with moderate current water, while site 2 is affected by WPP effluents, and this water increases current water, which leads to activates the suspended solids movement, in addition, the WPP effluents carries enough amount of suspended materials [42]

Regarding the spatial variation of dissolved oxygen and the percentage of oxygen saturation, the highest values were recorded at site 1. In contrast, the lowest values were recorded near WPP effluents at site 2, which lead to raising the water temperature and increasing the evaporation activities of water, In addition to the negative effect of hot water on plants, which is negatively reflected in the production of dissolved oxygen in the aquatic environment [42].

As for the temporal variation, the highest values were recorded during the winter season, while a clear decrease was recorded in the dissolved oxygen concentration and the percentage of oxygen saturation near hot WPP effluents during the summer because there is an inverse relationship between water temperature and the percentage of dissolved oxygen, and this may be due to the increase in metabolic rates at high temperatures, which It leads to a decrease in the levels of dissolved oxygen in the water [43].

The values of the biological oxygen demands in site 1 up ofWPP effluents ranged from 8.3 mg/L during June to 0.5 mg/L in March, while in site 2 near WPP effluents, the highest value was recorded 5.8 mg/L during February and the lowest value was 0.1 mg/L March, while at sites belowWPP effluents the highest value was 6.3 mg/L at site 5 during November and the lowest value was 0.5 mg/L at sites 3, 4 and 5 on March (Figure 12)

The statistical analysis found no significant differences among sites 3 and 5 at $P>0.05$, which differed significantly from the rest of the sites (Table 2).

As for the spatial variation, the highest value was recorded at site 1, and the lowest was at site 2 near WPP effluents, which contain chemical and industrial wastes that lead to increased microorganism activity, leading to dissolved oxygen depletion. As a result, organic matter decomposition [42].

As for the temporal variation, the high biological oxygen demand (BOD5) values appeared during summer and winter. The real reason is that it may be due to the presence of organic matter, including hydrocarbons, in addition to biodegradation and many pollutants, as well as the rot conditions and the reproduction of phytoplankton that can lead to oxygen depletion. When there is enough oxygen for organic decomposition, the carbon is converted to carbon dioxide, phosphorous into phosphate and nitrogen into ammonia and nitrate. However, when oxygen is insufficient, carbon turns into methane, and nitrogen compounds turn ammonia.

Odum [44] divided the water quality of water bodies according to the BOD values into BOD5=2 clean, BOD5=5 or more of questionable cleanliness. Therefore, the water quality, according to the rates recorded for the BOD5 values of the Tigris River, can be considered water of questionable cleanliness.

As for the spatial variation, the highest value was recorded at site 2 near WPP effluents, which amounted to 720 mg/L, while the lowest value was recorded at site 1, which amounted to 100 mg/L. The increase in total hardness likely resulted from dumping removed hardness material into the Tigris River. To obtain salt-free water used in the operations of WPP, these compounds are either suspended or dissolved substances, or calcium sulfate, calcium and magnesium carbonate, and others [45].

Water is divided according to the hardness, as water with less than 50 mg/L of calcium carbonate is not hard water. The value of calcium carbonate ranges from 50-100 mg/Lis medium hardness, while those that range from 100-200 mg/L of calcium carbonate are hard water, while those whose concentrations are more than 200 mg/L are very hard water[45], so the water of the Tigris River is very hard.

As for the temporal variation, It was shown that the highest values were recorded in the winter season due to industrial waste and hot WPP effluents, as well as the rainwater that descends into the river after the dredging of salts from the neighboring lands. The lowest values were recorded in the summer because of the large number of phytoplankton and their absorption of calcium and magnesium ions. Wasit Power Plant raises the total hardness rate by receiving wastewater from the purified treatment unit to generate steam [42].

As for spatial variation, the highest and lowest value of calcium in site 2 near WPP effluents through what the thermal power plant puts out of industrial water and the wastewater of the reverse osmosis filter, which raises the percentage of salts [42].

As for temporal variation, the highest value of calcium ions was recorded in the autumn season, and the lowest was in the summer. The highest value was in site 2 near WPP effluents due to the interaction of carbon dioxide with calcium, and then larger amounts of calcium are transformed into soluble bicarbonate [46]

Statistically, it was found that there were no significant differences at $P>0.05$ among the studied sites (Table 2). The spatial variation showed an increase in the sulfate values, which reached 500 mg/L at site 2 near WPP effluents, which may be due to the discharge of untreated local sewage with the WPP effluents. These ions can also be produced from the decomposition of organic matter or the use of chemical fertilizers in agriculture. Moreover, sulfur oxides resulting from fuel combustion often lead to water after dissolving in groundwater [48]

As for the temporal variation, the highest values were recorded in the summer, especially in June, and the lowest in the winter season in January. The reason may be due to the effect of the WPP effluents as a result of what it throws directly wastewater from the treatment unit into the river [42].

The spatial variation showed that the highest value was in site 2 near WPP effluents, which amounted to 240 mg/L, and the lowest value was recorded in site 5, which reached 60 mg/L. The reason may be due to the high concentrations of bicarbonate, as it is affected by the industrial water discharges from WPP effluents. So, the increase in these effluents leads to the liberation of carbon dioxide gas from the water and an increase in HCO_3 [47].

As for the temporal variation, the highest values were recorded in the winter and spring, and the lowest values were recorded in the summer and autumn. The decrease in bicarbonate concentrations during the summer may be due to the consumption of free carbon dioxide by the primary producing organisms and bicarbonate decomposition [49]. As for the increase in bicarbonate concentrations, it may be due to the effect of WPP sewage water thrown into the river, or it may be related to discharge, turbidity and high productivity, or it may be due to organic decomposition processes and its relationship to variation of carbon dioxide

As for the spatial variation, the highest nitrate value was recorded in site 2, which amounted to 4.65 mg/L in May near WPP effluents, and the lowest value recorded in site 1 was 0.15 mg/L during August. This may be due to the high temperatures near the effluents, the increase in the decomposition process or microorganisms, and the reduction of nitrates to nitrites due to the depletion of oxygen[49]. The decrease in its concentrations may be due to an increase in the preparation of phytoplankton, which is the cause of nitrate consumption and its low value [of 50]

As for the temporal changes, the highest values were recorded in the winter and spring seasons near the flows, and the lowest values in the summer, near the thermal site fluxes, and this is due to the high rates of metabolism and organic oxidation, which leads to the excretion of nitrates [37]. As for the summer months, it showed a clear decrease that may be due to an increase in the rates of photosynthesis by phytoplankton [51].

Regarding the spatial variation, the highest phosphate value was 0.066 mg/L, which was recorded in site 2 and site 3 near WPP effluents. This may be because the electric power plants release phosphate as a P_2O_5, which decreases gradually as we move away from the WPP effluents [52]. Phosphate in site 1 may be due to the abundance of phytoplankton and floating plankton and the adsorption of phosphite on mineral particles and organic matter. So, the phosphorous is taken up by the plankton, and this process is responsible for removing the phosphorous as aquatic plants and the deposition of part of the phosphorous compounds[53] *.exploit it*

Regarding the spatial variation, the highest values were recorded at site 2, which reached 268.4 mg/L near WPP effluents, and the lowest values were 103.7 mg/L, recorded at site 5. The source of the alkalinity of water is the result of industrial waste and domestic and sewage water, as increasing its concentration above the permissible limit leads to water pollution with biological and chemical waste, and the alkalinity values decrease with the consumption of free carbon dioxide by the primary producing organisms and the decomposition of bicarbonate. [49]

As for the temporal variation, the highest values were recorded in the summer and the lowest in the autumn and the beginning of winter, and the reason may be due to the high temperatures that raise the rates of decomposition of organic matter and then the transformation of insoluble calcium carbonate into soluble bicarbonate [54], the decrease in the values of total alkalinity in the winter due to the increase in CO_2 solubility due to the decrease in the presence of phytoplankton and thus the process of photosynthesis is less[55]

CONCLUSIONS

The genotypes of maize that interact With three sowing dates (26 July, 4 August, and 12 August) showed significant differences in the activity of the invertase enzyme for the genotypes. The best genotype was (Sara) which showed a value of 1.14 mg-1.units.protein. As for the sowing dates, the second sowing date (D2) was the best, which showed a value of 1.39 mg-1.units.protein. The expression of the INCW1 gene varied in the genotypes of three sowing dates with values ranging between (0.30) and (2.38), where the genotype (Sara) at the second sowing date (D2), which showed the value highest of gene expression (2.38) and the exact date (D3) gave INCW1 gene showed value (2.21) for genotype (Baghdad). The genotypes also varied in their tolerance to increase or decrease the gene expression, which is considered one of the most important sucrose decomposition genes for maize crops.

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