ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

The effects of Industrial Institutions on Ecological Factors of Tigris River through Baghdad Province

Luma H. A. Al-Azawii[1], Muhammad N.Al-Azzawi[2], Muhnned R. Nashaat[3]

1. Community Health Department, College of Health &Medical Technology, Middle Technical University, Baghdad, Iraq.

2. Department of Biology, College of Science, University of Baghdad, Baghdad, Iraq.

3. Agriculture Research Directorate, Ministry of Science& Technology, Baghdad. Iraq.

Manuscript Info

Manuscript History:

Received: 20 January 2015
Final Accepted: 25 February 2015
Published Online: March 2015

Key words:

Tigris River, Physical, Chemical factors, PAHs, industrial institutions.

Corresponding Author

Luma H. A. Al-Azawii

Abstract

Tigris River receives many pollutants when passing through Baghdad province because of increasing of population size, discharge of untreated industrials and agricultural wastes on the river. The present study was conducted from January to December 2013 on the Tigris River starting from Al-Muthana Bridge to Al-Zaufurania area before it's jointed with Diyalla Tributary. Six sites were chosen on the Tigris River along the Baghdad city. The concentrations of polycyclic aromatic hydrocarbons(PAHs) were determined with nineteen of physical and chemical parameters were analyzed based on importance of these parameters which are ranged as following: Air temperature (10 to 43)°C, water temperature (10 to 34)°C, pH (6.9 to 8.9), EC (490 to 1220) µs/cm, turbidity (10 to 125) NTU, Salinity (0.313 to 0.78) ‰, TDS (0.24 to 0.62) Mg/l, TSS (3 to 1170) Mg/l, TH (80 to 400) Mg/l, Ca^{+2} (40 to 256) mg/ L, Mg^{+} (5 to 350) mg/ L, Dissolved Oxygen (4.5 to 14.5) mg/ L, BOD_5 (1.5 to 7.3) mg/ L, COD (4 to 93) Mg/l, NO_3 (0.095to 2.164) mg/ L, PO_4^{-2} (3.03 to 176.5) µg/ L, HCO_3^{-2} (50 to 200) mg/ L, TOM (0.189 to 1.563) mg/ L, SO_4 (50 to 380) mg/ L, water current (22.2 to 50) cm/sec. The total PAHs were varied from (0.007 to 0.279) ppm.

This study showed that the water of Tigris River was hard and heavily contaminated by PAHs according to WHO (1998) and the deterioration of water quality was increased towards the downstream of Baghdad city according to discharge pollutants to the river.

The major source of polluted the water of Tigris River was industrial wastes containing organic, in organic and heavy metals ,associated with some homesteads and few agricultural practices.

INTRODUCTION

Water is the most delicate part of the environment which is a finite resource essential for agriculture, industry and even human existence .Without freshwater of adequate quantity and quality sustainable development will not be possible.

In the last few decades the demand of freshwater rises tremendously due to increasing populations and rapid Industrialization [1]. At the same time the pace of freshwater deterioration by anthropogenic activities is coupled with the ever-growing demands of water resources [2]. Due to the addition of industrial effluents containing organic pollutants and heavy metals into the river water the quality of water is deteriorating. Today, many organic compounds are produced from sources other than biological activities as anthropogenic activities like organic chemicals from industry, agriculture and municipal effluents [3].In fact, that 65 % of all the industrial institutions and factories were located in Baghdad; this condition generated ecological problems threatening the ecosystem of Baghdad city due to the drainage of sewage and by products of these institutions and factories directly to the body of the Tigris River [4].The present study aimed to investigate the effects of Baghdad city on some physical and chemical characters of the Tigris River.

Materials and Methods

Sampling was collected monthly from January to December 2013, six sites were chosen to collect water samples, and the locations of these sites were (Figure 1):

Site one (S1): located at Al- Tajiy area near Al- Muthana Bridge, this area is an agricultural area a consist of a grove of orange and other citrus tree,, this site was considerable as reference site.

Site two (S2): Located at Al-Jadriyah area near Al- Jadriyah Bridge and Baghdad University. The vertical distance between S1and S2 was 27 Km.

Site three (S3): Located at Al- Durah area about 500 m from Al- Durah power plant discharge. The vertical distance between S2and S3 was 3 Km.

Site four (S4): Located at Al-Durah area about 2800 m from Al- Durah refiner discharge. The vertical distance between S3and S4 was 6.570 Km.

Site five (S5): Located at Al- Rasheed area about 500 m from Al-Rasheed power plant discharge. The vertical distance between S4and S5 was 6 Km.

Site six (S6): Located at Al–Rasheed area near Al –Zafarania city southern Baghdad city before the jointed point between the Tigris River and Diyala Tributary. The vertical distance between S5and S6 was 10 Km.

.

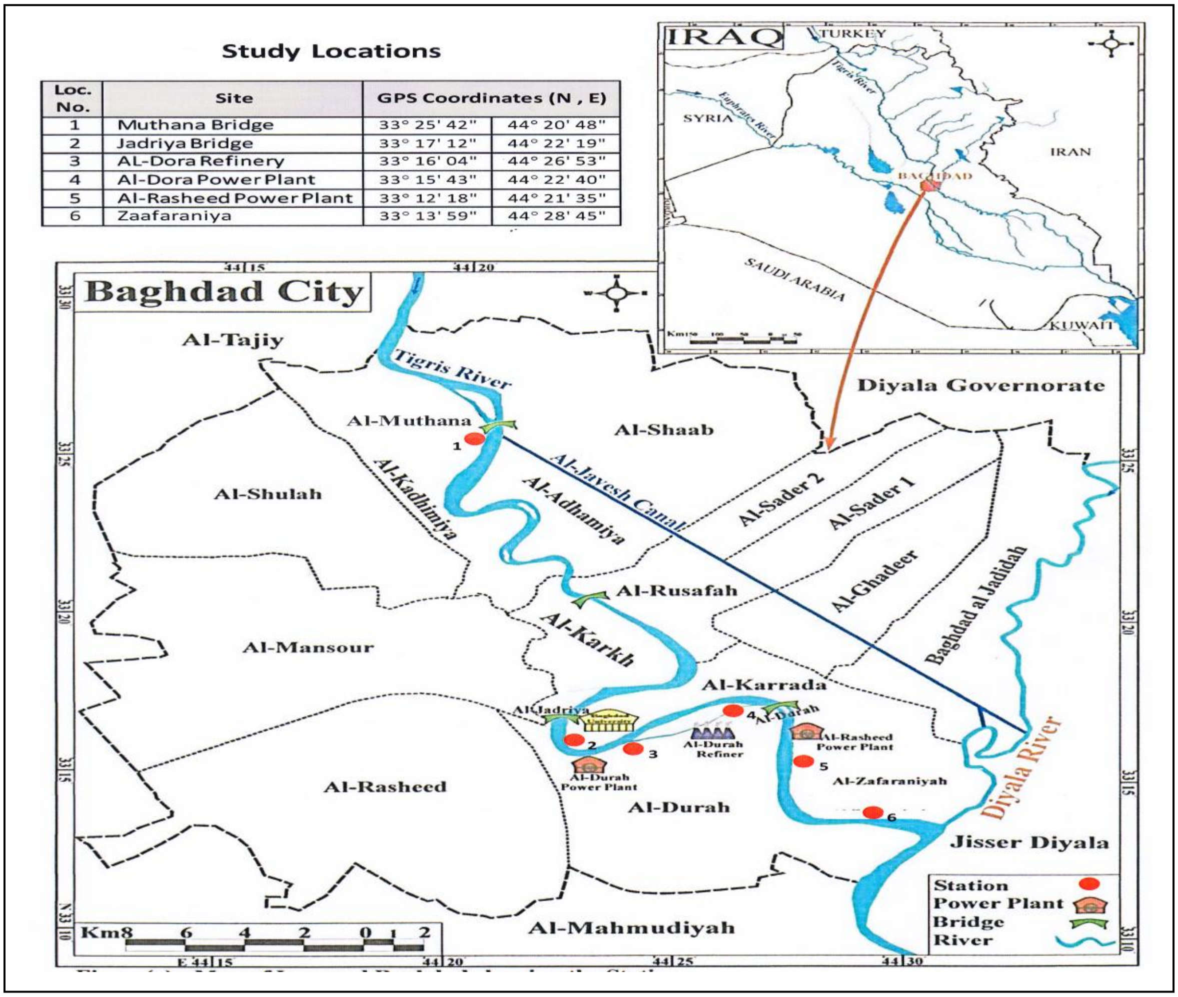
Air and water temperature were measured by mercury thermometer. The pH, Electrical Conductivity (EC), Total Dissolved Solid (TDS) had been measured by using a portable pH, EC and TDS meter (HANA instruments / HI - 9811), the results expressed as µ semins /cm (µs / cm) for electrical conductivity and g/l for measuring TDS. Electrical Conductivity value was then converted to salinity by the formula in APHA [5]. Turbidity measured by using a digital portable Turbidity meter, making by Jenwaw Company (Model – 6035). Dissolved Oxygen (DO) and Biological Demand (BOD_5) Winkler method described by APHA [5]. Total Hardness, and Calcium determined by titremetric methods. Magnesium ion and TSS concentrations were calculated according to APHA [5], Nitrate and phosphate measured according to APHA [6]. Bicarbonate was determined according to Degremont [7] Sulphate ion measured according to Brands and Tripke [8]. Total Organic Matter (TOC) determines by the method at Allen [9]. Chemical Oxygen Demand (COD) measured according to APHA [10].

The determination of polycyclic aromatic hydrocarbon (PAHs) by high- performance liquid chromatography (HPLC) with UV and fluorescence detection has been well established [11,12].

Least significant difference –LSD test was used to compare between means.

Results and Discussion

It was clear that Tigris River affected by the surrounding air temperature, the results showed high water temperature in summer months (34°C in August at station 6) and low water temperature in winter months (10°C recorded in January at station 1) (Figure 2,3 and Table 1). Statistical analysis revealed no significant differences ($P > 0.05$) were reported for surface water temperature except at station 2 with a positive correlation between air and water temperature ($r= 0.94$) (Table 2). Surface water temperature was highly coincided with surround air temperature as confirmed by a positive correlation between air and water temperature ($r=0. 942$, $P<0.0001$). So the variation of water temperature due to differ in time of measurements and environmental factors such as water current, depth of water, bottom materials, temperature of inlet water and exposure to direct sunlight and a degree of shading [13].



Study Locations

Loc. No.	Site	GPS Coordinates (N , E)	
1	Muthana Bridge	33° 25' 42"	44° 20' 48"
2	Jadriya Bridge	33° 17' 12"	44° 22' 19"
3	AL-Dora Refinery	33° 16' 04"	44° 26' 53"
4	Al-Dora Power Plant	33° 15' 43"	44° 22' 40"
5	Al-Rasheed Power Plant	33° 12' 18"	44° 21' 35"
6	Zaafaraniya	33° 13' 59"	44° 28' 45"

Figure 1- Map of Iraq and Baghdad showing the stations. Source: Ministry of Water Resources, 2012, Map Scale 1/100000.

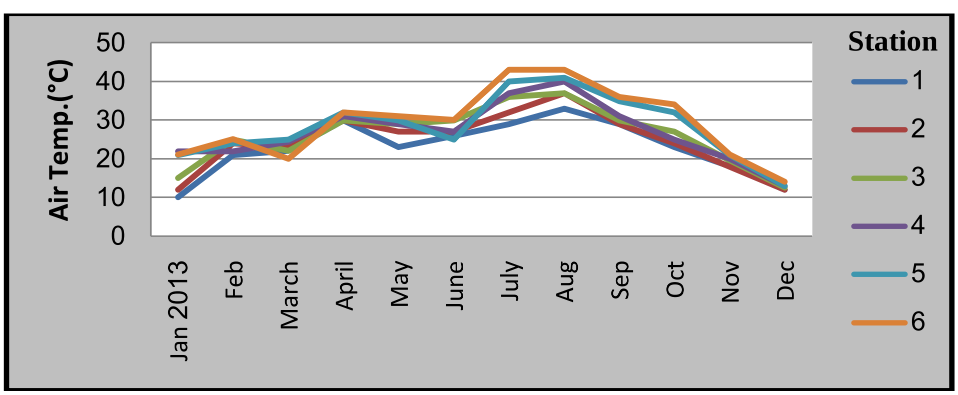


Figure 2- Seasonal variations of the air temperature at the study stations during January to December 2013.

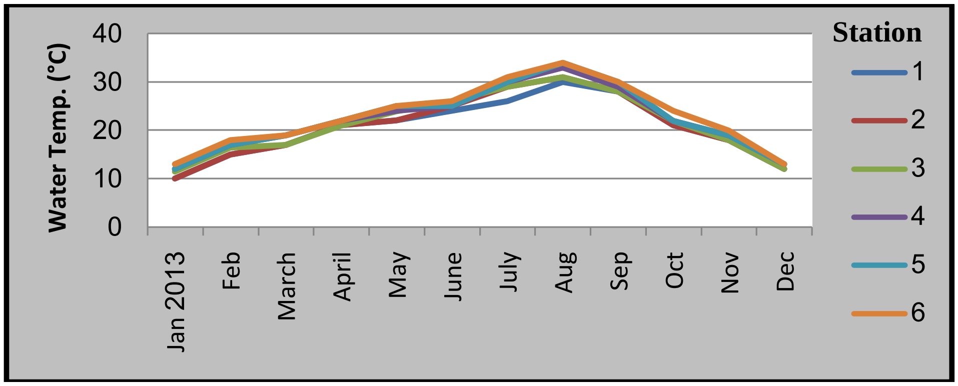


Figure 3- Seasonal variations of the water temperature at the study stations during January to December 2013.

The results of presenting the study showed that the highest value of turbidity was 125 NTU recorded in June 2013 at station 3 which may be due to the increase of planktonic algal growth [14]. Whereas the lowest value was 10 NTU recorded in January 2013 at station 1 similar observation has been made by Dutta *et al.* [15] (Fig. 4, Table 1). Turbidity and the light penetration in the Tigris River where are observed and mostly related to suspended solid substances, such as mud and silts, it increased during the period of rain and high discharge [16].So the increase in turbidity in the Tigris River from January to June 2013 caused by rainfall which causes an increase of water level and rapid flow with increase water suspended materials and mixing of water during rain period. The statistical analysis indicated that there were significant differences ($P \leq 0.05$) between stations of the present study.

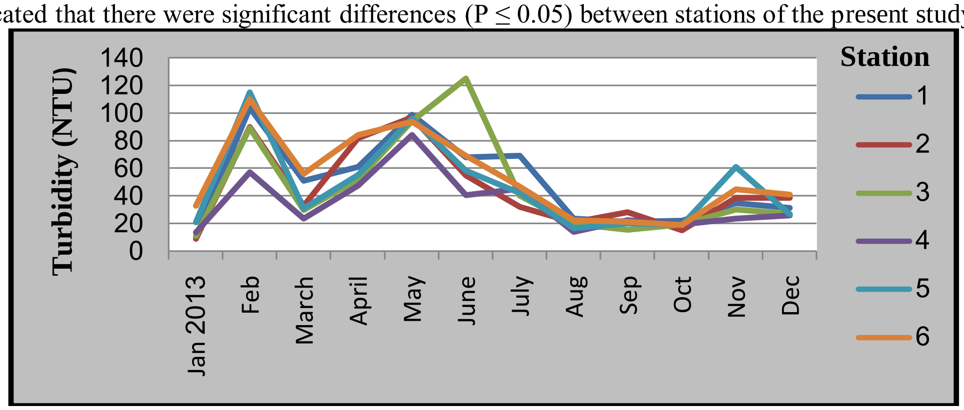


Figure 4- Seasonal variations of the turbidity at the study stations during January to December 2013.

The results of electrical conductivity and salinity obtained are indicated in(Fig.5, 6, Table 1). The value demonstrated that the highest value of EC was 1220 µs/cm in January at station 6 with salinity value was 0.78‰, while the lowest values of EC were 490µs/cm in June at station 3 with salinity value was 0.313 ‰. The highest concentration of electrical conductivity and salinity recorded during cold season probably related to high precipitation and soil leaching processes [17] or due to effluent loaded with salted and dissolved materials [18]. Increase in both EC and Salinity values were noticed in aquatic system that influence agricultural and industrial activities. The analysis of variance among stations showed that significant differences ($P \leq 0.05$) for electrical conductivity and salinity.

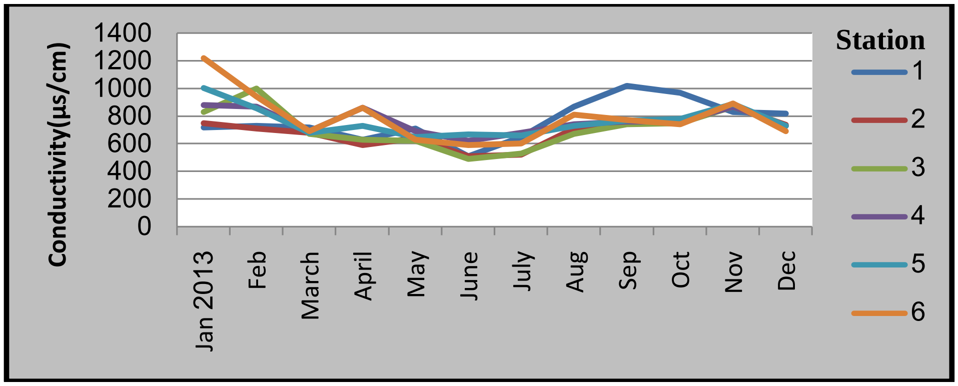


Figure 5- Seasonal variations of the conductivity at the study stations during January to December 2013.

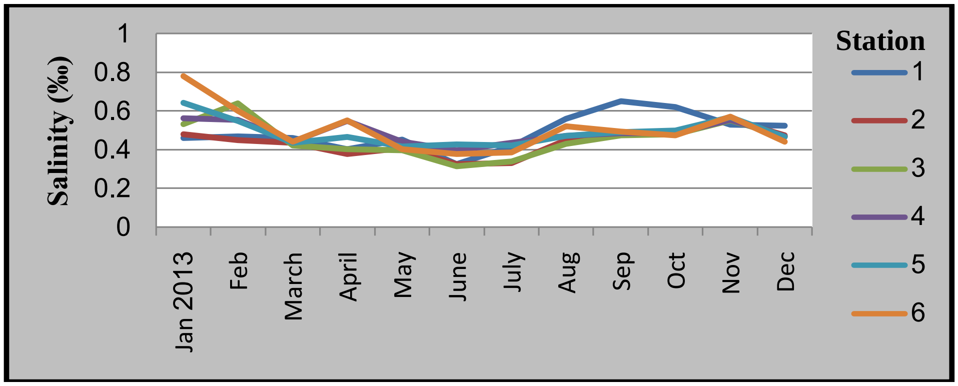


Figure 6- Seasonal variations of the salinity at the study stations during January to December 2013.

The pH value showed a limited monthly variation (Fig. 7, Table 1), the maximum value was 8.9 recorded at station 6 in February and the minimum value was 6.9 recorded at station 4 in January 2013. The pH concentrations recorded in the present study were within the narrow range and tend to weak alkaline as it is common in Iraqi Inland water [19]. This is due to buffering capacity of Iraqi natural waters which it is relatively high content of calcium bicarbonate [18,20,21]. No any significant differences ($P > 0.05$) were reported by statistical analysis in the study between stations for pH (Table 1), a positive correlation between pH and air and water temperature ($r= 0.107$) and ($r=0.088$), respectively(Table 2), were recorded that may be attributed to activities of algae and aquatic plants [22].

The highest concentration of total dissolved solid of the present study was 0.59 g/l observed on November 2013 at station 5 and 6 and while the lowest concentration was 0.24 g/l observed in June at station 1 and 3 (Fig. 8, Table 1). From the study results it found an increase in the TDS rates with the descending of the river towards the south, this may be related to increasing in the pollution on both river banks when passing through the Baghdad province, especially the industrial area [23]. Primary sources for TDS in receiving water are agricultural and residential runoff, leaching of soil contamination and point source water pollution discharge from industrial or sewage treatment plants [24]. Statistical analysis (Table 1) showed no any significant differences between stations ($P > 0.05$) except with stations 2 and 3. TDS and the electrical conductivity (EC) showed a positive correlation ($r=0.999$) with salinity and with TDS ($r=0.863$)(Table 2). Rise in conductivity is due to increasing TDS [25].

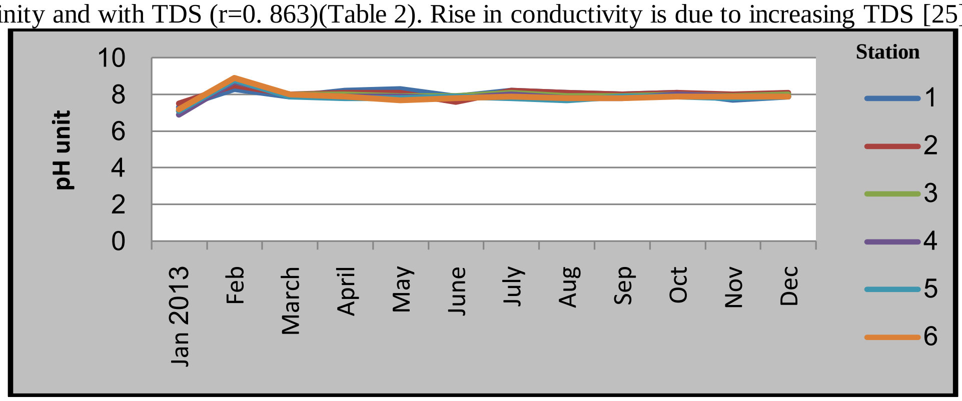


Figure 7- Seasonal variations of the hydrogen ion concentrations at the study stations during January to December 2013.

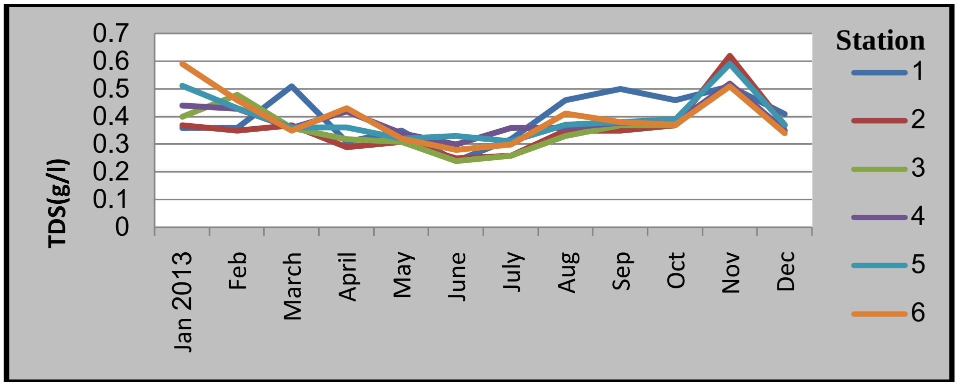


Figure 8- Seasonal variations of the Total Dissolved Solids at the study stations during January to December 2013.

The highest concentration of total suspended solid of the present study was 1170 mg/l observed in February at station 1, while the lowest concentration was 3 mg/l observed in August at station 6 (Fig. 9, Table 1). Statistical analysis indicated that no significant differences between stations for TSS. It is noted that during the rainy season there was very high level of TSS. This observation is similar with a study conducted by [26.27].

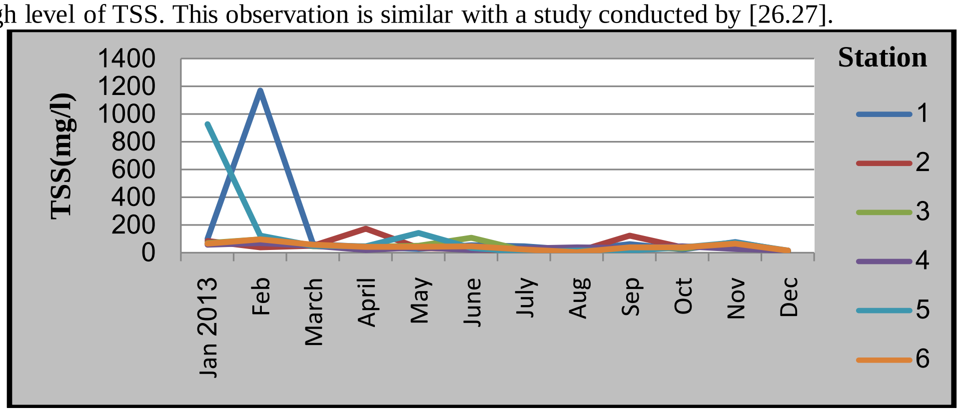


Figure 9- Seasonal variations of the Total Suspended Solids at the study stations during January to December 2013.

According to TSS values recorded in the present study, it can be noted that Tigris River ranged from clear water in autumn to turbidity water in spring USEPA [28]. Also the statistical analysis of TSS showed a positive correlation (r= 0.022) with dissolved oxygen. The higher values of TSS have negative effects, such as decreasing the amount of light that can penetrate the water, thereby slowing photosynthetic processes which in turn can lower the production of dissolved oxygen [29].

The maximum concentration of bicarbonates was 200 mg/lat stations 2 and 5 during January and December, whereas the minimum concentration was 50 mg/lat station 1 during October 2013 (Fig.10, Table 1). Total bicarbonate ions are abundant in the Iraqi inland water [30-33]. The variation in total bicarbonate values between different stations were not sharp, with slight increase occurred between January and June 2013. These increases in bicarbonate values were recorded in the Tigris River during winter and spring from earlier studied above. According to statistical analysis no significant differences (P > 0.05) were reported between all stations except at station and the bicarbonate showed a positive correlation (r= 0.109) with turbidity(Table 2).

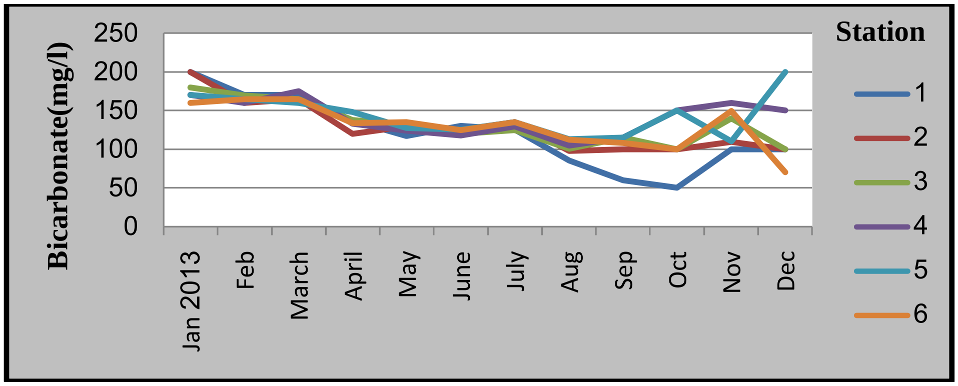


Figure 10- Seasonal variations of the bicarbonate at the the study stations during January to December 2013

The amount of Dissolved Oxygen in surface water ranged from 4.5 mg/l in April at station 4 and 5 to 14.5 mg/l in December at station 1 (Fig.11 Table 1). The weak decrease in DO of water may be due to its poor ability to hold oxygen at high temperature as a result of the high rate of microbial metabolism [34] and thus agree with other authors [35,36]. No any significant differences (P >0.05) were reported by statistical analysis between all stations. DO showed a negative correlation (r=-0.162, r= -0.076) and temperature (air and water), respectively (Table 2). Which these conformed to Kadhim *et al*. [35].

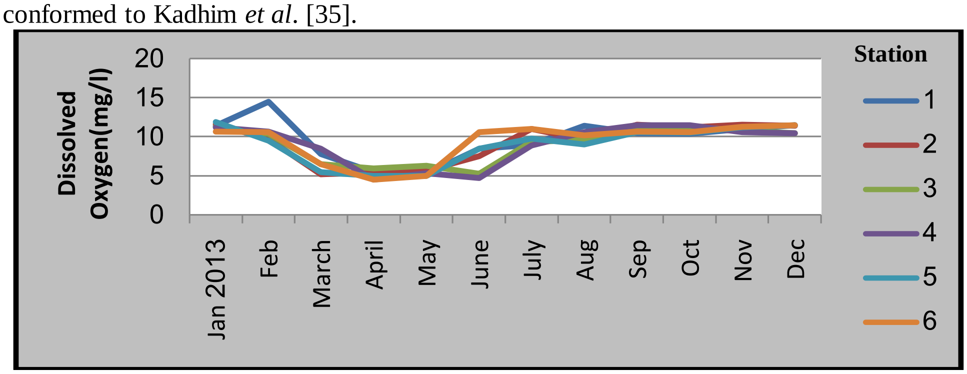


Figure 11- Seasonal variations of the dissolved oxygen at the study stations during January to December 2013.

The results indicate that the highest value of Chemical Oxygen Demand was 93 mg/l recorded at station 4 during May 2013 and the lowest value was 4 mg/l recorded at station 3 during June 2013 (Fig. 12, Table 1). The real cause of the variation among the study months and higher concentration that recorded at some sites is the presence of organic matter, especially hydrocarbon biodegradation and large number of pollutants, as well as, rot conditions and phytoplankton blooms which can lead to lower oxygen concentration [37]. The analysis of variance among stations showed significant differences ($P \leq 0.05$) and the highest significant ($P \leq 0.05$) was at station 4, whereas no significant differences between station 1 and 5 and between stations 3 and 6 (Table 1).

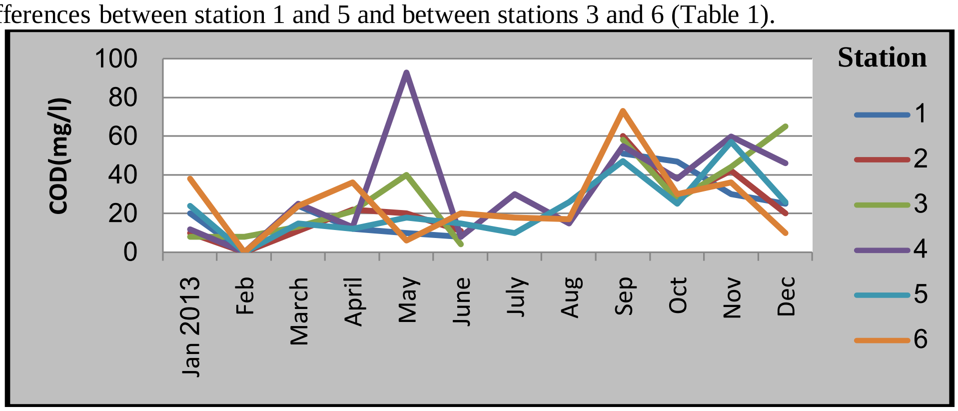


Figure 12- Seasonal variations of the Chemical Oxygen Demand at the study stations during January to December 2013.

It was found that the lowest value of biochemical oxygen demand was 1.2 mg/l in April at station 2, while the highest value was 7.3 mg/l in February at station 3 (Figure 13) and statistical analysis showed that no any significant differences (P > 0.05) between stations. The results of present study referred to high concentrations of

BOD_5 in some sites that exceed permissible limits (5 mg/l) recommended by WHO [38]. This is probably related to organic matter loads discharged into the river from the area near the sewage effluent and agricultural land. Comparable results were obtained by other authors [20,21,39.40].

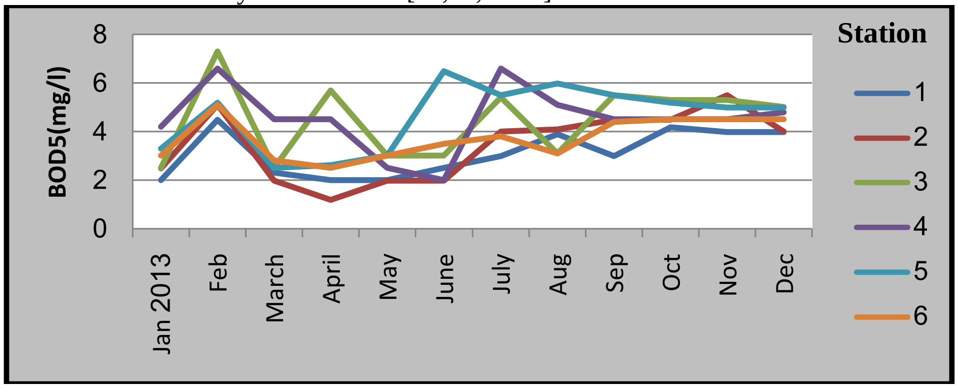


Figure (13): Seasonal variations of the Biological Oxygen Demand at the study stations during January to December 2013

The higher amount of Total Hardness was 400 mg/l at stations 2 and 5 during June and August, respectively, whereas the lowest amount were 80 mg/l were at station 2 during April (Fig.14, Table 1). The results of the present study referred to high concentration of total hardness as it is common in Iraqi inland water [42.42] high values of total hardness in Tigris River due to the major increase occurred after receiving the very hard water of Al-Tharthar Reservoir after junction with Tharthar-Tigris Arm [43]. According to USEPA [44] classification the water of Tigris River was very hard water. The results of statistical analysis refer those significant differences ($P \leq 0.05$) between stations of the present study.

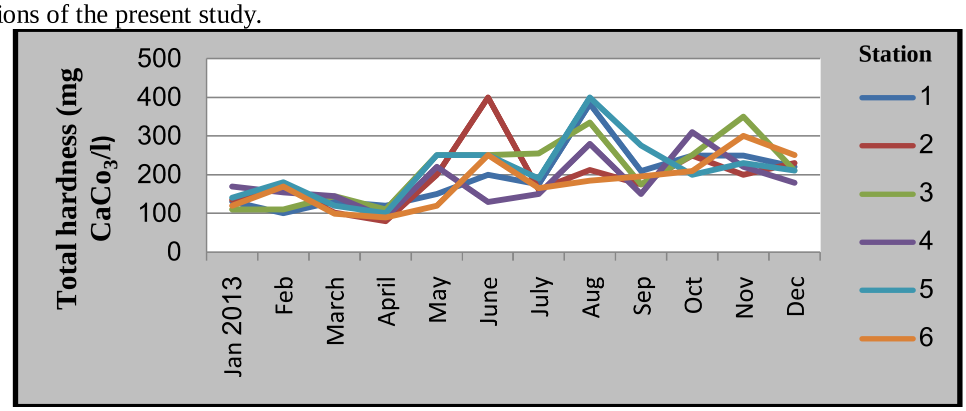


Figure 14- Seasonal variations of the Total hardness at the study stations during January to December 2013

The highest concentration of Calcium was 256 mg/l in August at station 5 while the lowest concentration was 40 mg/l in June at stations 1 (Fig.15, Table 1). Statistical analysis referred that significant difference ($P \leq 0.05$) between stations which were highest record at station 3. On the other hand the highest concentration of magnesium was 350 mg/l in June at station 2 while the lowest concentration was 5 mg/l in January and April at stations 1 and 3. Statistical analysis showed significant differences ($P \leq 0.05$) between stations of the present study. Present results indicated that concentrations of calcium were higher than magnesium concentrations in most months may be due to the solubility of CO_2 by calcium, which was higher than magnesium, so magnesium tends to precipitate [45] or may be due to high concentration of sulphate ions that precipitate magnesium as magnesium sulphate [46].

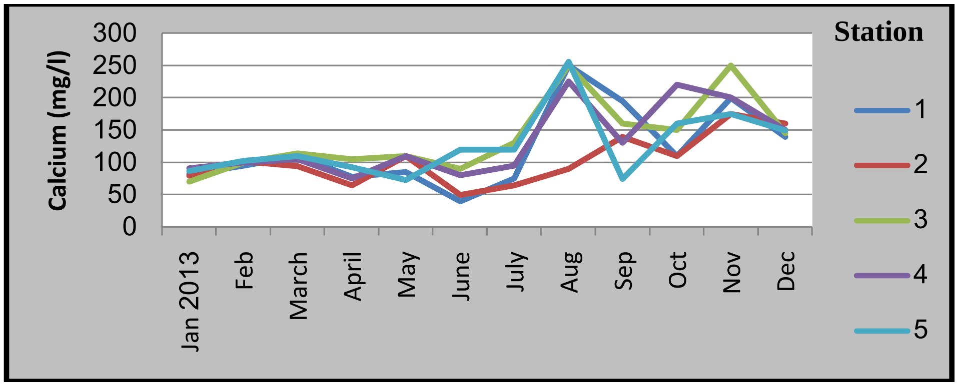


Figure (15): Seasonal variations of the Calcium hardness at the study stations during January to December 2013**.**

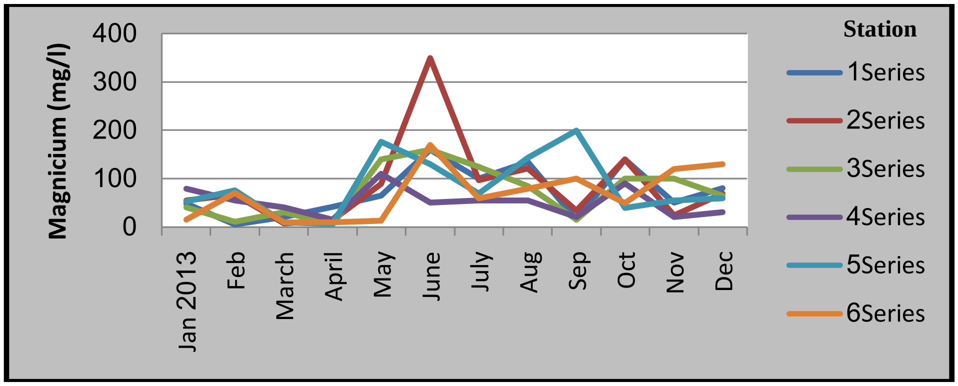


Figure 16- Seasonal variations of the magnesium hardness at the study stations during January to December 2013.

The sulfate concentrations in the Tigris River at present study were ranging between 50 and 380 mg/l (Fig.17, Table 1). These ranges were comparable to results recorded by different authors (Al-Lami *et al*. [47] in Tigris River; Salman, [21] and Mohamed [40] in Euphrates River).The results of statistical analysis refer that significant differences ($P \leq 0.05$) between stations**.** The variation among the study month and higher concentration were recorded at some sites may be possibly due to high concentration of SO_4^{-2} in the sewage water, which discharge without treatment of the Tigris River [48].

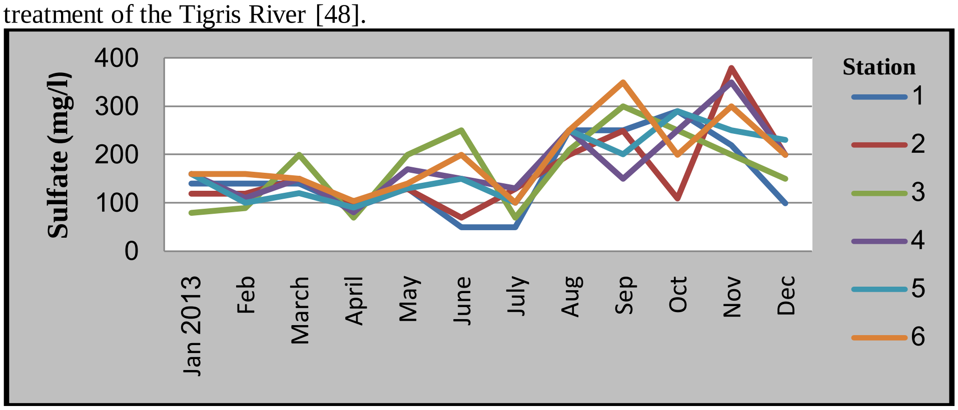


Figure 17- Seasonal variations of the sulfate at the study stations during January to December 2013

Seasonal variation of the present study shows that the highest concentrations of Nitrate (2.164 mg/l on November at station 1) were recorded during the wet season while the lowest concentrations (0.095 mg/l on September at station 1) were recorded during the dry season (Fig. 18, Table 1). This is possibly related to the change in water temperature and degradation process [37]. According to statistical analysis nitrate showed a no any significant difference ($P > 0.05$) were reported between stations at present study.

Generally the highest concentration of phosphate was 176.5 µg /l on November at station 1, while the lowest concentration was 3.03µg/l on April 2013 at station 6 (Fig.19, Table1). Statistical analysis showed a significant difference between stations ($P \leq 0.05$). Phosphate comes from fertilizers, pesticides, industrial and cleaning compounds. Natural sources include phosphate containing rocks and solid or liquid wastes. These are classified as orthophosphate, condensed phosphate and originally bound phosphate [49].

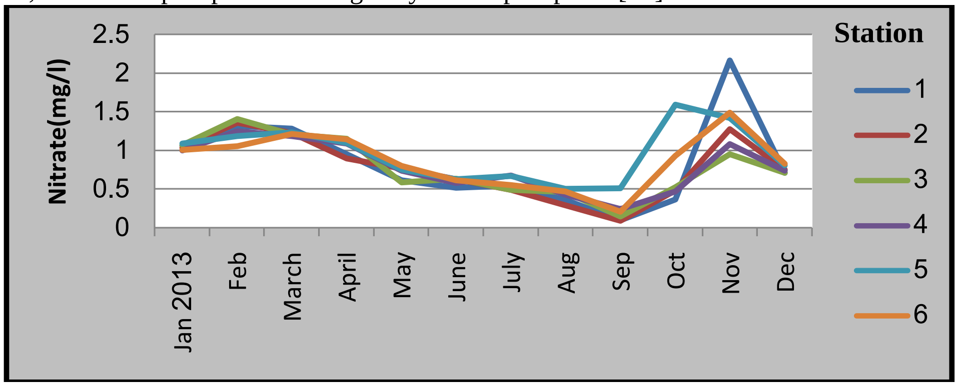


Figure 18- Seasonal variations of the nitrate at the study stations during January to December 2013

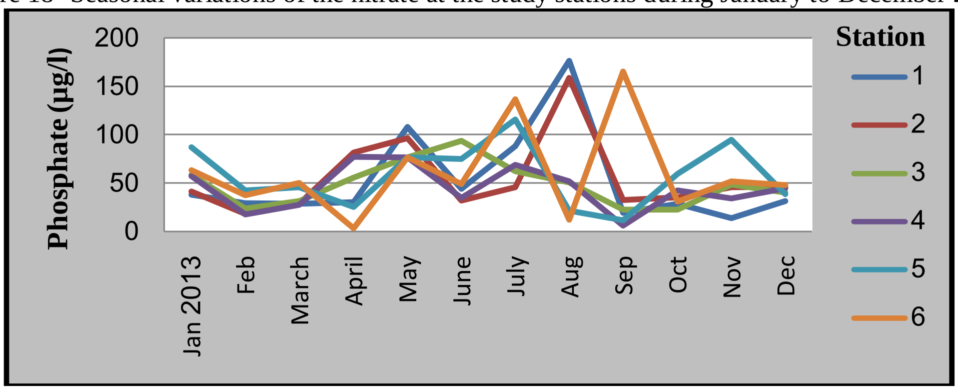


Figure 19- Seasonal variations of the Phosphate at the study stations during January to December 2013.

Current results of Organic Matter showed that highest content was 1.563% observed in summer at station 5, while the lowest content was 0.189% observed in winter at the station 3 (Fig. 20, Table 1). The highest percentages of TOM were in warm season that might be because of the rise of temperature and increasing active of micro-organisms which decomposes the dead parts from plants and animals. While the lowest percentages were in the cool season when the temperature is low and the active of decomposers is declined [50]. The statistical analysis indicate that were significant differences ($P \leq 0.05$) among stations for total organic matter. Also the OM showed a positive correlation (r=0.091) and (r=0.053) with air and water temperature, respectively. So a positive correlation between total organic matter and TSS (r=0.0618) and total organic matter with turbidity (r=0.0167)(Table 2). These results conformed to Ahmed [23].

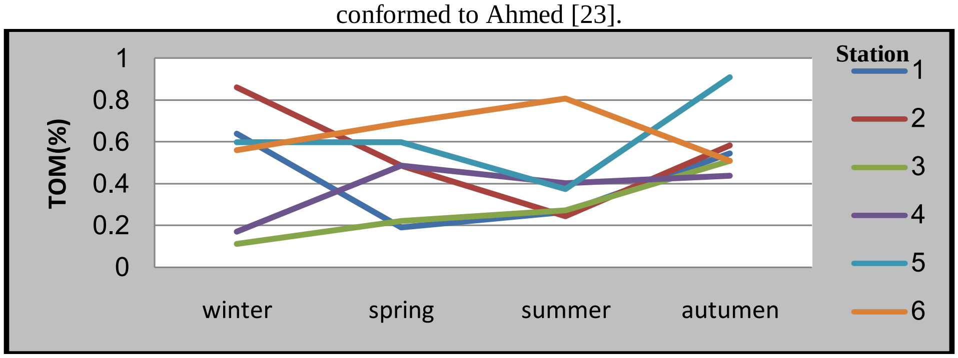


Figure 20- Seasonal variations of the Total Organic Matter at the study stations during January to December 2013.

The results of total polycyclic aromatic hydrocarbons (PAHs) showed that the highest value was 0.279ppm during August at station 3 and the lowest value was 0.007ppm during October at the same station.(Fig. 21,Table 1)

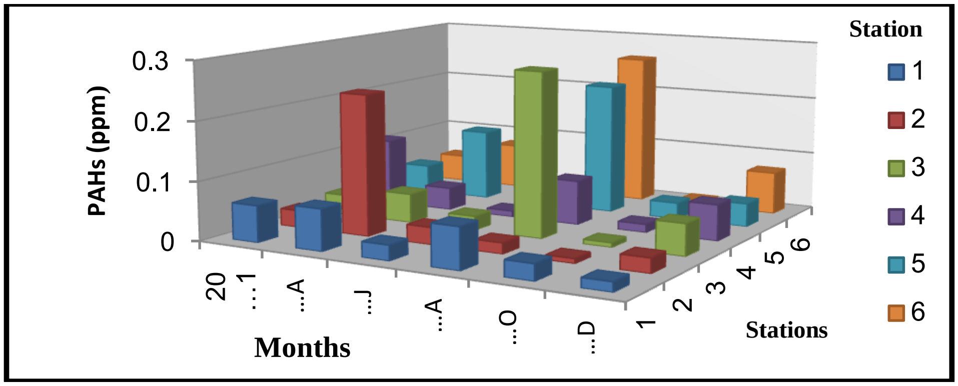


Figure 21- Seasonal variations of the Total polycyclic aromatic hydrocarbons at the study stations during January to December 2013.

Zhu *et al* [51] found a higher concentration of PAHs in summer than in winter which may be contributed to the sorption of PAHs on to the suspended particles and atmospheric deposition which increase during hot season. The concentration of PAHs may be reduced or diluted during periods of high flow of water [52].These finding agreed with present study in which high flow of water during winter and autumn whereas low levels of flow were recorded during summer.

In general the concentrations of PAH in water depend on several factors including properties of PAHs as hydrophobic nature with low solubility [53], interaction of several processes such as volatilization, bioconcentration, sedimentation, solubilization and biodegradation [54].

The total Polycyclic Aromatic Hydrocarbons levels at all stations of present study are higher than maximum admissible concentrations of Environmental Quality Criteria of United States, Σ PAHs= 0.03 µg/l for protection of human consumes of aquatic life [55]and was (7.9 µg/l to 273 µg/l) more than those recorded in other aquatic ecosystem in the world, suggesting that Tigris River sites were heavily contaminated depending on [56]which considered the water as heavily polluted when the concentration of total PAHs in it exceeding 10 µg/l. Similar results were obtained in the Shatt Al-Arab River and north west Arabian Gulf by [57,58] and in Langkawi island of Malaysia by [59].

Table 1- Range (First Line), Average and Standard Deviation (Second Line), for Physical-Chemical Characteristics & PAHs concentrations at study stations during (January - December) 2013.

Parameter \ Station	1	2	3	4	5	6
Air Temperature (°C)	10 - 33 23 b	12 – 37 23.61 b	12.5 -37 26.08 ab	13-40 26.79 ab	13 -41 28.25 a	14 -43 29.16 a
Water Temperature (°C)	10 -30 20.3 a	10 -31 6.6 b	11.5 -31 21.3 a	12 -33 22.08 a	12 -34 22.3 a	13 -34 22.9 a
Turbidity (NTU)	10 -104 49.57 ±31.06 ab	8.9 -97 42.19 ± 29.60 b	10.68 – 125 45.92 ± 36.88 ab	13.65 -84 34.73 ± 20.91 c	16.42 -115 46.64 ±32.01 ab	19.07 -110 53.49 ±29.95 a
Conductivity (µs/cm)	510 -1020 756±144.63 a	510 -870 673.07 ±105.68 b	490 -1000 710.83 ± 143.17 ab	620 -880 762.5 ± 88.22 a	650 -1005 762.91±107.29 a	590 -1220 785.83 ±177.63 a
Salinity (‰)	0.326- 0.652 0.489 ± 0.09 a	0.326 -0.556 0.429 ± 0.06 b	0.313 - 0.64 0.453 ± 0.091 ab	0.396 - 0.563 0.487 ± 0.056 a	0.416 -0.643 0.488±0.068 a	0.377 - 0.78 0.502 ±0.11 a
Total Dissolved solids(g/L)	0.24 -0.51 0.399 ± 0.089 a	0.25 -0.52 0.346 ±0.094 b	0.24 – 0.52 0.359 ± 0.080 b	0.3 -0.52 0.386 ± 0.057 a	0.31 – 0.59 0.393±0.081 a	0.28 – 0.59 0.395 ±0.09 a

Parameter \ Station	1	2	3	4	5	6
pH	7.3- 8.3 7.99 ± 0.28 a	7.5 -8.5 7.98 ±0.259 a	7.1 -8.7 7.95 ± 0.347 a	6.9 -8.7 7.88 ± 0.392 a	7.1 -8.8 7.86 ±0.370 a	7.2 – 9 7.9 ±0.40 a
Bicarbonate (mg/L)	50- 200 120.33±45.07 a	98 -200 32.01±126.23 b	100 -180 132.16±27.67 a	105 -175 140.83±23.07 a	110 -200 143.16 ±27.37 a	70 -165 129.91 ±28.83 a
Dissolved Oxygen(mg/L)	5.3- 14.5 9.73±2.65 a	5.2 -11.6 8.96±2.58 a	5.3 – 11.3 9.05±2.33 a	4.5 -11.5 9.041±2.70 a	5 -11.9 9 ±2.51 a	4.5 -11.5 9.43 ±2.53 a
Chemical Oxygen Demand (mg/L)	8 -51 25.22±15.38 bc	10 -60 23.4 ±16.57 c	4 – 65 28.8±21.89 b	8 -93 35.90 ±26.03 a	10 -57 25±14.67 bc	6 -73 28 ±18.34 b
Biological oxygen demand (mg \L)	2-4.5 3.116±0.957 a	1.2 -5.5 3.27 ±1.42 a	2.5 – 7.3 4.466±1.56 a	2 -6.6 4.525 ±1.33 a	2.5 -6.5 4.60 ±1.37 a	2.5 – 5.1 3.72 ±0.85 a
Total hardness as (mg $CaCO_3$/L)	100 -384 193.25±78.70 b	80 -400 184.30 ±82.10 b	110 – 350 212.5±83.89 a	90 -310 183.33±63.47 b	100 -400 212.08 ±79.98 a	90 -300 179.58±65.62 b
Calcium (mg/L)	40 -250 121.66 ±62.50 bc	50 -175 99.30±38.58 d	70 – 250 139.5±57.70 a	75 -225 131.75 ±54.42 ab	73 – 256 126.83 ±52.13 b	80 -180 110.5 ±30.34 cd

Magnesium (mg/L)	5 -160 71.58±51.79 b	8 -350 83.30 ±91.88 a	5 -160 73±53.28 b	15 -110 51.58 ±29.55 c	7 -200 85.25 ±63.07 a	10 -170 69.08±53.11 b
Sulfate (mg/L)	50 -290 154.16 ±80.39 c	70 -380 156.15±84.67 c	70 – 300 172.5±79.100 b	80 -350 179.16 ±73.66 b	90 -290 172.5 ±69.03 b	100 -350 192.75 ±75.72 a
Nitrate- Nitrogen ($mgNO_3$-N/L)	0.095 -2.164 0.83±0.56 a	0.091 -1.36 0.723 ± 0.401 a	0.1416 – 1.41 0.77 ± 0.37 a	0.241 -1.249 0.788 ± 0.32 a	0.501 – 1.59 0.95 ± 0.36 a	0.206 – 1.49 0.85 ± 0.35 a
Phosphate as $PO^{3}4$(µg/L)	13.93 -176.5 53.06±47.83 ab	18 -158.92 52.27 ±39.54 ab	22.85 – 93.68 49.089±22.25 b	6.25- 77.27 45.03 ±22.48 b	11.8 -115.7 57.96 ±32.24 a	3.03 – 165.5 60.26 ±47.42 a
Total Suspended Solid (TSS) (Mg/L)	12 -1170 141.75 ±0.032 a	9- 173 54.25±0.005 a	11 -107 47.75 ±0.003 a	16 -70 38.16 ±0.001 a	4- 930 124.33 ±0.02 a	3 -98 45 ± 0.002 a
Total organic matter TOC (%)	0.327 -1.103 0.706± 0.37 ab	0.42 -1.482 0.832 ± 0.439 ab	0.189 -0.879 0.478 ± 0.29 b	0.293 -0.836 0.642 ± 0.24 b	0.646 -1.563 1.07 ± 0.37 a	0.877 -1.392 1.105 ± 0.23 a
PAHs(ppm)	0.016-0.07 0.04±0.01 a	0.008-0.238 0.065±0.04 a	0.007-0.27 0.074±0.041 a	0.01-0.11 0.047±0.01 a	0.014-0.22 0.079±0.032 a	0.009-0.26 0.038±0.015 a

*Station that carrying similar character were no any significant difference between them

Table 2- Correlation coefficient among physical –chemical prosperities of Tigris River and PAHs compounds during (January- December) 2013.

	AirTem.	WaterTem.	Turb	Cond.	Salinity	TDS	pH	$CaCO_3$	DO	Mg	S	Nitrate	PO_4	BOD	TSS	TOM	COD	Ca	TH	PAHs
Water Tem.	0.49**																			
Turbidity	-0.02^{NS}	-0.08*																		
Cond.	-0.2*	-0.32**	-0.23^{NS}																	
Salinity	-0.29**	-0.3**	-0.22^{NS}	0.99**																
TDS	-0.31**	-0.31**	-0.23*	0.86**	0.89**															
pH	0.107^{NS}	0.08^{NS}	0.4**	-0.07^{NS}	-0.06^{NS}	-0.11^{NS}														
Bicarbon.	-0.37**	-0.5**	0.109^{NS}	0.02^{NS}	0.02^{NS}	0.02^{NS}	-0.16^{NS}													
DO	-0.16^{NS}	-0.07^{NS}	-0.4**	0.42**	0.42**	0.38**	-0.07^{NS}	-0.04^{NS}												
Magnes.	0.21^{NS}	0.31**	0.098^{NS}	-0.32**	-0.32**	-0.32**	-0.06^{NS}	-0.29**	0.02^{NS}											
Sulfate	0.12^{NS}	0.22^{NS}	-0.35**	0.31**	0.31**	0.44**	-0.1^{NS}	-0.31**	0.37**	0.007^{NS}										
Nitrate	-0.4**	-0.6**	0.21^{NS}	0.24*	0.24*	0.3**	0.3^{NS}	0.53**	-0.07^{NS}	-0.3**	-0.13^{NS}									
PO_4	0.25 *	0.26*	0.21^{NS}	-0.15 NS	-0.14^{NS}	-0.13^{NS}	-0.05^{NS}	-0.13^{NS}	-0.15^{NS}	0.13^{NS}	0.22^{NS}	-0.024*								
BOD	0.05^{NS}	0.06^{NS}	-0.21^{NS}	0.32^{NS}	0.32^{NS}	0.25^{NS}	0.27^{NS}	-0.04*	0.55**	-0.05*	0.22^{NS}	0.03^{NS}	-0.14^{NS}							
TSS	0.25*	0.19^{NS}	-0.08^{NS}	0.008^{NS}	0.01^{NS}	0.00^{NS}	-0.09^{NS}	-0.03^{NS}	0.02^{NS}	0.12^{NS}	0.11^{NS}	0.06^{NS}	-0.06^{NS}	-0.1^{NS}						
TOM	0.09^{NS}	0.05^{NS}	0.01^{NS}	0.04^{NS}	0.04^{NS}	0.15^{NS}	-0.03^{NS}	-0.03^{NS}	-0.02^{NS}	-0.07^{NS}	0.05^{NS}	0.1^{NS}	0.1^{NS}	0.25^{NS}	-0.07^{NS}					
COD	0.008^{NS}	0.12^{NS}	-0.3**	0.23*	0.23^{NS}	0.3**	-0.18^{NS}	-.03**	0.13^{NS}	-0.02^{NS}	0.4**	-0.25*	-0.25*	0.001^{NS}	0.1^{NS}	0.002^{NS}				

	AirTem.	WaterTem.	Turb	Cond.	Salinity	TDS	pH	$CaCO_3$	DO	Mg	S	Nitrate	PO_4	BOD	TSS	TOM	COD	Ca	TH	PAHs
Water Tem.	0.49**																			
Turbidity	-0.02^{NS}	-0.08*																		
Cond.	-0.2*	- 0.32**	-0.23^{NS}																	
Salinity	-0.29**	-0.3**	-0.22^{NS}	0.99**																
TDS	-0.31**	- 0.31**	-0.23*	0.86**	0.89**															
pH	0.107^{NS}	0.08^{NS}	0.4**	-0.07^{NS}	-0.06^{NS}	-0.11^{NS}														
Bicarbon.	-0.37**	-0.5**	0.109^{NS}	0.02^{NS}	0.02^{NS}	0.02^{NS}	-0.16^{NS}													
DO	-0.16^{NS}	-0.07^{NS}	-0.4**	0.42**	0.42**	0.38**	-0.07^{NS}	-0.04^{NS}												
Magnes.	0.21^{NS}	0.31**	0.098^{NS}	- 0.32**	- 0.32**	- 0.32**	-0.06^{NS}	- 0.29**	0.02^{NS}											
Sulfate	0.12^{NS}	0.22^{NS}	- 0.35**	0.31**	0.31**	0.44**	-0.1^{NS}	- 0.31**	0.37**	0.007^{NS}										
Nitrate	-0.4**	-0.6**	0.21^{NS}	0.24*	0.24*	0.3**	0.3^{NS}	0.53**	-0.07^{NS}	-0.3**	- 0.13^{NS}									
PO_4	0.25 *	0.26*	0.21^{NS}	-0.15 NS	-0.14^{NS}	-0.13^{NS}	-0.05^{NS}	-0.13^{NS}	-0.15^{NS}	0.13^{NS}	0.22^{NS}	- 0.024*								
BOD	0.05^{NS}	0.06^{NS}	-0.21^{NS}	0.32^{NS}	0.32^{NS}	0.25^{NS}	0.27^{NS}	-0.04*	0.55**	-0.05*	0.22^{NS}	0.03^{NS}	-0.14^{NS}							
TSS	0.25*	0.19^{NS}	-0.08^{NS}	0.008^{NS}	0.01^{NS}	0.00^{INS}	-0.09^{NS}	-0.03^{NS}	0.02^{NS}	0.12^{NS}	0.11^{NS}	0.06^{NS}	-0.06^{NS}	-0.1^{NS}						
TOM	0.09^{NS}	0.05^{NS}	0.01^{NS}	0.04^{NS}	0.04^{NS}	0.15^{NS}	-0.03^{NS}	-0.03^{NS}	-0.02^{NS}	-0.07^{NS}	0.05^{NS}	0.1^{NS}	0.1^{NS}	0.25^{NS}	-0.07^{NS}					
COD	0.008^{NS}	0.12^{NS}	-0.3**	0.23*	0.23^{NS}	0.3**	-0.18^{NS}	-.03**	0.13^{NS}	-0.02^{NS}	0.4**	-0.25*	-0.25*	0.001^{NS}	0.1^{NS}	0.002^{NS}				

**Highly significant (P<0.01).

*Significant (P<0.05)

NS: Non significant

Reference

1. Yisa, J. and Jimoh, T. (2010). Analytical studies on water quality index of river Landzu. Am. J. Applied Sci., 7: 453-458 .
2. Charkhabi, A.H. and Sakizadeh, M. (2006). Assessment of spatial variation of water quality parameters in the most polluted branch of the Anzali wetland, northern Iran. Polish J. Environ. Stud., 15:395-403 .
3. Readman,J.w.;Filman,G.I;BarTocci,J.;Villeneuve,J.P.;Catinni,C.;Mee,L.D. (2002).Petroleum and PAH Contamination of the Black Sea. Mar Pollyt. Bull., 44:48-62 .
4. Zubaidi, F. M. A. (2004). Urban ecological system, Tech. Rep. 9, Center of Arab Nation studies and Research.Iraq
5. APHA.(1998). Standard Methods for the Examination of Water and Wastewater. 20th Ed. American Public Health Association, Washington, DC.
6. APHA.(1985). Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Publ. 16th Ed.
7. Degremont, Company. (1979). Water treatment hand book. 5ed, Division of John Wiley & Sons, New York: 1186 pp.
8. Brands, H.J. and Tripke, E. (1982).Water manual. Vulkan-Verlag, Essem: 320pp.
9. Allan, J. D. (1976). Life history patterns in zooplankton, American Naturalist, 110(971): 165–176pp.
10. APHA.(2012). Standard methods for the examination of water and wastewater.22th Ed.American Public Health Association, Washington, DC.
11. USEPA (United State Environmental Protection Agency) .**1986**.Polynuclear aromatic hydrocarbons in drinking water using HPLC, method no. 8310.
12. USEPA(United State Environmental Protection Agency) .**1990** .Determination of polycyclic aromatic hydrocarbons in drinking water by liquid-liquid extraction and HPLC with coupled ultra violet and fluorescence detection , method no.550.
13. Bartram, J. and Ballance, R. (1996).Water Quality monitoring E & FN Spon, An imprint of Chapman & Hall, London.
14. Antoine, S. E. and Al- Saadi, H. A. (1982). Limnological studies on the polluted Ashar Canal and Shatt Al- Arab River at Basrah, Iraq. Journal of Int. Revue ges. Hydrobiol, 67(3): 405- 418pp.
15. Dutta,T. K. and Patra, B. C. (2013). Biodiversity and seasonal abundance of zooplankton and it's relation to physic-chemical parameters of Jumunabundh, Bishnupur, India.International Journal of Scientific and Research Publications,3(8): 1-7.
16. . Al-Lami, A.A. (1998). The ecological effects of Tharthar arm on Tigris River before its entrance Baghdad city. Ph. D. Thesis, Coll. Sci., Al-Mustansiriyah Univ., Iraq: 123pp. (In Arabic).
17. . Hutchinson,G.E.(1957).A treatise on Limnology. Vol., Geography, Physics and Chemistry, New York.
18. . Al-Lami, A.A. (2002). Water and sediment quality of Tigris River before and after Baghdad–Iraq. Iraqi Journal of Biology, 2(2): 289-296 (in Arabic).
19. Al-Saadi, H.A. and Maulood, B.K. (1991). The contribution of aquatic ecology for Iraq development. J. Coll. Educ. for Women, Univ. Baghdad, 2: 8-11. (In Arabic).
20. Hassan, F.M. (2004). A limnological features of Diwania River, Iraq Journal of Um –Salama for Science, 1(1): 119-124.
21. Salman, J.M. (2006). Environmental study of pollution on Euphrates River between Al–Hindia Dam and Al-Kufa city–Iraq .Ph.D. Thesis, Univ. of Babylon.Iraq,:135pp.
22. Davies, O.A.; Ugwumba, A.A.A. and Abolude, D.S. (2008).Physico -chemistry quality of Trans-Amadi (Woji) Creek port Harcourt,Niger Delta,Nigeria .J. Fish.Intern., 3(3): 91-97pp.
23. Ahmed, D. S. (2012).Investigation of copper and zinc metals in some benthic invertebrates in Tigris River in Baghdad City .M.Sc. Thesis,College of Science, University of Baghdad, Iraq: 160pp.
24. Boyd, C.E. (2000). Water Quality an Introduction.Kluwer Acadamic Publishers, Boston, USA, :330p.
25. Nalina, E.and Puttaiah, E.T.(2006). Studies on the ground water quality of Kadur & its surrounding areas, Karnataka. A Statistical Analysis. J. Aqua. Biol. 21 (2): 105-110pp.
26. Makhoukh, M.; Sbaa, M.; Berrahou, A. and Van Clooster, M.(2011). Contributionà letude physic chimique deseaux superficielles de l'oued Moulouya (Maroc Oriental) .Larhyss, 9: 149-169.

27. N'Diaye, A.D.; Mint, M. S. K.; EL- Kory, M. B.; Ould Kankou, O. S. A. andBaudu, M. (2014).Contribution to space and temporal study of the physicochemical quality of water from the Senegal River right bank, J. Mater. Environ. Sci. 5: 320-329pp.
28. USEPA (United State Environmental Protection Agency). (2002). National Recommended Water Quality Criteria. EPA-822-R-02-047.
29. Mason, C. F. (1998). Biology of fresh water pollution, 3nd Addison Wesley Longman Limited, London, England.
30. Sabri, A.W; Maulood, B.K. and Suliman, N.F. (1989). Limnological studies on river Tigris. Some physical chemical characters. J. Biol. Sci. Res., 20(3): 565- 579.
31. Nashaat, M. R. (2010). Impact of Al- Durah power plant on invertebrate's biodiversity in Tigris River.Ph. D. Thesis, Coll. Sci., Baghdad Univ., Iraq: 138pp.
32. Al-Saadi, H.A.; Hadi, R.A. M. and Al-Lami, A.A. (1999). Limnological studies on some marshes area in southern Iraq. J. Coll.Educ. for Women, Univ. Baghdad, 10(1): 264- 171.
33. Al-Saadi, H.A.; Al-Mousawi, A.H. and Al-Arijy, M.J. (1993).Physico-chemical feature of Al-Hammar marsh, Iraq. J. Coll. Educ. for Women, Univ. Baghdad, 4: 35-40pp.
34. Lewis,W.M. (2000). Basis for the protection and Management of tropical Lakes.Lakes Reserv.Res. Management, 5:35-48pp.
35. Kadhium, N. F.; Al-Amari, M.J. Y.; Hassan, F.M.(2013).The spatial and temporal distribution of epipelic algae and related environmental factors in Neel stream,Babilprovince,Iraq.International Journal of Aquatic Science,4(2): 23-32pp.
36. Khaire, B. S.(2012) .Studies on zooplankton population correla ted with some physico-chemical factors in Kambli water reservoir of Maharashtra, India.Ecorevolution, Colombo – Srilanka,:96-98pp.
37. Heemken, O. P.; Stachel, B; Theoblad, N. and Wenclawiak, B.W. (2000).Temporal Variability of organic micropollutants in suspended particulate matter of the River Elba at Hamburg and the River Mulde at Dessau, Germany. Arch, Environ. Contam. Toxicol., 38: 11-31pp.
38. WHO (World Health Organization Regional Office for the Eastern Mediaterranean Regional Centre for Environmental Health Activities CEHA)(2006). A compendium of drinking – water quality standards in the Eastern Mediterrean Region
39. Al-Mussawi, A. H. A.; Hussein, N. and Al-Aarajy, A. (1995).The influence of sewage discharge on the physic-chemical properties of some ecosystem at Basrah City .Iraq.Basrah J .Science, 13(1):135-148p.
40. Mohammed, A. B. (2007). Qualitative and quantitative studies of some Polycyclic Aromatic Hydrocarbons (PAHs) and limnology of Euphrates Riverfrom Al-Hindiya Barrage to Al-Kifil City-Iraq. Ph.D. Thesis, College of Science, University of Babylon, Iraq: 240p.
41. Hassan, F.M.; Hussain, A. and Al-Saadi, H.A. (1995).On the seasonal variation of phytoplankton populations in Hilla River.Iraqi Journal of College Education for Women.Univ. Baghdad, 6(2): 55-61pp.
42. Hassan, F.M. (1997).A limnological study on Hilla River.Al Mustansiriya Journal of Science, 8(1): 22-30pp.
43. Al-Lami, A.A. and Al-Aubaidi, K.H. (1996). A study on some physic-chemical characteristics of Tharthar Reservoir, Iraq.J. Coll. Educ. For Women, Univ. Baghdad, 7:20-28 pp. (In Arabic).
44. USEPA (United States Environmental Protection Agency). (2000). Bioaccumulation testing and interpretation for the purpose of sediment quality assessment (status an needs) .Office of Water (4305) Office of Solid Waste (5307W) EPA-823-R-00-001.
45. . Goldman, C.R. and Horne, A.J. (1983).Limnology.MaGraw-Hill Book Company, Tapan.
46. Al-Mousawi, A.H.; Al-Saadi, H.A. and Hassan, F.M. (1994). Spatial and seasonal variatios of phytoplanktonpopulation and related environments in Al-Hammar marsh, Iraq .Basrah J. Sci. B., 12(1): 9-20.
47. Al-Lami, A.A.; Kassim, T.I. and Al-Dulymi, A.A. (1999).A limnological study on Tigris River, Iraq. Sci. J. I.A.E.C., 1: 83-97.
48. Abdul Razzak, I.A. ;Sulaymon, A. H. (2009). Effects of discharging sewage of Baghdad to Tigris River on water quality. Eng. &Tech. Journal, 27(16):1-15pp.
49. Jayalakshmi,V.; Lakshmi,N. and SigaraCharya, A.M. (2011). Assessment of physico-chemical parameters of water and waste waters in and around Vijayawada. Int. J. Res. Pharm. Biomed. Sci. 2(3):1040-1046pp.
50. . Bass, D. and C. Potts.(2001). Invertebrate Community Composition and physicochemical conditions of Boehler Lake, Atoka Country, Oklahoma. Proc. Okla. Acad. Sci., 8: 21-29pp.

51. Zhu, L.; Chen, W.;Wang, J. and Shen, H. (2004). Pollution survey of Polycyclic Aromatic Hydrocarbons in surface water of Hazhou, China. Chemosphere, 56: 1085-1095.

52. Doong,R. and Lin,Y. (2004).Characterization and distribution of Polycyclic Aromatic hydrocarbon contaminations in surface sediment and water from Gao-Ping River, Taiwan.Water Research, 38: 1733-1744.
53. Vrana, B.; Pasch, A. and Popp, P. (2001). Polycyclic aromatic hydrocarbons concentrations and patterns in sediments and surface water of mansfed region, Saxony. Anhalt, Germany pub.
54. Nakata, H.; Sakai, Y.; Miyawaki, T. and Takemura, A. (2003). Bioaccumulation and toxic potencies of polychlorinated biphenyls and polycyclic aromatic hydrocarbons in tidal flat and coastal ecosystems of the Ariake Sea, Japan. Environ. Sci. Technol. 37: 3513-3521.
55. . USEPA (United States Environmental Protection Agency-Ecological Risk). (2006).Information on the toxic effects of various chemicals and group of chemicals.
56. WHO (1998). Polycyclic Aromatic Hydrocarbons. Guidelines for drinking water quality. Seconded addendum to vol.2.Health Criteria and other supporting information. World Health Organization, Geneva: 123-152 .
57. AL-Saad, T.H. (1995). Distribution and sources of hydrocarbons in Shatt Al-Arab Estuary and NW-Arabian Gulf.Ph.D. Thesis, College of Science, University of Basrah, Iraq.240.
58. AL-Saad, T.H. ;Shamshoom, S. M. and Abaychi, J. K. (1998).Seasonal distribution of dissolved and particulate hydrocarbons in Shatt Al- Arab Estuary and North- West Arabian Gulf. Mar. pollut. Bull. 36:850- 855

59. Nasher,E.; Heng, L.; Zakaria, Y. Z. and Surif,S. (2013). Concentrations and sources of polycyclic aromatic hydrocarbons in the sea water around Langkawi Island, Malaysia. Journal of Chemistry, Article ID 975781, 1-10