Effects of Discharging Sewage of Baghdad To Tigris River on The Water Quality

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Abstract

Tigris River one of the rivers that suffer from the effect of conservative pollutants. This study include the distribution of pollutants (which are BOD_5, TDS, pH, T.H., SO_4^{-2}, Na^+, and turbidity) in Tigris river between Al-A'imma bridge and Al-Jumhuria bridge ,a reach which is about (9 km) length within Baghdad city; which include four sewage pumping stations untreated discharged to the river.

It was conclude that the concentrations of pollutants were increase at the discharge points in the river and exceeding the acceptable limits according to the Iraqi standards specification of surface water , then BOD_5 and T.H. became within the acceptable values after (7.8 km) in the study region , and pH, TDS and Na^+ were within the acceptable ranges in all stations in the region, while SO_4^{-2} was exceed the allowable value (250 ppm) in all of the study region, and for turbidity it was reach to (4.5 NTU) on (8 km) in the study region. At the time of low discharges of Tigris river, sewage pumping stations should set at low discharge rate to decrease the pollutant's concentrations in Tigris river .

Keywords: (BOD_5) Biological oxygen demand, (TDS) Total dissolved solid, (T.H.) Total hardness, (pH) , ($SO_4^{-)}$) , (Na^+), (Tur.) Turbidity.

تأثيرات تصريف مياه الصرف الصحي لبغداد الى نهر دجلة على نوعية المياه

الخلاصة

ان نهر دجلة يعتبر من الانهار التي تعاني من تأثير الملوثات التي تصرف مباشرة اليه . تم في هذا البحث تطبيق نموذج الخلايا المتعددة لغرض معرفة انتشار الملوثات والمتمثلة في (الاوكسجين الحيوي المطلوب (BOD_5) ، المواد الذائبة الكلية (TDS) ، الأس الهيدروجيني (pH) ، العسرة الكلية (T.H.) ، ايونات الكبريتات (SO_4^{-2}) ، ايونات الصوديوم (Na^+) ، العكورة (Tur.)) على نوعية مياه نهر دجلة في المنطقة الواقعة بين جسر الأئمة وجسر الجمهورية والممتدة على طول (9 كم) ضمن مدينة بغداد ، والتي تحتوي على اربعة محطات للصرف الصحي تصرف مباشرة الى النهر . تم التوصل من خلال النموذج الرياضي الى ان تركيز الملوثات في النهر يزداد خاصة في المناطق التي يتم فيها التصريف مباشرة الى النهر ثم يبدأ تركيز BOD_5 .T.H بالانخفاض والعودة الى الحدود المسموحة بعد (300م) من اخر نقطة صرف اي بعد حوالي (7.8 كم) من منطقة الدراسة بينما قيم pH, TDS, Na^+ فأنها كانت ضمن الحدود المقبولة وعلى طول منطقة البحث , في حين ان تراكيز ايونات الكبريتات SO_4^{-2} كانت

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جميعها خارج الحدود المسموحة(250ppm) وعلى طول منطقة الدراسة , اما بالنسبة للعكـــورة turbidity فأن قيمتها وصلت الى (4.5 NTU) بعد (8 كم) من بداية منطقـــة الدراســـة , مـــن الضروري السيطرة على تصاريف محطات الصرف الصحي لجعل تراكيز الملوثات في ميـــاه نهر دجلة ضمن الحدود المسموح بها حيث لوحظ عند تشغيل هذه المحطات بطاقتها القصوى فأن تراكيز الملوثات يزداد خصوصا عندما يكون تصريف نهر دجلة قليل.

Introduction:

Fresh waters are facing an increasing load of the disposal of polluted waters due to rapid growth of industrial and municipal activities as well as the increase of land drainage due to agricultural activities. Outfalls effluents with high pollutant concentrations are discharged to fresh water without treatment causing near field and far field pollution conditions in rivers [1] .

The quantitative and qualitative study of water resources, their development and management become one of the major concerns of the society. The escalating demands on limited water resources, needs for maintaining suitable water quality for human, agricultural, and industrial uses and complex interactions of numerous elements of the man-water environment have necessitated the use of more sophisticated forecasting techniques. Such forecasting is essential in the planning, designing, and management of water resources system. [2]

Water quality studies have focused on cases where sever pollution problems are arises, especially in heavily populated urban areas. Baghdad city is over populated and produced a huge amount of wastewater from different sources which are disposed into Tigris River directly or after treatment. In the last few years, an increase of wastewater directly disposed in the river using pump stations of storm sewer network have caused high pollution levels in the river's water [3].

Most potential negative environmental impacts from the application of recycled water to the environment come from recycled water's origin as wastewater. These impacts include other water resources, potential contamination of surface and groundwater sources. Public health hazards, and other environmental impacts that may directly or indirectly affect the public. Fortunately, very few significant negative impacts have ever occurred. It is important that all public water systems serve water of the best possible quality to their customers [4].

Water quality characteristics fall into the following four broad categories:

1-Physical.

2-Chemical.

3-Biological.

4- Radiological.

The concentration of pollutant in the river is affected by water discharges and its velocities, which is continuously changes with time. The estimation of the velocities which is the major factor affecting the pollutant movement, is often based on physical models or actual measurements. Both are time-consuming and relatively expensive [5].

Tigris river facing the effect of conservative pollution due to the discharge of wastewater in it.

The present research is to study the effect of didcharge sewage pumping stations to the river on the water quality, the pollution sources include four sewage pumping stations: Fig.(1).

1-(RQ)sewage pumping station (S1)
2-(T1)sewage pumping station (S2)
3-(M112)sewage pumping station (S3)
4-(M108) sewage pumping station (S4)

Methodology:

-The limitation of this study is to cover a distance about nine kilometers length of Tigris river within Baghdad city between Al-A'imma bridge and Al-Jumhuriya bridge.

- The field work include collecting twelve samples from the river (before, after, and in the discharge collected
points), and four samples from the four sewage pumping stations within the study region, these samples were collected twice a month from 15/11/2005 to 30/4/2006.

-The laboratory work include measuring of BOD_5 , T.D.S , pH , T.H. , SO_4^{-2}, Na^+ , and turbidity for all the samples which were collected.

-The multiple-cells model method applied depending on the field results to predict the distribution of pollutants in Tigris river and the effect of them on the river water quality.

Objective:

The goals of this study are :-

-Examine the effect of pollutants on Tigris river water quality and explain the distribution of these pollutants within the study region and the distance at which the contaminants reach the acceptable values according to the allowable Iraqi standards.

-monitor the variation of pollutants in Tigris river water with respect to the location, flow, and contaminants concentration of waste- water which discharged from the sewage pumping stations to the river.

-Study and weigh the effect of pollutant's distribution in river water on the location of drinking water stations within the study region.

-Develop a mathematical model to determine the predictive distribution of pollutants in the river water due to the discharge of wastewater from four sources of sewage pumping stations.

Tigris river within Baghdad city

The present study includes part of Tigris River which is about 9 km , along this part, there are various sources of pollution from sewage pumping stations (RQ (S1), T1 (S2), M112 (S3), M108 (S4)). Fig.(1) .

The reference water level and flow gauging station which has been considered in the present study is Sarai Baghdad gauging station .

Tigris river is prone to considerable level of physical , chemical and biological pollution emanating from such water pollutants. These inflows have considerably changed the colour, smell, test and other characteristic of the river's water.

Experimental Work

The experimental work, in this study, can be divided into two parts; field work and laboratory work.

Field Work

Spot samples were collected in order to study the effect of discharge of wastewater from the sewage stations to Tigris river between Al-A'imma bridge and Al-Jumhuriya bridge on Tigris river water quality.

Twelve stations were chosen in the study region, which includes four discharge points as shown in Fig. (2), and four samples from the sewage pumping stations which were discharge directly to the river within the study region, these samples were collect from the same stations twice a month from 15/11/2005 to 30/4/2006. Table(1) shows the location and distances of these stations.

The water level of Tigris river for the days when the samples collected were measured at Sarai Baghdad Gauging Station then the values of flow of the river were found from the rating curve Fig. (3) and the results were tabulate in table (2).

Laboratory Work

River stream and outfalls sewage pumping stations samples were collecte using bottles of one-liter capacity from the middle of the river at the depth of (0.5m) , , the samples were collecte twice a month.

Seven constituents were involved in the present work , Biological Oxygen Demand (BOD_5), Total Dissolved Solid (TDS) , Acidity function (pH) , Total Hardness (T.H.), Sulphate ions ($SO_4^{=}$) , Sodium ions (Na^{+}), Turbidity (Tur.).

BOD_5 Test by Electrometer Method

The instrument used In this method is BOD meter (C/BSB/BOD inoLab). The electrode placed in (250 ml) diluted sample in order to measure the initial dissolved oxygen (D_1), and after 5 days the final dissolved oxygen was measured (D_2) [6].

then BOD_5 was calculated by:

$$BOD_5,(ppm) = \frac{D_1 - D_2}{P}$$

Where:

D_1= DO of diluted sample immediately after preparation, mg/l

D_2= DO of diluted sample after 5 days incubation at 20ºC, mg/l

P = decimal volumetric fraction of sample used (dilution factor).

TDS Test by Filtration Followed by Oven Drying

200 ml (V) of sample was filtered by filter paper to separate the suspended solid, then the beaker was weighted (A) and filled by the filtered sample ,the sample was dried in the oven at 105 ^{o}C for 5 hours ,the beaker with the dissolved solid was weighted again (B) [7].

Then TDS was calculated by :

$$TDS(ppm) = \frac{B - A}{V}$$

Where:

V= volume of sample, (L).

A=weight of beaker filled by filtered sample, (mg).

B= weight of beaker with the dissolved solid, (mg).

pH Test by Glass Electrode Method

This method was done by using the pH electrode meter . First of all the instrument was calibrated by using distilled water (pH=7), then the electrode was placed in (250 ml) of the sample in order to measure pH (the value was recordedafter2 minutes of placement). [7].

T.H. Test by Titration Method

A solution was prepared from 10 ml of water sample (V_1) and 10 drops of buffer solution (pH=10) in order to give the alkalinity characteristics, then one drop (10 mg) of Eriochrome black T reagent was added, so the solution became pink. This solution was titrated with (1 normality)(N) of H_2SO_4 acid until the solution became blue, the volume of acid was records (V) [8].

The T.H. was calculated by:

$$T.H.(ppm)(CaCO3) = \frac{V * N * MW * 1000}{V1}$$

Where:

MW = the molecular weight of $CaCO_3$

V= volume of H_2SO_4.

N= normality of H_2SO_4.

V1= volume of water sample, ml .

$SO_4^{=}$ Test by Atomic Emission Method

This method was carried out by using Inductivity Coupled Plasma Atomic Emission Spectrometer (AES), 1 ml of sample was placed in the (AES). The flame in the instrument was converted the sample into an atomic vapor and then thermally elevated the atoms to an excited state, when these atoms return to the ground state they emit light which was detected by the instrument, and the value was converted to concentration by special graph in the instrument [9].

Na^+ Test by Atomic Absorption Method

This method was done by using Atomic Absorption Spectrometry (AAS) , 1 ml of sample was placed in the (AAS).The sample ground state atom absorbs light energy of a specific wavelength as it enters the excited state, the instrument measured the amount of light absorbed and converted it to concentration by a special graph in the instrument [10].

Turbidity Test by Nephelometric Method

In this method the turbidity meter was used with a light source for illuminating the sample and photoelectric detector with a readout device to indicate the intensity of light scattered at right angle to the path of the incident light, the instrument was calibrated by using a standard liquid, then 50 ml of Nesler Tube was filled with the sample and placed in the instrument and measured the turbidity by the photoelectric detector.[10]

Results and discussion:

1-From the results of laboratory tests, the concentrations of the samples at stations 2, 5, 7, and 9 were very high compared with the other stations, because they were collected from the stations at the river at the discharge of the sewage pumping stations (S1, S2, S3, and S4) Fig. (4,5,6,7,8,9,10) .

2- The concentration of Na^+ at station (2) was higher than those at stations (5, 7, and 9) because the concentration of Na^+ in the sewage at station (S1) was more than the other stations (S2, S3, and S4) Fig. (9).

3- The BOD_5, TDS, and SO_4^{-2} concentrations at station (5) were higher than the other stations (2, 7, and 9) because of the higher concentrations of the discharge sewage from (S2) than those from (S1, S3, and S4) Fig. (4,5,8).

4- The BOD_5 concentration levels increase at the river at the discharge points, so they increase at distance 1.2 km by 350% of the acceptable limit , at distance 5 km by 420% of the acceptable limit, at distance 6.5km by 400% of the acceptable limit, and at distance 7.5 km by 380% of the acceptable limit, then they decrease at the other regions, and at (7.8 km) they reach the allowable values Fig.(4).

5- The TDS concentrations increase at the discharge points , these values were between (400 ppm - 1100 ppm) so they were within the acceptable values (1000 ppm) except at station (5) it was reached (1100) ppm due to high TDS concentration in the discharge sewage from (S2) at (5 km) Fig. (5).

6- The pH values decrease at the discharge points (2, 5, 7, 9) and they increase at the other points (1, 4, 6, 8, 10, 11, 12) in the river, because the values of pH in the discharge sewage were low, but the pH values remain within the acceptable values at all the study region Fig. (6).

7- The T.H. increase at distance 1.2 km by 140% of the acceptable limit, at 5 km by 160% of the acceptable limit, at 6.5 km by 150% of the acceptable limit, and at 7.5 km by 145% of the acceptable limit, then the concentrations return to the acceptable values at the other regions, the T.H. concentration reach the allowable Iraqi standard (500 ppm) at (7.8 km) Fig.(7).

8- The SO_4^{-2} concentrations increase at stations (2, 5, 7, and 9) due to the high concentrations of SO_4^{-2} in the sewage water which discharge without treatment to the river, and these values are exceed the allowable Iraqi standard (250 ppm) at all the study region, Fig. (8).

9- The Na^+ concentrations, are increase in stations (2, 5, 7, and 9) but these concentrations remain within the allowable Iraqi standards (150 ppm) because the Na^+ concentrations in (S1, S2, S3, and S4) are low ,Fig. (9).

10- The turbidity values, are increase at the discharge points in the river, but they were acceptable, these values were between (4.6 NTU – 16 NTU). Fig.(10).

11- Al-Karama water intake locate at (1.8 km) on the study region and Al-Wathba water intake locate at (4.8 km) on the study region,, at these stations BOD_5, TDS, pH, T.H, are acceptable according to the allowable Iraqi standard but the SO_4^{-2} values are exceed the allowable limit.

Conclusions

1-The concentrations of all contaminants increase at the discharge points in the river and decrease in the other points that's due to mixing with the river's water.

2-Field measurements on laboratory tests present that:

* BOD_5 concentration level are exceed the allowable Iraqi standards (40 ppm) in the river at the discharge points then they return to the acceptable values in the other points, and they reach the allowable Iraqi standard at (7.8 km) due to the mixing in the river.

* TDS are within the allowable standard (1000 ppm) except in the position (5) at (5 km) it reached (1100 ppm) because of high TDS concentrations in (S2).

* pH values are decrease at the discharge points because of the effect

of (S1, S2, S3, and S4) but it remain within the acceptable range (4-9).

* T.H. exceed the allowable Iraqi standard (500 ppm) in stations (2, 5, 7,9)because of the high concentration in (S1,S2,S3, and S4).

* SO_4^{-2} concentration levels are exceeding the allowable standard (250 ppm) at all the study region due to the wastewater which discharge to the river without treatment.

* Na^+ concentration levels are within the allowable standard (150 ppm) in all the studying points.

* Turbidity values are between (6 NTU - 16 NTU) then it return to (4.5 NTU) at (8 km).

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Table (1) The locations and distances of the sampling stations on Tigris river.

St. No.	Distance (Km)	Locations	Coordinates	
1	0.0	At Al-A'imma bridge	33º22'29".82N	44º21'19".22E
2	1.2	At (RQ) pumping station	33º21'55".54N	44º2054".82E
3	2.0	At Al-Adhamiya bridge	33º21'33".71N	44º21'14".30E
4	4.0	At Al-Sarafiya bridge	33º21'27".50N	44º22'21".12E
5	5.0	At (T1) pumping station	33º21'02".14N	44º22'17".30E
6	6.0	At Bab Almuadham bridge	33º20'33".20N	44º22'44".99E
7	6.5	At (M112) pumping station	33º20'26".12N	44º23'03".80E
8	7.0	At Al-Shuhada bridge	33º20'17".03N	44º23'16".52E
9	7.5	At (M108) pumping station	33º20'09".70N	44º23'26".01E
10	7.9	At Al-Ahrar bridge	33º19'55".80N	44º23'43".17E
11	8.5	At Al-Sinak bridge	33º19'42".22N	44º24'00".99E
12	9.0	At Al-Jumhuriya bridge	33º19'28".46N	44º24'15".05E

Table (2) Water Level and Flow of Tigris river at Sarai Baghdad Gauging Station.

Date	W.L.(m) Sarai Baghdad	Flow (Q_{in}) (m^3/sec)
15/11/2005	29.72	875
30/11/2005	29.08	698
15/12/2005	28.96	667
30/12/2005	28.90	652
15/01/2006	28.88	647
30/01/2006	28.94	660
15/02/2006	28.79	625
28/02/2006	28.72	607
15/03/2006	29.36	770
30/03/2006	29.20	730
15/04/2006	28.92	655
30/04/2006	28.88	645

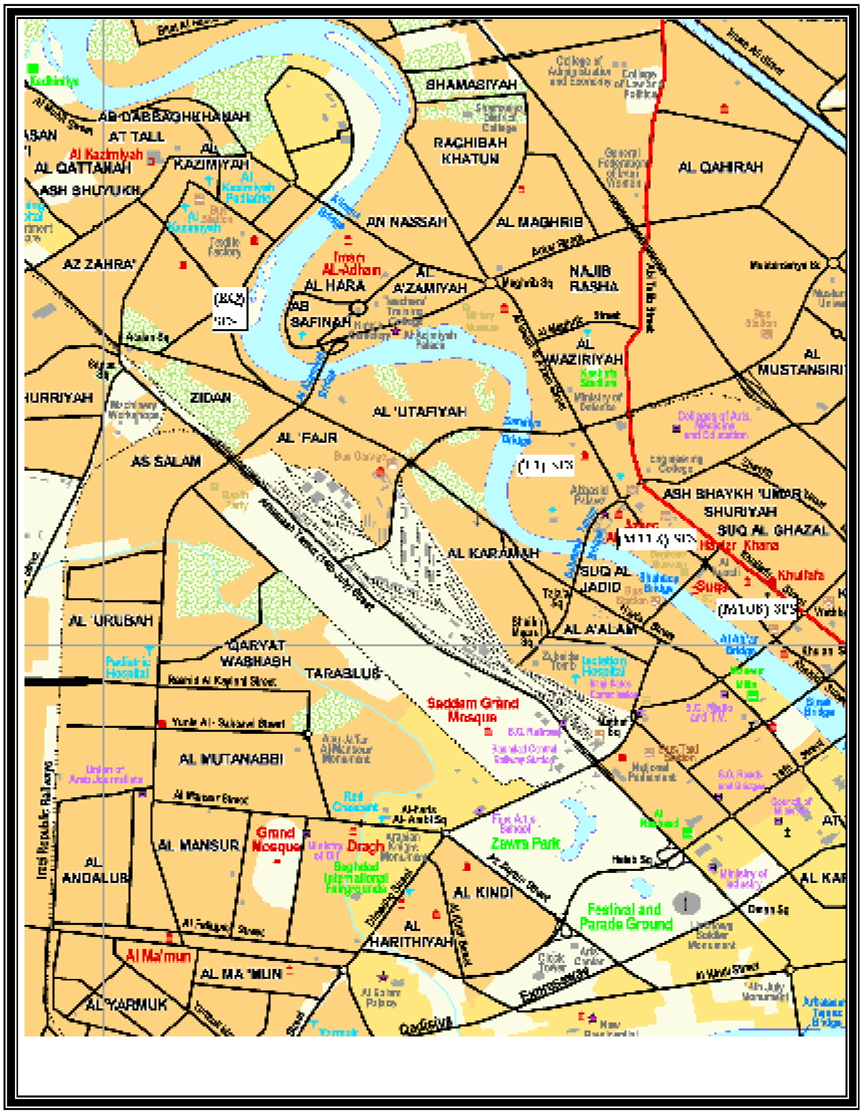

Figure (1) Tigris river between Al A'imma bridge and Al-Jumhuriya bridge

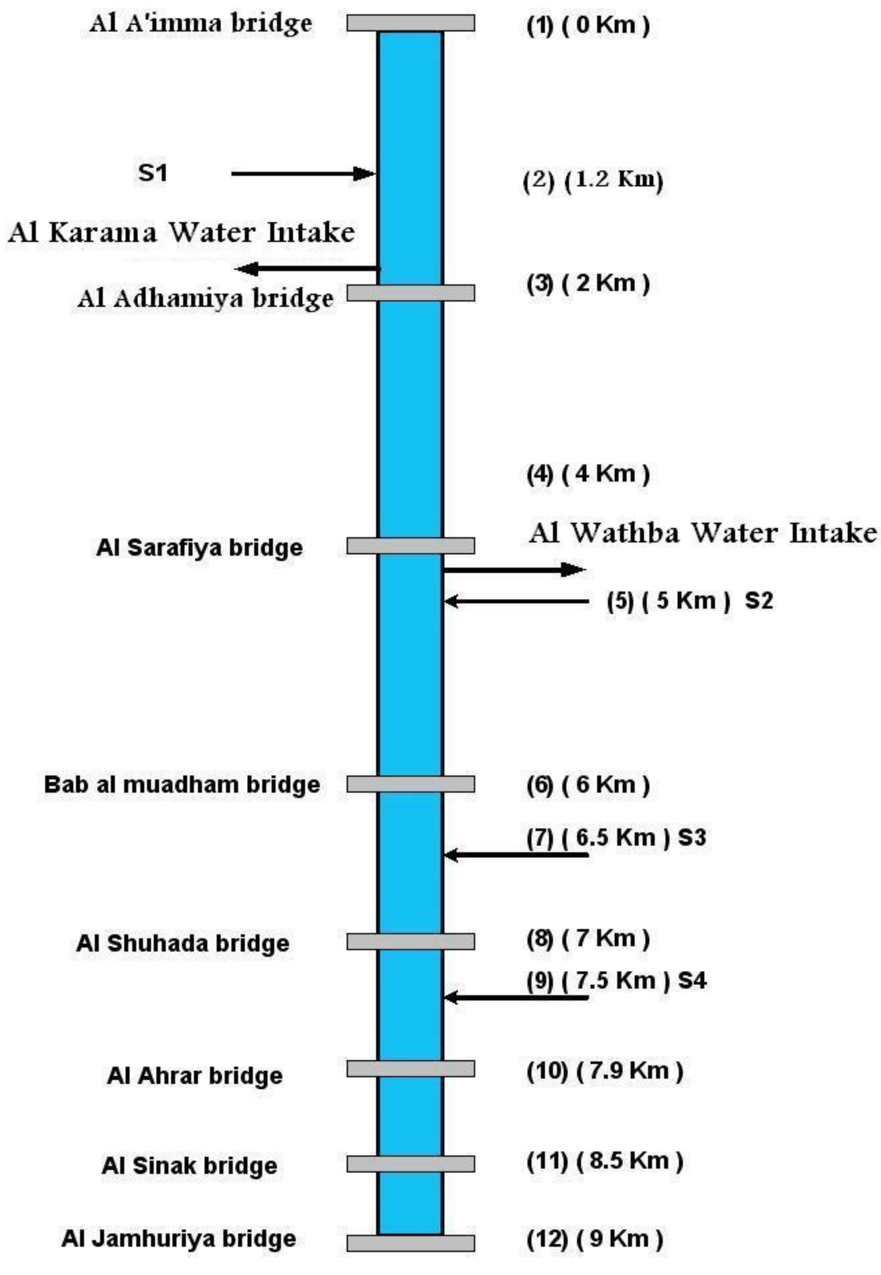

Figure (2) The schematic diagram of the study region

$Q = 32.014\,(Z - 24.01)^{1.89}$

$R^2 = 0.99206$

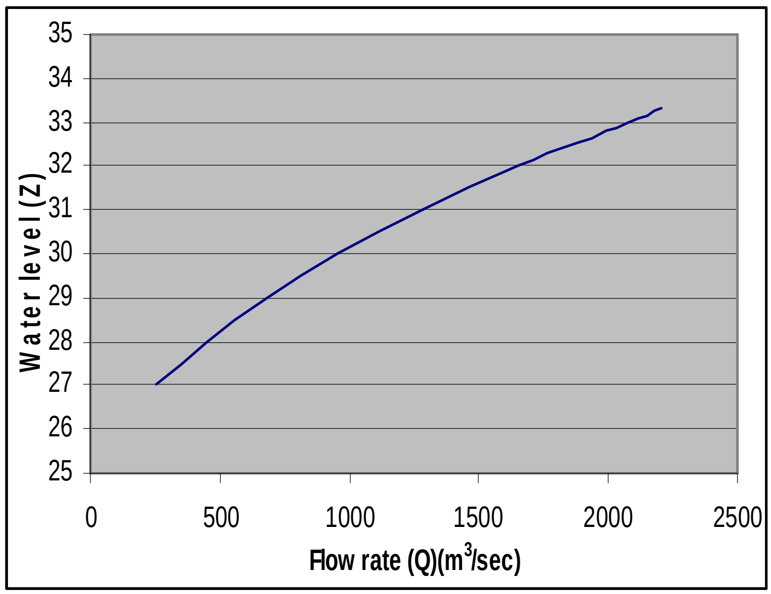

Figure (3) Rating Curve at Sarai Baghdad Gauging Station.

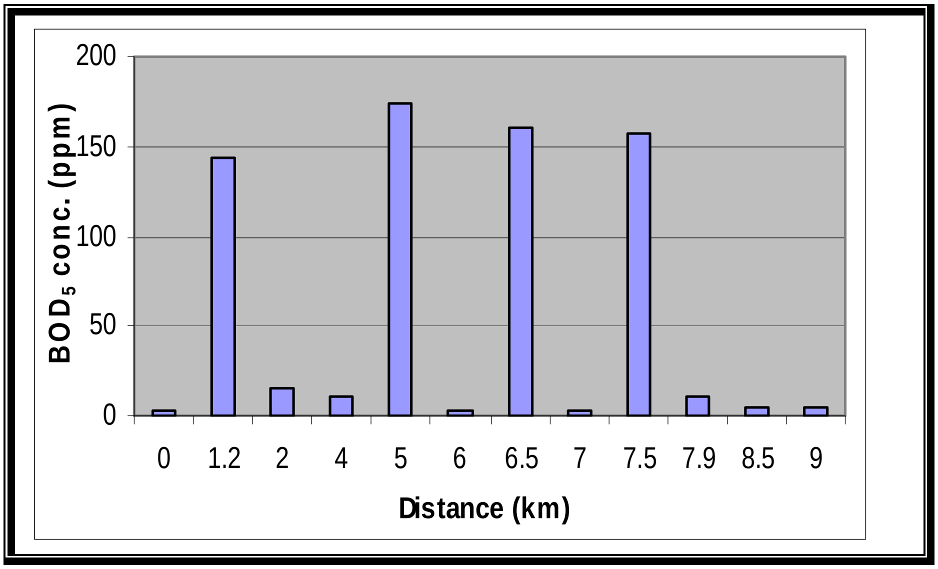

Figure (4) BOD_5 variation along the study region.
Allowable limit according to the Iraqi standards is (40 ppm)

Figure (5) TDS variation along the study region.
Allowable limit according to the Iraqi standards is (1000 ppm)

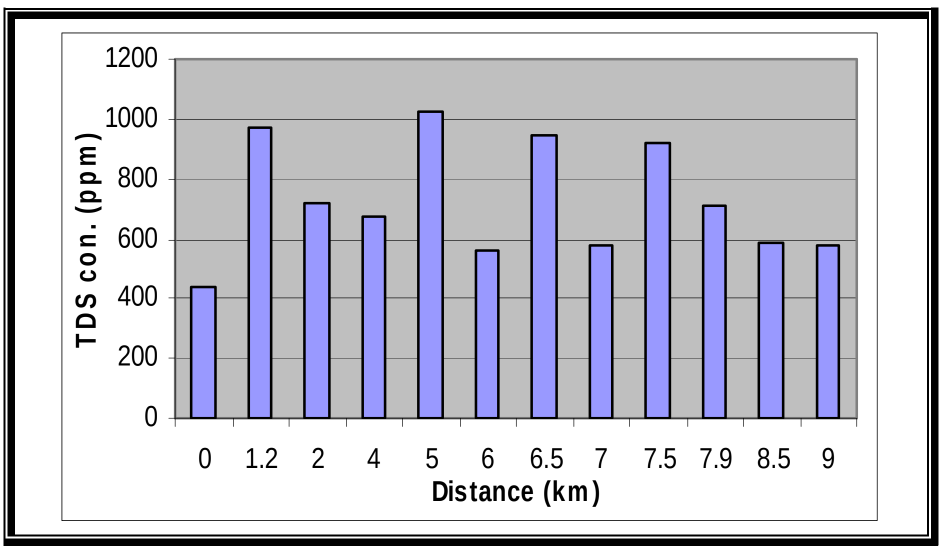

Figure (5) TDS variation along the study region.
Allowable limit according to the Iraqi standards is (1000 ppm)

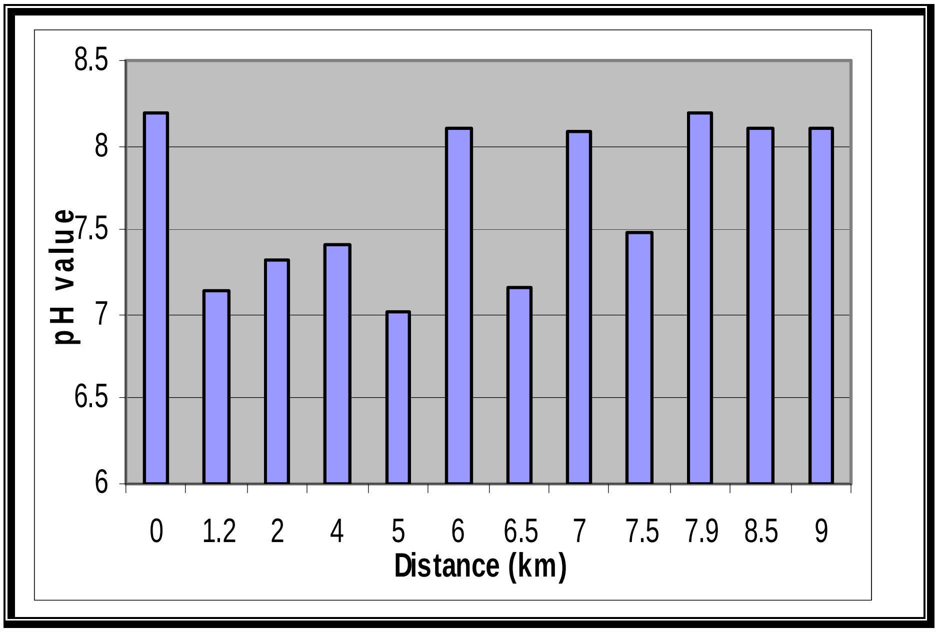

Figure (6) pH variation along the study region
Allowable limit according to the Iraqi standards is (from 4 to 9)

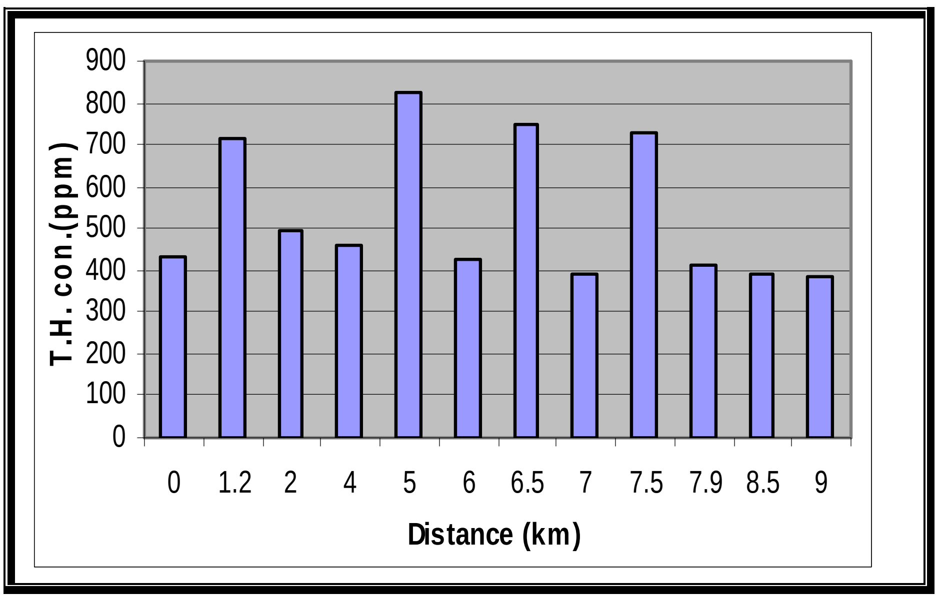

Figure (7) T.H. variation along the study region Allowable limit according to the Iraqi standards is (500 ppm)

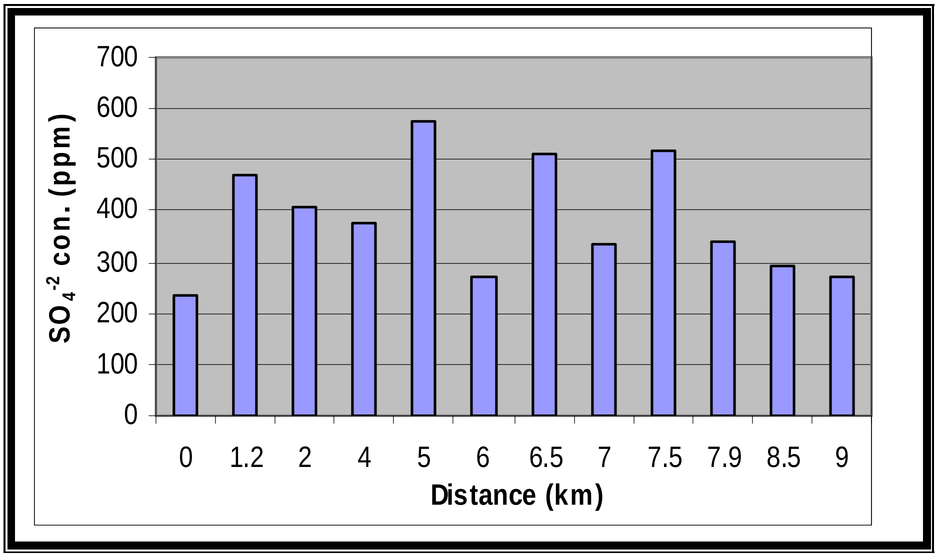

Figure (8) $SO_4^{=}$ variation along the study region
Allowable limit according to the Iraqi standards is (250 ppm)

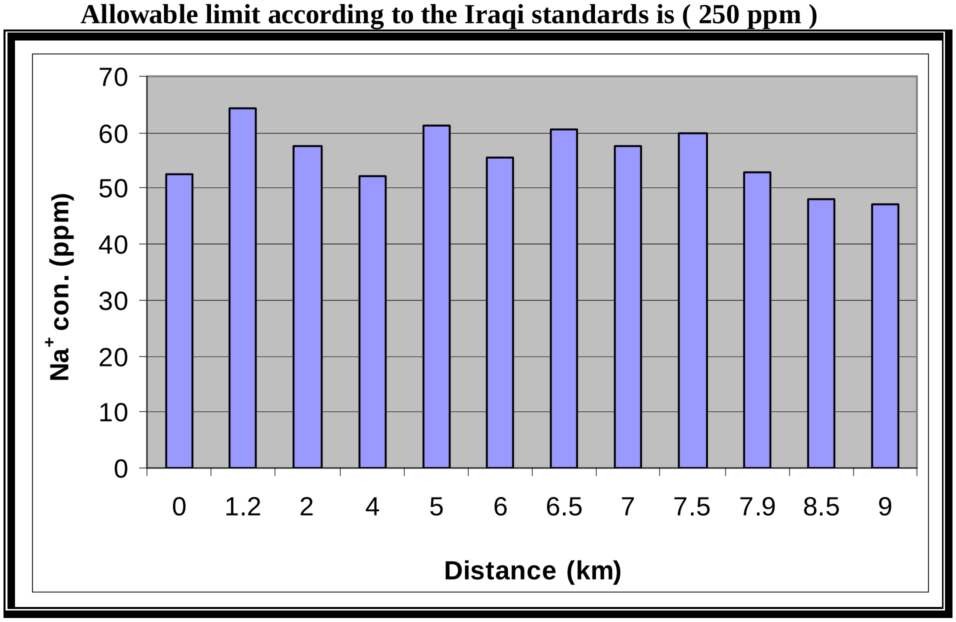

Figure (9) Na^{+} variation along the study region
Allowable limit according to the Iraqi standards is (150 ppm)

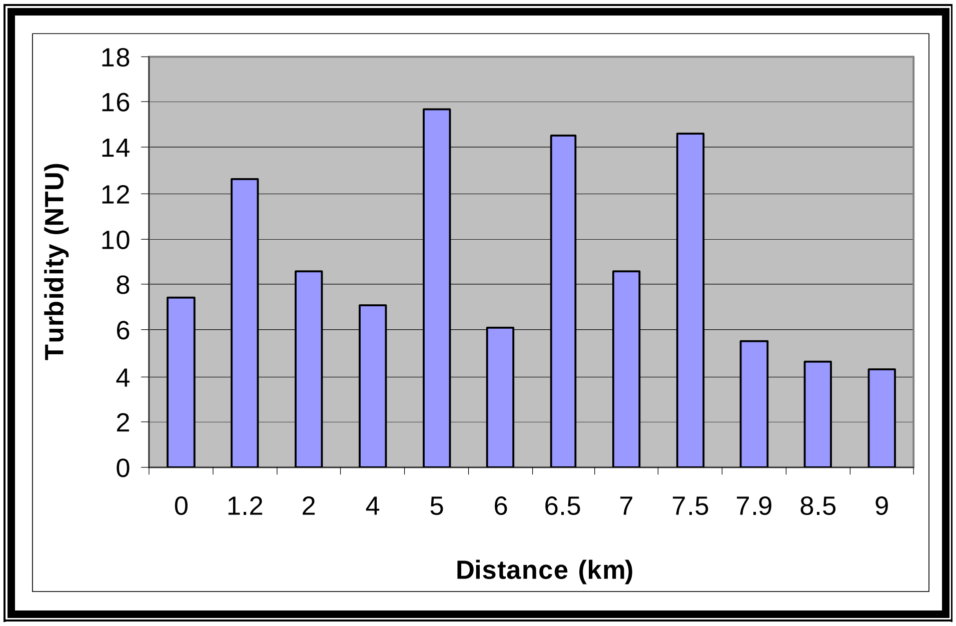

Figure (10) Turbidity variation along the study region