EVALUATION OF ENVIRONMENTAL IMPACT OF TIGRIS RIVER POLLUTION (BETWEEN JADIRRIYA AND DORA BRIDGES)

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ABSTRACT

Al-Saidiya PN pumping station raw sewage discharges forms the major pollution source to Tigris river between Al-Jadirriya and Al-Dora bridges, its main importance comes from its location upstream to Al-Dora water treatment plant.

In an attempt to evaluate the environmental effects on water quality within the river reach under study, special emphasis was put on evaluating the environmental impact of Al-Saidiya (PN) pumping station wastewater discharges on downstream intakes of water supply, using parameters Oil & Grease, DO, BOD and Coliform & Feacal coliform, in addition to SO_4, Cl & EC distributions in three dimensions.

It was found that most pollutants concentrations at Al-Dora WTP range within the permissible level for Iraqi raw waters; with the exceptions of Coliform and Feacal Coliform that are highly above the limits; SO_4 and BOD showed some high values.

Concentrations of pollutants NH_3, SO_4, BOD, Coliform and Feacal Coliform showed higher values at Al-Dora WTP site compared to Al-Qadissiya and Al-Rasheed WTPs sites.

Oil & Grease high concentrations measured at Al-Saidiya pumping station showed that it should not be allowed to discharge directly to the river.

Another importance of this location comes from the river hydraulic characteristics represented by the sharp U-shape bend that enhances the transversal mixing process, and hence facilitates the pollutants distribution, through the secondary currents and spiral flow.

الخلاصـــــــــة

تمثل المياه الثقيلة المطروحة من محطة مجاري السيدية مصدر التلوث الرئيسي لجزء نهر دجلة الواقع بين جسري الجادرية والدورة، حيث تتاتى اهميتها من موقعها الى الاعلى من مشروع الدورة لتصفية مياه الشرب.

تقييم الأثر البيئي لنوعية مياه النهر في منطقة الدراسة، تم من خلال تقييم الاثر البيئي للمياه الثقيلة المطروحة من محطة ضخ مجاري السيدية على مآخذ محطات مشاريع تصفية مياه الشرب الواقعة الى الاسفل منها باستخدام مؤشرات الزيوت والشحوم، نسبة الاوكسجين المذاب والمتطلب

الحيوي للاوكسجين، كذلك بكتريا القولون وبكتريا القولون البرازية، اضافة الى الكبريتات و الكلور والتوصيلية الكهربائية.

تم التوصل الى ان تراكيز غالبية الملوثات في منطقة مأخذ مياه مشروع تصفية ماء الدورة تقع ضمن المحددات العراقية المسموح بها لمياه النهر؛ باستثناء بكتريا القولون وبكتريا القولون البرازية حيث تعدتا الحدود المسموح بها بكثير؛ كذلك ظهرت بعض النسب المرتفعة لكل من الكبريتات والمتطلب الحيوي للاوكسجين.

اظهرت الملوثات الامونيا، الكبريتات، المتطلب الحيوي للاوكسجين، بكتريا القولون وبكتريا القولون البرازية نسب تراكيز اعلى في موقع مشروع الدورة لتصفية مياه الشرب مقانة بموقعي مشروعي القادسية و الرشيد لتصفية مياه الشرب.

اما فيما يخص الزيوت والشحوم، فان النسب المرتفعة التي تم الحصول عليها عند تحليل نماذج المياه الثقيلة الماخوذة من محطة مجاري السيدية فانها تشير بوضوح الى عدم جواز ضخ هذه المياه مباشرة الى النهر.

كما تتمتع منطقة النهر بخاصية هيدروليكية فريدة متمثلة بحنيتها الشديدة الهلالية الشكل التي تساهم في تعجيل عملية الانتشار العرضي والذي ينتج عنه النعجيل في عملية توزيع الملوثات في مياه النهر، من خلال التيارات الثانوية والجريان الحلزوني.

KEYWORDS
River, Pollution, Sewage, Bend, Coliform, Oil & Grease.

INTRODUCTION

Pollutants with the greatest potential for damage are man-made, and are often released through specifically designed structures into rivers and watercourses, pollution resulting from such structures approximate steady state conditions.

TIGRIS RIVER POLLUTION WITHIN BAGHDAD CITY

Tigris river water is considered the only source of potable water for the city of Baghdad, even though it is also considered a course for different types of wastewater discharges from various sources, that could be either treated or untreated such as many pumping stations discharging raw sewage directly to the river, causing severe pollution to its water, this pollution increases downstream as the river flows within Baghdad city.

Several water intakes are training on the river sides in taking raw water directly from the river in order, either to treat it and supply the city population with treated drinking water or using it for other different usages such as in cooling processes or as raw water supply.

This situation of discharging wastewaters directly to the river especially at the presence of water intakes downstream, in addition to health risk, urge fast movement to conduct intensive studies on the effect of these pollution sources on the river water quality especially at water treatment plants intake.

Among these badly affected regions, emerges the southern region of Baghdad city, between Al-Jadirriya and Al-Dora bridges. This region is characterized first by the discharge of direct, continuous raw sewage from Al-Saidiya pumping station (PN) to the river, just upstream of Al-Dora water treatment plant intake, but particularly by its sharp bend which has a major impact on the river flow and the dispersion of pollutants in this river reach.

DESCRIPTION OF THE RIVER REACH

The study reach covers a length of almost ten kilometers of Tigris River situated at the eastern southern part of Baghdad city, between Al-Jadiriya and Al-Dora bridges. The river reach is rich with its outfalls and water intakes projects. Some projects are dual functioning, i.e., taking raw water from the river and then discharging back the used water to the river. Al-Qadissiya water treatment plant intake will be considered as upstream, and Al-Rasheed water treatment plant intake, as downstream.

The reach is believed to be the most polluted region of Tigris River within Baghdad city. Beside that the river reach is considered as an important recreational area. The reach is characterized by its sharp U-shape (almost 180º) bend, as seen in **Figure (1)** below. After [*Google Earth*].

Fig (1) Layout of Tigris river system under study.

Whereas **Fig (2)** illustrates the Tigris River scheme for the southern part of Tigris river within Baghdad city.

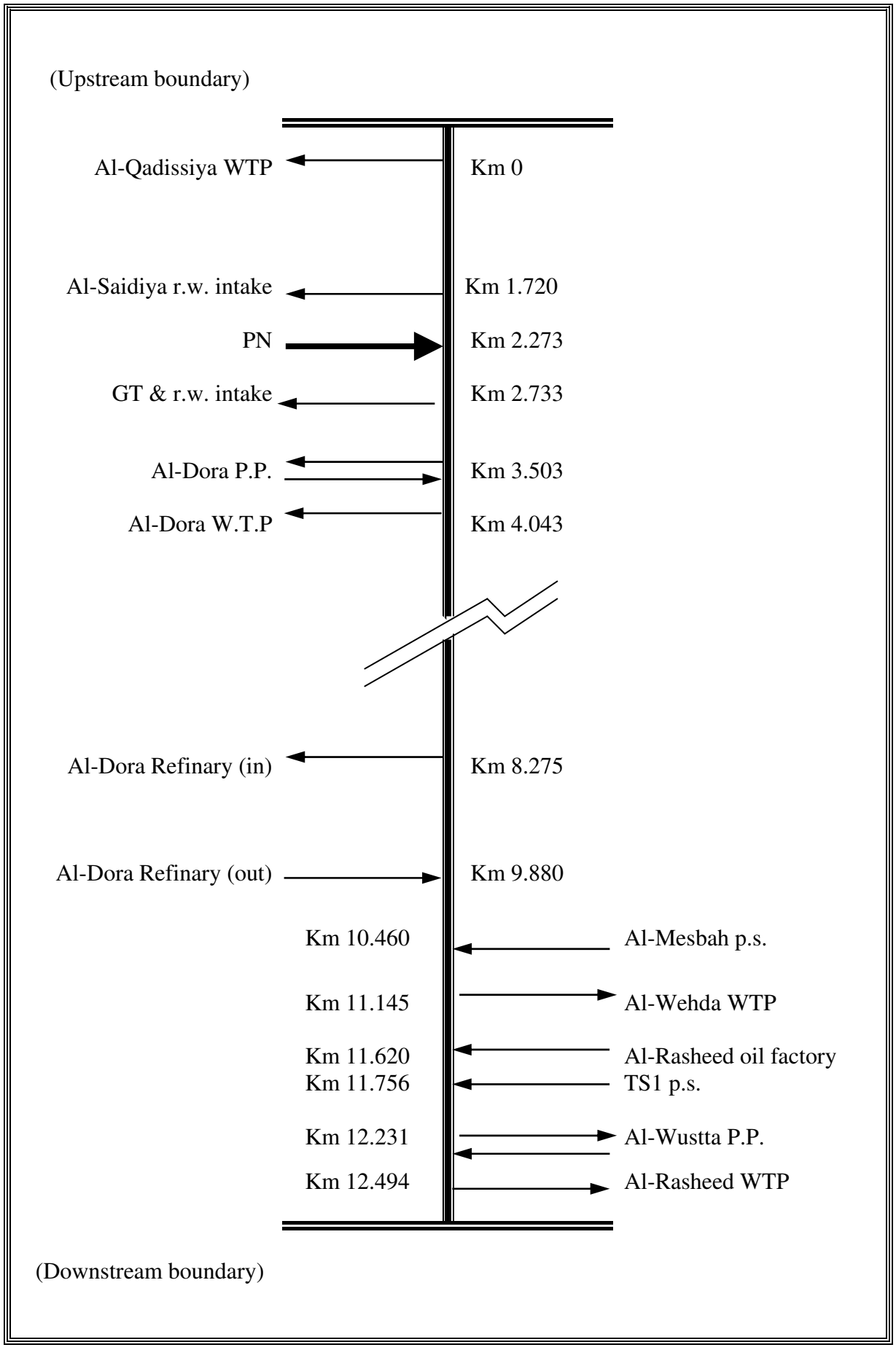
(Upstream boundary)
Al-Qadissiya WTP
Km 0
Al-Saidiya r.w. intake
Km 1.720
PN
Km 2.273
GT & r.w. intake
Km 2.733
Al-Dora P.P.
Km 3.503
Al-Dora W.T.P
Km 4.043
Al-Dora Refinary (in)
Km 8.275
Al-Dora Refinary (out)
Km 9.880
Km 10.460
Al-Mesbah p.s.
Km 11.145
Al-Wehda WTP
Km 11.620
Al-Rasheed oil factory
Km 11.756
TS1 p.s.
Km 12.231
Al-Wustta P.P.
Km 12.494
Al-Rasheed WTP
(Downstream boundary)

Fig (2) Tigris River scheme within the river study reach.

Al-Saidiya raw sewage pumping station (PN)

Al-Saidiya outfall, is sited on the outside edge of the almost 90º bend and is discharging raw sewage continuously and directly to Tigris River.

Al-Saidiya pumping station (PN) was designed, to be a combined sewerage overflow system, it was intended to operate only in wet weather and discharge diluted wastewater. [*Chief Site Engineer;UNDP, (1998)*].

The PN serves large areas, dense in population; the (**N**) line represents the lines network that collect wastewater from Al-Rasheed, Al-Bayaa and Hay Al-Aamel districts, while the (**P**) line represents the lines network that collect wastewater from Al-Mansoor, Al-Jihad and Al-Ghazalia districts.

At the location of Al-Saidiya pumping station raw sewage is directed to the screening unit in order to catch and remove the large objects from the raw sewage before it enters the pumps.

There are 12 vertical pumps which are controlled manually; their total flow capacity reaches 18 m^3/sec (6 pumps have a capacity of 2 m^3/sec and the other 6 have a capacity of 1 m^3/sec), they are discharging continuous raw wastewater directly to Tigris river at a rate of 6 m^3/sec in summer, while in winter the discharge drops to 3-4 m^3/sec in dry weather and increases to 11 m^3/sec during rainy days.

After the pumping stage raw sewage goes to the surge tank before being discharged by gravity to the river through two 2.5 m diameter pipes. The overflow half-circular channel of 4 m^3/sec capacity that was supposed to carry the raw sewage to Al-Dora pumping station is no more operational. [*Chief & Site Engineers; Amanat Baghdad*].

The discharge location into the river surface is about 150 m far from the PN location, where the discharge is performed through two pipes of 2.5 m diameter each, the outfall structure on the river bank consists of, the vertical structure surrounding the two pipes (8m × 3m), the discharge pipes are equipped with check valves; the horizontal structure on the river bank (10m × 13m) which is paved with big rocks to promote aeration of the sewage; the continuous discharge consist of dark-grey, odorous raw sewage, without floating objects, the wastewater plume trains along the river for a long distance before it is dispersed. **Fig (3)** below illustrates the PN outfall structure on the river bank while **Fig (4)** illustrates the raw sewage plume inside the river.

Fig (3) Al-Saidiya PN outfall structure.

Fig (4) Raw sewage training along the river bank.

CONCEPTS

River Bend

A natural meandering river can be said to represent one of the most complex fluid-flow situations encountered in the environment. Not only is the flow turbulent and strongly three dimensional, but its irregular topography and bathymetry are subject to constant change as a result of erosion, sediment transport and deposition processes. [*Leschziner,(1979)*].

In order to control the river's course and protect and develop the banks to safeguard the Tigris, the river's riveting and protection was implemented in the year 2002, it can clearly be seen along the river in Baghdad, the present case study reach that represents a steep bend, has benefited a lot in stopping the erosion of its outside bank and shaping a final look to the bend.

Effects of Bends

Bends in rivers induce secondary currents that increase the rate of transverse mixing and thereby to some extant reduce the dispersion coefficient. A much more important effect, however, is the tendency of bends to induce the sort of transverse velocity profile. At any natural bend the high velocities will be concentrated toward the outside bank and the low velocities toward the inside one. [*Fischer,(1979)*].

Due to secondary flow at river bends, flow at the surface is towards the outside of the bend, and in the lower half of the channel returns to the inside of the bend. The distribution of the primary velocities has been altered from a straight distribution by these flows. The velocity maxima at the surface has been displaced towards the outer bank, whilst the velocity peak at mid depth remains approximately at the channel centre line, in the area of little or no secondary circulation. [*Boxall,(2001); Bathurst,(1979)*].

Figure (5) illustrates the time average velocity profile at apex of a bend showing secondary currents.

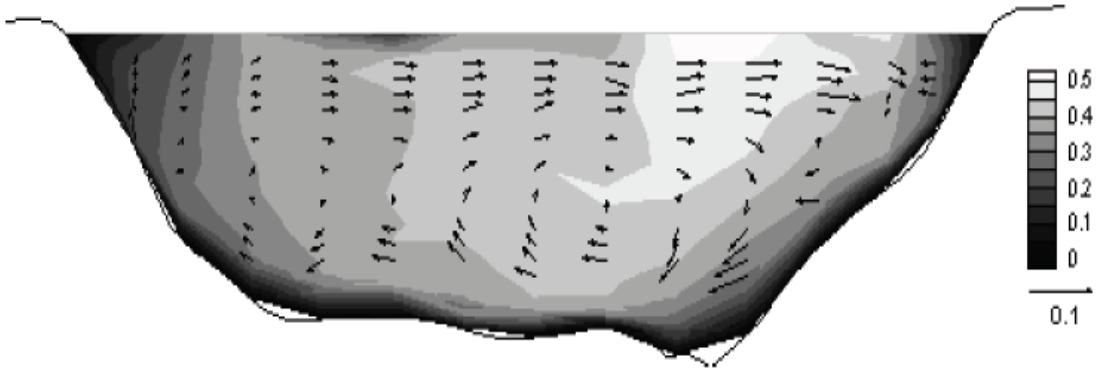

Fig (5) Time average velocity profile at apex of a bend showing secondary currents. [*Boxall,(2001)*].

River cross sections

Five cross sections of the river at the case study reach were chosen for the field work, as shown on **Fig (6)** below, these cross sections represent the sites on the river reach where the mixing of the wastewater, according to visual plume observation, is expected to be completed within the river.

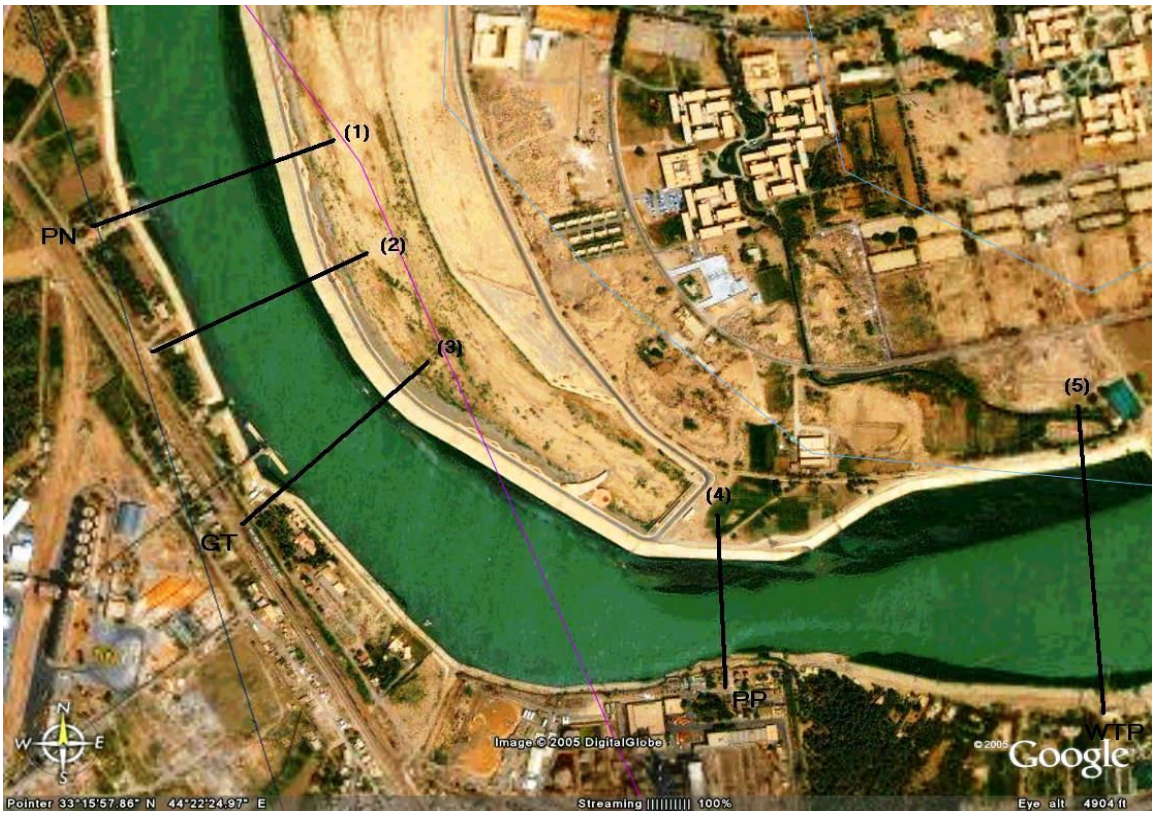

Fig (6) The upper part of the river reach with the five cross sections.

Fig (7) below represents one of the cross sections taken after the study of [*Euphrates Center,(1992)*]. It is oriented facing down stream, with the inside of the bend on the left hand side.

This figure illustrates the effect of bends on cross sections shapes. It also shows the sampling points taken in this section.

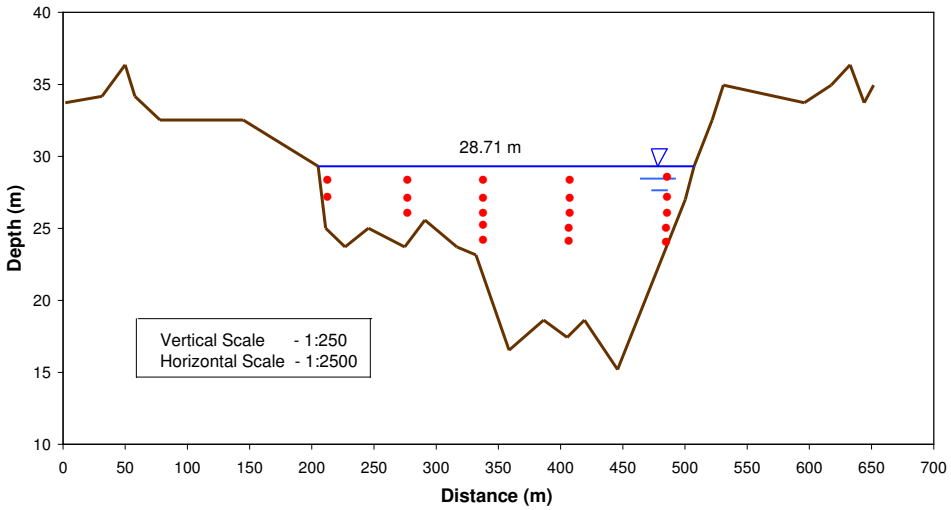

Fig (7) River cross section at the case study river reach, with example of cross sectional river sampling locations on 17/05/2005. (Section 3).

FIELD MEASUREMENTS

Different types of field measurements were performed, various data were gathered and various methods were used, this is attributed to the many parameters involved in the research mainly related to the effect of the bend.

These field measurements included personal observations, sites visits and interviews with officials and citizens of the region in addition to river and sites sampling and analysis, while data collection included statistical water quality data from (Amanat Baghdad/ Baghdad water supply Administration, Ministry of Environment/ Baghdad Administration, Ministry of Water Resources/ Water resources department, Geohydraulique and Euphrates center/ Tigris river training within Baghdad city.

River Sampling

Water samples were taken off by using a "Mecabolier bottle", which is formed with a profiled metallic hollow rod which can be closed from the water surface by two flaps, and which was made manually in the workshop of the Chemical Engineering Department / Baghdad University.

Samples were collected from the river reach using a boat, 20 samples were taken for each of the five cross sections on the same day, from different transverse locations and from different depths for every vertical line, in addition to the samples taken from the upstream location. Example of river cross sectional sampling in **Figure (7)** above.

Samples that were going to be analyzed for Oil & Grease were taken from the surface of the river; since water and oil do not mix, and because they are lighter in weight than water so Oil & Grease float on the top surface of the river's water, in the form of large scattered splotches.

As BOD will decay and might interact in the river above and beyond the mixing effect, [*Boxall,(2005)*], it will be considered as a water quality measurement only. Samples that will be used to be analyzed for DO & BOD will be grab samples that will be taken at 1 meter below the water surface from at least three locations representing each cross section and mixed together.

For mixing estimations a non-reactive, conservative parameter should be chosen, which, in this case, were SO_4, EC and Cl, taken from different locations and depths from each cross section, which covered the whole river widths and reaching depths of more than 10 meters below the river water surface.

Environmental Nuisances

The presence of wastewater discharges in this region, a region which should have been among one of the most developed and recreational sites in Baghdad, is creating much nuisances; this was observed visually on site and discussed with the river banks population:

1- Severe health risk as a result of pathogenic bacteria and feacal coliform directly discharged within the sewage to the river course.
2- The outfall is facing Baghdad University Al-Jadirriya Campus and Baghdad artificial lake.
3- Odor nuisances to the adjacent river bank region.
4- Effecting aquatic life in the river reach.
5- Direct pollution and malodorous to the neighborhoods and orchards on site.

APPLICATIONS AND RESULTS

River Reach System

Water quality statistical analysis were undertaken to determine the status of Tigris river pollution in a river reach of almost 12.5 km long, in order to find the major sources of pollution and their effect on the river water quality.

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Pollutants Analysis

Various pollutants were used to evaluate the degree of pollution along the river reach during the year of the study, they were chosen as parameters demonstrating the physical, chemical and biological characteristics of the river water at three different sites, Al-Qadissiya WTP intake at the upstream boundary of the river reach, Al-Dora WTP intake downstream of Al-Saidiya discharges outfall, and Al-Rasheed WTP intake at the downstream boundary of the river reach.

Fig (8) through **(13)** illustrate the effects of these pollutants on the water quality of the river reach at the three different sites in 2004. (based on data taken from Amant Baghdad/ (BWSA).

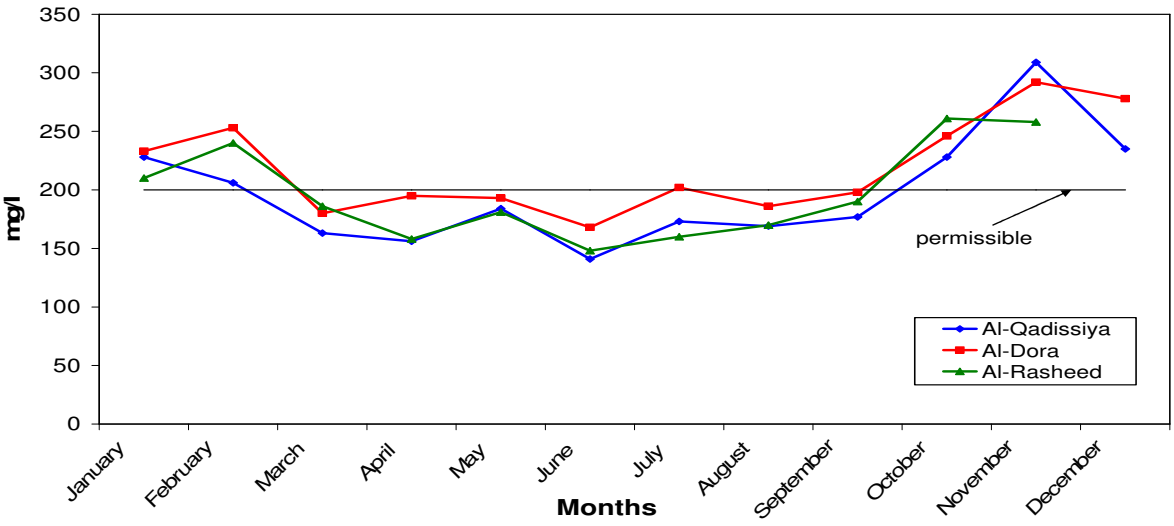


Fig (8) Monthly Sulfates as SO_4 concentration for the year 2004.

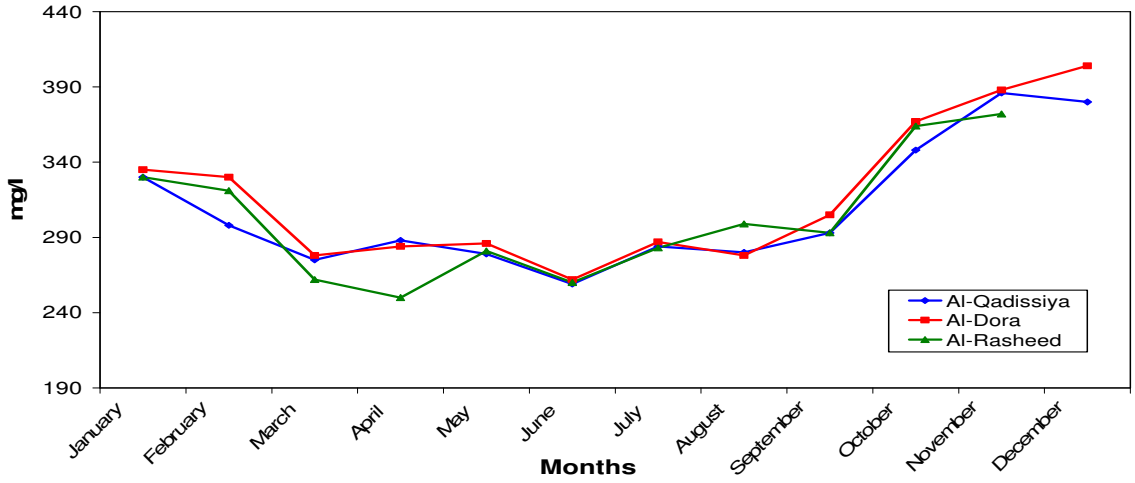


Fig (9) Monthly Hardness for the year 2004.

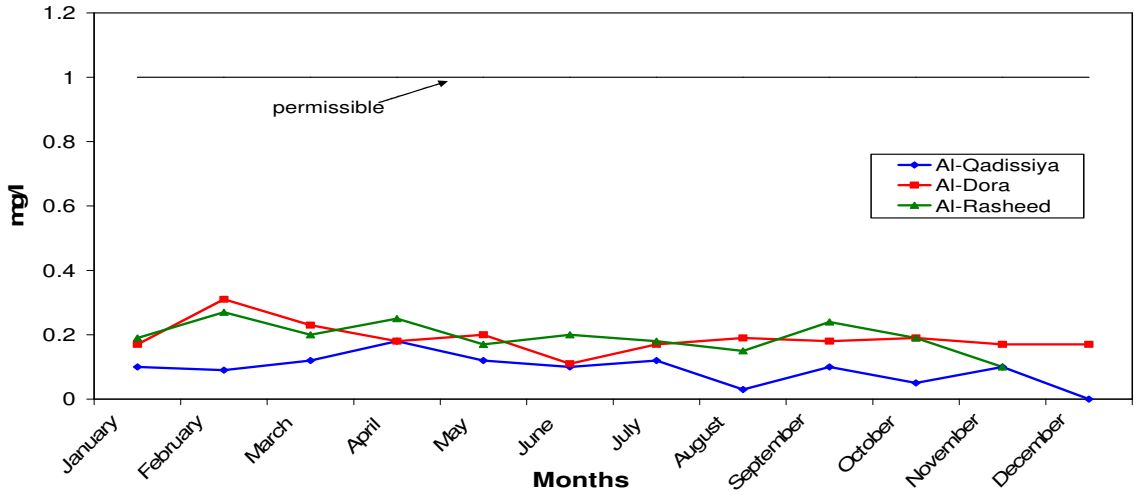


Fig (10) Monthly Ammonia concentration for the year 2004.

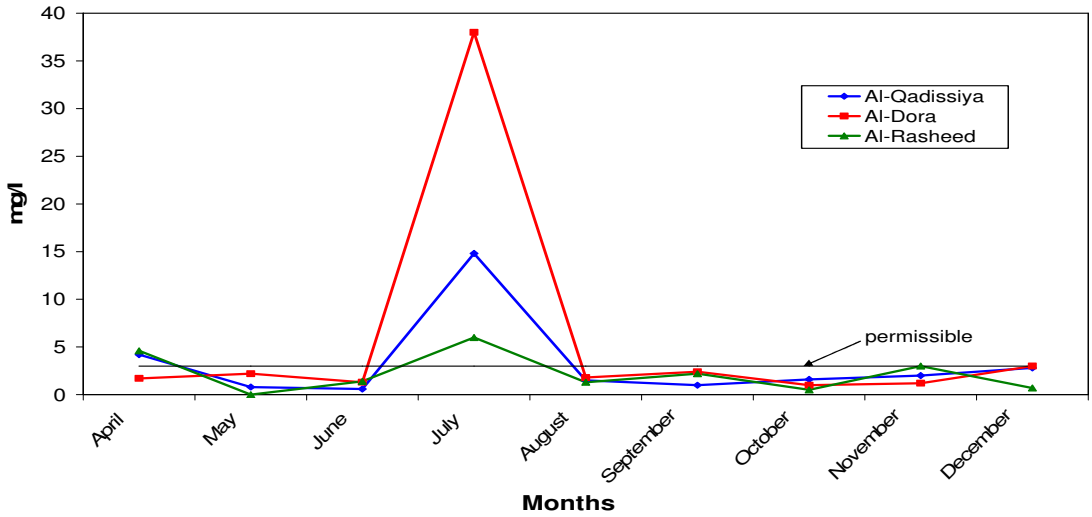


Fig (11) Monthly BOD concentration for the year 2004.

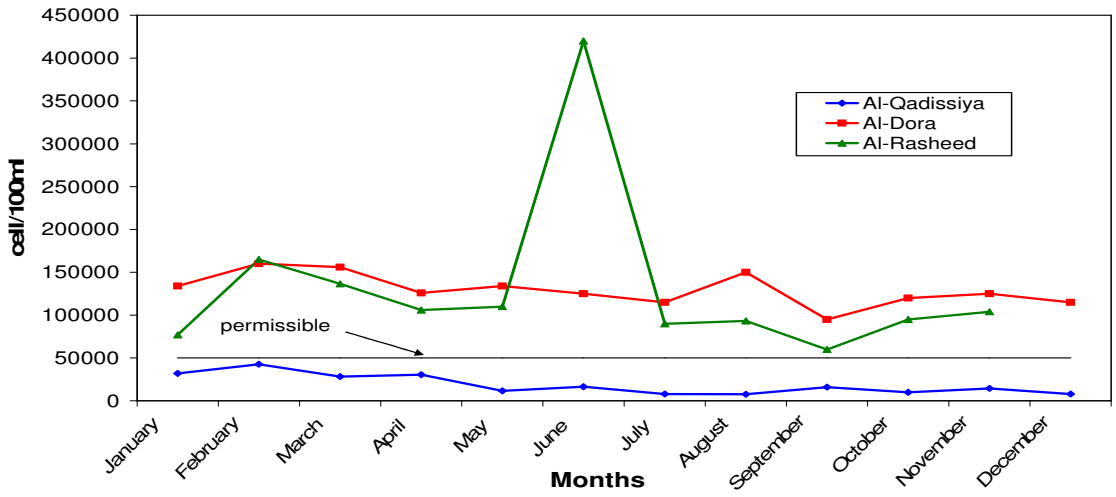


Fig (12) Monthly Coliform concentration for the year 2004.

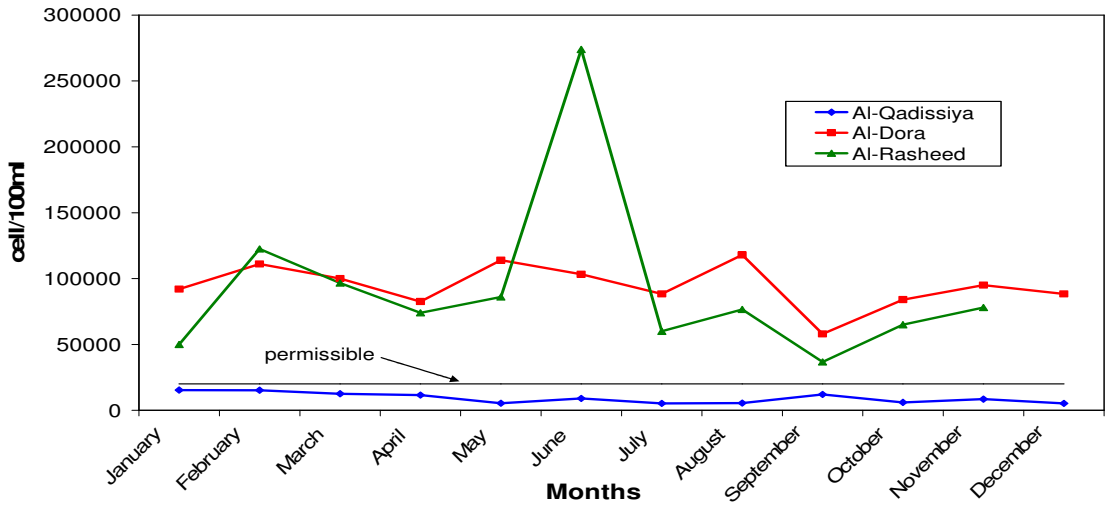


Fig (13) Monthly Feacal Coliform concentration for the year 2004.

Al-Saidiya outfall and Bend Region

Al-Saidiya hourly discharges Flow Hydrograph

The hourly of the flow of Al-Saidiya variation was studied and was found to be in the form of pulses of minimum three hours intervals, allowing it to be considered constant over each three hours of time in minimum.

By finding the area under the curve the exact daily discharge could be calculated. **Fig (14)** below illustrates Al-Saidiya discharges flow hydrograph examined during the period 27/02 – 06/03/2005, giving a discharge rate of 3.67 m^3/sec. While for the period 10 – 11/03/2005, i.e. for the two heavily rainy days it reached a maximum fixed rate of 11 m^3/sec throughout the whole specified period.

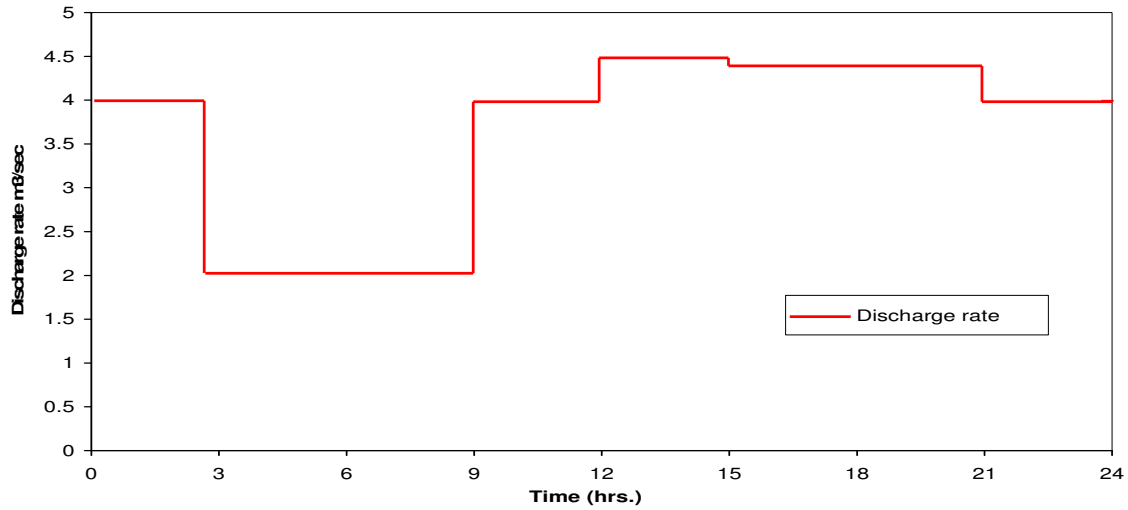


Fig (14) Al-Saidiya PN discharges flow hydrograph.

Effects on upper River Reach

In order to assess the impact of Al-Saidiya raw water discharges and the presence of the bend on the quality of the river water in this region, samples taken on 17/05/2005 at five longitudinal distances represented by the five cross sections under study were analyzed for different decaying (non-conservative) and conservative pollutants.

Figures (15) through **(20)** illustrate the effects of these pollutants on water quality of this river reach.

The first three Figures (15), (16), (17) represent pollutants that are measured on the basis of one grab representative sample for each cross section, while the other pollutants are measured on the basis of 20 samples for each cross section covering that section transversally and vertically, then plotted using both the average and maximum values for each longitudinal distance. Both upstream and PN discharge inside rectangles of Figures (18), (19), (20) are represented by only one sample each.

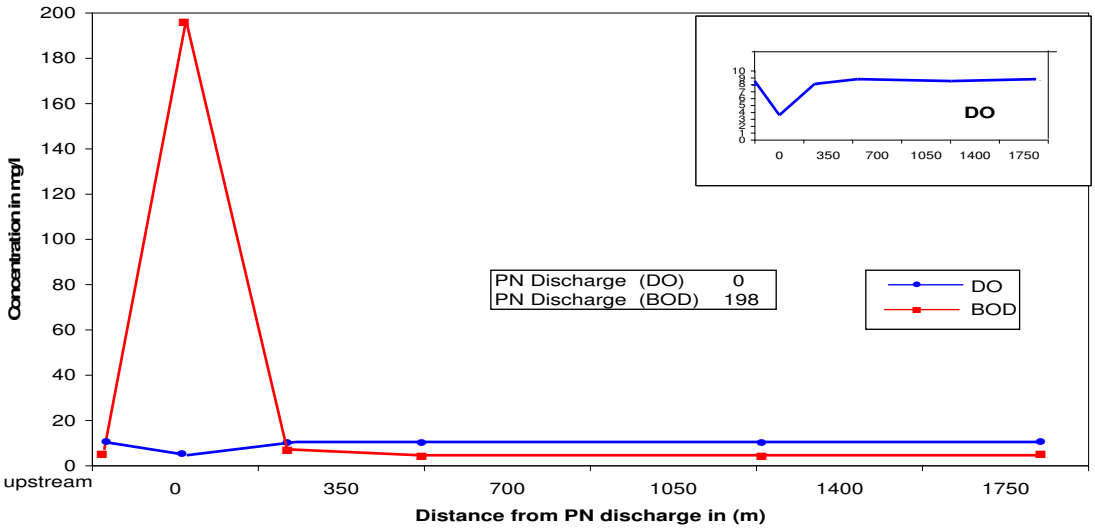


Fig (15). BOD & DO concentrations.

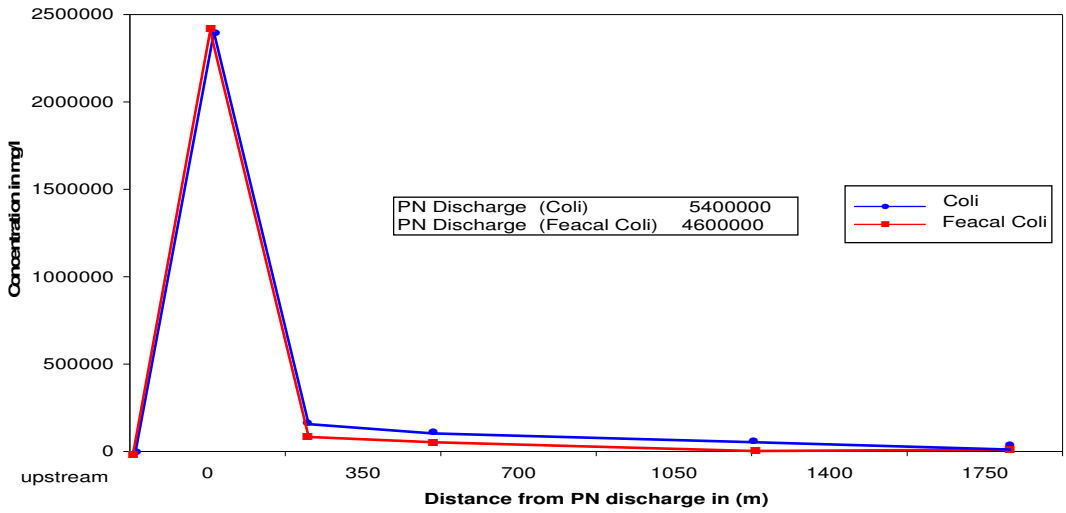


Fig (16). Coliform & Feacal Coliform concentrations.

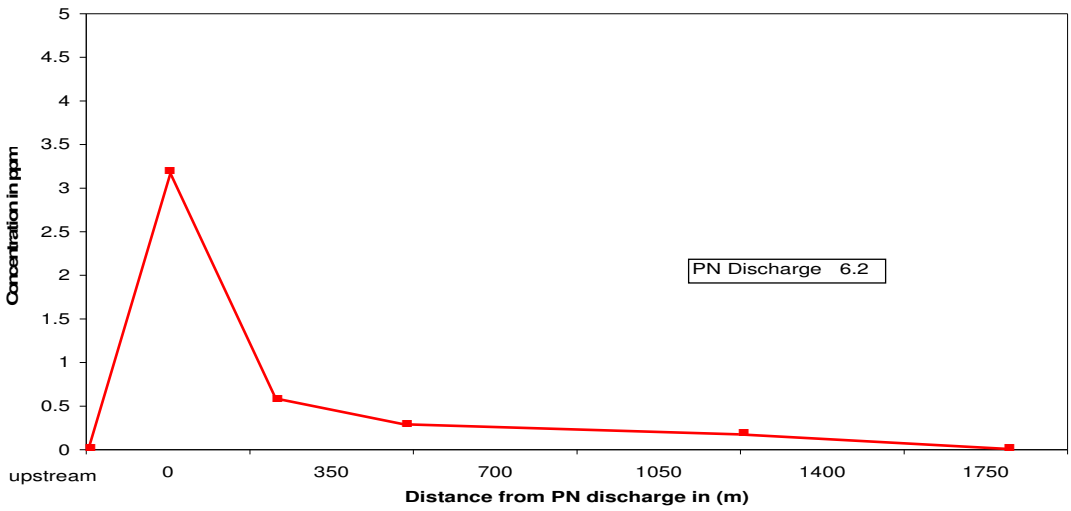


Fig (17). Oil & Grease concentration.

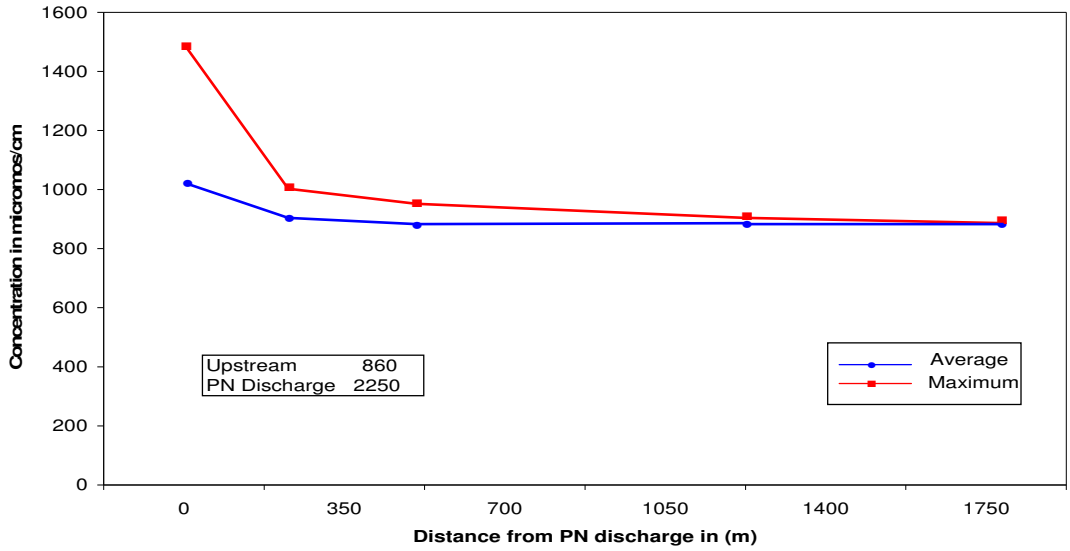
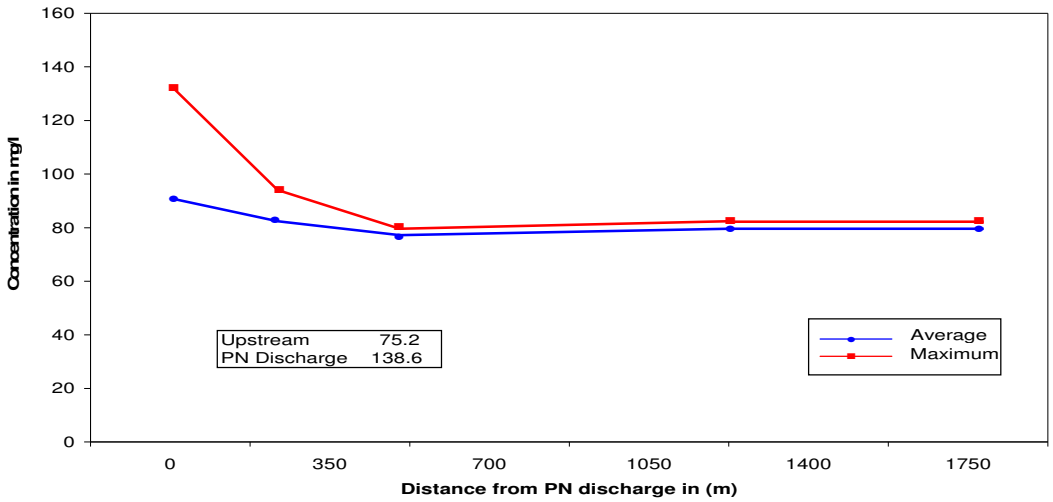


Fig (18). Average and Maximum EC concentrations.



Fig(19). Average and Maximum Cl concentrations.

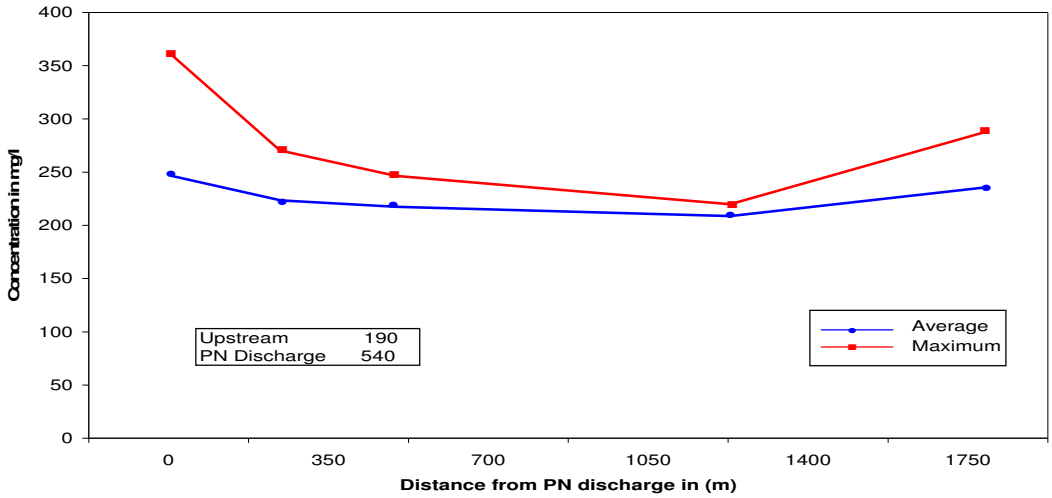


Fig (20). Average and Maximum SO_4 concentrations.

Discussions

1) From a logic point of view and considering all the malfunctions of raw sewage discharging directly to a unique water course for the population of a dense capital, the only solution that could be thought of, is to close that outfall and use the sewerage network as documented in the 1981 master plan [*UNDP,(1998)*]; i.e. Al-Saidiya PN should discharge sewage through the construction of a duplication of the west trunk sewer downstream of pumping station PN with a second Al-Dora pumping station delivering flows to Al-Kerkh WWTP; But since this is unlikely to take place within the near future, then other temporal alternative measures should be thought of.
2) According to the Iraqi standard specification for Oil & Grease, Al-Saidiya Pumping station PN, should not be allowed to discharge its untreated raw sewage directly to the river. Oil & Grease pose difficulties in handling and treatment [*Hammer,(1977)*].Oil & Grease under ordinary situations should be removed at their sources before entering the sewer lines, normally by using "Grease & Oil traps", these traps should generally be located at places such as garages, automobile repair workshops, restaurants and hotels kitchens and grease.
3) Al-Saidiya pumping station (PN) designs of 1981 master plan, proposed storm settlement tanks to receive the first flush of more polluted wastewater and provide partial treatment before discharging to the river, if these were to be constructed in the near future, considerations should be given to include the design with suitable methods for skimming the Oil & Grease separated on the top of these tanks.

CONCLUSIONS & RECOMMENDATIONS

Conclusions

Research field measurements, results and analysis, lead to the following conclusions:

2) Al-Saidiya PN discharges forms the major pollution source to the river within the southern part of Tigris river within Baghdad city, it forms between 1 – 2% of the river discharge and is located almost 2 Km upstream of Al-Dora water treatment plant; the cloud of pollutants while training along the river creates a visual and malodorous nuisance to the region.
3) It was found during 2004, that most of pollutants concentrations at Al-Dora WTP range within the permissible level of Iraqi standards for raw waters; with the exceptions of Coliform and

Feacal Coliform that are highly above the limits, while SO_4 and BOD showed some discrepancies.

4) Pollutants concentrations at Al-Saidiya pumping station are extremely high, but they decline sharply by dilution with river water due to the presence of the bend that enhances the transversal mixing process, and hence facilitates the pollutants distribution, through the secondary currents and spiral flow. Whereas Oil & Grease concentrations measured at Al-Saidiya PN pumping station showed much higher values than the to be allowed to discharge directly to water courses; the allowable concentration should not exceed 0.5 – 1 mg/l, whereas values as high as 77.4 mg/l were observed.
5) SO_4 curves show higher concentrations values at the last cross section, compared to the previous one, this is due to the usage of Na_2SO_4 for flushing the units of Al-Dora power plant, the effluent is discharged directly to the river [*Site Engineer*].
6) Pollutants concentrations at Al-Dora WTP, cross section (5), seem to be homogeneously distributed over the cross section, in what seems to be the completion of the transversal mixing; this relatively shorter distance than that for a straight channel could be attributed to the presence of the bend and cross sectional changes.

Recommendations

Recommendations are proposed both, for concerned parties to overcome malfunctions and improve facilities conditions; and for future researches as suggested topics in the field of Environmental engineering:

1) The completion of the sewerage network, as documented in the 1981 Baghdad sewerage master plan, should be considered a priority in the sanitation sector.
2) As a short term solution, changing Al-Saidiya outfall location and structure to be a bed release on the outside river bank instead of the actual surface release, in order to promote mixing and hence minimizing the impact of pollutants.
3) Intensive studies and researches should be conducted on the problems aroused from discharging Oil & Grease to the river.
4) Update river hydraulic parameters information using modern techniques that provide estimation of channel average properties, velocity distributions and tracers concentrations, instantaneously.
5) Conduct research surveys on other sources of wastewaters discharged directly to the river, including mixing analysis.

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