STUDYING OF HEATED WATER RELEASED FROM SOUTH-BAGHDAD ELECTRIC POWER STATION TO THE TIGRIS RIVER

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ABSTRACT

Thermal pollution occurs when heated wastewater is discharged into rivers, lakes, oceans, or other water bodies. This will raise the temperature of the water body above its normal level and, consequently, will harm the aquatic live.

Thermal Pollution problems will intensify as electricity usage increases unless substantial changes are made in the mode of discharge of the heated water.

This paper is aimed to study the effects of heated water released from South-Baghdad Power Station on the water quality of Tigris River. Many parameters are test such as: Temperature (T), Total suspended solids (TSS), Total Dissolved Solids (TDS), Electrical Conductivity (EC), Hydrogen Ion (pH) and the dissolved oxygen (DO). Other parameters are tested to describe the heated water components such as Biochemical Oxygen Demand (BOD), Oil+Grease, and PO_4.These parameters are compared with the allowable limits of rivers according to the Iraqi standards NO.25/1967 and found that some parameters exceed the allowable limits.

الخلاصة

يحدث التلوث الحراري عندما يتم طرح مخلفات سائلة حارة الى الانهار، البحيرات، المحيطات او اي جسم مائي. حيث ان هذه المخلفات تؤدي الى زيادة درجة حرارة الجسم المائي فوق المستوى الطبيعي مما يؤدي الى اضرار في البيئة المائية.

إن التلوث الحراري تزداد حدته نتيجة لزيادة الحاجة للطاقة الكهربائية ما لم تتخذ تغييرات جوهرية في طريقة طرح المياه الحارة.

يهدف البحث إلى دراسة المياه الحارة المطروحة إلى نهر دجلة من محطة جنوب بغداد لتوليد الطاقة الكهربائية وبيان تاثيرها على نوعية مياه النهر. تم قياس عدة متغيرات مثل: درجة الحرارة،المواد الكلية العالقة،المواد الكلية الذائبة،التوصيلية الكهربائية،الرقم الهيدروجيني و الأوكسجين الذائب. وكذلك تم أجراء عدة فحوصات على المياه المطروحة مثل المتطلب الحيوي للأوكسجين، الزيوت و الشحوم والفوسفات.و قد تم مناقشة الفحوصات مع المحددات العراقية لصيانة الانهار رقم 25 لسنة 1967 حيث تبين ان بعض المتغيرات تزيد عن الحدود المسموحة خلال فترة القياس.

INTRODUCTION

The major industries produce the heated wastewater are: Steam Electric Generating Plants, petroleum refineries, steel Mills, chemical plants, etc.

Water bodies of water lose and gain heat much more slowly than do land or masses, and under most circumstance, water temperature is fairly constant and changes gradually with the season.

Thermal pollution problems will intensify as electricity usage increases unless substantial changes are made in the mode of discharge of the heated condenser cooling water. Steam generation of electrical power plant requires rejection of tremendous quantities of waste heat typically 58% - 67% of the energy input to the plant from the generation units to the surrounding (**Paily et al., 1974**). This heat is transferred in the condensers from the low-pressure steam to the cooling water, and then directly to the atmosphere by the means of a cooling tower, or directly discharge to the water body(Fig.1).

The directly discharge of heated water to the river can be more dangerous to the health of the receiving water than organic pollution. Higher temperature reduces solubility of oxygen and chemical reactions proceed at a faster pace (**Masters,1998**).

Al-Jalaby (1994) developed a two-dimensional numerical model for the simulation of the spread and mixing of thermally polluted water disposed into the river flow. This model considers the effect of density difference between the pollutant density and the river water density. Finite difference up winding scheme is used to solve partial differential equations, which include the momentum conservation, energy conservation and (K-ε) turbulence model. The results of this model are verified by integral heat balance analysis. This model is found to be sensitive to the variation in the river velocity and density. It is also insensitive to the variations in wind speed.

Li-Ren and Righetto (1998) presented unsteady state two-dimensional model to simulate the velocity and temperature fields in the estuary of the Yangtza River in Brazil. The computation is based on the advanced turbulence depth averaged two equations (k-ε) model. Variations of bottom topography and water surface elevation are included. The distribution of velocity and temperature computed by turbulence model (k-ε) is compared with experimental results and field data. It is found that the simulation by using (k-ε) model can provide more details of flow fields and temperature distribution than once by using phenomenological algebraic for models of eddy viscosity and diffusivity.

Bormans and Webster (1998) investigated the thermal stratification dynamics of the slow-flowing rivers of the Marray-Darling Basin. The net surface heat flux and the river discharge are the two most important parameters that determine the stratification status of the rivers with little effect from direct wind mixing. Excellent agreement between measured and simulated temperature profiles under a wide range of river discharge and meteorological forcing is obtained.

Cakiroglu and Yurteri (1998) presented the mathematical model to predict the long-term effects of once through cooling systems on local fish population. The fish life cycle model simulates different life stages of fish by using appropriate expressions represented by growth and mortality rates. The heart of the developed modeling approach is the prediction of plant caused reduction in total fish population by estimating recruitment to adult population with and without entertainment of ichthyoplakton and impingement of small fish. The model is applied to a local fish species, gilthead (Sparus aurata), for the cause of a proposed power plant in the Aegean region of Turkey. The simulation indicates that entertainment and impingement may lead to a population reduction of about 2% to 8% in the long run.

Joody (2001) developed one and two dimensional numerical models for the simulation of the spread and mixing of thermally polluted water disposed into the river released from the AL-Doura Power Station starting from the outfall up to 1000m downstream. The momentum and thermal –energy equations were used to describe the distribution of velocity and temperature in river. The two dimensional model also incorporates with the (k-ε) model to calculate the distribution of turbulent viscosity. The two dimensional model also discusses two cases; the first case neglects the effect of vertical velocity distribution, while the second case include it. Comparison of observed data on Feb, 3,2001 and July, 27,2001 with data computed by two-dimensional model shows good agreement with error of 0.57% and 1.95% respectively.

Al-Suhaili and Jasim (2006) applied two dimensional numerical model for estimating temperature distribution in a river. This model was found to be sensitive to the wind speed. A laboratory physical model was built to find experimental data. The comparison of the observed results from Al-Doura Power Station and laboratory physical model with those computed by the numerical model showed a good agreement and the maximum absolute difference percentage were 16.2 %, 8.6 % respectively.

Measurements and Field Work

A river reach of 500 m Long was involved in the present work. It is started from the outfall structure of South-Baghdad station and extended to 500 m downstream. Samples were collected to predict the essential variation of the water quality after the heated water discharge.

The cooling system applied in South-Baghdad power station is once through cooling system in which the cooling water is withdrawn from the river via two pipes (1.4 m diameter), and then it is conveyed to underground rectangular channels that convey the cooling water to the six condensers with water temperature increase to about 10- 15 °C. The heated water returns to the river via an underground discharge channel and an outfall structure located in the shoreline downstream on the intake structure.

Different field measurements were performed and different data were gathered, which can be mainly classified as stream, wastewater and raw water sampling.

Stream sampling is considered to represent and give reliable measurements of water quality constituents along the stream reach. Seven parameters are involved in the present work. These parameters are temperature (T), dissolved oxygen (DO), Electrical conductivity (EC), total suspended solids (TSS), total dissolved solids (TDS) and hydrogen ion (pH).

The temperature and dissolved oxygen were measured by using portable device. While, the remaining measurements were collected every week using plastic bottle of 0.5 liter capacity and sent to laboratory of the Power Station to be tested. Collection of samples was usually conducted using a boat.

Tables from 1 to 6 show the values of TSS, TDS, EC, pH, T, BOD, Oil & grease and PO_4. While, figure from 2 to 7 show the variation of dissolved oxygen concentrations along the study reach

Table (1): The concentration of TSS, TDS, EC and pH at the upstream with time

Date	TSS (mg/l)	TDS (mg/l)	EC (micromhos/cm)	pH	T °C
14/3/2002	71	510	819	7.98	20
21/3/2002	29	595	988	7.9	21
28/3/2002	42	499	810	7.87	24
4/4/2002	45	502	816	7.9	21
11/4/2002	51	765	1015	7.88	22
20/4/2002	56	437	776	7.92	25
27/4/2002	56	437	728	7.8	27
1/5/2002	45	744	1068	7.99	26
8/5/2002	40	713	995	7.89	24.5
16/5/2002	59	752	1046	8.1	26

20/5/2002	78	723	1012	8.1	29
4/6/2002	38	345	738	8.08	27
11/6/2002	41	422	902	8.07	28
18/6/2002	25	560	949	8.19	28
25/6/2002	21	588	915	8.19	28.8
2/7/2002	33	498	822	8.1	28
9/7/2002	30	522	884	7.98	29
15/7/2002	14	494	821	7.9	31

Table (2): The concentration of TSS, TDS, EC and pH at the outfall with time.

Date	TSS (mg/l)	TDS (mg/l)	EC (micromhos/cm)	pH	T ◦C
14/3/2002	51	535	883	7.99	28.8
21/3/2002	20	677	989	7.98	37
28/3/2002	19	554	990	7.88	33.5
4/4/2002	19	655	1002	7.89	36
11/4/2002	22	778	1055	7.9	34
20/4/2002	41	756	1050	7.9	31
27/4/2002	40	510	913	7.88	33
1/5/2002	38	810	1226	7.91	35
8/5/2002	30	832	1150	7.83	35.5
16/5/2002	49	827	1280	8.09	37
20/5/2002	66	770	1077	8.1	35.5
4/6/2002	21	391	791	8.05	36.3
11/6/2002	12	610	975	7.88	37.5
18/6/2002	8	615	979	7.9	39
25/6/2002	10	519	988	7.91	42.3
2/7/2002	13	575	885	8.1	43.2
9/7/2002	15	603	938	7.87	44.5
15/7/2002	8	588	975	7.09	46

Table (3): The concentration of TSS, TDS, EC and pH at the downstream (50 m far from outfall) with time.

Date	TSS (mg/l)	TDS (mg/l)	EC (micromhos/cm)	pH	T ◦C
14/3/2002	62	530	950	7.98	26
21/3/2002	25	610	969	7.99	26
28/3/2002	22	522	950	7.89	31
4/4/2002	22	651	971	7.9	33
11/4/2002	31	772	1075	8.1	31
20/4/2002	42	580	958	8.0	29.5

27/4/2002	42	502	888	7.9	31
1/5/2002	39	785	1123	7.97	29
8/5/2002	33	809	1166	8.00	32.9
16/5/2002	55	775	1100	8.1	35
20/5/2002	68	705	1063	8.09	34
4/6/2002	25	372	690	8.1	31
11/6/2002	15	534	790	7.9	36
18/6/2002	10	512	752	7.91	36.7
25/6/2002	15	533	760	7.91	39
2/7/2002	14	511	693	8.15	41.5
9/7/2002	18	552	771	7.91	41.7
15/7/2002	12	510	753	7.14	43.5

Table (4): The concentration of TSS, TDS, EC and pH at the downstream (100 m far from outfall) with time.

Date	TSS (mg/l)	TDS (mg/l)	EC (micromhos/cm)	pH	T ◦C
14/3/2002	66	551	952	7.98	24
21/3/2002	25	608	961	7.89	30
28/3/2002	25	510	912	7.88	28.8
4/4/2002	29	648	966	7.9	30
11/4/2002	35	770	1027	8.1	28.5
20/4/2002	46	575	913	8.0	28
27/4/2002	47	420	835	7.9	30
1/5/2002	40	783	1100	7.97	26.7
8/5/2002	35	591	983	8.09	31
16/5/2002	56	725	1019	8.11	32.9
20/5/2002	70	751	1060	8.1	32
4/6/2002	29	341	558	8.1	28.5
11/6/2002	22	478	710	7.95	33.7
18/6/2002	16	440	703	8.01	34.5
25/6/2002	16	391	681	8.00	36
2/7/2002	19	377	605	8.16	37.4
9/7/2002	19	463	710	8.00	39.6
15/7/2002	20	400	675	8.00	41

Four parameters are involved in the present work, which are biochemical oxygen demand five day (BOD_5), Oil+grease, TSS, and (PO_4), These samples were collected once in a month (started from April and ended in July)

Table (5): The concentration of B.O.D$_5$, Oil+Grease, TSS and PO$_4$ in heated water.

	April	May	June	July
BOD$_5$ (ppm)	17	40	60	52
Oil+Grease (ppm)	112	24	45	29
TSS (ppm)	44	41	34	19
PO$_4$ (ppm)	0.75	0.7	0.44	0.38

Table (6): The concentration of BOD$_5$, Oil+Grease, TSS and PO$_4$ in raw water.

	April	May	June	July
BOD $_5$ (ppm)	10	22	48	46
Oil+Grease (ppm)	105	16	19	25
TSS (ppm)	75	76	55	70
PO$_4$ (ppm)	0.4	0.5	0.3	0.3

Results and Discussion

- The TSS concentration decreases at the outfall location in which the temperature increases. The increase of temperature will have effect on density of water (density decreases with temperature increase), therefore the suspended solids will move downward the river bottom. But in the case of washing of condensers, the concentration of TSS increases at the outfall because the washing water will be released to the river directly.
- The maximum TSS concentration measured at outfall location on 3/1/2002 and its equal 188-ppm, this high value may be attributed to the high concentration of TSS released from the condensers of power plant at that time, while the minimum TSS concentration measured at outfall location on 18/6/2002 and 15/7/2002 which is equal 8 ppm.
- TDS and EC concentrations increase at the outfall location due to increase in the dynamic energy of molecules, this leads to an increase in the dissolution salts in turn in (TDS) and (EC), For example the concentrations of TDS and EC on 21/3/2002 are 677 ppm and 989 micromhos/cm at outfall location, while they equal 610 ppm and 969 micromhos/cm at 50 m far from outfall location in which the temperature of water river decreases.
- Maximum concentration of TDS measured at outfall location on 3/1/2002, which is equal 895 ppm while the minimum concentration of TDS measured upstream on 4/6/2002,which is equal 345 ppm. On the other hand, the maximum concentration of EC measured at outfall location on 16/1/2002, which is equal 1220 micromhos/cm.while the minimum concentration measured at 100 m far from outfall location on 2/7/2002, which is 605 micromhos/cm. Moreover the concentration of EC some times exceeds the allowable limits (1000 micromhos/cm).
- The test of stream water at the study reach shows there is no effective change in pH concentration mainly at the outfall location; this can be attributed to the logarithmic equation of pH. Field observation shows, those concentration levels of pH are acceptable along the study reach and still with allowable limits of Iraqi Standards (from 7 to 8.5).
- The concentration of Dissolved Oxygen (DO) is often used as index for water quality. At least 4 (mg/l) are required to maintain a balance of desirable species in the water. On the other hand, field observation shows that the concentration of dissolved oxygen is acceptable along the study reach,

i.e greater than allowable limit of Iraqi Standards (more than 5 mg/l), but there is sudden dropping at the outfall location because of temperature increasing.

- The test of heated water released to the Tigris River shows that there are illegal concentrations of BOD_5 and Oil. The high concentration of Oil (above 10 mg/l according to the Iraqi standards, see tables 5 and 6) comes from the State Company for Vegetable Oils which disposes high concentration of oil upstream the South-Baghdad Power Station. Also the power plant itself disposes oil to the pipe of heated water. BOD_5 test shows there is illegal concentration in June and July (above 40 mg/l according to the Iraqi standards) because the difference in inlet and outlet water temperature. Also the State Company for Vegetable Oils disposes high concentrations of BOD_5 and TSS up stream Power Station at that time. PO_4 concentrations are within the permission value of Iraqi standard which is (3 ppm).

CONCLUSIONS

- The dissolved oxygen of water river does not drop under the allowable limits (5 mg/l according to the Iraqi standards) so that there is no sever effect on the organisms lived in the river.
- The concentrations of total dissolved solids are within the allowable limits (1000 mg/l according to the Iraqi Standards) along the study reach.
- The Electrical Conductivity exceeds the allowable limits (1000 micromhos/cm) along the study reach in some tests during the study period.
- The pH concentration is not affected by increase in temperature in study reach.
- The heated water samples showed that the concentration of BOD_5 are slightly rising comaired with the samples taken from the raw water.

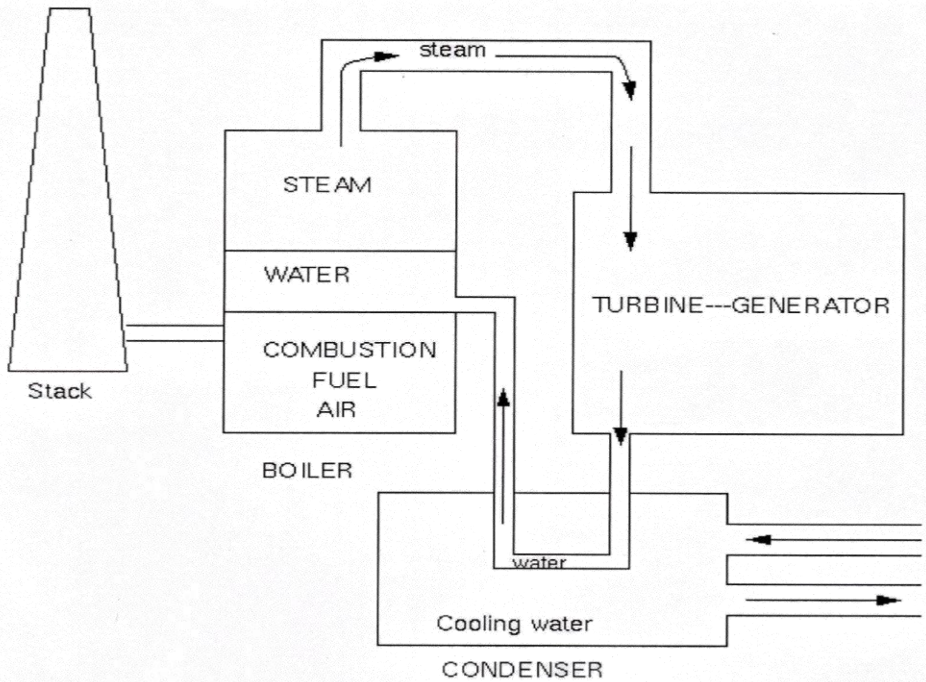

Figure (1): steam electric power plant

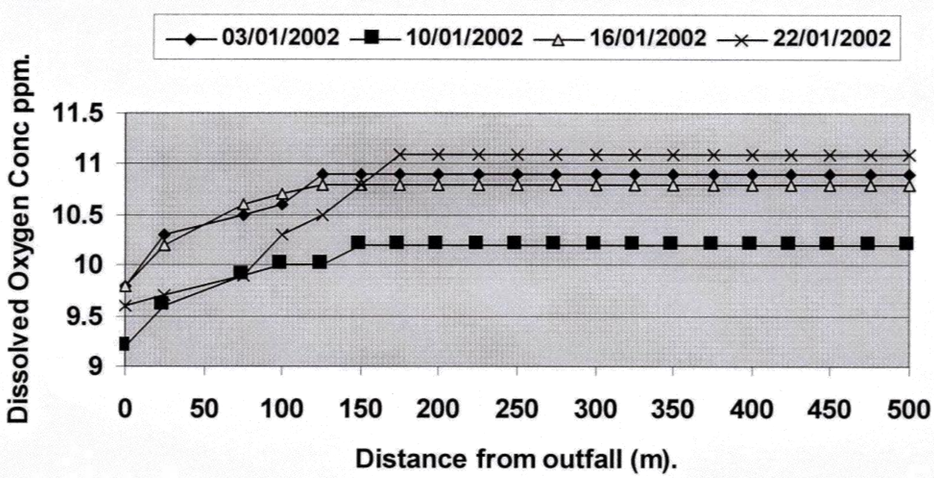

Fig (2): Concentration of Dissolved Oxygen along the study reaches in Jan/2002.

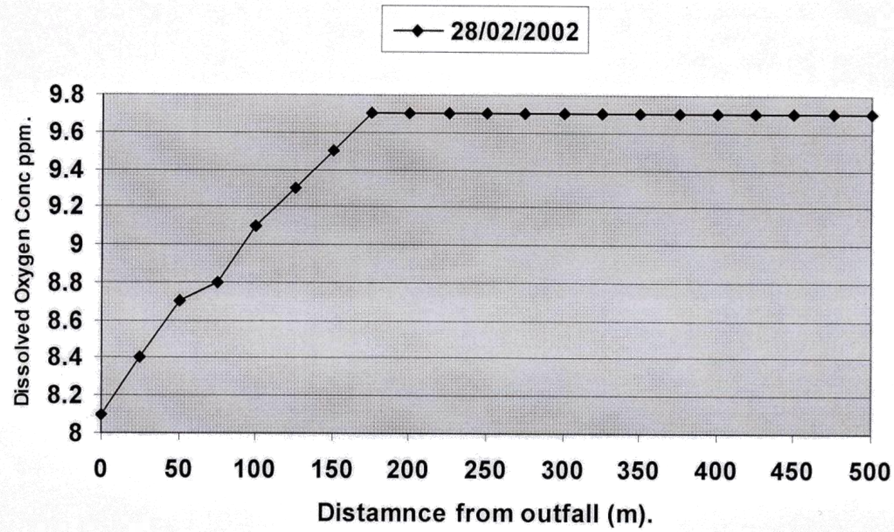

Fig (3): Concentration of Dissolved Oxygen along the study reaches in Feb/2002.

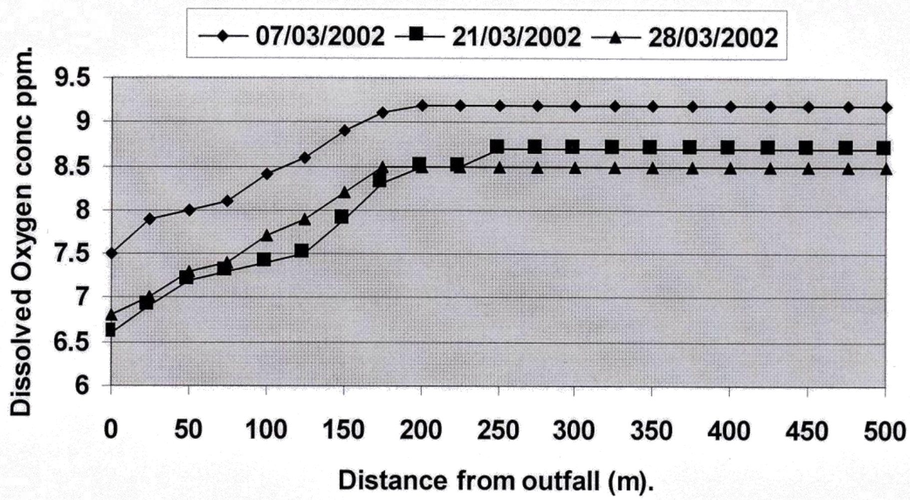

Fig (4): Concentration of Dissolved Oxygen along the study reaches in Mar/2002.

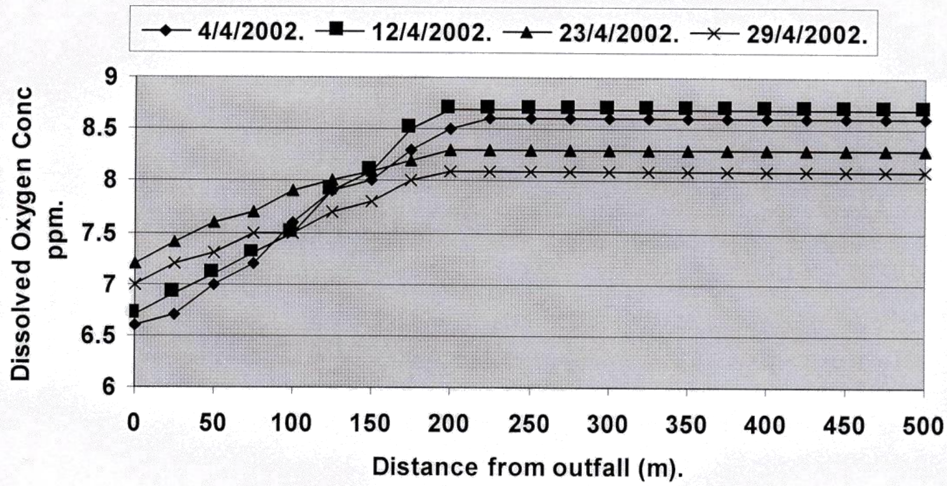

Fig (5): Concentration of Dissolved Oxygen along the study reaches in April/2002.

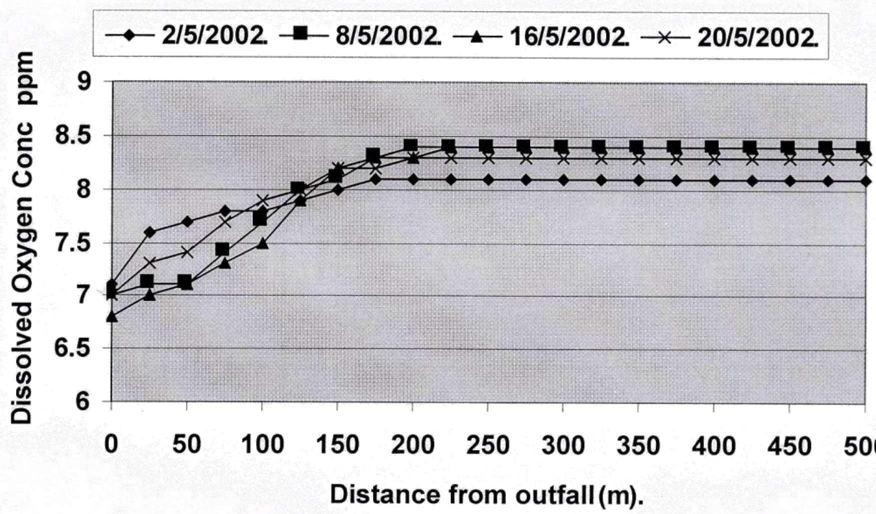

Fig (6): Concentration of Dissolved Oxygen along the study reaches in May/2002.

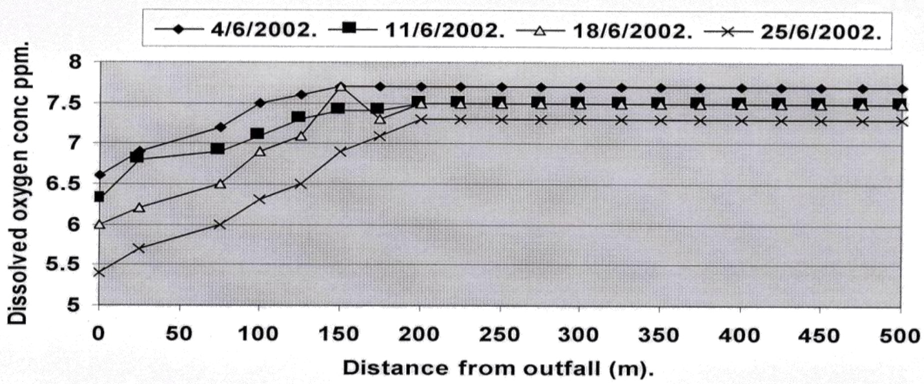

Fig (7): Concentration of Dissolved Oxygen along the study reaches in June/2002.

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