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Modeling the Effect of Pollution on Dissolved Oxygen (Do) Content of River Benue in Makurdi Town

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ABSTRACT: *River Benue, one of the two major rivers in Nigeria is polluted due to human activities in the area and the environs. Samples were taken from different sources for the study. Field sampling, laboratory analysis and regression analysis, modeling of Dissolved Oxygen with distance for the months in question were carried out. The maximum DO was found to be 5.4 mg/l in the month of July while the minimum DO recorded in August was 3.2 mg/l. Comparing this with WHO standards, there was depletion of oxygen which is detrimental to aquatic life. It was found that DO in the river falls within 4mg/l to 5mg/l as minimum values as specified by WHO for fish and aquatic life. The models formulation for months of April to August yielded values of coefficient of correlation ranging from 0.6693 to 0.7376 implying good fitting.*
Keywords*: Aquatic life, Dissolved Oxygen, Modeling, Pollution, River.*

I. INTRODUCTION

Dissolved Oxygen (DO) from the atmosphere is absorbed by river water. Natural water has a DO content of 8 to 10mg/l depending on its temperature. Dissolved oxygen makes the water taste good. A minimum of 4mg/l to 5mg/l is essential for fish and aquatic life. Surface water will have more DO due to greater surface area contact with atmosphere. Organic wastes utilize dissolved oxygen for biological decomposition. Inorganic materials also utilize oxygen in a reduced state for oxidation. So depletion of DO indicates utilization by organic and inorganic compounds, contamination from domestic and industrial wastes.

Water is among the major essentials that nature provides for the sustenance of life for plants, animals and humans. Water is undoubtedly the most precious natural resource that exists on our planet. The total quantity of fresh water on earth could satisfy all the needs of the human population if it were evenly distributed and accessible. Without water, life on earth would be non-existent. It is essential for the growth and prosperity of all habitats on our planet earth. Although we as humans recognize this fact, we overlook it by polluting our rivers, lakes and oceans. Subsequently, we are slowly but surely harming our planet to the extent that organisms are dying off at very alarming rate. In addition to innocent organisms dying off, our drinking water sources have become adversely affected as is the case for water used for recreational purposes. In order to combat water pollution, we must understand these problems and become part of the solution. Impairment of the quality of water is a manifestation of water pollution. Raven et al (1998) divided water pollution into eight categories, viz: sediment pollution, sewage disease agents, organic compounds and inorganic plant and algae nutrients (e.g. nitrogen and phosphorus). Others are inorganic chemicals, radioactive substances and thermal pollution. Besides the discharge of specific pollutants in water, the construction of dams, reservoirs and river diversions can also degrade water quality. The uses we make of water in lakes, rivers or ponds and streams are greatly influenced by the quality of water we find in them.

Activities such as fishing, swimming, boating, shipping and waste disposal have different requirements for water quality. Water of a particularly high quality is needed for portable water supplies. In many parts of the world, the introduction of pollutants from human activity has seriously degraded water quality even to the extent of turning pristine trout streams into foul open sewers with few life forms and fewer beneficial uses.

Oxygen – Demanding Materials

Anything that can be oxidized in the receiving water with the consumption of dissolved molecular oxygen is termed oxygen-demanding material. These materials are usually biodegradable organic compounds. The consumption of dissolved oxygen, DO poses a threat to fish and other higher forms of aquatic life that must have oxygen to live. The critical level of DO varies greatly among species. For example, brook trout may require about 7.5mg/l of DO while carp may survive at 3mg/l. As a rule, the most desirable commercial and game fish require high levels of dissolved oxygen. Oxygen demanding materials in domestic sewage come primarily from human waste and food residue. Particularly noteworthy among the many industries that produce oxygen-demanding wastes are the food processing and paper industries. Naturally occurring organic matter, such as animal droppings, crop residues or leaves that get into the water from non-point sources contribute to the depletion of dissolved oxygen.

The concentration of dissolved oxygen in a river is an indication of the general quality of the river. All rivers have some capacity for self-purification naturally. As long as the discharge of oxygen-demanding wastes is well within self-purification capacity of the river, the DO level will remain high and a diverse population of plants and animals, including game fish, can be found. As the amount of wastes increases, more DO will be used for its degradation resulting to depletion of DO in the water. The stream loses its capacity to cleanse itself and the DO level decreases. When the DO drops below about 4 to 5 mg/L, most game fish would have been driven out. If the DO is completely removed, fish and other higher animals are killed or driven out and extremely noxious conditions result. The water becomes blackish and foul smelling as the sewage and dead animal life decompose under anaerobic conditions.

Time and effort have been put over the years to improve the water quality in rivers, employing a combination of heuristic and mathematical techniques. The adoption of water quality modeling is essential for prediction or forecasting which is an important ingredient in formulating water pollution control policies. Review of literatures shows many studies of river water quality modeling. Kahlig (1979) derived a procedure for short term prediction of downstream pollution using an exact solution of Taylor's dispersion equation. Farvimond and Nelson (1980) presented a method for simulating the gross changes in river water quality which may result from natural variations in flow and systematic changes to flow regimes. In Nigeria, Moses (1979) studied aspects of the physic-chemical characteristics of Cross River and reported that water quality of the new Calabar River was mainly influenced by natural regimes. Odokuma and Okpowashi (1997) monitored the organic pollution of the new Calabar River. Nwaogozie and Ogelle (1997) reported linear and non-linear relationships between pollutants and consistent time trends in degree of pollution. Aboiyar (2001) investigated the pollution of River Benue in Makurdi but the work was limited in scope. Akpen and Eze (2006) investigated the pollution of River Benue in Makurdi and reported that consistent microbial pollution is greater in dry season while chemical and physical pollution occasionally occurs, and came up with a mathematical model to predict future pollutions.

River Benue is one of the two major rivers in Nigeria. It originates from the Cameroun mountains and flows west ward through Makurdi to meet the River Niger at Lokoja in Kogi State. Its tributaries include but are not limited to River Dongo, Katsina – Ala, Ofu, Maboro, Bantaji and Taraba. Along the Makurdi new bridge, the river is 1.194km wide with an average depth and cross-sectional area of 7.82m and 4608.42m^2 respectively (Akpen and Eze, 2006). The valley of the river is covered with sediments and consists of land areas below 300m above sea level. The flood plain, which is characterized by extreme swamps, is good for dry season irrigation farming. Makurdi town located in the Benue valley experiences a tropical climate with distinct dry and wet seasons. The wet season lasts for seven months, starting from April and ends in October. There are however, usually one or more early heavy rains in January, February or March. The dry season begins in November and ends in March. Within the same period, the area experiences two distinct weather situations while harmattan with cold and chilly weather is experienced from December to early February. The average maximum and minimum daily temperatures are 35ºC and 21ºC respectively (Akpen and Eze, 2006). The river is subjected to various sources of pollution. Industrial wastes from the Benue Brewery Limited (BBL) and Nigeria Bottling Company (NBC), all located along Gboko road are channeled into the river. Also, wastes from the new bridge are washed into the river. Other sources of pollution of the river include feaces from humans defecating directly into the river, waste from animals and human waste from land to the river as well as fertilizers and other chemicals applied to crops that are usually grown at the river banks.

II. DATA COLLECTION, SAMPLING AND LABORATORY ANALYSIS

Water samples were taken monthly at a depth of 0.5m from the surface of the water at a distance of 6m from the right bank at five sampling points, marked BBL (Benue Brewery Limited), Blinks (Benue Links), an Abattoir, WWORKS (Greater Makurdi water works) and Wadata, (Building materials market). BBL is upstream of the point where effluents from BBL and NBL enter the river. BLINKS is downstream of BBL, a distance of 4km; Abattoir is down stream of BLINKS at a distance of 2.5km; WWORKS, is downstream of Abattoir at a distance of 4.5km and Wadata is downstream of W/works at a distance of 3km. The sampling period covered six months, from April to September.

HACH model 9071 was used. Water samples were collected in 60ml glass stopper BOD bottles and contents of one dissolved oxygen, 2 reagents powder pillow were added immediately to stopper and inverted several times to mix. The samples were then allowed to stand for the flocs formed (brownish like) to settle. The stopper was then removed and contents of one dissolved oxygen, 3 powder pillows added and closed. The flocs dissolved leaving a solution which was then treated with 2.000N sodium thiosulphate titration cartridge until the sample changed from yellow to colourless. The reading from the digital counter window (screen display of the conductivity meter) was then multiplied by 0.1 to obtain the DO concentration in Mg/l which was used for the analysis. Records of flow depth were collected from the Federal Inland Waterways Authority, Makurdi (Figure 16).

III. MATHEMATICAL MODELLING DEVELOPMENT OF REGRESSION MODELS

DO for the months, under study were subjected to regression modeling. Regression models were chosen because of their reliability even with limited data with a secondary advantage of ease of calibration and application. DO is the independent variable and regressed with the months as dependent variable. A plot of the dependent variables against the independent variable yielded either linear or non-linear relationship. Mathematically, both the linear and polynomial models are represented as:

$$Y = a_0 + a_1 x \quad (1)$$

$$Y = A_0 + A_1 x + A_2 x_2 + \ldots + A_n x_0 (A_n + 0) \quad (2)$$

Where a_0, a_1, A_0, A_1, A_2, … A_n, are the coefficients of the regression models. A computer program Microsoft Excel was then used to calibrate the models.

The summary of the model is shown in the Table 2. The high coefficient of correlations (R) implies the regression models are representative of the observed field/laboratory data and hence are reliable tools for prediction of river water quality in the study area. To verify the models presented figures 9 to 14, it is observable that the data points lie either on the regression models or close to the curves, justifying their reliability as prediction tools for dissolved oxygen concentration for River Benue in the area.

Table 1: Dissolved oxygen (mg/l) - April – September 2010

DISTANCE	SAMPLING	Dissolved Oxygen (mg/L April – Sept. 2010					
(KM)	POINT	April	May	June	July	Aug.	Sept.
0	BBL	4.26	4.2	4.46	4.5	4.3	4.5
4	BLINKS	4.8	4.8	4.9	5.0	4.83	4.9
6.5	ABATTOIR	4.3	4.4	4.63	4.6	4.4	4.5
11	WATER	5.2	5.26	5.33	5.39	5.2	4.2
	WORKS						
14	WADATA	4.83	4.86	4.93	5.0	4.93	4.96

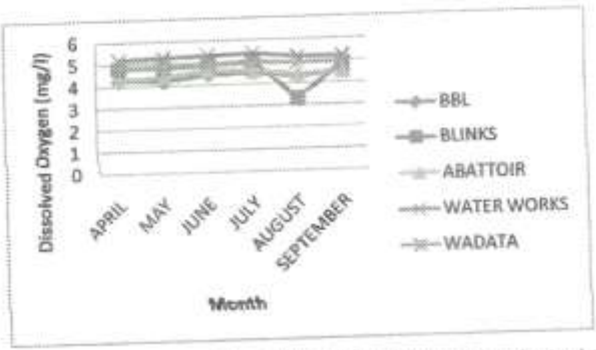

Figure 3: Dissolved Oxygen at the various sampling point from April to September

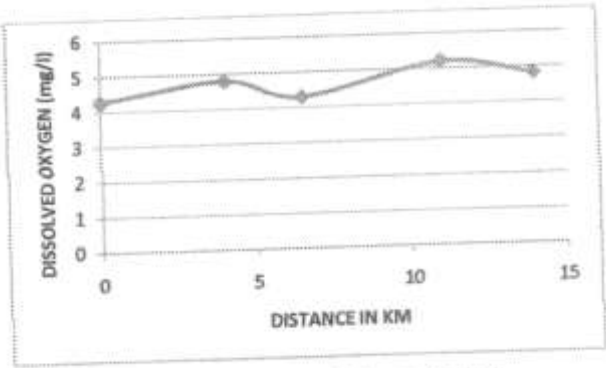

Figure 4: Dissolved Oxygen against Distance for the month of April

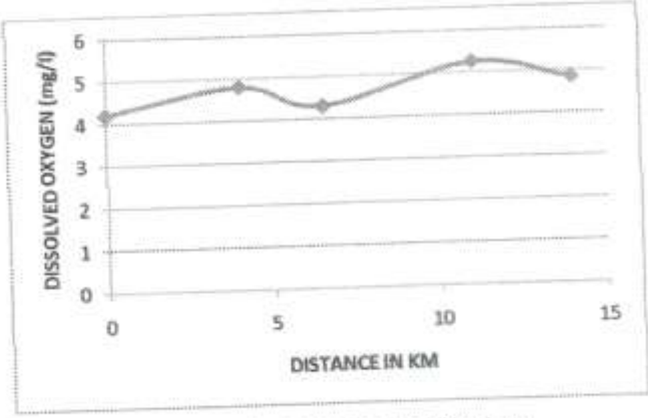

Figure 5: Dissolved Oxygen against Distance for the month of May

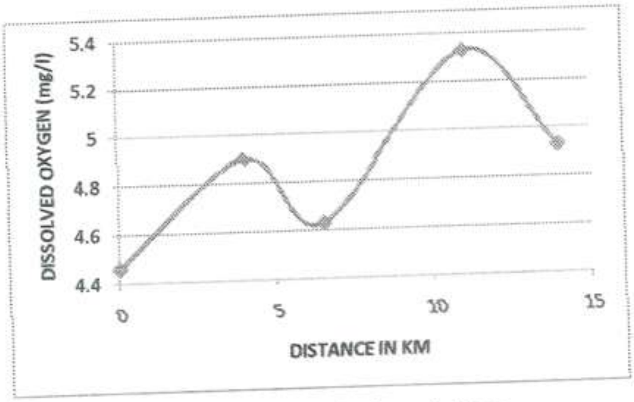

Figure 6: Dissolved Oxygen against Distance for the month of June

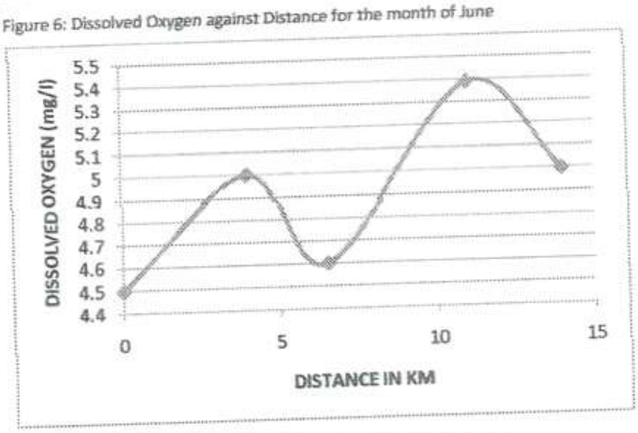

Figure 7: Dissolved Oxygen against Distance for the month of July

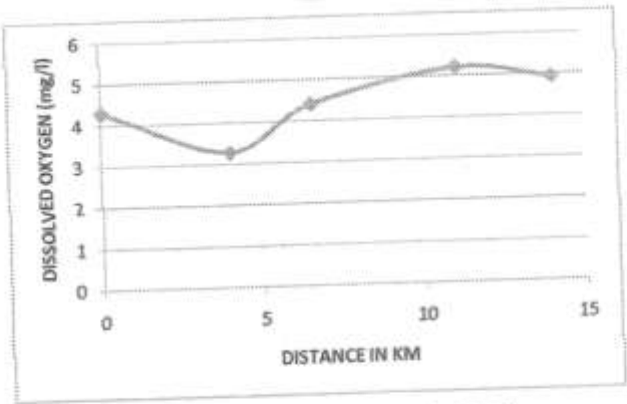

Figure 7: Dissolved Oxygen against Distance for the month of August

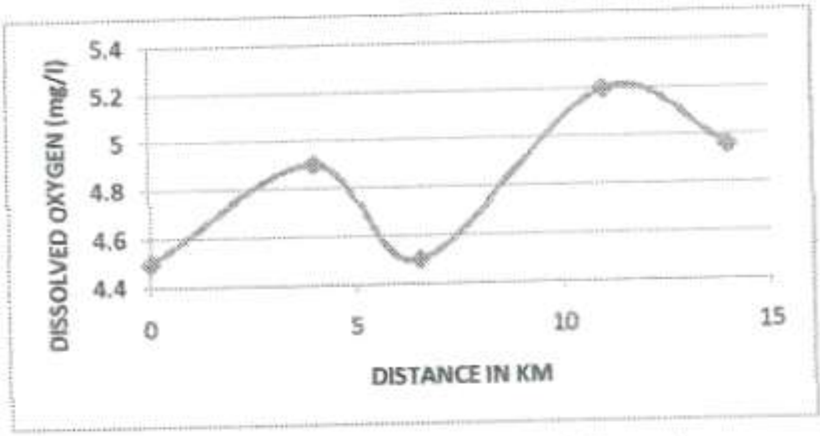

Figure 8: Dissolved Oxygen against Distance for the month of September

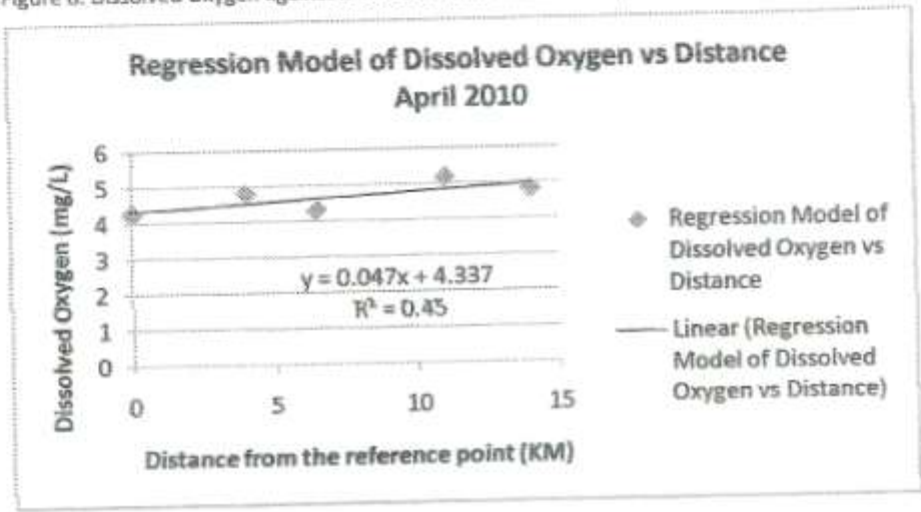

Figure 9: Regression model of Dissolved Oxygen vs Distance for the month of April

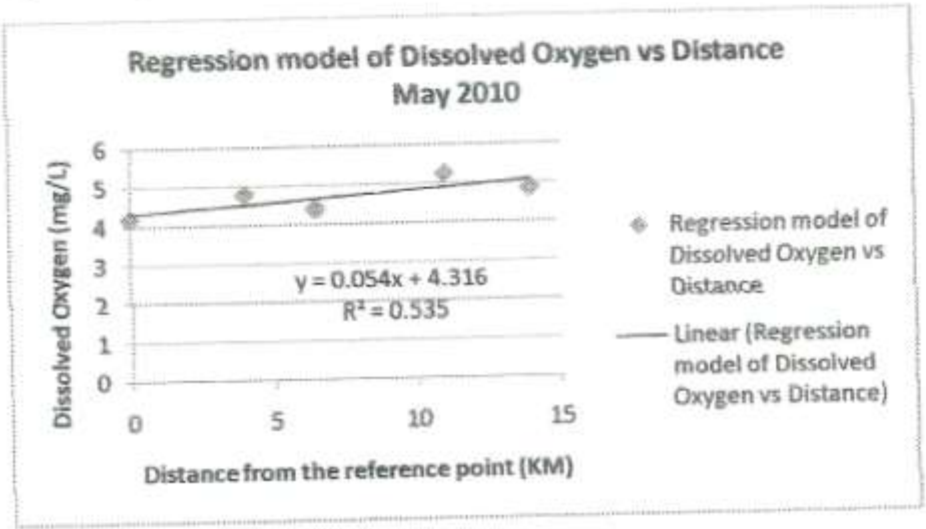

Figure 10: Regression model of Dissolved Oxygen vs Distance for the month of May

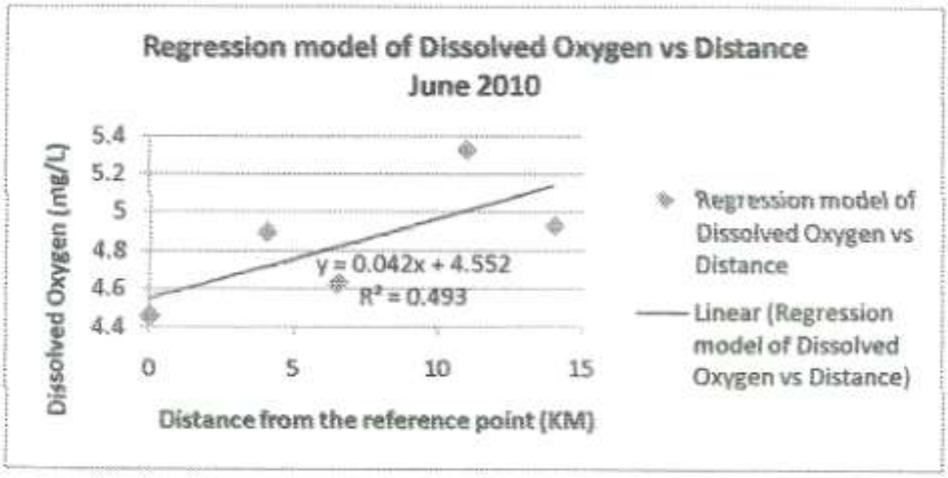

Figure 11: Regression model of Dissolved Oxygen vs Distance for the month of June

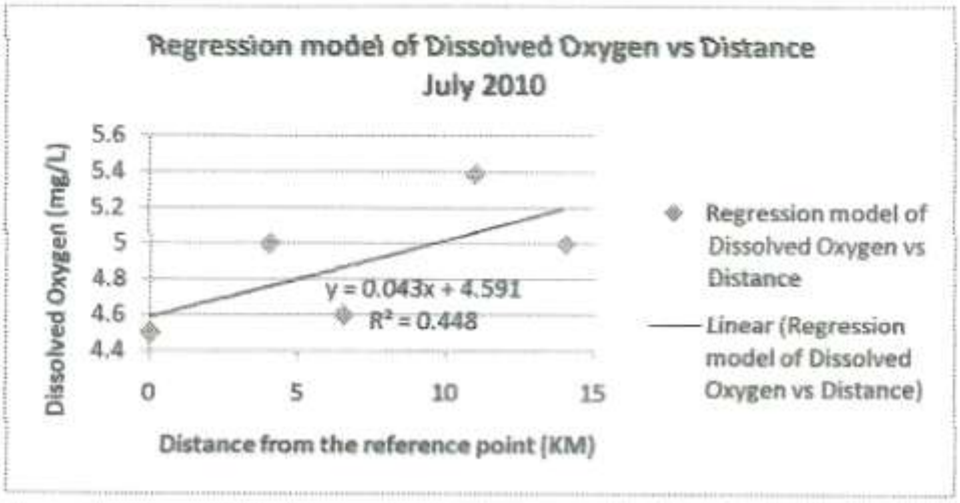

Figure 12: Regression model of Dissolved Oxygen vs Distance for the month of July

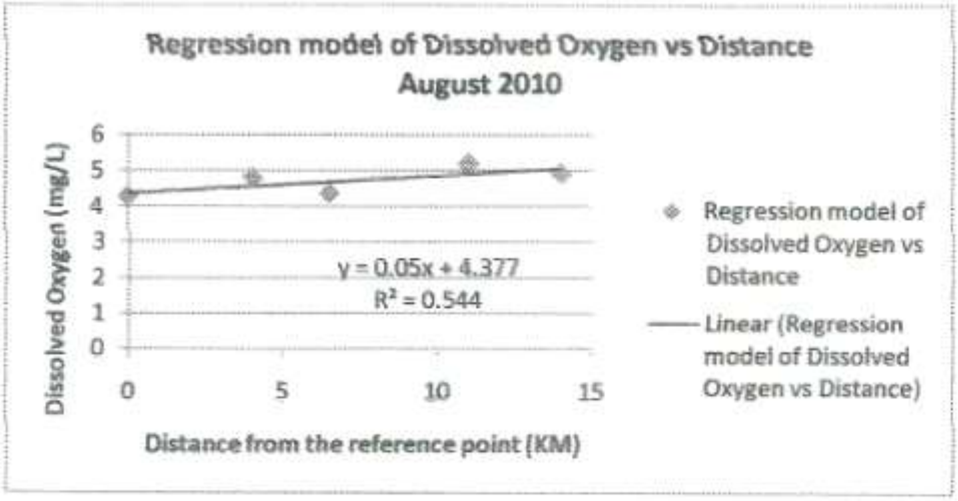

Figure 13: Regression model of Dissolved Oxygen vs Distance for the month of August

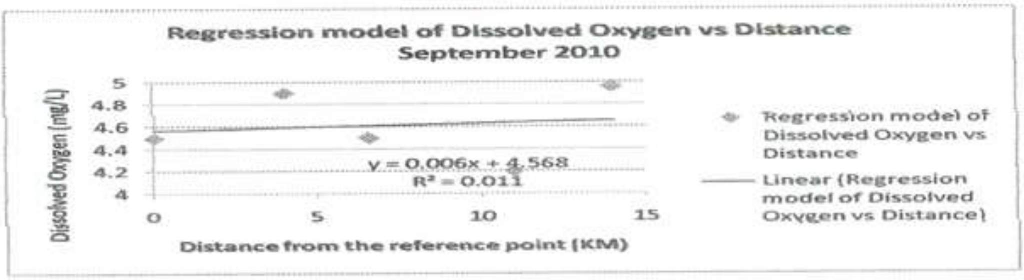

Figure 14: Regression model of Dissolved Oxygen vs Distance for the month of Septem

Figure 15: Rainfall distribution for Makurdi(*Source, Federal Inland Water Ways Depart*

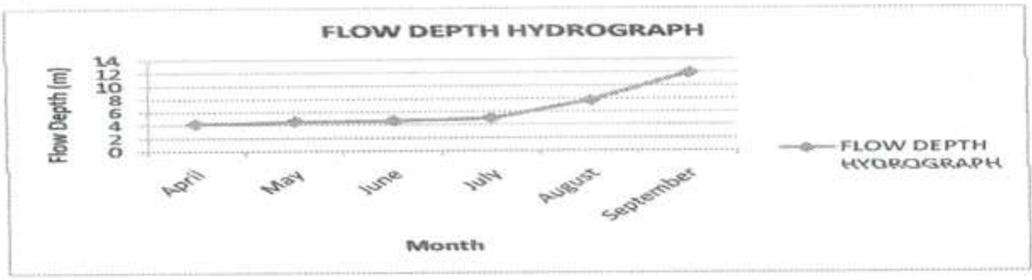

Fig 16: Flow Depth Hydrograph.

Table 2: SUMMARY OF THE MODELS

Independent Variable y	Dependent Variable x	Regression model	R^2	R
DO	Distance	Y = 0.047x + 4.337	0.450	0.6708
DO	Distance	Y = 0.054x + 4.316	0.535	0.7314
DO	Distance	Y = 0.042x + 4.552	0.493	0.7021
DO	Distance	Y = 0.043x + 4.591	0.448	0.6693
DO	Distance	T = 0.050x + 4.377	0.544	0.7376
DO	Distance	T = 0.006x + 4.568	0.011	0.1049

IV. RESULTS AND DISCUSSION

The World Health Organization stipulates that the minimum DO in any river water should be 5mg/l. Results obtained for the various months were analyzed to determine the effect of pollution on River Benue. Makurdi Reach.Water Works had DO above 5mg/l. The other sampling points had DO slightly less than 5.0mg/l. It was only Benue Links with DO of about 3.3mg/L which might be due to grease, lubricants etc. from the Benue links workshop that flowed into the river, covering the surface of the water. Fig 4 to Fig 8 confirm that along the distance from Benue Links to Wadata, DO was within the range required by WHO. From the results, the greater the pollution, the lesser, the DO.

V. CONCLUSION

Comparing the result with WHO standards, it was found that there was depletion of oxygen in August which is detrimental to aquatic life (Oxygen sag noticed in the graphs plotted). From the results, DO in the river fell within the minimum of 4 mg/l to 5mg/l as specified by WHO for fish and aquatic life. The models yielded values of coefficient of correlation ranging from 0.6693 to 0.7376, implying good fitting. The regression models developed in this study are good tools for monitoring and prediction of water quality in the river investigated. The models have both cost and time saving devices.

REFERENCES

[1]. Aboiyar, W (2001). "Physico-Chemical Properties of River Benue at the New Bridge" Unpublished B.SC. Thesis Benue State University, Makurdi, Nigeria.

[2]. Akpen, G.D and Eze, R.A.M (2006). "Water Pollution Modeling of the River Benue in the Reach of Makurdi Town" Journal of Nigeria Society of Engineers, NSE Technical Transaction Vol. 41 No. 2.

[3]. Farvimond, M.S and Nelson, J.A.R (1980), "Flow-Driven Water Quality Simulation Models". Water Research Pergamon Press, Great Britain Vol. 14 No. 8 pp 1157-1168.

[4]. Kahlig, P. (1979). "One-Dimensional Transient Model for Short-Term Prediction of Downstream Pollution in Rivers". Water Research, Pergamon Press, Great Britain Vol. 13, No. 12 pp 1311-1316.

[5]. Moses, B.S (1979). "The Cross River Nigeria, it's Ecology and Fisheries" in Proceedings of the International Conference on Kainji Lake and River Basin Development in Africa. Lake Kainji Research Institute, New Bussa, Nigeria. Pp 335-370.

[6]. Nwaogozie, I.L and Ogelle, E. (1997). "Water Quality Modeling of Rice Irrigated Obina River, Uzo Uwani". J. Water, Air and Soil Pollution. Kluwer Academics Publishers, Netherlands, Vol. 100 pp 197-222.

[7]. Odokuma, I.O and Okpokwashili, G.C (1997). "Seasonal Influences of the Organic Pollution Monitoring of the New Calabar River, Nigeria". Environmental Monitoring and Assessment, Kluwer Academic Publihsers, Netherlands, Vol. 45 pp 45-56.

[8]. Raven, P.H; Berg, I.R and Johnson, G.B (1998). Environment, 2nd Edition, Sander College Publishing pp 480-488.