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Analysis of Pollution of River Challawa by Industrial Effluents

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Abstract—The physicochemical characteristics associated with industrial effluent discharge from the Challawa and Sharada Industrial Estates in Kano, Kano State, northern Nigeria and the dominant influence on water quality, 10.644 km stretch downstream the water course were investigated. Test period covered the wet and dry seasons with laboratory analysis of field samples and study area. The effluents discharge into River Challawa at two point sources: at Yandanko and Tamburawa respectively. The results obtained indicated that the DO values ranged from 2.4 mg/l to 1.9 mg/l, while the BOD_5 ranged from 443 mg/l to 1654 mg/l; the COD ranged from 1296 mg/l to 4565 mg/l. The self-purification factor (f) for the River Challawa varies between 0.40 per day and 0.56 per day which puts the river in the sluggish stream category and as a heavily polluted stream.

Keywords*-water quality, industrial effluents, point sources, self-purification factor, wet and dry seasons.*

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I. INTRODUCTION

River Challawa is an important resource which supplies water for irrigation, drinking water after treatment, agricultural and fishing activities. It is true that self-purification processes which occur in a stream enable it to safely handle some wastewater discharges; there is a limit to its assimilation capacity. An increase in the concentration of organic material stimulates the growth of bacteria. The concentration of effluent waste discharge can be so great that the receiving water body is completely devoid of oxygen. The indiscriminate discharge of waste water effluents and municipal sewage into the river jeopardizes to a great extent the health of aquatic living organisms. For a safe sustainable environment, there is a need for a proper assessment of streams and rivers in Nigeria to ensure control of waste discharge within a stream assimilation capacity which will subsequently result in improved water quality and optimum utilization [1].

II. STUDY AREA

The study was carried out from three different areas: on (i) Challawa River with eight sampling stations, (ii) Waste discharges from effluents in the Sharada Industrial Estate such as the Unique Leather Finishing and others discharging into the Salanta river and flowing through Sabuwar Gandu, Kumbotso and entering the Challawa river at Tamburawa. There were a total number of five sampling points here; (iii) The third sampling point was from the industries in the Challawa Industrial Estate, made up of Mario-Jones industrial effluent, God’s Little industrial effluent, Maimuda industrial effluent, Clobus industrial effluent and Fata industrial effluent and the confluence of the waste discharges from the Challawa Industrial Estate which finally discharged directly into the Challawa River at Yandanko.

There were five sampling points at the Challawa Industrial Estate. There were eighteen (18 No) sampling points in all. Other industries in the areas include the textile industries and bottling company.

Detailed reconnaissance survey of the study area was carried out to ascertain the sampling points. The survey was made by locating the industrial industries in the estates and following the flow through to the points of discharge on Challawa River. Fig. 1 shows a schematic view of the study area. A detailed survey of all the points of wastewater discharge into Challawa river were noted and sampling stations designated 1 to 18 were established as explained earlier.

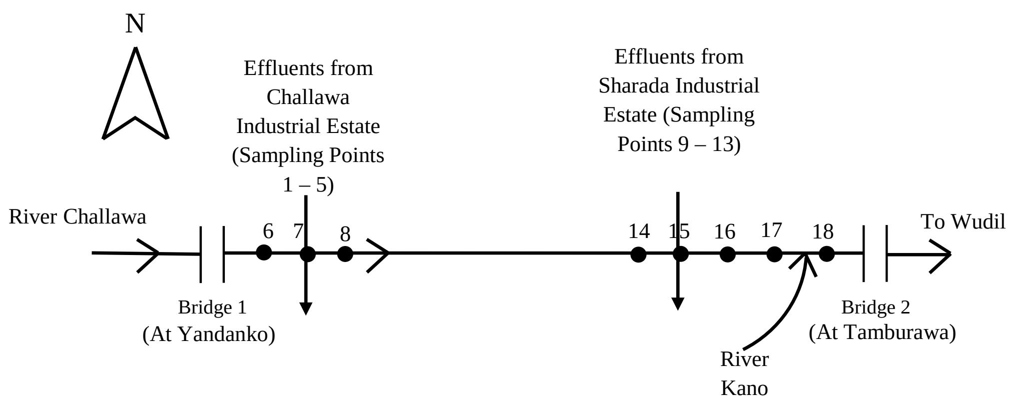

Figure 1. A schematic outline of River Challawa, effluent discharges, sampling points and confluence with River Kano

ISSN: 2321-8169
1821 – 1826

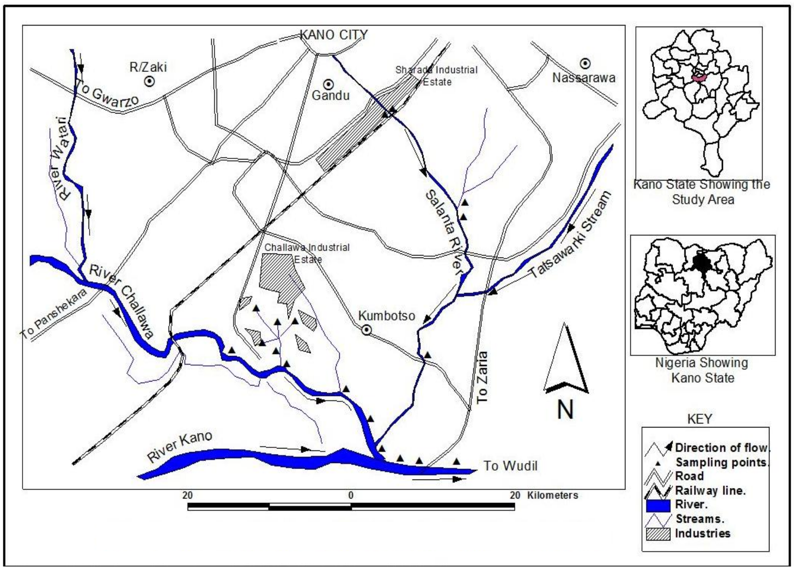

Figure 2. Map of River Challawa showing the sampling points

III. SCOPE OF STUDY

The study is composed of three (3) major aspects: The first aspect is the reconnaissance survey and field work for the gathering of in-situ information on Dissolved Oxygen, the acquisition of raw wastewater effluent sample for BOD, COD, TDS analysis as well as information on other hydrodynamic factors such as stream velocity, depth and width. The sampled reach was limited to 10.644km from the upstream at Yandanko to the downstream at Tamburawa.

The second aspect was the laboratory analysis of the industrial effluents for physical, chemical and bacteriological characteristics.

The final aspect was the development of the k_2 model establishing the relationship between the parameters and developing the Oxygen sag curve for the area investigated based on the data collected.

IV. LITERATURE REVIEW

Many attempts have been made to relate empirically the reaeration rate constant to key stream parameters [2]. The most commonly used states that [3]:

$$k_2 = \frac{3.9V^{1/2}}{H^{3/2}} \qquad (1)$$

where: k_2 = reaeration coefficient at 20°C (day $^{-1}$)
V = average stream velocity (m/s)
H = average stream depth (m)

To adjust the temperature to stream temperature, the following equation is applied.

$$k_2 = k_{20}\theta^{T-20} \qquad (2)$$

where θ is the measured temperature.
Appropriate value of θ is recommended by early researchers, i.e.:

θ = 1.135 for T ranging from 4 °C – 20°C
θ = 1.056 for T ranging from 20 °C – 30 °C

Reference [3] also produced a model for the determination of the reaeration constant of any medium slope to be:

$$k_2 = 46.2679\frac{U^{2.696}}{H^{3.902}} \qquad (3)$$

Reference [4] also produced a model for the determination of reaeration constant of any medium slope to be:

$$k_2 = 1.923\frac{U^{1.325}}{H^{2.006}} \qquad (4)$$

Reference [4] later improved the equation by considering temperature as a factor which influences reaeration constant as follows.

$$k_2 = 5.06(1.024)^{T-20}\frac{U^{0.919}}{H^{1.673}} \qquad (5)$$

Reference [5] showed that:

$$k_2 = 3.93\frac{U^{0.5}}{H^{1/5}} \qquad (6)$$

Reference [6] analyzed the polluted status of Amadi Creek and its management, considering the effect of hydraulic radius in place of the depth of the river at different location, and obtained.

$$k_2 = 11.635\frac{U^{1.0954}}{R^{0.016}} \qquad (7)$$

Reference [7] confirmed in his work that reaeration rate constants (k_2) depend on the condition of the river. A fast moving shallow stream will have a higher reaeration rate constant than a sluggish stream of a stagnant pond or lake.

The method used for the computation of reaeration coefficient was based on

$$k_2 = \frac{aV^{a_1}}{H^{a_3}} \qquad (8)$$

where: k_2 = reaeration coefficient (d^{-1})
H = depth of stream (m)

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1821 – 1826

V = velocity of flow (m/s)

a, a_1, a_2 were constants obtained using regression equations

V. METHODOLOGY

Samples for water quality analysis were collected in 1000ml plastic containers which were initially washed with detergent and rinsed in distilled water. The containers were finally rinsed with diluted sulphuric acid before sampling. Samples were tested immediately but for those that needed preservation, 2ml. of conc. H_2SO_4 were added per litre and kept in the refrigerator at 4°C. Dilutions were carried out as required for samples that were heavily polluted before analysis.

All field meters and equipment were checked and calibrated according to the manufacturer's specifications. The pH meter was calibrated using buffers of 4.0, 7.0 and 10.0 [8]. The Total Dissolved Solid/Conductivity meter was calibrated using the potassium chloride solution provided [8]. pH and Temperature were measured using portable HACH conductivity meter. Determination of the TDS (total dissolved solids) and total suspended solids (TSS) were carried out in the laboratory using the spectrophotometers. Chemical Oxygen Demand (COD) was determined by the dichromate digestion method while the Biochemical Oxygen Demand (BOD) was determined by the dilution method. In situations where measurements have to be taken in-situ, such as Dissolved Oxygen (DO), pH, and TSS, spectrometers calibrated according to manufacturers' specification were used.

VI. EFFECT OF INDUSTRIAL EFFLUENTS ON THE WATER QUALITY OF RIVER CHALLAWA

The effects of the industrial effluents from the Challawa Industrial Estate and the Sharada Industrial Estate on the River Challawa are shown in Fig. 3 to Fig. 11 and are described as follows:

A. *Temperature*

The industrial effluents affect the water quality in the River Challawa more in the wet season than in the dry season as shown in Fig. 3 with average temperatures of 30.1°C, 31.2°C respectively at the upstream and downstream sections. In general, the average temperature in River Challawa is less than the standard value of 40°C prescribed by the Federal Environmental Protection Agency (FEPA) for industrial effluents.

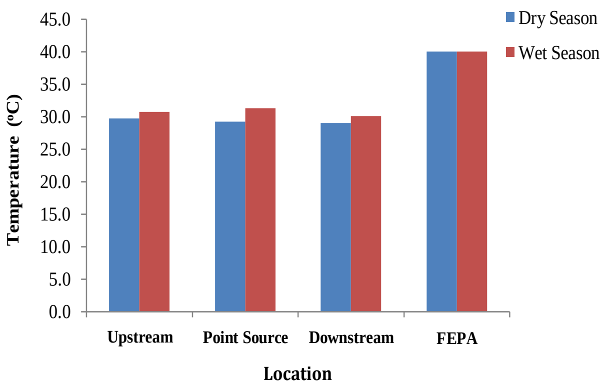

Figure 3. Temperature of Challawa River in the dry and wet seasons

B. *pH*

The pH values of the industrial effluents from the industrial estates affect the water quality of River Challawa more in the dry season than in the wet season with average values of 7.8 and 7.1 respectively in the downstream. The industrial effluents have an alkaline effect on the River Challawa water quality. The average value of pH is higher than the standard of 6.9 as prescribed by the Federal Environmental Protection Agency (as shown in Fig. 4).

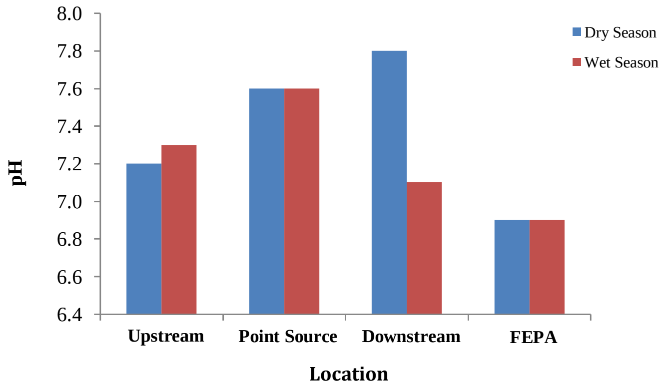

Figure 4. pH of Challawa River in the dry and wet seasons

C. *Chemical Oxygen Demand (COD)*

The water quality of River Challawa for the Chemical Oxygen Demand (COD) was drastically affected by the industrial effluents in the dry and wet seasons with average values of 3847 mg/l and 4565 mg/l for the corresponding dry and wet seasons respectively. Fig. 5 shows the COD values for both dry and wet seasons which far exceed the prescribed standard value of 50mg/l by the Federal Environmental Protection Agency [9].

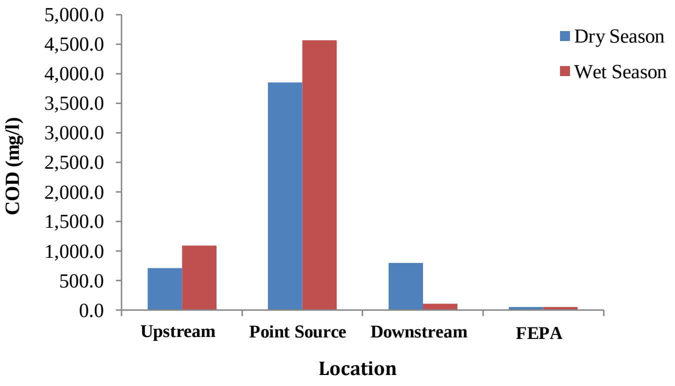

Figure 5. COD of Challawa River in the dry and wet seasons

D. *Biochemical Oxygen Demand (BOD)*

The Biochemical Oxygen Demand (BOD) is a very important water quality parameter that is used to evaluate organic pollution of a stream. With particular reference to River Challawa, the water quality was negatively impacted by the industrial effluents from the industrial estates. The negative impact was much more observed with values of 1241mg/l and 1654mg/l during the dry and wet seasons respectively at the Point Source as shown in Fig. 6. However, the BOD values

ISSN: 2321-8169
1821 – 1826

obtained far exceed the standard value of 50mg/l prescribed by the Federal Environmental Protection Agency (FEPA).

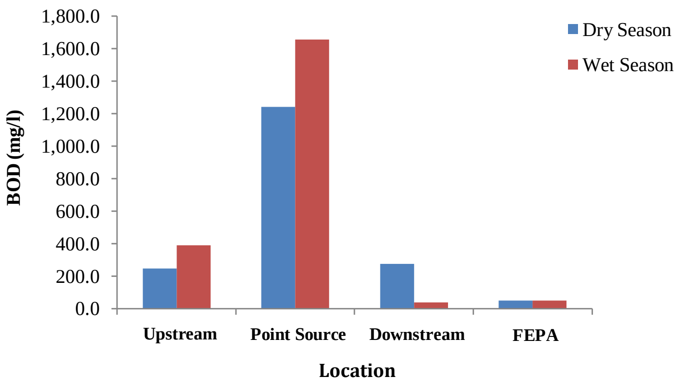

Figure 6. BOD of Challawa River in the dry and wet seasons

E. *Dissolved Oxygen (DO)*

The dissolved oxygen is a very important water quality indicator and a minimum value of 5mg/l is prescribed by the World Health Organisation as needed for the survival of living organisms. The water quality of River Challawa has been drastically affected by the industrial effluent from the industrial estates with values of 1.1mg/l and 1.9mg/l at the downstream section for the dry and wet seasons, as shown in Fig. 7.

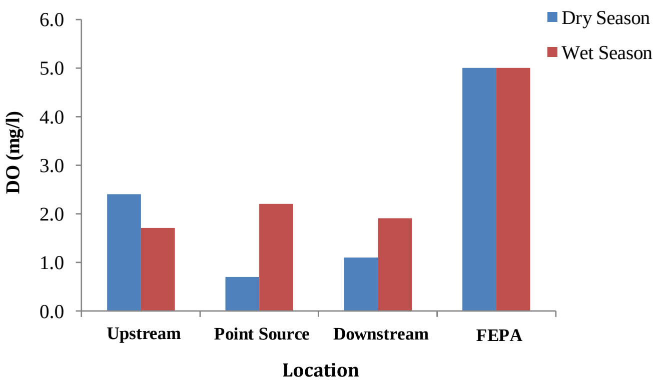

Figure 7. DO of Challawa River in the dry and wet seasons

F. *Total Suspended Sediments (TSS)*

The effect of suspended sediments on water quality is to reduce the penetration of sunlight rays into the stream, thereby reducing the amount of oxygen that could be assimilated into a given stream. The suspended sediment values of 393mg/l and 240mg/l were measured at the Point Source for dry and wet seasons respectively. As shown in Fig. 8, the values of the suspended sediment in River Challawa far exceed the amount of 30mg/l prescribed by the Federal Environmental Protection Agency [8].

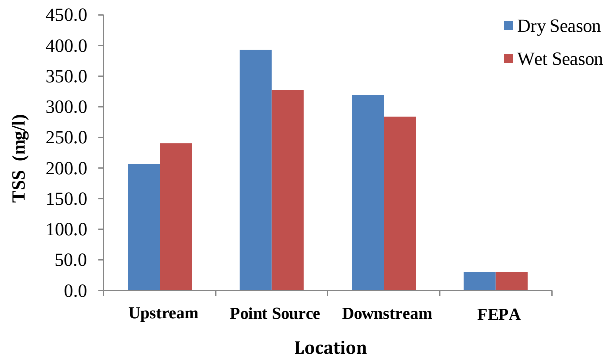

Figure 8. TSS of Challawa River in the dry and wet seasons

G. *Total Dissolved Solids (TDS)*

The standard value of 2000mg/l was prescribed by the Federal Environmental Protection Agency (FEPA) for the Dissolved Solid in polluted streams. However, the values of 2843 mg/l and 743 mg/l were measured at in River Challawa for the dry and wet seasons respectively as shown in Fig. 9.

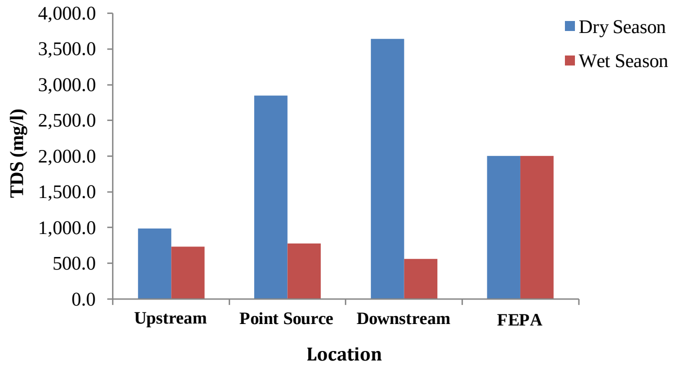

Figure 9. TDS of Challawa River in the dry and wet seasons

H. *Total Solids (TS)*

The values of 3236mg/l and 1094mg/l were obtained at the point source in River Challawa for the dry and wet seasons and shown in Fig. 10. The values received at the point source were higher than the 2030mg/l standard value prescribed by the Federal Environmental Protection Agency (FEPA).

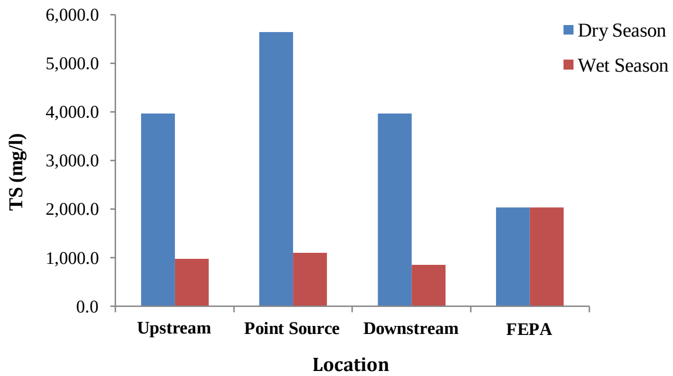

Figure 10. TS of Challawa River in the dry and wet seasons

I. *Coliform and e. coli Concentrations*

Fig. 11 shows the coliform concentrations of 53.4 cfu/100ml and 46.5 cfu/100ml and *e-coli* concentrations of 17.4

ISSN: 2321-8169
1821 – 1826

cfu/100ml and 15 cfu/100ml in River Challawa in the dry and wet seasons respectively, signifying the pollution of the stream.

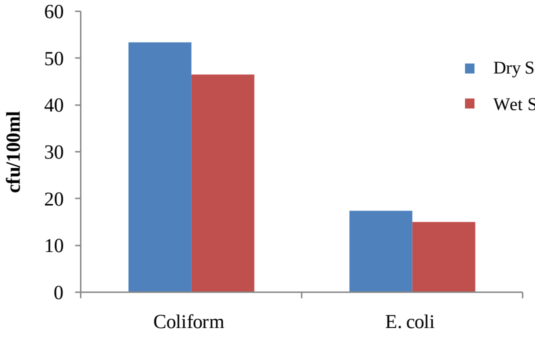

Figure 11. Coliform and *e. coli* concentrations in River Challawa in the dry and wet seasons

J. Oxygen Deficit

Fig. 12 shows the trend of oxygen deficit with increased distance along River Challawa showing self purification up to 9km from the upstream, where waste industrial effluents are introduced.

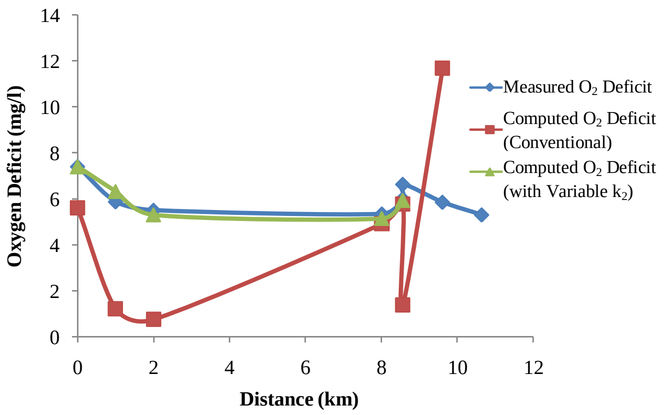

Figure 12. Oxygen Deficit against Distance

Tables I and II show the seasonal effect of Challawa and Sharada Industrial Effluents on River Challawa River at Yandanko and Tamburawa sections.

TABLE I. SEASONAL EFFECT OF CHALLAWA INDUSTRIAL EFFLUENTS ON RIVER CHALLAWA AT YANDANKO

S/N	Parameter	Dry Season			Wet Season		
		Upstream	Point Source	Downstream	Upstream	Point Source	Downstream
1.	Temperature	29.7	29.2	29.0	30.7	31.3	30.1
2.	pH	7.2	7.6	7.8	7.3	7.6	7.1
3.	COD	707	3847	792	1087	4565	103
4.	BOD	247	1241	274	389	1654	37
5.	DO	2.3	0.0	1.9	2.4	0.0	2.0
6.	TSS	296	636	239	263	971	241
7.	DS	330	9527	6283	5333	12000	843
8.	TS	626	10163	6522	5596	12971	1084

TABLE II. SEASONAL EFFECT OF SHARADA INDUSTRIAL EFFLUENTS ON RIVER CHALLAWA AT TAMBURAWA

S/N	Parameter	Dry Season			Wet Season		
		Upstream	Point Source	Downstream	Upstream	Point Source	Downstream
1.	Temperature	28.0	29.7	28.3	30.9	29.7	31.2
2.	Ph	7.0	7.1	7.4	7.0	4.7	7.2
3.	COD	800	2751	1497	209	1296	521
4.	BOD	281	610	530	75	443	177
5.	DO	2.4	0.7	1.1	1.7	2.2	1.9
6.	TSS	207	393	320	240	327	283
7.	DS	986	2843	3640	734	767	560
8.	TS	1193	3236	3960	974	1094	843

VII. CONCLUSION

Samples of wastewater from industrial effluents from Challawa and Sharada industries in River Challawa where these wastewaters are discharged into were collected and analysed in the laboratory. The wastewaters from the tanneries were very high in BOD, COD, SS, TDS and Total Solids. With such high concentrations of pollutants, their discharges into the two rivers constitute serious sources of pollution and threat to public and environmental health. This was evident from the results of water quality analysis of several samples collected from different sections of the Challawa River. The values of the pollutants, especially with respect to BOD, Suspended Solids, dissolved COD and Total Solids, were above the FEPA standards.

The procedure for sampling and analysis of wastewater could be time consuming and fraught with pitfalls, especially when results are needed urgently in cases like an outbreak of contagious water borne disease. However, mathematical models can be designed which provide a simple, economic and precise means of interpreting results leading to satisfactory findings.

Interrelationships were established between some physico-chemical wastewater pollution indicators where reliable correlations were established using statistical analysis. This indicates the reliability of the relationships which suggests that it can be used to predict the levels of pollution by the parameters investigated and possibly proffering a preventive measure prior to detailed investigation of industrial pollution monitoring.

Re-aeration, settling and de-oxygenation experiments were also conducted in the laboratories. The re-aeration coefficients were low in comparison with values obtained from some rivers in Southern Nigeria perhaps because of high temperature in the semi-arid area. High temperature reduces the level of oxygen absorption from the atmosphere.

The re-aeration co-efficient varies along the river reaches and its variability may be the reason why the use of average values over a long river in computing oxygen sag may not yield correct predictions. The BOD reaction constant was relatively within the normal range with an average value of 0.251. The average settling velocity was 0.157/min.

VIII. RECOMMENDATIONS

The recommendations arising from this work are as follows:

- The industrial industries should treat their waste to avoid further pollution of Challawa River with its negative effects on public and environmental health.
- The BOD in River Challawa can be predicted using the relationship obtained from the study to reduce cost and time, especially for monitoring purposes.

REFERENCES

[1] P.J.W. Roberts, “Marine disposal”, New World Wat., pp. 111-113, 1995.

[2] C.M.A. Ademoroti, Standard Methods for Water and Effluents Analysis. Foludex Press Ltd. Ibadan, 1996, 182pp.

[3] D.J. O’Connor, and W.E. Dobbins, “Mechanism of re-aeration in natural streams”, Transaction of the American Society of Civil Engineers, vol 123, pp 641-666, 1958.

[4] M.A. Churchill, H.L. Elmore, and R.A. Buckingham, “The prediction of stream reaeration rates”, Journal of Sanitary Eng. Division ASCE 88 (SA4) pp 1-46, 1962.

[5] C. Gualtieri and P. Gualterie, “Statistical analysis of reparation rate in streams”, International Agricultural Engineering Conference (ICAE) 99, Pechino, China, pp. 14117, December 1999.

[6] J.C. Agunwamba, C.N. Maduka, and A.M. Ofosaren, “Analysis of pollution status of Amadi Creek and its management”, Journal of Water Supply Research and Technology—AQUA 55.6., 2006, pp 427-435

[7] C.M.A. Ademoroti, “Environmental management: Case studies in industrial wastewater treatment”, in Environmental issues and Management in National Development, P.O. Sada, and F.O. Odemerho, Eds. Evans Brothers Publishers Ltd., Nigeria, 1988.

[8] HACH, Water Analysis Handbook, 3rd ed., HACH Company; Loveland, Colorado USA, 1997, pp. 5-7.

[9] FEPA, Guidelines and Standards for Environmental Pollution Control in Nigeria, Nigeria, 1982, pp 54-55.