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Assessment of the Impact of Effluent Discharges on the Quality of Aba River South Eastern Nigeria

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Abstract- The study assessed the impact of effluent discharges on the quality of Aba River South Eastern Nigeria. Twenty two water samples were collected at discharge points of the following industries; Nigerian Breweries, 7Up bottling Co, PZ Industries, Starline and Abattoir. Standard methods were adopted for field and laboratory analysis of samples collected upstream and downstream. The parameters analyzed include; Potassium, Sodium, Nitrate, Phosphates, Sulphates, Bicarbonates, Conductivity, pH, Iron, Calcium, Magnesium, Turbidity, Chloride, Alkalinity, BOD, Total dissolved solids, COD, Total hardness, Total suspended solids. Comparison of results obtained with WHO standard showed that Nitrates at PZ Industry and Abattoir recorded values of 47.4Mg/l and 55.22Mg/l respectively which exceeded WHO value of 10; Turbidity values of 43.33NTU at Abattoir was higher than the WHO limit of 29, BOD values of 12.87Mg/l and 14.86Mg/l at 7UP and Starline Industries also exceeded the range of 4-7 by WHO. However, other parameters analyzed were lower or within WHO limits. The value of pollution index is 1.317 which indicates that the river is moderately polluted. The source of pollution is attributable to industrial and abattoir activities whose effluent discharges impact the quality of Aba River. The River can therefore not be used in its present form for any domestic purpose without treatments. Periodic monitoring of the river and introduction of cost-effective methods of production technologies, such as, on-site waste separation and reduction; and effluent recycling methods are recommended.

Keywords- *Abattoir, industrial waste-water, Aba River, sample analysis, effluent recycling, pollution index*

I. INTRODUCTION

Industrialization is considered the cornerstone of development strategies due to its significant contribution to the economic growth and human welfare, but it carries inevitable costs and problems in terms of pollution of air and water resources. Specially, water bodies near to industrial areas have been extremely affected from disposal of waste which can alter the physical, chemical and biological nature of the receiving water body. So, industrial waste is the most common source of water pollution in the present day world and it increases yearly due to the fact that industries are increasing because most countries are getting industrialized (Gyawali, Techato and Yuangyai, 2012)[1]. Industrial waste-water originates from the wet nature of industries which require large quantities of water for processing and disposal of wastes. Most industries are therefore, located near water sources.

Industrial waste contamination of natural water bodies has emerged as a major challenge in Nigeria. Estuaries and inland water bodies, which are the major sources of drinking water in Nigeria, are often contaminated by the activities of the adjoining populations and industrial establishments. Wastes entering these water bodies are both in solid and liquid forms. These are mostly derived from industrial, agricultural and domestic activities. As a result, water bodies which are major receptacles of treated and untreated or partially treated industrial wastes have become highly polluted. The resultant effects of this on public health and the environment are usually great in magnitude. Comparing with other sources, industries are the major sources of polluting the river system of Nigeria. High level of pollutants in river water systems causes an increase in biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), toxic metals such as Cd, Cr, Ni and pH and coliform and hence make such water unsuitable for drinking, irrigation and aquatic life (Bello and Oyedemi, 2009) [2].

With competing demands on limited water resources, industrial pollution remains one of the major problems facing Nigerian cities. As societies throughout the world become more aware of the issues involved in water pollution, there has been considerable public debate about environmental effects of effluents discharged into aquatic environments. So, one of the most critical environmental problems of Nigeria is improper management of vast amount of wastes generated by various industrial activities. In the case of Aba River, most industries have been using large volume of water but without efficient wastewater treatment plants and so, routinely discharge their wastes directly into the river. So, the objective of the study was to evaluate the effects of industrial waste disposal on Aba River from the collected samples. Rivers are by far the cheapest form of water supply compared to other sources like groundwater and seawater desalination. According to Amadi (2010)[3], meeting water quality expectations for streams and rivers is required to protect drinking water resources, encourage recreational activities and to provide a good environment for fish and wildlife. Therefore, water quality evaluation and management is of ecotoxicological importance. Changes in water chemistry of rivers are usually anthropogenic via domestic, industrial and agricultural discharges which may in turn result to degradation of the aquatic ecosystem (Ezigbo, 1989)[4]. The continuous drift of people to the urban centres aggravated the pollution of Aba River as it forms the effluent discharge point for industrial and agricultural waste by the heavy and light industries that flank both sides of the river along Aba-Port-Harcourt express way.

Industrialization, like other human activities that impact on the environment, often results in pollution and degradation. Aba City is becoming fairly industrialized, although some of these industries are situated some distance away from rivers; their effluents are channeled into such rivers as Aba River (Ogbeibu and Edutie, 2002)[5]. One of these industries is a soft drink industry and the wastewater from its operation is conveyed over a distance by an underground tunnel and discharged into Eziama River. These effluents which are rich in organic and inorganic substances are capable of producing adverse effects on the physical, chemical and biotic components of the environment and either directly or indirectly on human health. Industrial, abattoir, sewage, municipal wastes are been continuously added to water bodies hence the effect on the physiochemical quality of water making them unfit for use for livestock and other organisms (Dwivedi and Pandey, 2002)[6].

Aba is a developing industrial and agricultural city in Abia state of Nigeria. Aba lies between latitude $5^{o}05'$ to $5^{o}30'$ North and longitude $7^{o}15'$ to $7^{o}40'$ East in Abia State of Nigeria and is characterized by relatively low elevation and near flat topography which enhances its runoff. Aba River is a tributary of Imo River and is the major river that passes through Aba town; and it is an important economic river in Abia State. The river originates from the northern Ngwa hinterland of Aba and stretches down to Cross River state where it empties with its creeks into the Atlantic Ocean. The River flows in North-South direction and joins the Imo River. The river is recharged by precipitation and groundwater. The river is used for various human activities including car washing, domestic uses, rearing of farm animals and fishing. It receives wastes from the industries, for example, Nigeria breweries Ltd, Paterson Zochonis (PZ) and abattoirs sited along its course. The study is part of the Niger Delta Basin and is underlain by the Benin Formation of Miocene to the recent age.

II. MATERIALS AND METHODS

Samples were collected at the upstream and downstream points for the purpose of comparative studies. Twenty two different water samples were each collected with high grade plastic bottles of one liter capacity at a depth of 1 meter below the water surface from the ten designated sampling points and tightly closed. The samples were placed in a cooler box and protected from direct sunlight and then taken to the laboratory for analysis. During collection, care was taken to avoid the trapping of air within the bottle by completely immersing the bottle within the respective water sample until the bottle was completely filled in with the water.

The following parameters were tested; colour, odour, taste, turbidity, pH, total hardness (TH), calcium, magnesium, total alkalinity (TA), chloride, sulphate, nitrate, phosphate, and total dissolved solids (TDS), Also biochemical oxygen demand (BOD), chemical oxygen demand (COD) and electrical conductivity (EC) were analyzed. Standard methods were adopted for the analysis of the water samples.

The Pollution index (Pij) of the River was computed using the formula developed by Horton (1965)[7] Multiple items of water quality are expressed as Cij and permissible levels of the respective items expressed as Lij.

$$P_{IJ} = \left[\sqrt{\left(max\, C_I/L_{IJ}\right)^2 + \left(mean\, C_I/L_{IJ}\right)^2/2} \right] \quad (1)$$

III. RESULTS AND DISCUSSIONS

Table 1 presents result of the physiochemical tests on the samples collected upstream and downstream of the selected locations.

TABLE I. MEASURED PHYSIOCHEMICAL PARAMETERS AND WHO STANDARDS (WHO, 2007) [8]

Parameters	Site 1		2		3		4		5		
	NB (UPS)	NB (DS)	7UP (UPS)	7UP (DS)	PZ (UPS)	PZ (DS)	Starline (UPS)	Starline (DS)	Abattoir (UPS)	Abattoir (DS)	WHO STD
Potassium	7.90	6.32	5.38	4.14	9.54	5.87	3.61	1.43	12.42	8.46	-
Sodium	8.94	7.01	9.81	7.40	8.49	6.76	5.03	2.44	9.34	6.01	-
pH (at 29^0c)	8.01	7.54	8.42	7.94	6.33	4.23	6.92	4.38	7.90	7.01	6.5-8.5
Total dissolved solids	56.14	48.01	37.64	32.40	27.22	19.32	26.10	16.32	22.44	18.32	500-1000
Calcium	8.80	6.10	14.44	10.32	3.67	2.43	5.51	2.43	32.76	24.03	-
Magnesium	8.13	7.04	7.60	5.91	1.12	1.02	3.30	1.76	5.90	4.28	-
Total hardness	8.47	6.57	11.02	8.12	13.21	9.34	4.41	2.32	19.87	14.16	-
Chlorides	31.01	18.62	36.61	21.38	48.60	34.21	23.30	12.45	30.42	4.20	200-500
Sulphates	8.04	6.01	9.30	7.63	8.50	5.45	6.61	3.25	20.32	3.41	250
Nitrates	3.86	2.58	4.04	2.08	47.4	12.43	2.73	0.54	55.22	7.38	≤10
Electrical Conductivity	69.10	63.13	51.19	48.16	30.54	22.43	32.20	28.75	41.54	20.01	<100
Phosphates	5.23	3.89	6.16	5.10	12.32	8.54	4.40	3.32	12.97	9.82	100
Iron	2.01	1.73	2.10	1.80	3.88	1.32	1.98	0.43	6.98	3.90	5.7
Bicarbonates	34.40	21.90	18.04	15.16	22.43	13.34	28.81	17.54	39.33	32.42	-
Alkalinity	40.43	35.30	51.26	39.91	23.30	19.72	12.61	4.89	67.22	9.01	≤600
Total suspended solids	5.54	4.92	3.87	2.96	10.54	4.54	3.03	2.54	9.23	2.34	35
Biochemical Oxygen Demand	6.87	4.90	12.87	9.88	2.90	1.87	14.86	8.97	4.48	3.52	4-7
Chemical Oxygen Demand(COD)	38.54	24.54	42.43	20.64	16.43	11.87	31.22	28.22	32.23	24.64	120

(UPS-Upstream; DS-Downstream)

Note: µS/cm (unit of conductivity), NTU (unit of turbidity), with the exception of pH, conductivity and turbidity, all others are in milligram/litre. (NTU: Nephlometric turbidity unit).

A. pH

The pH of samples analysed at different sites ranged from 4.38 to 8.42 upstream and downstream respectively. The obtained results indicate that water samples at site 1, site 2 and site 5 are slightly alkaline whereas the samples at sites 3 and 4 are acidic in nature (See Fig. 1). The desirable range of pH set by WHO is 6.5 to 8.5. Therefore, the whole samples except the sample at site 3 are within the safe limit.

Water with a pH outside the normal range may cause a nutritional imbalance or may contain a toxic ion which can adversely affect the growth and development of aquatic life. As pH affects the unit processes in water treatment that contribute to the removal of harmful organisms, it could be argued that pH has an indirect effect on health. Water generally becomes more corrosive with decreasing pH; however, excessively alkaline water also may be corrosive.

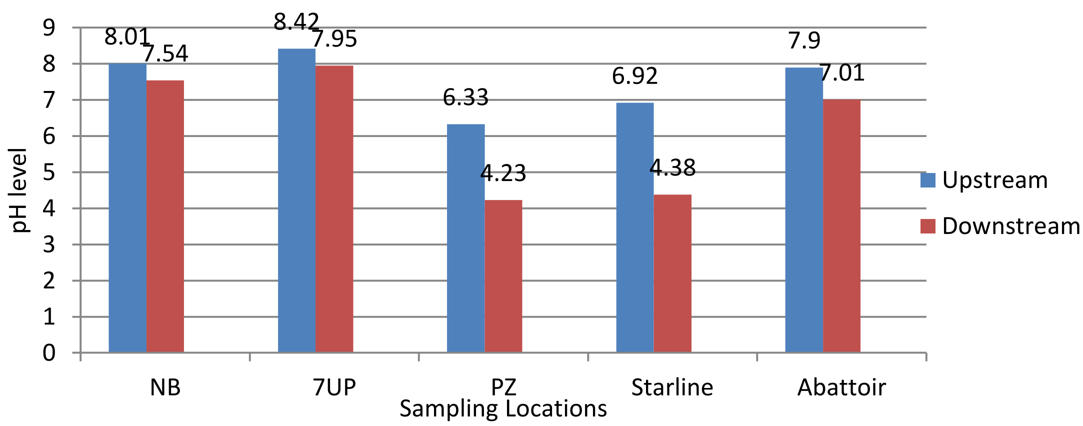

Figure 1. Variation of pH level at different sites

B. Turbidity

The maximum permissible limit of turbidity in surface water by WHO is any value less than or equal to 29, turbidity at sites 1, 2 and 4 are within WHO standard limit for both upstream and downstream samples. The case is different in sites 3 and 5 upstream which have values of 31.87 and 43.33 respectively, although their downstream samples have values which are within WHO limit. Comparatively higher values of turbidity at site3 and site5 may be attributable to the higher suspended and colloidal matters such as clay, silt, and finely divided organic and inorganic matter in the study area.

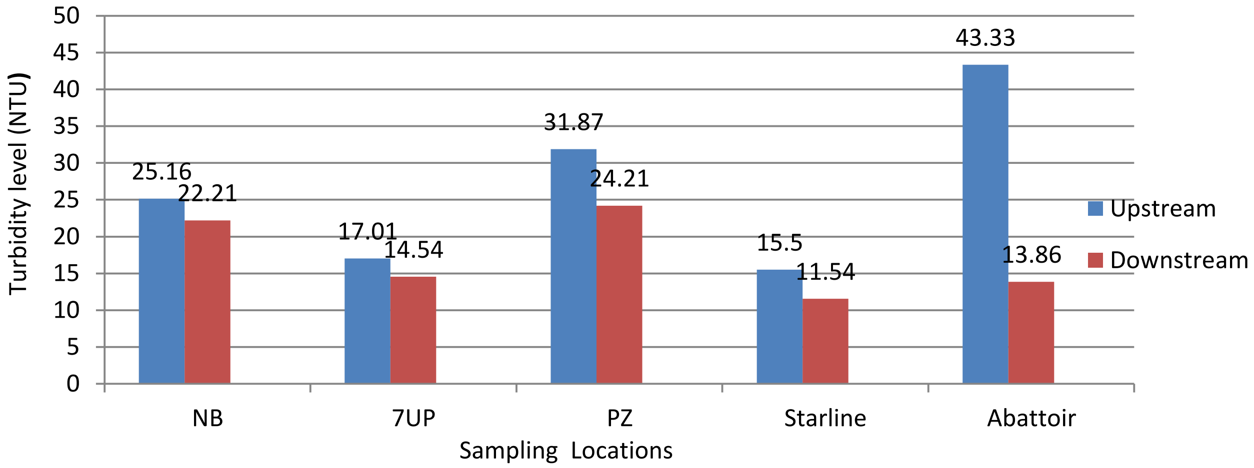

Figure 2. Variation of Tutbidity at different sites

C. Total hardness

Results from the tests showed that Total hardness concentrations were highest (19.87-14.16) in effluents from the abattoir site and lowest (2.3-4.4mg/l) from Starline Industry location (Fig. 3) Hardness of water generally indicates the concentration of calcium and magnesium ions in the water and the high level of this may be attributed to the mixing of sewage effluents into the river water. Hardness causes incrustations in water distribution systems and excessive soap consumption in washing.

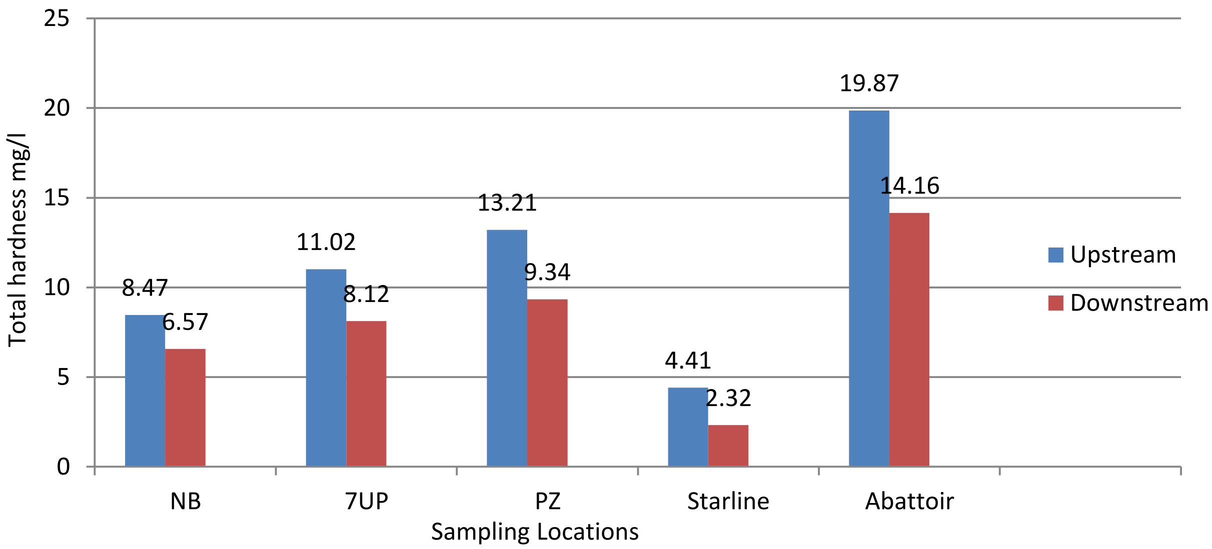

Figure 3. Variation of Total hardness at different sites

D. Calcium

Results from Fig. 4 showed that Calcium concentrations were highest in the abattoir sampling site. Water containing high Ca is not suitable for washing and bathing, and in factory boilers. It causes concretion in the body and may cause intestinal diseases and stone formation. Higher concentration of Mg can cause hardness of water and exerts cathartic and diuretic actions in human body.

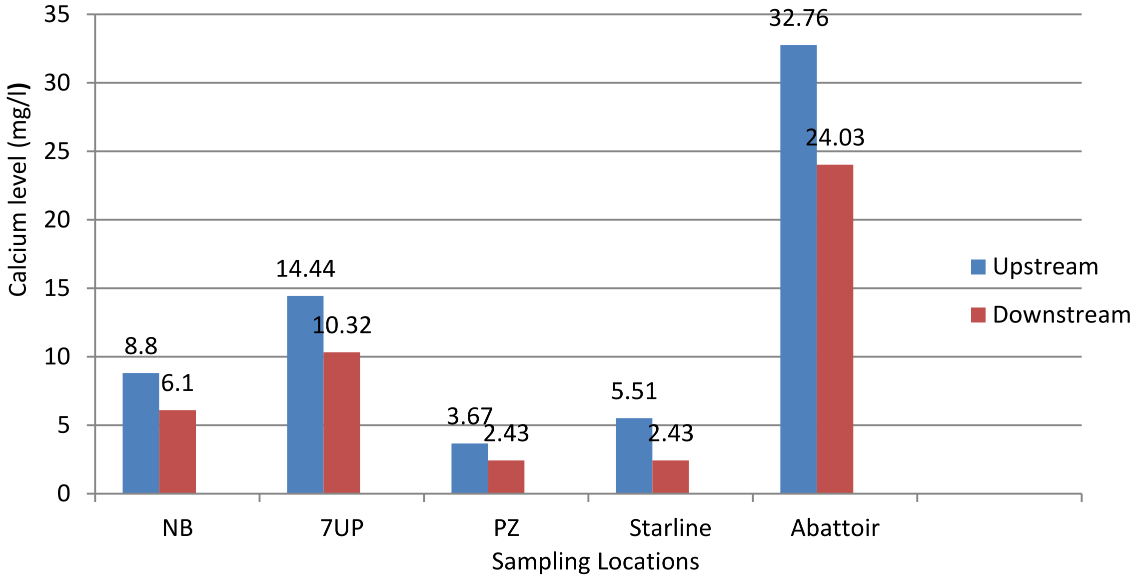

Figure 4. Variation in the value of Calcium level at different sites

E. Total alkalinity

Total alkalinity values in the present study as recorded in Fig. 5 range from 4.89mg/l to 67.22mg/l. The maximum permissible limit of alkalinity according to WHO standards in surface water is 600mg/l. Water samples collected from the various sites had concentrations of alkalinity below the maximum limit set by WHO. The high alkalinity level may be associated with comparatively higher pH values and higher concentrations of chlorides, sulphates, phosphates and other ions present in the river which may have been impacted by the effluent discharges.

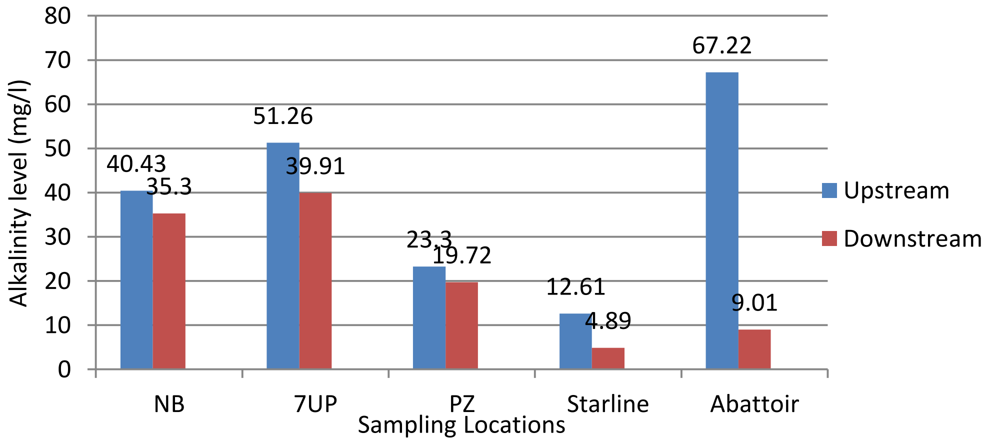

Figure 5. Variation of Alkalinity level at different sites

F. Chloride

The values for chlorides in all the sites are within the desirable limits (Fig. 6). The higher content of chlorides upstream could be attributed to the heavy discharge of sewage waste and effluents from the chemical industries. Higher concentrations of chloride in water can impart undesirable taste, may cause corrosion in the distribution system and may harm growing plants.

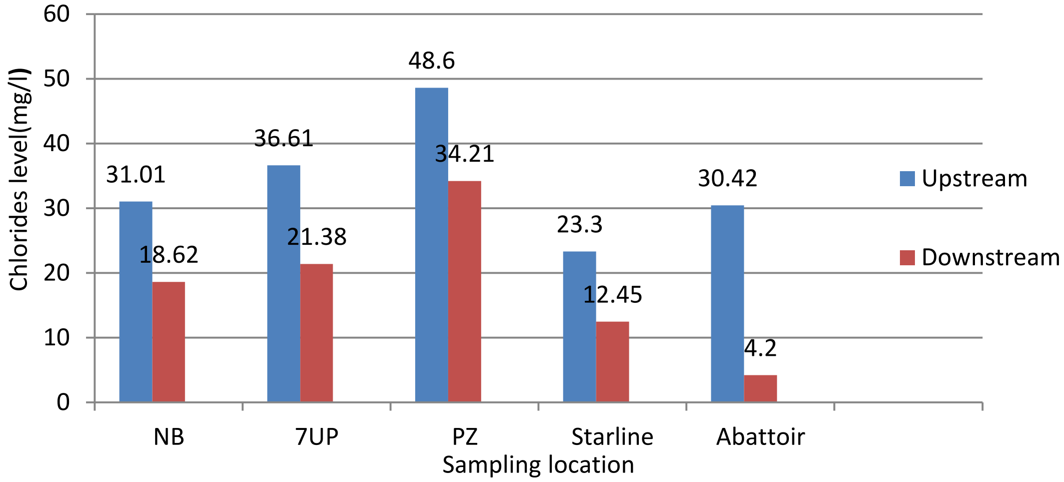

Figure 6. Variation of Chloride levels at different sites

G. Sulphate

Sulphate concentrations of water samples varied from 3.25mg/l to 20.32mg/l which are all less than the standard limits of the WHO. It is important to note that sulphate concentrations from abattoir samples are highest (Fig. 7) even though lower than WHO limit.

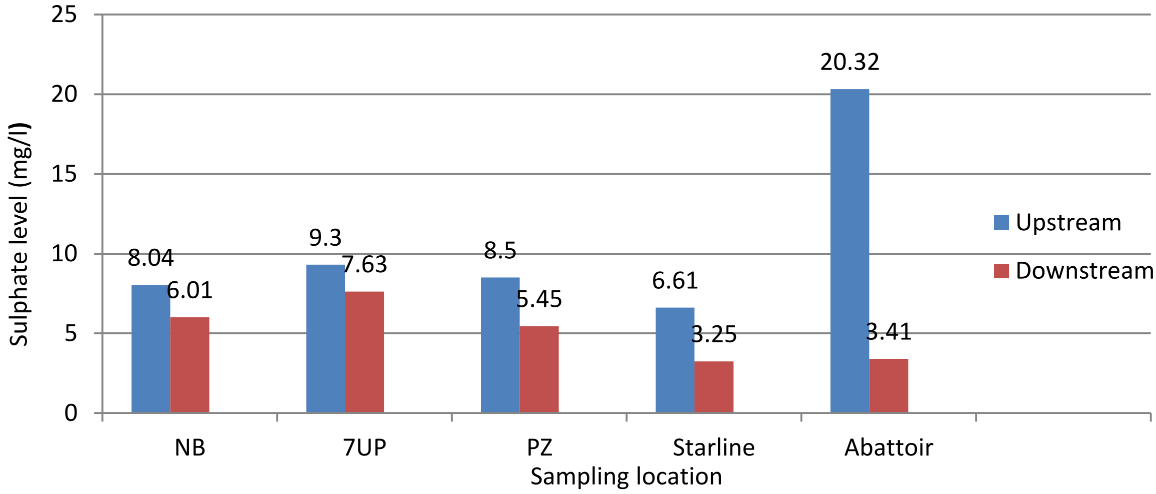

Figure 7. Variation of Sulphate levels at different site

H. Nitrate

Nitrate concentration of water samples in the study ranged from 0.54mg/l to 55.22mg/l at both upstream and downstream locations. It can be deduced that the upstream value at both sites 3 and site 5 are above the WHO permissible limit. Concentrations greater than the permissible levels may indicate pollution effects from feedlot runoff, sewage or fertilizers. Results from studies show that consumption of waters with concentrations greater than 10 mg/l, as nitrogen may be injurious to pregnant women, children, and the elderly.

I. Phosphate

The concentration of phosphate in water samples in the present study varied from 3.32mg/l to 12.97mg/l. The study clearly shows that content of all the water samples are well within the desirable limit (Table 1).

J. Total Dissolved Solids (TDS)

The desirable and maximum levels of TDS in surface water prescribed by WHO are 500 mg/l and 1000 mg/l respectively. From the study, the water sample collected from the entire sites has an acceptable value because they ranged from 16.32mg/l to 56.14mg/l. Increased level of TDS might be impacted by the dissolution of higher concentrations of chlorides, calcium, magnesium, sulphates, organic and other inorganic particles which resulted from the discharge of sewage, industrial and solid waste into the river. Excessive TDS in water can cause changes in taste, excessive scales in water pipes, water heaters, boilers and household appliances. Concentration of TDS that are too high or too low may limit growth and lead to the death of many aquatic life forms.

K. Total Suspended Solids (TSS)

In the study, the highest TSS value was obtained in water sample collected from site 3 with a value of 10.54mg/l at the upstream. However, all the TSS concentrations are below the acceptable WHO concentration standard. However, are all the TSS concentrations are below the acceptable WHO standards. High concentration of TSS in river water is an index that it is severely polluted.

L. Biochemical oxygen demand (BOD)

BOD values of water samples in the study varied from 1.89mg/l to 14.86mg/l. Four of the sites have concentration values higher than WHO acceptable standards. High BOD values clearly indicate pollution and may be attributed to the percolation of waste water loaded with biodegradable compounds, which might be the result of untreated sewage, solid and industrial waste discharged from each site into the Aba River.

M. Chemical Oxygen Demand (COD)

All the water samples analyzed showed that they are all below the WHO standard. The low levels of COD in water samples at different sites clearly indicate that the waste materials discharged into these water bodies are low oxygen demanding materials, which do not cause depletion of dissolved oxygen in water. Higher BOD and COD levels of any water sample indicate that such water samples are highly polluted. It may be attributed to the high demand on dissolved oxygen by the wastes discharged in to the water bodies and which render them unfit for drinking, irrigation and also its use for recreational purpose greatly reduced.

N. Electrical Conductivity (EC)

The values obtained from the study ranged from 20.01 to 69.10 µS/cm and the standard is any value less than or equal to 100 µS/cm and the values obtained are less than 100 µS/cm specified in WHO standard (WHO, 2007). Earlier studies show that a high positive correlation between electrical conductance and chloride concentration. Also, a high positive correlation between electrical conductance and Total dissolved solids of water. Also, higher conductivity alters the chelating properties of water bodies and creates an imbalance of free metals availability for flora and fauna (Dwivedi and Pandey, 2002

O. Pollution Index

The pollution index of the River Based on the results above was computed as 1.317 using "(1)". This indicates that the River is moderately polluted.

IV. CONCLUSION

The study has shown that effluents from industries have significant effects on the water quality of the receiving river. This is depicted by the fact that there is a general increase in concentration of the parameters analyzed upstream as opposed to downstream. Although the values in some cases were lower than the maximum allowable limits by WHO, the continued discharge of untreated effluents into the river may result in severe accumulation of those contaminants. With the present obsolete processing technologies of the area, the numerous manufacturing and animal processing activities will continue to enrich the receiving river with key pollutants and easily degradable carbon compounds leading to further oxygen depletion in the river.

Conclusively, the quality of Aba River is influenced by wastewater from industrial and abattoir activities; understanding the condition of rivers is critical if Nigeria is to develop an effective surface water quality monitoring in the country. It changes with the seasons and geographic areas, even when there is no pollution present, therefore we must pay close attention to water quality by monitoring and testing, the provision of quality water to the ever increasing population of Nigerians cannot be over emphasized. Without an adequate water supply, the millions of Nigerians will suffer, agriculture will be hampered, and the recreational industry will suffer.

It is recommended that local regulating bodies and environmental legal authorities should revise and adopt current international standards to produce.

The local bodies and environmental legal authorities should interfere with this situation to produce an internally cohesive institutional framework for waste management. The pollution levels should be reduced by strict enforcement of Environmental Management Act and waste effluent regulations to ensure that the effluent discharged is within the permissible limits. It is thus recommended that waste treatment plants must be established with each industry with proper follow-up. Further, efficient environmental laws and social awareness program must be undertaken with respect to potential threat of industrial and other waste to the environment.

REFERENCES

[1] Gyawali, S., Techato, K. and Yuangyai, C. Effects of industrial waste disposal on the surface water quality of U-tapao River, Thailand. International Journal of Environment Science and Engineering. Pp 1-5. (2012).

[2] Bello, Y. O. and Oyedemi, D. T. A. The impact of abattoir activities and management in residential neighborhoods: A Case Study of Ogbomoso, Nigeria. Kamla-Raj Soc Sci. Journal. Vol. 19(2). Pp 121-127. 2009

[3] Amadi, S.O. Impact assessment of industrial effluent on water quality of the receiving Alaro river in Ibadan Nigeria. Journal of African medical Association. Pp 1-13. 2010.

[4] Ezigbo, C.A. (1989). Effluent management for enhancing environmental protection: Journal of Public policy analysis. Pp 23-31.

[5] Ogbeibu, A. E. and Edutie, L.O. (2002). Impact of brewery effluent on the water Quality of Ikpoba River; Southern Nigeria. African Journal of Environmental Pollution and Health. Vol. 1 (1). Pp 1-12. Press London. Pp 369-377

[6] Dwivedi, B.K. and Pandey, G.C. (2002). Physiochemical factors and algal diversity of two ponds in Faizabad, India. Journal of Discovery and Innovations.Pp 361-370.

[7] Horton R.K. (1965).An Index number system for rating water quality. Pollution control fed. 37(3).1965.

[8] WHO, (2007). Guideline for surface water quality. health criteria and other supporting information, Geneva: Pp 264-400.