

Levels of ammonia – nitrogen, carbon dioxide, dissolved oxygen, and biochemical oxygen demand in Asa river, Ilorin, Nigeria.

Adebayo, S.A and Usman, L.A

Department of Chemistry, University of Ilorin, Nigeria

Received 20 September 2009; received in revised form 12 November 2009; accepted 1 December 2009

Abstract

The impact of municipal and industrial waste discharges into Asa river in Ilorin, Kwara State, Nigeria was investigated. Sections of the river along its course within the metropolis were studied by collecting water samples from five different points; Asa Dam, Unity Bridge, Station Bridge, Amilengbe Bridge and Kangile Village. Sampling and analysis were carried out at monthly interval (April 2008 to March 2009) for a period of twelve months covering both the rainy and dry seasons. Concentrations of ammonia – nitrogen ($\text{NH}_3 - \text{N}$), carbon dioxide (CO_2), dissolved oxygen (DO) and biochemical oxygen demand (BOD_5) were determined at each sampling point as a measure of organic pollution in the river. The results indicate that the quality of Asa river water was acceptable before entering and after leaving the town but pollution sets in as the river flows through the town indicating that the river receives significant inputs of wastes from both domestic and industrial sources. Also, the level of pollution was found to be season dependent.

Keywords: Pollution, river, waste, domestic, industrial

Introduction

The potential pollution index of Nigeria rivers was still considered to be low (Zoeteman, 1976). However, the astronomical growth in population (as revealed by the 1991 and 2006 national population census) with the resultant increase in human activities pose a serious threat to river water quality due to increase in the rate of discharge of crude domestic and trade sewage into streams and rivers which out-steps the self – purification capabilities of the rivers. This results in severe deterioration of river water quality. For example discharge of water containing high ammonia level into Okrika river near Port-Harcourt from a fertilizer company was reported to have caused massive fish kill and socio – economic problems for the artisanal fishery industry in the surrounding village. Similarly, rivers Rido and Romi in Kaduna were reported to be grossly polluted by spillage of petroleum product from the Kaduna refinery (FEPA, 1991).

Asa river catchment basin is about 1040 km² in area, straddling two states of Nigeria (Osun and Kwara). Of this, only about 309 km² lies in Osun State (Oyegun, 1983). The importance of the river to socio – economic growth of Ilorin town and its environs can not be over emphasized. The river serves as water source for both industrial and domestic uses. About 70 % of domestic and industrial water requirements of the town and its environ is obtained from Asa river. That probably explains why most industries in the town are sited along its bank or its tributaries. Besides this, the river is being used for agricultural activities such as irrigation of farmlands and fishing. It is also used for recreational purposes (particularly at Asa Dam).

In view of the above – mentioned importance of the river to the town, coupled with the phenomena growth in population (as shown by 2006 national population census figures) and economic activities in the town in recent time with the resultant effect on the water quality of the river and the health implication of this on the residents (WHO, 1976), the river deserves constant monitoring. Hence, this study was designed to measure the level of organic pollution in the river as an assessment of the impact of both domestic and industrial waste discharges into the river.

Materials and methods

Sampling Site

The map showing the sampling sites is as shown in Fig. 1. Five sampling points were identified along the river's course in the town. They are:-

Point I (Asa Dam): - The river is dammed at this point with large volume of water before the river enters the town.

Point II (Unity Bridge): It is about 5 km from point I. The river receives significant run - off waters from farmland and industrial effluents between points I and II.

Point III (Station Bridge): This point is about 1km from sampling point II. The river receives run - off water from streams and drainages from heavily populated residential area. Significant commercial activities with the resultant huge waste generation occur between points II and III.

Point IV (Amilengbe Bridge): This is about 1.5 km from point III. The river receives a lot of run - off from drainages and refuse dumps between points III and IV.

Point V (Kangile Village): This is at the outskirts of the town. It is about 8 km from point IV.

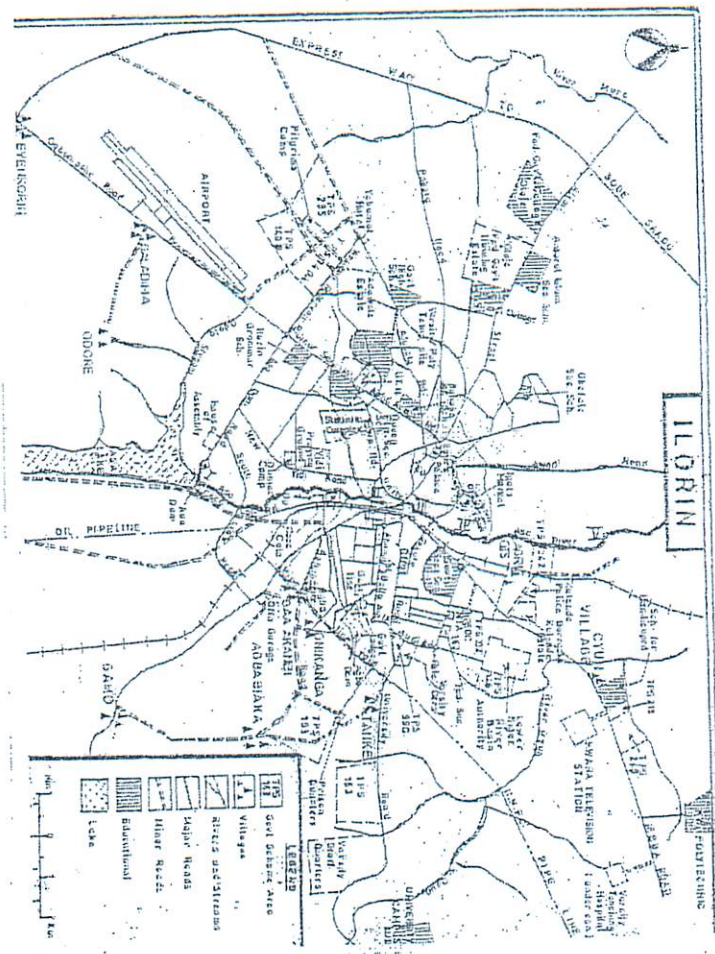


Fig. 1: Map of Ilorin metropolis showing the sampling points on Asa River

Sampling

Samples were collected at approximately monthly intervals from April 2008 to March 2009 (12 months) covering both the rainy and dry seasons. Sample collections usually took place between the hours of 7.00 and 10.00. Standard sampling method for river water was used (Hanson, 1973, Olajire and Imeokparia, 2000). Samples for the determination of dissolved oxygen (DO) were collected in pre – cleaned dark glass containers and fixed on the spot with Winkler reagent while pre – cleaned plastic containers were used for samples for $\text{NH}_3\text{-N}$ and CO_2 determination.

Methodology

Standard methods recommended for the analysis of river water were used for the determination of all parameters (Onianwa *et al.*, 1991). Storage and treatment of water samples were done according to recommended standard methods (APHA-AWWA-WPCF, 1975). All reagents used in this work were of analytical grade.

Results and discussion

The results of analysis are shown in Tables 1 – 5. The value of each parameter for the month is an average of three determinations.

Table 1: Concentrations of $\text{NH}_3\text{-N}$, CO_2 , DO and BOD_5 at Point 1(Asa Dam)

Parameters	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR
$\text{NH}_3\text{-N}$ (mg/l)	7.3	6.8	6.7	6.8	6.7	6.0	5.8	4.5	7.8	7.8	7.8	7.7
CO_2 (mg/l)	3.5	3.6	3.6	3.5	3.6	3.5	3.6	3.8	3.6	3.4	3.2	3.4
DO ($\text{mgO}_2\text{/l}$)	17.1	18.0	18.8	19.6	19.7	19.9	21.4	24.6	21.0	18.8	16.7	17.2
BOD_5 ($\text{mgO}_2\text{/l}$)	5.4	5.2	5.0	4.6	3.8	3.8	3.6	3.0	5.5	5.5	5.6	5.6

Table 2: Concentrations of $\text{NH}_3\text{-N}$, CO_2 , DO and BOD_5 at Point II (Unity Bridge)

Parameters	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	MEAN
$\text{NH}_3\text{-N}$ (mg/l)	13.5	13.5	13.3	13.1	12.5	11.7	11.5	10.5	11.5	13.0	14.5	14.1	12.7
CO_2 (mg/l)	2.8	2.9	2.9	3.0	3.0	3.1	3.5	3.6	3.5	3.0	2.6	2.8	3.1
DO (mgO_2/l)	14.7	14.9	15.0	15.3	15.8	16.6	17.0	18.4	14.9	12.9	11.6	14.5	15.1
BOD_5 (mgO_2/l)	7.4	6.6	6.6	6.4	6.3	5.8	5.4	4.2	5.4	6.6	7.7	7.6	6.3

Table 3: Concentrations of $\text{NH}_3\text{-N}$, CO_2 , DO and BOD_5 at Point III (Station Bridge)

Parameter	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	MEAN
$\text{NH}_3\text{-N}$ (mg/l)	14.9	14.7	14.6	14.5	14.0	13.5	12.7	11.0	12.8	14.5	16.1	15.6	14.1
CO_2 (mg/l)	2.4	2.6	2.5	2.6	2.8	2.9	3.5	3.6	3.5	3.0	2.4	2.5	2.9
DO (mgO_2/l)	11.8	12.2	12.8	13.4	14.2	14.7	15.7	15.8	13.7	12.0	10.6	11.2	13.2
BOD_5 (mgO_2/l)	7.6	7.4	7.2	7.1	6.8	6.0	5.9	4.7	5.8	7.2	8.6	7.9	6.9

Table 4: Concentrations of $\text{NH}_3\text{-N}$, CO_2 , DO and BOD_5 at Point IV (Amilengbe Bridge)

Parameter	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	MEAN
$\text{NH}_3\text{-N}$ (mg/l)	16.0	15.8	15.5	15.1	14.5	14.5	14.0	12.6	13.5	15.4	17.3	16.5	15.1
CO_2 (mg/l)	2.2	2.3	2.4	2.7	2.5	3.0	3.2	3.5	3.6	2.9	1.8	2.2	2.7
DO (mgO_2/l)	11.6	11.8	12.5	13.1	13.9	14.0	14.2	14.6	12.5	10.2	9.3	11.2	12.4
BOD_5 (mgO_2/l)	8.4	8.1	8.1	8.0	7.9	7.8	7.6	5.0	7.4	7.8	8.8	8.6	7.8

Table 5: Concentrations of $\text{NH}_3\text{-N}$, CO_2 , DO AND BOD_5 at Point V (Kangile Village)

Parameter	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR
$\text{NH}_3\text{-N}$ (mg/l)	7.4	6.9	6.8	6.7	6.8	6.1	5.9	4.7	6.9	7.4	8.3	7.8
CO_2 (mg/l)	3.5	3.7	3.8	3.5	3.6	3.7	3.8	4.0	3.7	3.5	3.3	3.5
DO (mgO_2/l)	17.0	17.9	18.9	19.3	19.3	19.8	21.1	24.3	20.9	18.8	16.2	17.1
BOD_5 (mgO_2/l)	5.3	5.1	4.9	4.6	4.2	3.8	3.3	2.9	3.6	4.8	5.5	5.1

$\text{NH}_3\text{-N}$ concentrations were generally low in Asa dam and Kangile village i.e. the first and last sampling points with annual average of 6.8 and 6.2 mg/l respectively. It rose steeply at the Unity Bridge with a value almost twice that of Asa Dam. This sharp rise in concentration could be attributed to the discharge of wastes carried by tributaries which empty into the river between point I and II. Also, the discharge of industrial effluents into the river by the industries which are mostly located between points I and II is another strong contributory factor. Many of the industries in the town are sited along points I and II as the region is an industrial layout. The concentrations continued to rise at station bridge (Point III) and reached a peak at Amilengbe (Point IV) before finally dropping sharply at Kangile Village (Point V). Points III and IV are both located within the heart of the town with heavy residential population with resultant heavy waste generation (both domestic and commercial), which ultimately finds its way into the river via run – off from streams, drainages or by direct discharge of solid /liquid waste into the river. According to Manahan (1993), NH_3 is the initial product of the decay of nitrogenous organic waste and its presence frequently is indicative of such waste. Consequently, the increasing concentration of $\text{NH}_3\text{-N}$ downstream strongly indicates continuous addition of nitrogenous organic waste mainly from domestic and industrial sources downstream. This position is further corroborated by the increase in Biochemical Oxygen

Demand (BOD_5) down stream in similar pattern with NH_3-N up to Amilengbe bridge and a decrease in the carbon dioxide (CO_2) content (due to increase in level of photosynthesis i.e. increase in CO_2 consumption) as a result of increase in the deposition of domestic wastes particularly human waste into the river.

Signs of eutrophication such as massive growth of green algae and aquatic plants on the surface of the river were discernible at points II, III and IV with consequent decrease or absence of fish as a further confirmation of pollution of the river by domestic wastes. However, the drop in value of NH_3-N , BOD_5 and the rise in CO_2 at Kangile village, which is on the out-skirt of the town can be ascribed to 'self - purification' process of the river. According to Soltero (10), one of the most important indicators of organic pollution in the course of a river is the development of an 'oxygen - sag' along the river. The concentration of Dissolved Oxygen (DO) decreases from Asa Dam (Point I) down to Amilengbe Bridge (Point IV) and then increased again at Kangile village. The 'oxygen - sag' noticed between point II - IV (Fig. 2) is a further confirmation of the organic pollution at these points occasioned by indiscriminate discharge of domestic waste either directly into the river or as run - offs through drainages or streams, which finally enter the river.

A general trend that could be seen from the Tables (1-5) is that highest concentrations of DO and CO_2 were recorded in the month of November while lowest concentrations were recorded in February and vice versa for NH_3-N and BOD_5 . The explanation for this could be that the month of November was the last month of the rainy season coupled with characteristic heavy rainfall in the last two preceding months, there was large volume of water in the river with the consequent increase in 'self - purification'. While on the other hand, the month of February corresponded to the last month of dry season and the river was characterized by small volume of water with little 'self - purification' capability. Also, during the dry season, there was easier accessibility to the river banks for various human activities such as dumping of refuse, defecating etc unlike the rainy season where the banks became difficult to reach.

Levels of DO, BOD_5 and eutrophication are known to affect the survival of fishes in river. The presence and types of fishes in a river have been used as 'indicator' of the river water quality. For example, absence of fish indicates gross pollution; presence of some fishes only indicates some pollution while a river which supports a wide variety of fishes may be considered clean (Jonnalagadda et al, 1991). Between points II and IV, no fishing activity was noticed, indicating heavy pollution but intensive fishing activities were observed at Egbejila (before point I) and the Asa Dam (point I) indicating little or no pollution at these points.

On the basis of water quality classification adopted in a number of countries according to Prati *et al* (1971), Asa river water quality was acceptable at Point I (Asa Dam) and Point V (Kangile village) in term of BOD_5 while Point II (Unity bridge) and point III (Station bridge) were slightly polluted and that of point IV (Amilengbe) was polluted. On the basis of NH_3-N , the river was polluted at point I and V and heavily polluted between points II - IV. The trend of the results obtained is similar to the work of Ajayi and Adeleye (13), Jonnalagadda et al (Jonnalagadda et al, 1990, Adebayo and Adediran, 2005).

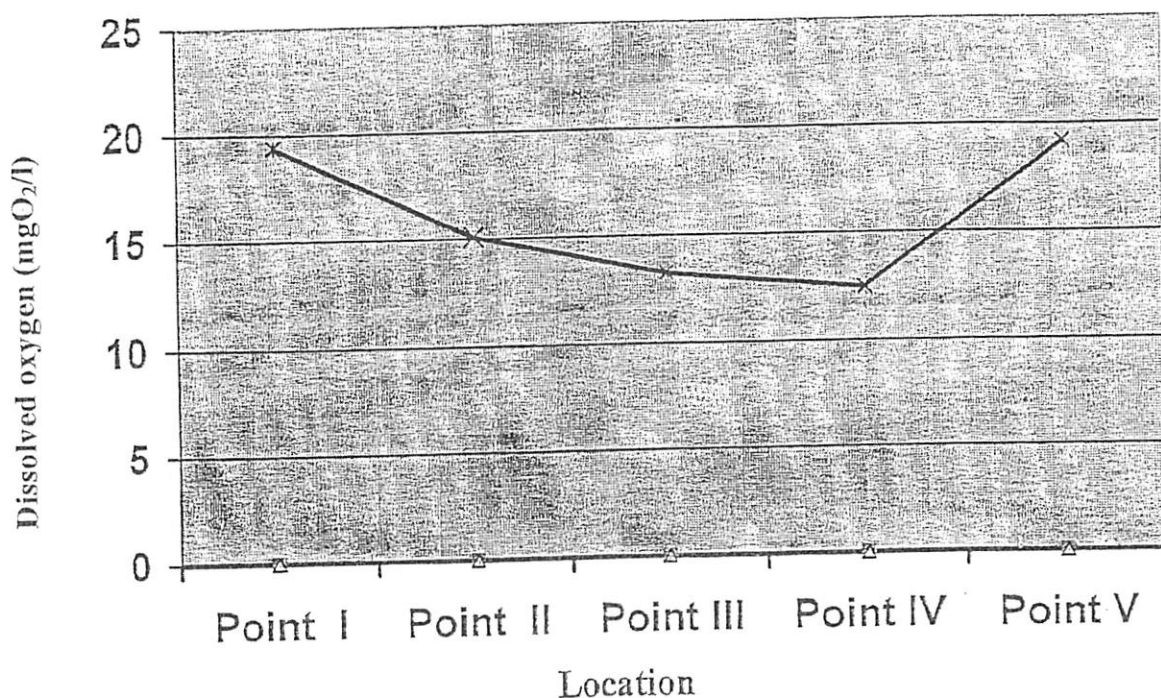


Fig. 2: 'Oxygen sag' Along Asa River

Conclusion

From the results contained in the Tables above and comparing with standards used in water quality classification, it can be concluded that Asa river was polluted especially with organic pollutants as a result of waste being discharge into the river and that the level of pollution increases down stream as it transverse the heart of Ilorin town. However, the river was able to recover from the pollution shortly after leaving the town due to 'self – purification'. Also, the level of pollution of the river was high during the dry season and low during the rainy season because of the small volume of water in the river with little 'self-purification' capability. The waste being discharged into the river apart from polluting the river, causes shallowness of the river thus rendering it non – navigable. Because of this, the use of the river for water transportation is made impossible.

References

- Adebayo S.A and Adediran G.O. (2005), Effect of Waste Discharges on the Water Quality of Asa River in Ilorin, Nigeria; *Science Focus*, 10 (2), 116-122
- APHA – AWWA – WPCF (1975), Standard Methods for the Examination of Water and Waste Water, 14th Edition, APHA, Washington.
- Ajayi, S.O; Adeleye, S.A. (1977), Preliminary Studies on Rivers Ogunpa and Ona in Ibadan, Nigeria, *Bull. Chem. Soc. Nig*; 2,71-85.
- Federal Environmental Protection Agency (FEPA) (1991): National Interim Guidelines and Standards for Industrial Effluents, Gaseous Emissions and Hazardous Wastes Management in Nigeria, (71-72)
- Hanson, N.W (1973), Official, Standardized and Recommended Methods of Analyses, 323.
- Jonnalagadda S.B, Mathuthu A.S, odipo R.W and Wandiga S.O. (1991), River Pollution in Developing Countries, A Case Study III, Effect of Industrial Discharges on Quality of Ngong River waters in Kenya. *Bull. Chem.. Soc. Ethiop.* 5 (2), 49-64.

- Jonnalagada S.B; Mathuthu, A. S; Odipo R.W; and Wandiga S.O. (1990), River Pollution in Developing Countries, A Case Study; Effect of Waste Discharges on Quality of Ruiruaka River Waters in Kenya. *Bull. Chem. Soc. Ethiop.* 4 (2), 89-103.
- Manahan, S.E. (1993), Fundamentals of Chemistry, 423.
- Oyegun R. (1983), Water Resources in Kwara State, 5-10
- Olajire A.A., Imeokparia F.E. (2000); A Study of the Water Quality of the Osun River; Metal Monitoring and Geochemistry, *Bull. Chem. Soc. Ethiop.* 14 (1), 1-8.
- Onianwa, P.C; Adeyemi, O.G and Sofunwa, H.A.A. (1991). Pollution of Surface and Ground Water Around Aperin Solid Waste Land Fill Site in Ibadan City, *Nig. J. Science*; 45
- Prati, L. Pavanello, P., Pesarin, F., (1971), *Water Research*, 5, 741-751
- Soltero, R.A. (1969), *Waste Research* (Oxford), 3, 17.
- World Health Organization (1976), *Surveillance of Drinking Water*, WHO, Geneva.
- Zoeteman B.C.J (1976) : The Potential Pollution Index as a Tool for River Water Management, 85-90.