Journal of Environmental Science and Technology

ISSN 1994-7887

science alert

ANSInet
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Journal of Environmental Science and Technology 1 (2): 56-64, 2008
ISSN 1994-7887

An Assessment of the Impact of Abattoir Effluents on River Illo, Ota, Nigeria

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Abstract: The aim of this research was to assess the impact of abattoir effluents on River Illo in Ota, Nigeria. In order to achieve this set objective seven sampling locations were chosen along the river course. The choice of locations was to reflect the variations in concentrations of the following important parameters of water quality issue: pH, conductivity, total dissolved solids, total suspended solids, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, ammonia and nitrate among others. The choice of these parameters was based on their relative importance in abattoir effluents composition. Results of analyses revealed impairment in the quality of River Illo by the wash down from the abattoir activities. Dissolved oxygen concentrations ranged between 0.01 and 4.6 mg L^{-1} while the highest concentrations of TSS and TS of 1026 and 1071.5 mg L^{-1}, respectively were obtained at the point of abattoir effluents discharge. The BOD mean value of 312.9 mg L^{-1} obtained for the river water is far above the highest permissible value of 30 mg L^{-1} allowed by the Federal Environmental Protection Agency for discharge into receiving water bodies in Nigeria. The mean value of 783 mg L^{-1} obtained for the COD of the river body corroborates the pollution of the water body. The current water quality status of River Illo from the discharge of abattoir effluents therefore poses both environmental and health hazards to users. In order to redress this and ensure public health safety, River Illo needs adequate treatment before use.

Key words: Abattoir, water quality, impact, slaughter house, purification

INTRODUCTION

Surface and groundwater pollution is a major problem beclouding most developing nations. The source and nature of contamination however vary from one nation to another. Aside, very few percentage of the population in these nations has access to good and safe water while most surface water is either contaminated by industrial effluents or sewerage. The pollution can either be of point source or non-point source. Point sources of pollution occur when pollutants are emitted directly into the water body e.g., from industrial sewage or municipal wastewater pipes. A non-point source delivers pollutants indirectly through environmental changes such as pollution from urban run-off (TCEQ, 2002; Krantz and Kifferstein, 2005). Major known sources of water pollution are municipal, industrial and agricultural. The most polluting of them are sewage and industrial waste discharges into rivers. Industrial effluents mostly contain heavy metals, acids, hydrocarbons and atmospheric deposition (Alam *et al*., 2007). Agricultural run-off is another major water pollutant as it contains nitrogen compounds and phosphorus from fertilizers, pesticides, salts, poultry wastes and wash down

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from abattoirs. Contaminants are usually of varied composition ranging from simple organic substances to complex inorganic compounds with varying degrees of toxicity. Pollution of surface water, the natural habitat for aquatic animals could have consequential impact on man either directly or indirectly since less than 1% of the world's freshwater, about 0.007% of all water on earth is readily accessible for direct human use (UNESCO, 2006; Krantz and Kifferstein, 2005). The pollution of surface water body in any form is a critical issue in water resource management. However, reports have it that large numbers of water bodies in developing nations of the world are grossly polluted. The water quality situation therefore becomes very critical in these countries and of great environmental and public health concerns (World Bank, 1995; WHO/UNICEF, 2005; UNESCO, 2006).

In Nigeria, available reports cite gross contamination of most major River bodies across the nation by discharge of industrial effluents, sewage and agricultural wastes among others (World Bank, 1995). Contamination of river body from abattoir wastes which is the main focus of this study could constitute a significant environmental and health hazards (World Bank, 1995; Coker *et al*., 2001; Nafarnda *et al*., 2006; Osibajo and Adie, 2007). The location and operation of abattoirs are generally unregulated, aside, they are usually located near water bodies where access to water for processing is guaranteed. The animal blood is released untreated into the flowing stream while the consumable parts of the slaughtered animal are washed directly into the flowing water (Adelegan, 2002). Sangodoyin and Agbawe (1992) identified improper management and supervision of abattoir activities as a major source of risk to public health in South Western Nigeria. Wastes from slaughterhouses typically contain fat, grease, hair, feathers, flesh, manure, grit and undigested feed, blood, bones and process water which is characterized with high organic level (Bull *et al*., 1982; Coker *et al*., 2001; Nafarnda *et al*., 2006).

The total amount of waste produced per animal slaughtered is approximately 35% of its weight (World Bank, 1998). In an earlier study, Verheijen *et al*. (1996) found out that, for every 1000 kg of carcass weight, a slaughtered beef produces 5.5 kg of manure (excluding rumen contents or stockyard manure) and 100 kg of paunch manure (partially digested food). The weight of a matured cow varies with size, ranging from 400 kg for thin, 550 kg for moderate to 750 kg for the extremely fat (Hammack and Gill, 2002). Scahill (2003) gave more detailed statistics on both life and dead weight of a cow in his study. A cow weighing 400 kg would have its carcass weight reduced to about 200 kg after slaughter. Furthermore, it looses about one-third in fat and bone after passing through the butcher. Hence a 400 kg live weight animal will give about 140 kg of edible meat which represents only 35% of its live weight. The remaining 65% are either solid or liquid wastes. Corroborating the above findings, Gannon *et al*. (2004) showed in their study that a slaughtered cow produced 13.6 kg of blood (with bovine blood density ranging between 0.01 and 0.15 g cc^{-1}). Moreover, the volume of water required for meat rendering or processing ranged between 1.5 and 10 m^3 t^{-1} of product for hogs, 2.5 and 40 m^3 t^{-1} of product for cattle and 6 and 30 m^3 t^{-1} of product for poultry. The organic load from abattoirs could be very high. Tritt and Schuchardt (1992) reported a COD level as high as 375000 mg L^{-1} for raw bovine blood. Comparatively, in another study conducted by Mittal (2004), on abattoirs in Québec, Canada, typical values for a range of parameters in abattoirs wash down were given: TS concentrations (2333-8620 mg L^{-1}); TSS (736-2099 mg L^{-1}); while average levels of nitrogen and phosphorus were evaluated at 6 and 2.3 mg L^{-1}, respectively. Hence, abattoir effluents could increase levels of nitrogen, phosphorus, total solids in receiving water body considerably. Excess nutrients cause the water body to become choked with organic substances and organisms. When organic matter exceeds the capacity of the micro-organisms in water that break down and recycle the organic matter, it encourages rapid growth, or blooms, of algae, leading to eutrophication. Equally, improper disposal systems of wastes from slaughterhouses could lead to transmission of pathogens to humans and cause zoonotic diseases such as Coli Bacillosis, Salmonellosis, Brucellosis and Helminthes (Cadmus *et al*., 1999). Improper management of abattoir wastes and subsequent disposal either directly or indirectly into river bodies portends serious environmental and health hazards both to aquatic life and humans. The current study therefore aimed at assessing the water quality of River Illo and the impacts of abattoir effluents on its quality.

MATERIALS AND METHODS

The Study Area

River Illo which is the focus of this study is located within River Owo catchments area in Ota, Ogun State, Nigeria. The river drains 24 km stretch of land along the boundary of Lagos and Ogun States. Ota town lies between latitudes 60° 30 and 60° 50 N and longitudes 30° 02' and 30° 25' E, with a very close proximity to the city of Lagos. It is the fourth largest city in Ogun State with an estimated population of about 103,332. The Ota segment of River Illo where an abattoir is located is the main thrust of the current study. The abattoir is a small-scale business enterprise and it is managed by an Association of independent butchers. The slaughtering area measures 150 m^2 in size, fenced with sandcrete blocks while the floor is made of concrete slab. An average number of slaughtered animals per day are 15 cows, 20 sheep and goats. Normal abattoir operations are carried out from Monday to Saturday. The blood wash and the process water from the abattoir is channeled directly into River Illo; about 10 m away from the slaughter slab (Fig. 1).

Field Sampling and Laboratory Analysis

Field sampling was carried out at the tail end of the dry season in March 2006. Seven water samples designated S_1 to S_7 were collected from the sampling locations along the river course as shown in Fig. 1. Sample S_1 was collected at a distance of 10 m upstream of S_2, while S_2 is the abattoir effluent discharge point into the river body and it is designated 0 m distance.

Samples S_3 to S_7 were taken downstream of S_2 and at distances of 10, 20, 30, 50 and 100 m, respectively. The full description of the sampling locations is shown in Table 1. At each sampling location, water samples were collected in polyethylene bottles. All bottles were previously washed with non-ionic detergent and finally rinsed with deionized water prior to usage. Before the final water samplings were done, the bottles were rinsed three times with the river water at the points of collection.

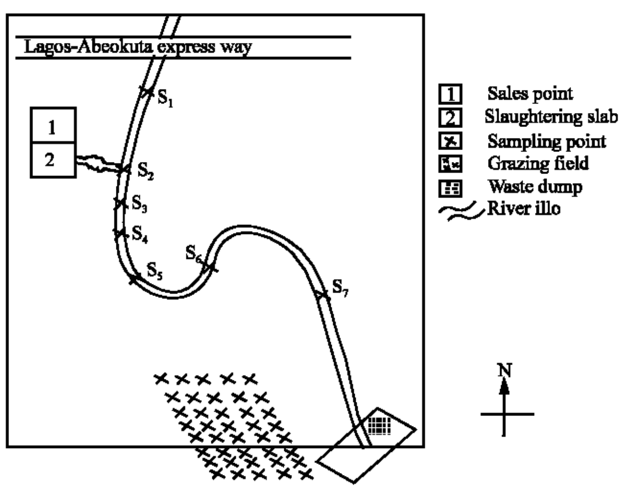

Fig. 1: A sketch of studied area with sampling points

Table 1: Sampling location description

Designation	Distances upstream and downstream from point of discharge (m)	Characteristics
S_1	10	Sampling point located 10 m upstream with respect to the abattoir effluent discharge point. It serves as control
S_2	0	Sampling point at abattoir effluent discharge point
S_3	10	Sampling point located 10 m downstream of the point of discharge
S_4	20	Sampling point located 20 m downstream of the effluent discharge point
S_5	30	Sampling point located 30 m downstream of the point of effluent discharge
S_6	50	Sampling point located 50 m downstream of the point of effluent discharge. Noted at this point was narrowing of the river width with vegetation
S_7	100	Located 100 m downstream of the point of effluent discharge

The sample bottles were labeled according to each sampling location. Samples for microbiological analysis were collected in 500 mL sterilized bottles with its mouth stoppered with foil and rubber band. All samples were preserved at 4°C and transported to the laboratory.

The physico-chemical analyses of the various water quality parameters were conducted following standard analytical methods (APHA, 1992). Results of laboratory analysis were subjected to data evaluation by standard statistical methods (Chapman, 1992) and results were compared with WHO and various Nigerian water quality guidelines (FEPA, 1991; FMEnv, 2001; WHO, 2004; NSDWQ, 2007).

RESULTS AND DISCUSSION

The pH of the River Illo is slightly acidic with pH values ranging between 6.20 and 6.90. As known, pH is the indicator of acidic or alkaline conditions of water status; hence the mean pH value of 6.64 obtained for the river body is within the WHO pH tolerance level of drinking water quality standards (Tables 2-4). The TDS values ranged between 45.5 mg L^{-1} at S_2 and 87.7 mg L^{-1} at S_3. It is interesting to note that the minimum value of 45.5 mg L^{-1} was obtained at S_2, the point of abattoir effluents discharge into the river body.

Figure 2 shows a noticeable decrease in TS levels downstream of S_2 indicating existence of a varying level of waste assimilation capacity within the river body. Dissolved oxygen values obtained for S_1 to S_7 varied between 0.01 and 4.6 mg L^{-1} as shown in Table 2. The DO is a measure of the degree of pollution by organic matter, the destruction of organic substances as well as the self purification capacity of the water body. The standard for sustaining aquatic life is stipulated at 5 mg L^{-1} a concentration below this value adversely affects aquatic biological life, while concentrations below 2 mg L^{-1} may lead to death of most fishes (Chapman, 1992). The DO level at S_1, 10 m upstream of S_2, of 4.6 mg L^{-1} was slightly below the level required for the sustenance of most aquatic life, even though the sampling point was found to be the most aerated sector of the river body. At S_2 however, contamination of the river body by the abattoir wash down is more evident. The obtained DO value at this point stands at 0.01 mg L^{-1}. This value is 500 times lower than the tolerance level necessary to support aquatic life. Re-aeration of the river body picked up gradually at S_4 and progressed till S_5, 30 m away from S_2. At S_6, deterioration in the oxygen saturation level could be noticed, with DO concentration dropping to 0.39 mg L^{-1} before it picked up again at S_7 to 3.9 mg L^{-1}. The obtained values for TSS, BOD and COD as shown in Table 2 and Fig. 3, respectively corroborate this inference. The microbiological results, presented in Table 5 indicate gross pollution of the water body at the point of abattoir effluents discharge. At this point, the mean Faecal Coliform count of 2.0×10^3 cfu/100 mL was obtained.

A zero count was recorded at S_1 and from S_3 to S_7, distances upstream and downstream from point of abattoir effluent discharge. For other parameters such as NH_4 and NO_3 their values as shown

Table 2: Physico-chemical characteristics of River Illo

Sample	Distance (m)	pH	TDS (mg L^{-1})	Cond (µS cm^{-1})	TSS	TS	DO	BOD	COD	NH^{+}_{4}	NO^{-}_{3}	PO^{+}_{4}
					---------- (mg L^{-1})		---------	(g L^{-1})	------------------	(mg L^{-1})		--------------
S_1	10	6.7	87.5	105	360	447.5	4.60	170	425	0.04	0.15	0.05
S_2	0	6.8	45.5	196	1026	1071.5	0.01	670	1675	4.40	0.19	3.05
S_3	10	6.6	87.7	143	420	507.7	0.39	270	675	0.13	0.15	0.09
S_4	20	6.5	77.9	153	524	601.9	2.70	270	680	0.18	0.14	0.16
S_5	30	6.9	73.7	150	400	473.7	3.70	140	350	0.21	0.10	0.15
S_6	50	6.8	79.9	176	692	771.9	0.39	380	950	0.52	0.17	0.19
S_7	100	6.2	87.3	113	384	471.3	3.90	290	725	0.11	0.22	0.07

Table 3: Descriptive statistics of physico-chemical characteristics of river Illo

Parameter (mg L^{-1})	Min.	Max.	Mean	SD	Variance	Range	Std. Error
pH	6.20	6.90	6.64	0.24	0.06	0.70	0.09
Cond (µS cm^{-1})	105.00	196.00	148.00	32.19	1036.00	91.00	12.17
TS	447.50	1071.50	620.79	228.45	52188.68	624.00	86.35
DO	0.01	4.60	2.24	1.94	3.75	4.59	0.73
BOD	140.00	670.00	312.86	176.33	31090.48	530.00	66.65
COD	350.00	1675.00	782.86	440.61	194140.48	1325.00	166.54
NH_4^+	0.04	4.40	0.80	1.60	2.55	4.36	0.60
NO_3^-	0.10	0.22	0.16	0.04	0.00	0.12	0.02

Table 4: Various drinking water quality standards and effluent limitation guidelines

Parameter (mg L^{-1})	Drinking water quality standards: Nigerian interim standard	Drinking water quality standards: WHO standard	Effluent limitation guidelines discharge (All industries)
pH	6.5-8.5	6.5-8.5	6.0-9.0
TDS	500	500	2000
Conductivity (µS cm^{-1})	1000	1000	NS
TSS	NS	NS	30
DO	NS	NS	NS
BOD	NS	10	30
COD	NS	100	NS
NH^{+}_{4}	5	0.5	NS
NO^{-}_{3}	50	10	20

NS = Not Specified

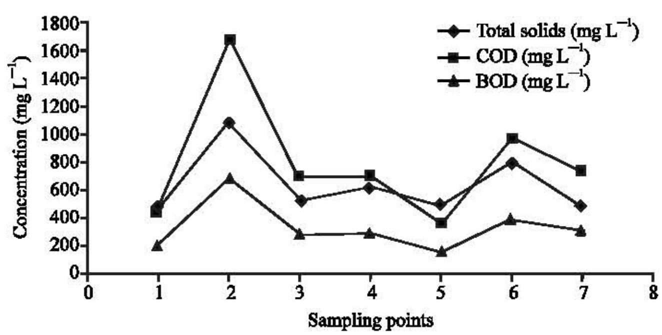

Fig. 2: Trend of TS, BOD and COD levels in River Illo

in Table 2 are quite acceptable compared with WHO and Nigerian interim water quality standards. For example, NH_4 level aside from the point of effluent discharge and at S_6 ranged between 0.04 and 0.21 mg L^{-1}, below the WHO tolerance level of 0.5 mg L^{-1} in surface water for drinking purposes. The highest value of 4.4 mg L^{-1} obtained at S_2 is a direct effect of discharge of the abattoir effluents on River Illo. However, concentrations of NH_4^+ downstream of S_2 would have indicated the fact that the river body is quite safe in terms of ammonia pollution except at S_6 where a relatively low

Table 5: Faecal Coliform counts in water samples

Sampling distance (m)	Faecal coliform* (cfu mL^{-1})
-10	0
0	20000
10	0
20	0
30	0
50	0
100	0

*: WHO Standard 0 cfu/100 mL

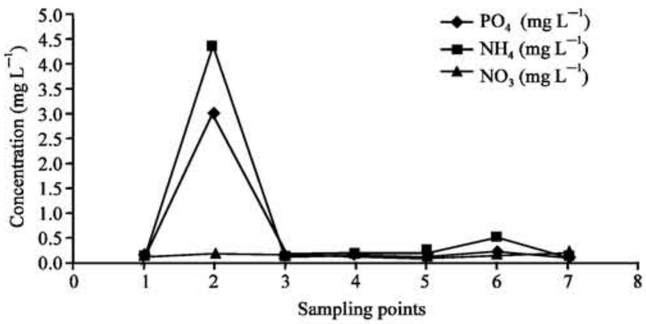

Fig. 3: Trend of NH_4, PO_4, NO_3 levels in River Illo

Fig. 4: Land and water pollution from abattoir activities

value of 0.52 mg L^{-1} was obtained. Figure 3 shows the trend in NH_4^+ along the river course. The conductivity levels in the surface water body ranged between 146 and 196 µS cm^{-1}, most freshwaters values range between 10 and 1000 µS cm^{-1} (Chapman, 1992).

The pollution of River Illo is much more pronounced at S_2 indicative of the impact of abattoir effluents discharge on the river body. This is corroborated by high values of TSS and TS recorded in water samples put at 1026 and 1071.5 mg L^{-1}, respectively. A general trend of increasing assimilation capacity could however be inferred from Fig. 2 and 3 along the river course downstream of S_2. Even though higher values of TS in surface waters are usually attributable to the presence of silt and clay particles (Chapman, 1992), the observed elevated value of 1071.5 mg L^{-1} of TS specific to S_2 is not unconnected with the presence of high level of particulate matter from the abattoir wash down (Fig. 4).

The mean DO concentration of 2.4 mg L^{-1} obtained for River Illo is indicative of its level of contamination. Dissolved oxygen is an important factor that determines the quality of water in lakes and rivers hence, the higher its concentration, the better the water quality. The drop in DO level from 4.6 mg L^{-1} at S_1 to 0.01 mg L^{-1} at S_2 defines the putrid condition of the river at this point. The re-aeration of the river noticed at S_3 could not be sustained beyond S_5. The sharp drop in the DO concentration at S_6 (0.39 mg L^{-1}) from 3.7 mg L^{-1} at S_5 indicates additional source(s) of organic contamination at this very segment other than the discharge of abattoir effluents at S_1. Biological respiration, including one induced by decomposition processes, reduces DO concentrations. Hence, the visible depletion in dissolved oxygen concentration at S_6 is best associated with wash down of organics from the solid waste accumulated near S_6. Observations on the field show an evidence of eutrophication process setting in at this point. Eutrophication results when fresh water is artificially supplemented with nutrients, it results in an abnormal increase in the growth of water plants. Hence, the resulting eutrophication process could produce problems such as bad tastes and odours as well as green scum algae. The growth of macrophyte and other rooted plants decreases the amount of oxygen in the water body (Chapman, 1992; Krantz and Kifferstein, 2005). In small rivers like Illo, occurrence of pockets of high and low concentrations of dissolved oxygen is likely, signifying different rates or cycles of biological processes within the water body along its flow path.

The obtained values for TSS, BOD and COD as shown in Table 2 corroborate this inference. Both the BOD and COD are important water quality parameters and are very essential in water quality assessment. Therefore, the more organic material there is in the abattoir effluents, the higher the BOD. They both indicate the level of organic pollution in water quality assessment. River Illo from the results obtained is organically polluted prior to the discharge of abattoir effluents as shown in Table 2. The absence of Faecal Coliform downstream of S_2 is not the true reflection of the microbiological status of River Illo. Filtration method of microbiological analysis would have clearly indicated otherwise.

Results obtained in this study revealed that the quality of River Illo has been impacted negatively by the activities of the abattoir. Analyzed water samples for the following specific water quality parameters TSS, DO, BOD and COD were above the Nigerian Regulatory Standards and WHO permissible limits (FEPA, 1991; FMEnv, 2001; WHO, 2004; NSDWQ, 2007). The direct discharge of abattoir effluents into River Illo raised the levels of these contaminants at the point of discharge, even though there is a noted increased attenuation in the levels of the parameters downstream.

In conclusion, the following recommendations are made so as to enhance the quality of river Illo and as well protect the public health of the people who depend on it as a source:

- Simple physical treatment of effluents from the abattoir could be carried out by use of a retention pond. The use of retention ponds for pre-treatment of abattoir effluents is an effective physical treatment method in reducing BOD and COD levels (Sangodoyin and Agbawe, 1992).
- Waste management practice by waste reduction, re-use and recycling should be encouraged when and where appropriate and essential. Entrepreneurs dealing in animal wastes such as bones, manure and blood should be encouraged through enabling government policies to convert abattoir wastes to useful products.
- Abattoirs operators should be enlightened by both the State Environmental Protection Agency and NGOs on impacts of wash down from abattoirs on public health, the environment and the fragility of the ecosystem.
- Regular monitoring of activities of abattoirs by the State Environmental Protection Agency and representatives of the municipal government is recommended in order to enhance compliance with hygienic requirements and sanitary regulations governing abattoir operation in the state.
- The research could be expanded to include treatability of abattoir effluents by biological treatment process.

ACKNOWLEDGMENT

The authors are grateful to the management of Covenant University, Ota, for providing the enabling environment for the conduct of this research.

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