Environmental Impact of Abattoir Effluents on Surface Waters of River Idemili

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ABSTRACT

The physico-chemical parameters of River Idemili that receives effluents from an abattoir located close to its bank in Umuota Akuora Village, Obosi, Idemili North Local Government Area of Anambra State Nigeria, was determined using standard methods. High water temperature (30.03 ± 0.01 °C), low dissolved oxygen (1.03 ± 0.04 mg/l), higher levels of BOD (5.53 ± 0.04 mg/l) and higher levels of hardness (4.02 ± 0.03 mg/lCaCO₃), nitrate-nitrogen (6.82 ± 0.03 mg/l), phosphate-phosphorus (3.13 ± 0.004 mg/l) and conductivity (52.21 ± 0.05 µscm⁻¹) which were recorded in station 2 was attributed to discharge of abattoir effluents into the station. Lower levels of the physico-chemical parameters were, however, recorded in station 3. Improvement can be achieved by prohibiting the discharge of untreated abattoir effluents into the river considering the usefulness of this river to the community; waste water treatment should be applied in order to minimize the influence on water quality.

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1. INTRODUCTION

Water is a finite resource that is very essential for human existence, agriculture, industries, etc (Calamari and Naeve, 1994; Aina and Adipe, 1996). It could be described as the engine of life because water in its varied forms accounts for more than 70 percent of the entire earth and life forms. Fresh water has become scarce commodity due to over exploitation and pollution (Gupta and Shunkle, 2006; Patil and Tijane, 2001; Singh and Mathur, 2005).

Rivers are the most important freshwater resources for man. Unfortunately, river water in developing areas is increasingly being polluted by man. Several rivers in urban and semi urban areas of Nigeria have been polluted with untreated solid waste and waste waters. This high pollution status threatens and in many cases, has already altered the ecological balance of most rivers in Nigeria (Arimoro and Osakwe, 2006; Zabbey and Hart, 2006; Arimoro and Ikomi, 2008). Untreated organic effluents from abattoir contaminants flushed into streams particularly in areas of human activities pollute rivers and streams.

Mason (1996) reported that the excessive production of organic matter leads to the buildup of "sludge" and the mineralization process consumes all dissolved oxygen from

a water column. Organic effluents also frequently contain large quantities of suspended solids which reduce the light available to photosynthetic organisms and on setting out, alter the characteristics of river bed, rendering it an unsuitable habitat for many organisms (Raheem and Morenikeji, 2008). This study presents a comprehensive report on the influence of abattoir wastes on the physico-chemical parameters of River Idemili.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

River Idemili (Figure 1) is a hydrographic stream in South-eastern Nigeria. It is located at an elevation of 64 meters above sea level and its coordinates are 6°7'0"N and 6°46'0" E. The river lies approximately 7 kilometers south of Onitsha, along the old Owerri-Onitsha Trunk road. This tropical area has an average annual rainfall of 2000mm. The river's tributaries include Idemili stream and close to this river is an abattoir house located at its bank. Slaughtering of cows occurs within the slaughter house while roasting of cow heads, skin and hind limbs with wood and condemned tyres occur in the open. These activities have darkened the soil within the roasting area while waste water from washing of roasted cow parts and abattoir drain into the river. Three stations were sampled.

Figure 1: Map of the Study Area.

Station 1

This station had a mixture of sandy and loamy soil with intensive agricultural activities occurring around the river. It is wide and deep. Light penetrates directly into this station. There are no canopies of leaves and true aquatic littoral flora consists of macrophytes growing along the river banks which include *Pennisetum purpureum*, *Colacasia esculenta* and *Elaeis guineensis*.

Station 2

The abattoir is located close to this station. It has sandy, loamy and clayey soil. The soil is mostly oily because of the slaughtering activities. Human activities in and around this station include slaughtering of cows, roasting and washing of cow hides and viscera. Macrophytes in this station include *Bambuseae* sp., *Heteropogon contortus* and *Raphia hookeri*.

Station 3

This station is located near the bridge across the river that is along Owerri-Onitsha express road. The soil is sandy and human activities in and around this station includes performing of rituals by idol worshippers, washing of motorcycles, swimming and dumping of refuse. *Psidium* sp., *Algae* and *Heteropogon contortus* were among aquatic plants observed in this station.

2.2 Collection of water samples

Water sample collection was done forth nightly for twelve months (January to December) between 9am to 10am, using

acidified plastic bottles. Water sample for dissolved oxygen, which was collected using 500 ml Nessler bottles at about 12 noon. Air and water temperatures were determined in situ by 2 min. immersion of mercury in bulb thermometer. Transparency was measured using a 25 cm secchi disc. Other physico-chemical parameters were measured based on methods described in APHA (1989).

2.3 Data analysis

Data obtained from the study were expressed as mean $\pm$ S.D of triplicate determinations. Differences in means were compared using analysis of variance (ANOVA) at $p < 0.05$. Where the difference in ANOVA is significant least significant difference (LSD) was used to separate means.

3. RESULTS

Mean values of physicochemical parameters in the 3 stations are presented in Figures 2-12.

Air temperature (°C)

Air temperature varied significantly ($p < 0.05$) at the study stations. The highest mean air temperature value (35.76 ± 0.01 °C) was recorded in March while the lowest mean value (25.52 ± 0.00 °C) was obtained in July (Figure 2). Station 2 with the highest mean air temperature (35.76 ± 0.01 °C) is significantly higher ($p < 0.05$) than station 1 with the lowest mean value (25.52 ± 0.00 °C) and station 3 (25.90 ± 0.28 °C) which are not significantly different from each other.

Figure 2: Mean variation in air temperature (°C) in relation to stations of River Idemili.

Water temperature (°C)

Mean water temperature values for the study stations varied significantly ($p < 0.05$) from 25.15 ± 0.07 °C at station 1 in July to

30.03 ± 0.01 °C at station 2 in February (Figure 3) in the three study stations. Station 2 is significantly higher ($p < 0.05$) than stations 1 and 3 which are not significantly different from each other.

Figure 3: Mean variation in water temperature (°C) in relation to stations of River Idemili.

pH

The mean pH values of River Idemili did not vary significantly ($p > 0.05$) from 5.00 ± 0.00 at station 1 in November to 6.76 ± 0.04 at station 3 in September in the three stations (Figure 4).

Figure 4: Mean variation in pH in relation to stations of River Idemili.

Turbidity (NTU)

Turbidity varied during the study. The minimum value (12.02 ± 0.02 NTU), station 1 and maximum value (53.00 ± 0.00 NTU), station 3 were respectively obtained in

November and May (Figure 5). One-way analysis of variance revealed that the mean turbidity values in the three stations were significantly different ($p < 0.05$). Station 3 is significantly lower ($p < 0.05$) than stations 1 and 2 which are not significantly dissimilar.

Figure 5: Mean variation in turbidity (NTU) in relation to stations of River Idemili.

Dissolved Oxygen (mg/l)

Figure 6 revealed that the maximum mean value of dissolved oxygen was recorded in station 1 (5.48 ± 0.02 mg/l). This was followed by station 3 (5.45 ± 0.00 mg/l). The minimum mean

value of dissolved oxygen was recorded in station 2 (1.03 ± 0.04 mg/l). Station 2 is significantly lower ($p < 0.05$) than stations 2 and 3 which are not significantly different from each other. The values of dissolved oxygen in the stations ranged from 1.03 ± 0.00 mg/l (Station 2) in January to 5.48 ± 0.00 mg/l (station 1) in July.

Figure 6: Mean variation in dissolved oxygen (mg/l) in relation to stations of River Idemili.

Biochemical Oxygen Demand (BOD) (mg/l)

Station 1 had the lowest biochemical oxygen demand mean value (1.02 ± 0.69 mg/l) in March (Figure 7). The highest

mean value (5.53 ± 0.04 mg/l) was recorded in May. Station 2 with the highest mean value (5.53 ± 0.04 mg/l) is significantly higher ($p < 0.05$) than stations 1 and 3 which do not differ significantly.

Figure 7: Mean variation in biochemical oxygen demand (mg/l) in relation to stations of River Idemili.

Alkalinity (mg/l CaCO_3)

The mean values of alkalinity which ranged from 0.21 ± 0.01 mg/l at station 1 and 4.22 ± 0.03 mg/l at station 2 were both obtained in June (Figure 8). Analysis of variance result showed a significant difference ($p < 0.05$) in alkalinity at the three stations. Station 2 is significantly higher ($p < 0.05$) than stations 1 and 3 which are not significantly different from each other.

Figure 8: Mean variation in alkalinity (mg/l CaCO_3) in relation to stations of River Idemili.

Hardness (mg/l CaCO_3)

There was wide variation in mean values of hardness recorded during the study. Station 1 had the lowest mean value of 0.52 ± 0.03 mg/l while station 2 had the highest mean

hardness concentration (4.02 ± 0.03 mg/l) (Figure 9). Station 2 is significantly higher ($p < 0.05$) than stations 1 and 3 which did not differ significantly from each other. Hardness mean values in the months varied between 0.52 ± 0.03 mg/l in April (station 1) and 4.02 ± 0.03 mg/l in July (station 2).

Figures 9: Mean variation in hardness (mg/l CaCO₃) in relation to stations of River Idemili.

Nitrate-nitrogen concentration (mg/l)

The mean concentration of nitrate-nitrogen recorded for the three stations ranged from 3.52 ± 0.03 mg/l at station 1 to 6.82 ± 0.03 mg/l at station 2 (Figure 10). Station 2 with highest

mean value (6.82 ± 1.03 mg/l) was significantly higher ($p < 0.05$) than stations 1 and 3. The highest mean concentration value (6.82 ± 1.03 mg/l (station 2) and the lowest mean value (3.52 ± 0.03 mg/l, station 1) of nitrate-nitrogen were recorded in September and January respectively.

Figure 10: Mean variation in nitrate-nitrogen (mg/l) concentration in relation to stations of River Idemili.

Phosphate-phosphorus concentration (mg/l)

Figure 11 showed that the range of mean phosphate-phosphorus values recorded during the study was 0.02 ± 0.01 mg/l at station 1 in April and May, and 3.13 ± 0.04 mg/l at

station 2 in July. The mean concentrations of phosphate-phosphorus at station 2 is significantly higher ($p < 0.05$) than that of stations 1 and 3 which are not significantly different from each other.

Figure 11: Mean variation in phosphate-phosphorous (mg/l) in relation to stations of River Idemili.

Conductivity (μscm^{-1})

The lowest mean value for conductivity was recorded at station 1 ($31.02 \pm 0.01 \text{ mg/l}$) in January (Figure 12) while the

highest mean value of $52.21 \pm 0.05 \mu\text{scm}^{-1}$ was recorded at station 2 in October. The mean conductivity values at the three stations are not significantly different ($p > 0.05$).

Figure 12: Mean variation in conductivity (μscm^{-1}) in relation to stations of River Idemili.

4. DISCUSSION

The mean air and water temperature range recorded from River Idemili are typical of tropical rivers. Water temperature falls within the surface water stipulated range of $25\text{--}30^\circ\text{C}$ for aquatic organisms (WHO, 1984). The maximum water temperature obtained in station 2 can be attributed to abattoir effluent discharge from the abattoir located around this station. Temperature rise depends on the amount of heat discharge, the mode of release, the properties and quantity of receiving waters, climate and weather (Haslam, 1990; Reheem and Morenikeji, 2008). An increase in temperature will lead to an increase in the rate of chemical reactions and formation of dangerous complexes. It also shortens the life cycles of some invertebrates in a river below a heated discharge (Raheem and Morenikeji, 2008).

pH measures the acidity or basic nature of solution (Chapman, 1996). The maximum pH in station 3 may be due to the photosynthetic activities of algal and plant growth in this station. pH is a vital environmental characteristic that decides the physiological, metabolic survival, and growth of aquatic organisms (Ramanathan *et al.*, 2005). The mean pH recorded indicates that River Idemili was slightly acidic. Normal biological activity is restricted to 6–8, for natural water (Adakole and Anunne, 2003; Adakole, *et al.*, 2008). pH varied slightly at the study stations with an approximate mean range of 6.8 ± 0.04 to 5.00 ± 0.00 . This is in consonance with the observation of Wetzel (1975) that, low pH are found in natural water rich in dissolved organic matter. The low variability of pH value could be as a result of abattoir wastes not having significant effect on the pH of the River. Hynes (1975) has attributed low variability to streams being resistant to pH changes to chemical buffering effects. Although definitive, pH range of the aquatic systems is an important indicator of the water quality and the extent of pollution in watershed area (Adakole, 2007). Ibemenuga and Inyang (2007) recommended a pH range of 6.5–9.5 as suitable for aquatic life.

Turbidity was highest in station 3 as a result of excessive algal growth, riparian vegetation, in addition to the abattoir effluent transported downstream from station 2. Turbidity measures the clarity or cloudiness of water. The more suspended solids in the water the murkier it seems and the higher the turbidity (Rao, 1993). High turbidity will reduce primary production and also oxygen levels in pond which will increase the susceptibility of fish to fungal diseases (Boyd, 1979).

Dissolved oxygen is an important gas, necessary for respiration of aquatic biota hence Adeniji (1986) described it as one of the most important substances which aquatic organisms cannot survive without. Dissolved oxygen is a relative measure of the amount of oxygen that is dissolved or carried in a given medium (Chiya and Izumi, 1995). The minimum concentration of dissolved oxygen in fresh water necessary for aquatic fauna to live in is about 5 mg/litre (Odiete, 1999). Dissolved oxygen mean value obtained for the three stations ranged from $1.03 \pm 0.04 \text{ mg/l}$ in station 2 to $5.48 \pm 0.2 \text{ mg/l}$ in station 1. These values were lower than the value Offem *et al.* (2011) reported for Calabar River, and the WHO (2004) limit of 6.0 mg/l. The low dissolved oxygen recorded during the study could be attributed to high organic pollution. BOD which measures organic pollution of aquatic bodies was maximum in station 2. This could be due to abattoir effluents containing large amounts of organic waste which was as a result of the abattoir located here.

Low alkalinity values were recorded in the three stations. ANOVA revealed significant difference ($p < 0.05$) in the mean concentrations of alkalinity in the three stations.

The mean hardness values for the stations which ranged from $0.52 \pm 0.03 \text{ mg/l CaCO}_3$ in station 2 falls within the classification of soft water. This probably was due to inflow of rain water which neutralizes the chemical composition of the abattoir effluent within the river. The maximum mean value of hardness recorded in station 2 could be due to concentration effect from entry of organic effluents and

evaporation due to high temperature based on the hardness classification of water; soft (0-55 mg/lCaCO₃), slightly hard (56-100 mg/lCaCO₃), moderately hard (101-200 mg/lCaCO₃ and 201-500 mg/lCaCO₃ as modified from Outreach Department (OD) of natural Water Resources Institute Kaduna (1997).

Nitrate-nitrogen is among the common nitrogen compounds occurring in dissolved particulate and gaseous forms. Nitrate-nitrogen is soluble and easily absorbed by aquatic biota. Generally, the mean value (4.57±0.9 mg/l) of nitrate concentration in River Idemili was lower than the WHO (2004) limits of 10 mg/l for rivers and streams. Odiete (1999) noted that a characteristic feature of most tropical waters is low rate which results in rapid utilization of nutrients. The low level of nitrate-nitrogen also indicates the good health status and self-purification capacity of the river despite the discharge of abattoir waste into it as excessive concentrations of nutrients can over stimulate aquatic plant and algal growth and cause oxygen depletion and eutrophication which may deprive fish and invertebrates of available oxygen in the water (Agwa *et al.*, 2013).

Phosphate-phosphorus is among nutrient determinants of phytoplankton productivity and hence fish production (Welcome, 1978; Boyd and Lichtkoppler, 1979; Wetzel and Likens, 1978; King, 1998). The concentration of phosphate-phosphorous above 0.5 mg/l was an indication of pollution (Agarwal, 1991; Raheem and Morenikeji, 2008). This indicates that station 1 with the maximum mean phosphate-phosphorous concentration (1.6±0.75 mg/l) is polluted. This station is mostly polluted compared with station 1 (0.25±0.19 mg/l) upstream and station 3 (0.42±0.23 mg/l) downstream.

Electrical conductivity in natural waters depends on the geology, land use, flow, runoff, ground water inflows' temperature, evaporation and dilution. The higher mean value 45.71±0.01 uscm⁻¹ recorded in station 2 may be attributed to concentration effect of the water due to abattoir effluent discharged through this point into the river. Conductivity of freshwater ranged from 10-1000 µscm⁻¹ but may exceed 1000 µscm⁻¹ (Asuquo, 1999; Offem *et al.*, 2011). The mean value of conductivity recorded for the three stations is within the range for fresh water.

5. CONCLUSION

The result of this study revealed that the abattoir effluents discharged into River Idemili impacted negatively on the physical and chemical characteristics of the river. Since water quality attributes are prime factors that influence the survival of aquatic life, there is need to treat abattoir effluents before discharge into the river.

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