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Physico-Chemical and Microbial Analysis of the Impact of Abatoir Effluents on Ogun River Course

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Abstract: There is always need for reduction in the impact of natural and most especially anthropogenic pollution to enhance water quality, food safety and sustainable development. This led to assessing the impact of Lafenwa abattoir effluents on Ogun river course in Abeokuta, Nigeria. Three sample locations were chosen along the river course (up, middle and down streams). Physico-chemical and microbial properties analyzed using standard laboratory procedures were temperature, pH, conductivity, turbidity, total solid (TS), total dissolved solid (TDS), total suspended solid (TSS), dissolved oxygen (DO), acidity, alkalinity, total hardness, calcium and magnesium hardness, chloride, iron and nitrate. Temperature ranged from 26.8-27.0^{0}C, pH between was 7.92-7.96, Conductivity from 103.7-105.0 µS/cm, Turbidity between 30.9-31.2 NTU, TS, TDS and TSS were between 46-143 mg/L, DO ranged from 5.5-6.0 mg/L, Acidity and Alkalinity were from 0.1-0.5 mg/L, Total, Ca and Mg hardness ranged from 14-50 mg/L, Cl^-, Fe and NO_3 were from 0.3-52 mg/Kg. Total bacteria count was between 2.5-4.7 x 10^2 Cfu/ml and *Escherichia coli* was above 160 Cfu/ml. All the parameters studied were within the permissible standard limit of WHO and NSDWQ, except turbidity, total suspended solid, magnesium hardness, total bacterial and *Escherichia coli* counts. Ogun river was impaired by the abattoir wash down of effluents therefore, its quality status may posse environmental and health hazards to the end users. To improve and ensure its quality and safety, adequate discharge prevention, management and treatment before use is required.
Keywords: Ogun river**,** pollution, water quality, physico-chemical and microbial properties, hazard and safety.

1.0 Introduction

Water is an important substance to all life both living and non-living and also is regarded as a universal solvent capable of dissolving nearly all solutes. Water quality is known to perform essential roles in human health and overall well being. Developing countries' river water in urban areas are treated by water corporations or plants before city circulation but in most villages, there are inadequate infrastructure for water treatment so people use water directly, leading to increased water borne diseases[8]. Globally, the health of organisms especially man depends on the quality of water at his domain. The quality of water is therefore an issue of great environmental concern, according to Nouri *et al.,* (2008), water quality is determined by both natural and anthropogenic forces. The natural forces include precipitation rate, weathering process and soil erosion, while the anthropogenic forces are urban and agricultural activities such as domestic, municipal industrial and agricultural wastes[14].

Ogun river serves as a source of water supply for bathing, washing, fishing and drinking for Abeokuta populace, neighboring villages and also serves as a drain for most solid waste, organic water from abattoirs located along the river course. Abattoir operations produce a characteristic highly organic waste with relatively high level of suspended solid and other oxygen consuming wastes. The effluent contain high level of organic matter due to the presence of manure, blood, fats, grease, hair, grit, undigested feeds and also contains high level of salts, phosphates and nitrates. The total amount of waste produced per animal slaughtered is approximately 35% of its weight. Studies by Verheigen *et al*., (1996) found that for every 100 kg of carcass weight, a slaughtered beef produces 5.5 kg of manure (excluding rumen contents or stockyard manure) and 10 kg of punch manure (partially digested food) and similar results were obtained by Schahill, (2003).

The pollution load on a water body from abattoir effluent can be quite high, studies done in Canada and Nigeria showed very high contaminants levels in abattoir effluent[3,4]. Most of these contaminants are known to be hazardous to human beings and aquatic life. Likewise, improper disposal of effluent from slaughter house could lead to transmission of pathogens to humans and cause diseases from *Escherichia coli*, Bacillius, Salmonella infections, Brucellosis and Helminthes disease and infections[5].

Water quality degradation interferes with vital and legitimate water uses at any scale and pollution of water resources reduces the availability of clean and safe drinking water to most of the world's population[9]. Keating, (1994) reported that in developing counties an estimated 80% of all diseases and over one third of deaths are caused by consuming contaminated water. It is evident that human activities around Ogun river would have accelerated effect on its quality so this study was therefore conducted to assess the impact of Lafenwa abattoir effluent on the physico-chemical and microbial quality of Ogun river in Abeokuta, Nigeria.

2.0 Materials and Methods

2.1 Study Area

The choice of locations is to reflect the variations in concentrations of some important water quality parameters. Ogun river is at $8^0 41^1 0^{11}$ N $3^0 28^1 0^{11}$ E and 8.68333 ^{0}N 3.4667 ^{0}E flowing through Ogun state to Lagos state from Oyo state near Saki where it rises[17].

2.2 Sample Collection

Sample containers were washed with detergent, rinsed several times with tap water and finally with distilled water. Plastic containers for acid were soaked in 10% $HN0_3$ for 24 hours, rinsed with distilled water and finally kept in styfoam until the time for analysis. The samples were collected at about 10 m below the river surface at each point and then covered immediately to avoid contamination. The samples were collected at three points (upstream, middle stream and downstream) which were 100 m away from each other. This sampling design was used so that each sample represents the entire effluents discharged from the abattoir into the Ogun river in Lafenwa area. Microbial count and temperature of each sample was taken immediately.

2.3 Methods

Sample analysis

Standard analytical methods[18] were used for each physico-chemical and microbial parameter analyzed at the Ogun State water corporation Laboratory at the Presidential boulevard, Abeokuta, Nigeria.

2.3.1 Temperature determination

The degree of hotness or coldness of water that was determined by using mercury in glass thermometer. The thermometer was dipped into each already poured water sample in a beaker but the thermometer was always rinsed with distilled water before and after each use, and the unit of measurement is degrees centigrade (^{o}C)[18].

2.3.2 pH determination

pH is the hydrogen ion concentration of water, was determined by using a CORNING pH meter model 7 calibrated by inserting the probe in pH 4.0, 7.0 and 10.0. The probe was dipped into each water sample and the pH measurement recorded[18].

2.3.3 Conductivity determination

This was carried out using a conductivity bridge meter (Hach multi-parameter). The probe was dipped into each water sample and the conductivity measurements recorded in μScm^{-1} (microsiemen per centimeter) [18].

2.3.4 Turbidity determination

This was measured by simple comparison of the interference of light rays passing through each water sample with that of standard samples. Hach spectrophotometer was used after it has been calibrated by 5 and 10 NTU standards and the unit of measurement was NTU[18].

2.3.5 Total solids determination

A clean and dry evaporating dish of known weight was used. A was filled with 100 cm^3 of each water sample and evaporated to dryness in an oven at 102-105 ^0C to a constant weight. The evaporating dish was later transferred to a desiccator, cooled and weighed to constant weight B. The difference in weight between the empty dish, and the dish plus the leftover of sample gives the Total solid expressed mathematically below in mg/L[18].

$$\text{Total Solids mg/L} = \frac{(B-A) \times 1000}{\text{Vol. of Sample}}$$

2.3.6 Total dissolved solids determination

It was determined by filtration and evaporation methods. About100 cm^3 of each water sample was filtered using a 0.45 µm glassfibre (millipore) and the filtrate was poured into a clean dry crucible of known weight (Initial weight) A. This was evaporated in an oven at 102-105 ^oC and cooled in a desiccator until a constant weight B was obtained. The increase in weight of the final weight over that of the initial is the total dissolved solid[18].

$$\text{Total dissolved Solids mg/L} = \frac{(B-A) \times 1000}{\text{Vol. of Sample}}$$

2.3.7 Total suspended solid determination

This was obtained by subtracting the values of Total dissolved solids from the Total solids and it's expressed in mg/L[18].

Total Suspended Solid mg/L = Total Solids – Total Dissolved Solids.

2.3.8 Dissolved oxygen determination - Modified Winkler method

Water sample to be tested was collected into a 300 mL BOD bottle with special care to avoid adding air, filled completely and stoppered. Stopper removed and 1 mL of manganous sulfate solution and 1 mL of alkaline-potassiumiodide-sodium azide solution was at the surface of the liquid. Stopper replaced, air bubble trapping avoided and shaken well by inverting the bottle several times. Shaking repeated after floc has settled halfway and floc was allowed to settle a second time. 1 mL of concentrated sulfuric acid was added allowing the acid to run down the neck of the bottle above the surface of the liquid. Restoppered and top bottle rinsed to remove any acid and shaken well until the precipitate dissolved. About 200 mL of the treated sample corresponding to the original sample was titrated, correcting for some sample loss during reagents addition. This volume was calculated using the formula:

mL of sample to titrate = 200 x [300/(300-2)] = 201 mL

About 201 mL of sample from the BOD bottle was poured into an Erlenmeyer flask. As the solution color was reddish-brown, it was titrated with 0.0250 N sodiumthiosulfate until the solution was a pale yellow (straw) color after adding 1 mL of starch indicator. The amount of titrant used was recorded [20].

The concentration of DO in the sample was calculated using the following formula:

$$\text{mg/L DO} = \frac{\text{(mL titrant x normality of titrant x 8000)}}{\text{equivalent volume of sample titrated}}$$

2.3.9 Acidity determination

The 0.02M NaOH was standardized with 0.02M H_2SO_4. About 100 cm^3 of each water sample was taken into a conical flask and three drops of phenolphthalein indicator added which was titrated against standard NaOH. A pink solution was obtained at the endpoint[18].

$$\text{Total Acidity mg/L} = \frac{\text{Vol. of Base x Molarity of base x 50,000}}{\text{Vol. of Sample}}$$

2.3.10 Alkalinity determination

The 0.02M H_2SO_4 was standardized with 0.02M NaOH Solution. About100 cm^3 of each water sample was taken into a conical flask and three drops of methyl orange indicator added which was titrated against standard H_2SO_4. A colorless solution was obtained at the endpoint[18].

$$\text{Alkalinity mg}CaCO_3\text{ mg/L} = \frac{\text{Titre value x Molarity of acid x 50,000}}{\text{Vol. of Sample}}$$

2.3.11 Total hardness determination

The EDTA solution was standardized with standard $CaCO_3$. About 100 cm^3 of each water sample was taken into a conical flask and 2 $cm^3$of Ammoniumchloride buffer was added followed by six drops of Solochrome Black T indicator which was mixed together thoroughly and titrated against the standard 0.01M EDTA solution. A tinge blue solution was obtained at the endpoint[18].

Total Hardness in mg/L $CaCO_3$ (ppm)

$$= \frac{\text{Titre Value x } CaCO_3 \text{ equivalent of EDTA x 1000}}{\text{Vol. of Sample}}$$

1ml of 0.01M EDTA equivalent 1mg $CaCO_3$

2.3.12 Calcium hardness determination

About 100 cm^3 of each water sample was measured into a conical flask and 2 $cm^3$of NaOH buffer was added followed by 0.4 g of Murexide indicator and was thoroughly mixed together and titrated against standard 0.01M EDTA solution. A purple solution was obtained at the endpoint[18].

Calcium Hardness in mg/L $CaCO_3$ (ppm)

$$= \frac{\text{Titre value x } CaCO_3 \text{ equivalent of EDTA x 1000}}{\text{Vol. of Sample}}$$

1ml of 0.01M EDTA equivalent 1mg $CaCO_3$

2.3.13 Magnesium Hardness Determination

The difference between Total Hardness and Calcium hardness gives Magnesium hardness in ppm (mg/L)[18].

2.3.14 Chloride determination

The 0.0282M Silver nitrate was standardized with 0.0282M Sodium chloride standard. About 100 cm^3 of each water sample was taken into a conical flask and 1 cm^3 of 5% Potassium chromate indicator was added and titrated against standard Silver nitrate solution. A permanent brick red solution was obtained as the end point[18].

1ml of 0.0282M Silver nitrate is equivalent to 0.355 mg of Chloride.

2.3.15 Atomic Absorption Spectrophotometric (AAS) of analysis of Iron

Iron Digestion

About 100 $cm^3$of each water sample was digested using 5cm^3 of conc. HNO_3 in a Pyrex flask with a glass cover placed in an oven to evaporate. The heating was continued to complete the digestion till a light colored substance was obtained. The flask was washed with distilled water, filtered and the filtrate made up to 50 cm^3 in a standard volumetric flask. This solution was then used for Iron determination at 248.3 nm using Atomic Absorption Spectrophotometer (AAS)[18].

Atomic Absorption Spectrophotometric (AAS) of analysis of Iron

The instrument was set up with a previously established optimum setting. Secondary or less sensitive lines were used to reduce necessary dilution, as desired. Five standard solutions within the range before and after the test solution were used, and the Percentage transmittance and Absorbance re-established each time. Calibration curves were prepared from the coverage of each standard before and after each test. The concentrations of the unknown Iron was read directly or from the plot of Absorbance against concentration in mg/L (ppm)

Calculation: (mg of metal in aliquot/L) x F= mg metal/L

Where F = final dilution/ml aliquot[18].

2.3.16 Nitrate Determination

The Hach DR 2010 spectrophotometer was used. The appropriate stored program NO for nitrate powder pillow (455) was entered followed by pressing 500 nm. 25 cm^3cell containing 25 $cm^3$of sample followed by the addition of the content of one nitrate reagent pillow was allowed to react for 1 min and then 5 mins using shift timer. A second 25 cm^3sample cell was filled with 25 $cm^3$of sample solution (blank). As the timer beeps, the display showed and the cell containing blank was placed in a cell holder and the light shield was closed. The instrument was zeroed by pressing zero and the prepared sample was placed in the cell holder, the light shield was closed and the READ button was pressed. The result in mg/L of nitrate was displayed on the instrument[18].

3.0 Result and Discussion

3.1 Result

Table 1: Mean of physical parameters of Ogun river samples

Point/ Location	Temp ^0C	pH	Cond. µS/cm	Turb. NTU	TS mg/L	TDS mg/L	TSS mg/L	DO mg/L
Upstream	26.9	7.92	103.5	30.9	125	46	79	5.5
Middle stream	26.8	7.93	105.0	31.0	143	48	95	6.0
Downstream	27.0	7.96	103.8	31.2	138	47	91	5.6
(WHO,2006; NSDWQ, 2007 standard)	<40	6.5-9.5	1200	5.0	500-1500	500	40	500

Cond.: Conductivity, Turb.: Turbidity, TS: Total solids, TDS: Total dissolved solids, TSS: Total suspended solid DO: Dissolved oxygen

Table 2: Mean of chemical parameters of Ogun river water samples

Point/ Location	Acidit ymg/L	Alkalinity mg/L	Total hardness mg/L	Ca hardness mg/L	Mg hardness mg/L	Cl^{-1} mg/L	Fe mg/L	NO_3^- mg/L
Upstream	0.5	0.1	41	26	14	46	0.3	0.9
Middle stream	0.15	0.1	43	30	17	49	0.4	0.4
Downstream	0.1	0.1	50	27	23	52	0.4	0.4
(WHO,2006; NSDWQ,2007 Standard)	≤25	100	500	NS	20	250	3.0	50

Ca: Calcium, Mg: Magnesium, Cl: Chlorine, Fe: Iron, NO_4: Nitrate, NS: Not specified

Table 3: Mean microbial content of Ogun river samples

Point / Location	TBc $x10^2$	E. coli
Upstream	2.5	>160
Middle stream	4.7	>160
Downstream	4.5	>160
WHO, 1999 Standard	<10	NIL

TBc: Total bacterial count, E.coli: *Escherichia coli* count.

3.2 Discussion

The physico-chemical and microbial parameters obtained across the course of Ogun river adjoining Lafenwa abattoir are as shown above, temperature is important to aquatic environment and life since physical, chemical, biochemical and microbial activities are temperature dependent[21]. It ranges from 26.8-27.0^{0}C with the downstream having the highest value of 27^{0}C, which shows that the temperature values obtained corroborates those of Akan *et al.*, (2010), Saidu and Musa (2012) of 26-29 ^{0}C and is within WHO (2006) standard. The pH is slightly neutral ranging from 7.92-7.96 which is within WHO standard of 6.5-9.5. Aquatic organisms are heavily affected by pH because most of their metabolic activities are pH dependent[12]. These values however are normal for aquatic lives, and have minimal effects on acidity[11]. Conductivity in water is used to indicate dissolved solids content of water because the concentration of ionic species determines the degree of current conducting in an electrolyte which is unsafe for aquatic live when above the standard permissible limit[7]. Conductivity ranges from 103.5-105 µS/cm which are within WHO standard permissible limit of 200-1200 µS/cm. The Turbidity of all samples analyzed are above WHO (2006) standard permissible limit with the downstream having the highest of 31.2 NTU since it's the first point of high abattoir effluent discharge. Furthermore, the level of Total Suspended Solid (TSS) ranged from 79-95 mg/L while the upstream had the lowest value of 79 mg/L. The value of the TSS are above the WHO (2006) permissible limit of 40 mg/L for the discharge of waste water into surface water which might be due to solid organic waste with high level of suspended solids from manure, blood, fats, grease, hair, grit and undigested feeds. Total dissolved solid ranged from 46-48 mg/L while the Total Solid ranged from 125-143 mg/L which is below the 1500 mg/L WHO permissible limit. The concentration of dissolved oxygen (DO) is higher at middle stream with value of 6.0 mg/L and low at upstream with value of 5.5 mg/L. DO measures the degree of pollution by organic matters, the destruction of organic substances as well as the self purification capacity of the water body, the depletion of DO at the upstream may be attributed to the huge amount of organic waste which require high level of oxygen for chemical oxidation and breakdown, thereby resulting in the deterioration in oxygen. DO values obtained were below WHO (2006) standard permissible limit of 8 mg/L for waste discharge into water. The standard for sustaining aquatic life is stipulated at 5 mg/L, a concentration below this value will adversely affect aquatic biological life, while concentration below 2 mg/L may lead to death for most fishes[6]. This implies that DO of the river can adequately sustain lives. The acidity and alkalinity ranged from 0.1-0.5 mg/L which are within the permissible limit of WHO (2006) which could be linked to the overall activities taking place in this area.

The Total hardness of the water sample ranged from 41-50 mg/L which was also below the WHO (2006) allowable limit of 500 mg/L and Calcium hardness value is not specified by WHO standard so pollution cannot be predicted but the value of Magnesium hardness ranged from 14-23 mg/L with downstream above WHO standard as a result of the immediate abattoir discharge from magnesium containing substances. The Chloride, Iron and Nitrate values are all within the permissible limit of WHO (2006) standard permissible limit.

Iron in substancial quantities can make water unsuitable for food processing[23] and the low Nitrate is in conformity with Edokpayi, 1988 that says most tropical waters have low nutrient values, a feature considered common for natural and polluted waters.

From the bacteriological dissent, it was observed that the bacterial count ranged from 2.5–4.7x10^2 Cfu/ml for the Upstream, Middle Stream and Downstream sampled points. This is unacceptable by the WHO (1999) standard guideline which is supposed to be less than ten (<10) Cfu/ml. However *Escherichia coli* are observed to be > 160, which is above WHO permissible standard of zero. E. coli usually contaminates meat and leafy vegetables and its count is used extensively as a basis for regulating the microbial quality of drinking water. Its presence in drinking water poses a serious threat to health of consumers since it's an intestinal parasite indicating fecal contamination[24]. The presence of E.coli in water is used as an indicator to monitor the possible presence of other harmful microbes such as *Eryptosporidium giardia*, Shigella and *noro virus*.

Some of the identified effects of effluents discharge on such water bodies include nutrient enrichment, deterioration of water qualities, destruction of spawning grounds for aquatic and marine life, general fish kill, etc[22].

All physico-chemical and microbial parameters were within WHO standard permissible limit except turbidity, total suspended solids, magnesium hardness, total bacterial count and *Escherichia coli* count. This calls for health concern for the environment, aquatic organisms, plants, animals and humans.

4.0 Conclusion

The result revealed that Ogun river is indeed polluted by Lafenwa abattoir effluent discharge which might lead to deterioration of water quality caused mainly by solid organic waste with high level of suspended solids from manure, blood, fats, grease, hair, grit, undigested feeds and fecal contaminants. Other possible sources of pollution could be point source discharge from industrial effluents (solid, liquid etc), non-point source discharge which includes wastes from agricultural (pesticide, herbicide, insecticide, crop waste etc) and domestic activities by poorly planned settlers nearby Ogun river.

5.0 Recommendation

Lafenwa abattoir users' needs to improve on their waste management system so as to minimize the danger posed to aquatic organisms, environment and human whose life and survival depends on Ogun river water. There should be periodic monitoring of human activities and Ogun river quality to determine the level of safety with regard to contamination and conformity to WHO standard permissible limits. There is a dire need to properly prevent, manage and control Lafenwa abattoir discharges.

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