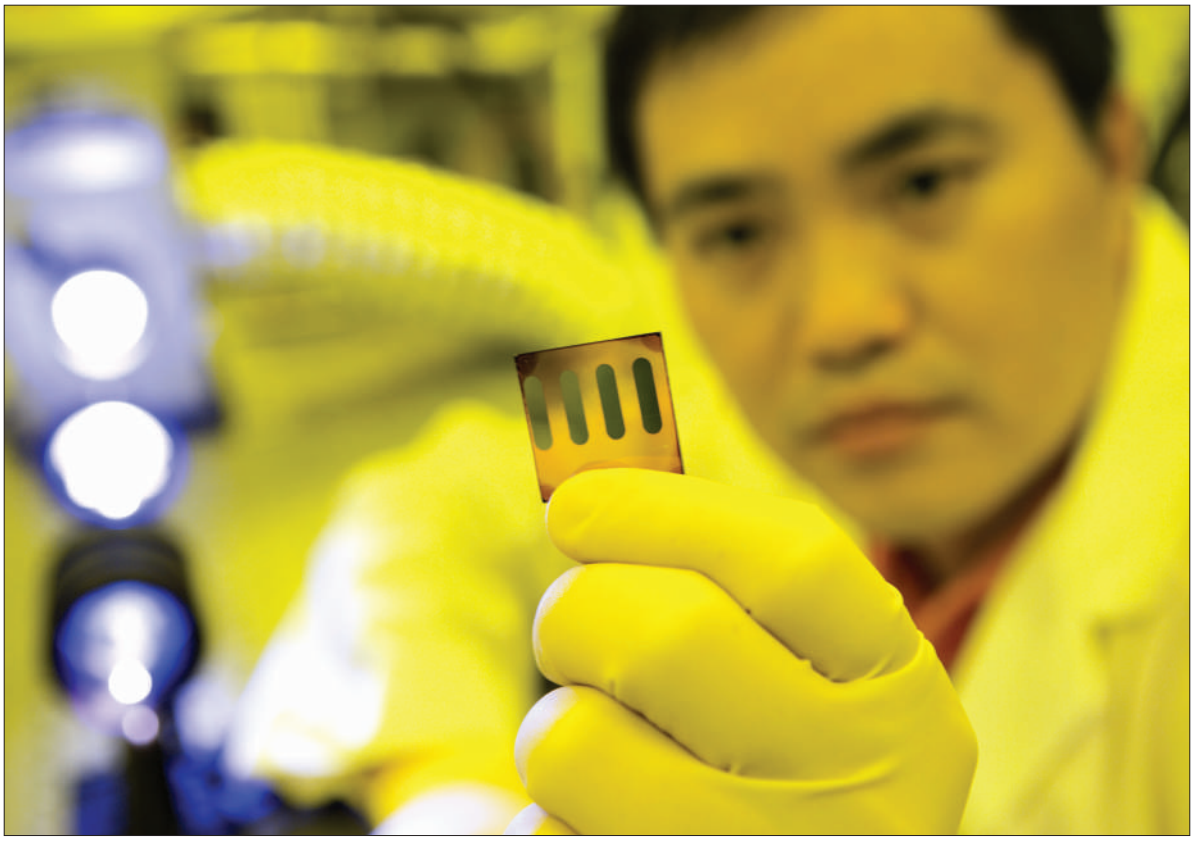

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Research Article
Aquatic Habitat as a Septic Tank of Pollutants with Reference to the Water Quality of the Niger River Basin Drained by a Major Abattoir in Southern Nigeria

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Abstract

Background and Objective: The pollution of the immediate soil environment and water quality of the rivers that drained a major abattoir in Southern Nigeria was investigated to access its impact on the immediate and far away environment. **Materials and Methods:** Five hundred grams of soil samples made up of 3 composite samples were collected from the abattoir with the aid of a hand soil auger at 10-15 cm depth into clean plastic bags. The 500 mL of each of the wastewater (water samples from washing of the slabs and tables of the slaughtered animals) and rivers water (the lower Niger River at Swale market at points where it drains the abattoirs) were collected from each point and were pooled together to constitute a composite sample. The total viable bacterial counts and hydro-chemical characteristics were measured using internationally approved methods for the assessment of water. **Results:** Bacteria with hydrocarbon utilizing potentials were isolated from the soil within the abattoir with *Bacillus* and *Alcaligenes* species most abundance and the least, respectively. The physicochemical properties of the River's water, abattoir soil, wastewater that drain the lower Niger Delta Rivers at Swale market showed maximum deviation from the recommendation limit by various regulatory bodies with the exception of the pH. **Conclusion:** An abattoir, as a facility involved in producing food for human consumption there is a need for the routine assessment, because huge wastes are being generated in the processes involved in dressing animals for human consumption, which may have negative impacts impact on the ecosystem, especially human.

Key words: Soil, waste water, abattoir, Niger Delta Rivers, viable bacteria, human consumption

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The quality of water is not debatable for human because it linked with human health and life. The threats impose by water borne diseases and epidemics are common occurrence in the developed and developing countries. Water sources were polluted by domestic wastage and unhygienic disposal of human wastes in rural areas whereas industrial wastages discharged into natural water sources in urban areas[1].

Adverse effects of the activities of man upon the aquatic environment are of growing concern[2]. Changes in physical factors (water temperature, oxygen levels, pH and salinity) as well as in biological stressors (food availability and pathogens) can produce effects upon resident aquatic organisms and ultimately affect their productivity and detrimental effects on the food chain. One of the major factors for aquatic pollution in developing countries is that all the drainages are directed to the water body without considering the implication. Similarly, poor urban development without adequate sewage and waste disposals has predispose Rivers to pollutants[3].

Different kinds of burning/roasting activities are carried out in abattoirs in Southern Nigeria. The use of wood and expired/condemned tyres for burning bones, cattle hide, roasting of meat, chicken and fish with coal and wood all contribute to environmental pollution. There is also significant evidence to indicate that such pollutants released to the atmosphere are transported over long distances by atmospheric wind movement and deposited elsewhere[4,5].

Huge wastes are generated in the processes involved in dressing animals for human consumption that are washed either directly or indirectly into the water body. Thus, they have effect beyond the immediate environment where they are released. The waste from the animal find their way into the aquatic environment through various pathways, where these non-polar, toxic, semi-volatile and fairly persistent substances may remain within the water body unchanged for a period of time, undergo degradation to simpler compounds (there are microbes that are associated with the degradation of these contaminants in the abattoirs as well as in the receiving water bodies) which may be more toxic and/or more persistent than the parent compounds or get reversibly transferred into the atmosphere by volatilization[6]. The ultimate fate of these pollutants including partitioning into various aquatic environmental compartments (water, suspended solids, sediments and biota), though depend on a number of factors including: Concentration, dilution, water solubility, biogeochemical processes taking place, adsorption to soils, suspended particulates and sediments, lipophilicity and bioaccumulation in living organisms[7].

An abattoir, as a facility involves in the production of food for human consumption. However, beside the huge wastes generated in the processes of dressing animals, the environment is not hygienic as the activities of abattoirs is characterize by filthiness and contamination to surface and ground water sources as abattoir is poorly manage in Africa. Wastes generated and animal blood is simply directed into river bodies. In Nigeria, abattoirs are generally sited close to river bodies in order to have access to water for meat and fish processing. It is importance to note that the effluent from abattoirs is high in organic matter as a result of manure, blood, fats, grease, hair, grit and undigested feeds[8], all of which affect the quality of surface and ground water. Hence, the objective of this investigation was to assess the health status of the abattoir vicinities and the receiving water body at the lower Niger Delta River, Nigeria.

MATERIALS AND METHODS

Site location and sampling collections: Samples were collected monthly from January, 2019 to June, 2019 and were collected from abattoirs (Swale market) and lower Niger River (at points where it drains the abattoirs). The map coordinates of the abattoir location are 40°53'42.9576" (North) and 6°16'39.7164" (East).

Soil samples: Five hundred grams of soil sample made up of three composite samples were collected into a sterile container and transported to the laboratory in ice packs and stored in the refrigerator.

Waste water samples: Wastewater produced after washing the slabs, tables, utensils and washing of roasted cowhide of the slaughtered animals were collected from drainages along 3 sampling points in each abattoir into 1.5 L sterile bottles.

River water sampling: Besides washing all the containers used for sampling with deionised water, they were also rinsed thoroughly with sample water at the point of collection. Water samples were taken from various sections located along the River where abattoirs effluents are channeled. Sampling was done in the morning hours between 6 am and 9 am, which is the range of periods of animals laughtering and utilization of the River's water by butchers in this region. Special bottles were used for collection to determine BOD and DO in the River's water, while clean plastic containers were used for other parameters. One millimeter of Winkler A and B was inserted into the DO bottles immediately the water was

sampled, this is to help maintain the sharpness of bacteria present in the water sample before analyzing the sample in the laboratory. Samples were transported to the laboratory in an ice bag cooler to maintain the optimum temperature.

Physicochemical properties assessment: Electrical conductivity was determined using a calibrated (0.01 M KCl) conductivity meter that was inserted into the water immediately after collection. The turbidity of the water samples was measured using Shimadzu UV-160A double beam UV recording spectrophotometer at the wavelength of 400 nm. Total suspended solid was determined by entering program number 20 for total suspended solids on the Shimadzu UV-160A recording spectrophotometer at 400 nm. Total dissolved solids, the gravimetric method as described by APHA[9] was used. Total hardness and total alkalinity were measure by the titration method of Boyd and Tucker[10]. Dissolved oxygen concentration and BOD were measured by the Winkle rmethod[10], while, phosphate and nitrate were determined using colorimetric method

Microbiological analysis: Total heterotrophic bacteria (THB) and total coliform (TC) were determined with the nutrient agar plates using the spread plate technique as described by Prescott *et al.*[11]. Total hydrocarbon utilizing bacteria (THUB) was determined using vapour phase transfer method of Hunter *et al.*[12]. Total heterotrophic fungal count (THF) was determined using the potato dextrose agar (PDA) onto which 1 mL of 10% lactic acid was added to suppress bacterial growth[13]. The Vapour Phase Transfer method of Mnif *et al.*[14] was adopted to determine the population of hydrocarbon utilizing fungi (THUF).

Purification of isolates: Sterile inoculating loop was used to pick pure isolates from a distinct culturally and morphologically different colony from the various media plates. These were subjected to streaking on sterile nutrient agar in plates until pure distinct colonies were formed.

Identification of the Isolates: Pure bacterial isolates were subjected to oxidase test, catalase test, indole test, methyl red test, Voges Proskauer test, starch hydrolysis test, urease test, citrate test, sugar fermentation test and triple sugar iron agar test, follow the methods described by Collins *et al.*[15] and Barnett and Hunter[16]. Pure mould isolates were identified using their morphological features followed by microscopic examination of their wet mounts prepared with lactophenol-cotton blue and reference made to a fungal identification atlas by WHO[17]. Yeast isolates were also identified using their morphological characteristics, followed by microscopic examination of their wet mount prepared with normal saline, reference was also made to a fungal identification atlas by WHO[17]. The yeast isolates were further identified using Gram-staining, sugar fermentation and oxidation and fermentation tests.

Data analysis: The following physicochemical properties of waters, pH, electrical conductivity, turbidity, total suspended solid (mg L^{-1}), total dissolve solid, alkalinity, total hardness, salinity, nitrates, phosphate, dissolve oxygen and biological oxygen demand. Physicochemical properties of the river were compared with water quality guidelines[18].

Statistical analysis: One-way analysis of variance[19] was used to test for significant difference in the value of the parameters from the three matrixes (abattoir soil, waste water and the River water). The p-value of 0.05 or less was considered significant[20].

RESULTS

Total microbial counts: The mean of the microbial load count (CFU g^{-1}) from abattoir soil, wastewater and Swale River water samples in Yenagoa Bayelsa State Nigeria (Table 1). The highest and lowest mean total heterotrophic bacteria of 8.0×10^7 CFU and 2.0×10^7 CFU g^{-1} were obtained in abattoir soil sample and the river water sample. The total hydrocarbon utilizing bacteria, highest of 4.2×10^5 CFU g^{-1} was recorded in the wastewater samples and the river water samples had the least of 3.6×10^5 CFU g^{-1}. The total coliform of 8.0×10^5 CFU g^{-1} was reported in the soil samples and the least of 4.0×10^5 CFU g^{-1} was observed in the wastewater samples.

The mean count of total heterotrophic fungi of 2.4×10^5 CFU g^{-1} was the highest recorded from soil samples. The least THF load of 1.2×10^5 CFU g^{-1} was obtained in river water samples. Hydrocarbon utilizing fungi count of 1.62×10^3 CFU g^{-1} in soil samples to 1.2×10^3 CFU g^{-1} obtained in river water samples.

Table 1: Total microbial load count (CFU g^{-1}) from abattoir's vicinity, Niger-Delta Nigeria

	Microbial loads		
Microbes	Soil samples	Wastewater's samples	River water's samples
THB	8.00×10^7	6.00×10^7	2.00×10^7
THUB	3.70×10^5	4.20×10^5	3.60×10^5
TC	8.00×10^5	4.00×10^5	7.00×10^5
THF	2.40×10^5	1.80×10^5	1.20×10^5
THUF	1.62×10^3	1.40×10^3	1.20×10^3

THB: Total heterotrophic bacteria, THUB: Total hydrocarbon utilizing bacteria, TC: Total coliform, THF: Total heterotrophic fungal count, THUF: Total hydrocarbon utilizing fungi

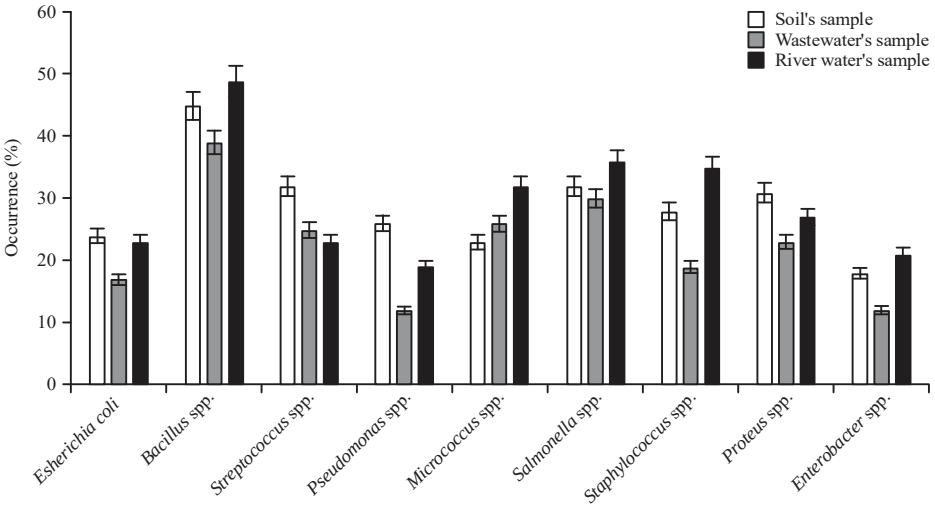

Fig. 1: Frequency of bacteria isolated from abattoir's vicinity, Niger-Delta Nigeria

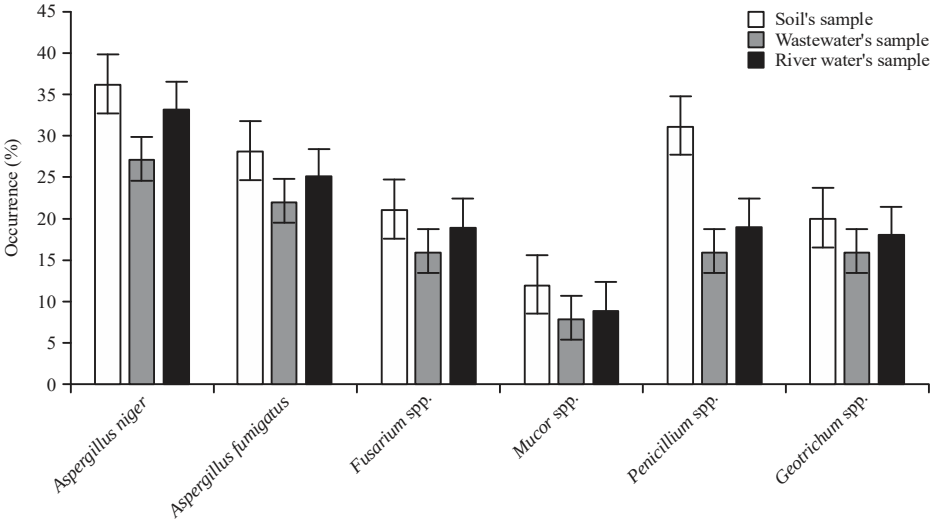

Fig. 2: Frequency of fungi Isolated from abattoir's vicinity, Niger-Delta Nigeria

Frequency of bacterial isolates: The distribution of bacteria isolated from abattoir's soil samples, waste water's samples and Swale River's water sample in Yenagoa Bayelsa State Nigeria revealed the present of the following isolates, *Bacillus* spp., *Escherichia coli*, *Streptococcus* spp., *Staphylococcus* spp., *Pseudomonas* spp., *Micrococcus* spp., *Salmonella* spp., *Enterobacter* spp. and *Proteus* spp. (Fig. 1).

The most abundant bacteria specie was *Bacillus* spp., with 20.16% of occurrence. Others were, *Escherichia coli* (12.23%), *Streptococcus* spp. (10.28%), *Staphylococcus* spp. (11.52%), *Pseudomonas* spp. (16.04%), *Micrococcus* spp. (9.46%), *Salmonella* spp. (13.16%), *Enterobacter*.

A Kruskal-Wallis H test showed that there was no statistically significant difference in bacterial loads among the three matrixes, χ^2 (3) = 2.075, p>0.05.

Frequency of fungi occurrence: Fungi species identified are, *Aspergillus niger*, *Aspergillus fumigatus*, *Penicillium* spp., *Fusarium* spp., *Mucor* spp. and the yeast *Candida* spp. (Fig. 2). The most frequently occurrence isolate in all the matrixes is the *Aspergillus* spp., with a percentage occurrence of 25.75 and 23.25% for *Aspergillus niger* and *Aspergillus fumigatus*, respectively. *Penicillium* spp. had 23% occurrence. While others are: *Geotrichum* spp. (18.75%), *Fusarium* spp. (18.75%) and *Mucor* spp. (8.33%) (Fig. 2). The percentages of occurrence of fungi with hydrocarbon utilizing potentials are *Aspergillus* spp. (22.22%), *Fusarium* spp. (16.66%), *Penicillium* spp. (33.33%), *Geotrichum* spp. (16.66%), *Mucor* spp. (5.55%) and *Candida* yeast occurred at 5.55%.

Table 2: Physicochemical properties of abattoir's vicinity, Niger-Delta Nigeria

Parameters	Abattoir's soil (Mean±SE)	Wastewater's (Mean±SE)	River's water (Mean±SE)	WHO (DPR/FMEnv.)
pH	4.65±0.20	5.32±0.52	5.90±0.30	6.5-9.2
Electrical conductivity (μS cm^{-3})	1518.00±5.10	1311.00±2.70	1014.00±3.80	1250
Turbidity (NDU)	21.50±0.10	18.20±2.10	18.20±3.90	15
TSS (mg L^{-1})	36.00±2.10	24.00±3.20	45.00±5.30	20
TDS (mg L^{-1})	1011.00±4.10	2210.00±2.90	1850.00±3.10	300-600
Alkalinity (mg L^{-1})	77.00±1.40	54.00±0.50	113.00±2.70	30-500
Total hardness	1120.00±3.20	1300.00±9.00	1250.00±2.80	1500
Salinity (mg L^{-1})	178.00±3.20	116.00±2.10	210.00±1.30	35
NO_3 (mg L^{-1})	22.80±0.40	16.10±1.60	41.40±3.10	20
SO_4 (mg L^{-1})	43.00±1.10	32.00±0.80	56.00±0.20	500
PO_4 (mg L^{-1})	3.20±0.30	1.60±0.10	3.80±0.50	0.4
DO (mg L^{-1})	1.30±0.40	1.80±0.50	2.10±0.10	5
BOD (mg L^{-1})	760.00±3.10	910.00±1.80	530.00±6.10	20

A Kruskal-Wallis H test showed that there was no statistically significant difference in fungal loads between the soil and wastewater samples, χ^2 (3) = 2.032, p>0.05. However, there was statistical significant differences between the soil and River water samples, χ^2 (3) = 1.014, p<0.05 and between the waste water and the River water sample, χ^2 (3) = 1.1892, p<0.05 .

Physicochemical properties of abattoir's soil, wastewater and Swale River's water samples: The results of the physicochemical properties of abattoir soils, wastewater and Swale River water samples with their respective WHO/FEPA recommendation limit is shown in Table 2. The highest mean pH value was 5.90±0.30 recorded in river water sample while the least pH value was 4.65±0.20 obtained from abattoir soil sample. The highest mean electrical conductivity was 1518±5.10 μS cm^{-3} observed in abattoir's soil sample while the least value recorded was 1014±3.80 from River water samples. The turbidity test revealed 2.50±0.10 NDU (abattoir water sample), 18.20±2.10 NDU (waste water's sample) and 18.20±3.90 NDU (river water sample). Total suspended solid (TSS) showed River water had the highest (45±5.30 mg L^{-1}), while the waste water had the least 24.0±3.20 mg L^{-1}. Total dissolved solids (TDS) values were 1011±4.10, 210±2.90 and 1850±3.10 mg L^{-1} in abattoir water, waste water and river water samples, respectively.

The highest salinity of 410±1.30 was observed in River water sample, while the least of 116±2.10 was recorded in the waste water sample. The nitrate (NO_3) values for abattoir's soil water, wastewater and River water were 22.80±0.40, 16.10 and 41.40 mg L^{-1}, respectively. The highest and least values of sulphate (SO_4) reported in this study were 56±0.20 (river water sample) and 32±0.80 mg L^{-1}.

The phosphate revealed that the river water had the highest (3.80 mg L^{-1}) and wastewater had the least (1.60 mg L^{-1}). Dissolved oxygen (DO) values obtained from the showed that abattoir soil had the least (1.30±0.40 mg L^{-1}), while the River water had the highest (2.10±0.10 mg L^{-1}). The BOD values ranged between 530-910 mg L^{-1} in all the matrixes examined (Table 2).

DISCUSSION

The bacteria identified in the three matrixes (abattoir soil, wastewater and River water) were *Bacillus* spp., *E. coli*, *Streptococcus* spp., *Staphylococcus* spp, *Pseudomonas* spp., *Micrococcus* spp., *Salmonella* spp., *Enterobacter* spp. and *Proteus* spp. *Bacillus*, *Micrococcus*, *Proteus*, *Pseudomonas* and *Staphylococcus* in these matrixes are hydrocarbon utilizing bacteria. Drilling wastes are known to be degraded by bacterial isolates such as species of *Staphylococcus*, Serratia *Acinetobacter*, *Alcaligenes*, *Clostridium*, *Enterobacter*, *Nocardia*, *Bacillus*, *Actinomyces*, *Micrococcus* and *Pseudomonas* sp., by Benka-Coker and Olumagin[21].

The presence of *E. coli*, *Salmonell* and *Micrococcus* in these samples may be attributed to the discharge of the content of animal bowels onto the soil, the washing of the slabs, tables and utensils of the slaughtered animals and the abattoirs effluents that drains the River. Similar observations were reported by Adesemoye *et al.*[22] and Ogbonna *et al.*[1].

Bacillus spp. was the abundance species observed in this study and this may be attributed to the fact that the bacteria these organisms are indigenous to soil environment and are known for their persistence in the soil[23].

This investigation also reported the characterization of five genera of fungi from contaminated matrixes. Out of the five genera reported in this study, four demonstrated hydrocarbon utilizing potentials namely, *Aspergillus*, *Fusarium*, *Geotrichum* and *Penicillium*. The presence of these fungi could be attributed to their ability to degrade hydrocarbons, which may be useful in bioremediation procedures by Darsa *et al.*[24]. Similarly, Ibrahim *et al.*[25] demonstrated the ability of *Aspergillus*, *Penicillium*, *Mucor*, *Rhizopus* and *Candida* species isolated from Forcados effluent to biodegrade hydrocarbons.

Meanwhile, the occurrence of these fungi may be detrimental to the aquatic organisms, as most of these fungi were reported in *Clarias* spp., collected from abattoir contaminated Ogba Rivers in Edo State Nigeria Abolagba and Igbinevbo[26]. Their present in aquatic organisms may be detrimental to human as they biomagnifies along the trophic level, with man being at the top.

The physicochemical properties of the river's water, abattoir soil, wastewater that drain the lower Niger Delta Rivers at Swale market showed maximum deviation from the recommendation limit by various regulatory bodies with the exception of the pH. The pH in the matrixes ranged between (4.65-5.90), which is within the recommendation limit. Electrical conductivity measures material's ability to allow the flow of an electric charge and is measured by the presence of total concentration of ions. The conductivity levels in the soils ranged between 1510-1612 μS cm^{-3}, wastewater 1289-1320 μS cm^{-3} and river's water 998-1022 μS cm^{-3}. The conductivity values were above the European economic community (EEC) maximum of 1250 μS cm^{-3} in all except the river water sample. The high values observed in some matrixes may be attributed to the decomposition and mineralization of organic matter within the abattoir environment.

The turbidity recorded in all the matrixes was higher than the recommendation limits. This indicates the presence of hazardous chemical and microbial contaminants and have significant implication[27]. The turbidity reported in the River's water can signal pollution events in the catchment, in this investigation it can be attributed to the abattoir and the market that drain the river. The implication of the high turbidity in source waters can harbor microbial pathogens, which can be attached to particles and impair disinfection and could be detrimental downstream users.

The most common pollutant in the world is "dirt" in the form of TSS and in this investigation the total suspended solid observed in the matrixes were above the recommendation limits, with the river's water having the highest. The high river's water concentration could be attributed to the various inlets that drain the rivers apart from the market and the abattoir. The implication is that the concentration of the TSS may get to a level that settle out onto a River's bottom and cover aquatic organisms, eggs, or macro-invertebrate larva[22]. This coating can prevent sufficient oxygen transfer and result in the death of buried organisms. Similarly, suspended solids decrease the effectiveness of drinking water disinfection agents by allowing microorganisms to be shielded from disinfectants within solid aggregates.

Similar trend was observed in the total dissolve solids in the river's water. The principal constituents of TDS are usually calcium, magnesium, sodium and potassium, carbonate, hydrogen-carbonate, chloride, sulfate and nitrate anions. The implication of the reported TDS in this river's water is that it may affect its taste and quality. The palatability of drinking-water has been rated by regulatory bodies of t asters in relation to its TDS level as follows: Excellent, <300 mg L^{-1}, good, between 300 and 600 mg L^{-1}, fair, between 600 and 900 mg L^{-1}, poor, between 900 and 1200 mg L^{-1} and unacceptable, >1200 mg L^{-1}. Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste. High concentration of TDS observed in this study may be the result of organic particles scaled from the surface of the roasted, blood, gut content and other particulate materials from abattoir floor and tables being discharged into the soil and rivers.

The alkalinity, which is a measure of the buffering capacity of a system which indicates that the water with high alkalinity is considered to be well buffered against acidic input. The alkalinity levels in all the matrixes is lower than the WHO permissible limit of 30-500 mg $CaCO_3$ L^{-1}.

Nitrate, sulphate and phosphate are chemical substances required for microbial growth and proliferation. Nitrate and sulphate values were higher than phosphate values and are below WHO permissible limits, with the exception of the nitrates in the River's water. Excess concentration of nitrate can give rise to methaemoglobinemia, a situation whereby hemoglobin is oxidized to methemoglobin, the heme iron becomes (Fe^{3+}) and is incapable of binding oxygen. Methemoglobinemia is suspected in any cyanotic patient with no evidence of heart and lung disease. Cyanosis is due to decreased oxygen saturation. Phosphates had the lowest recorded values (among nutrients assessed) and the value was higher than the WHO limit of 0.4 mg L^{-1} for domestic and industrial waters. The levels of nutrient reported in this investigation can cause eutrophication and may pose problem to the aquatic organisms living in the River.[28]

The dissolved oxygen values reported in all the matrixes were less than the recommendation limit of 5.0 mg L^{-1}, an indication of extreme environmental stress[29].

Biochemical oxygen demand indicates the amount of organic matter degradable by microbial metabolism on the assumption that the water has no bactericidal or bacteriostatic effects[9]. The BOD values recorded in all the matrixes were very high, higher than the WHO permissible limit. This can be attributed to the fact that abattoir activities generate huge organic and inorganic wastes[29].

CONCLUSION

The occurrence of these microbes may be detrimental to the aquatic organisms and human as they biomagnifies along the trophic level, with man being at the top. The physicochemical parameters obtained in this study indicate that the abattoir activities have negative impact on the soil, river's water and the immediate environment, thus abattoir activities constitute a major source of pollution in the investigated rivers. Hence, there is urgent need to sensitize operators of abattoirs on the health and environmental impacts of emptying effluents from abattoir to the environment, especially the aquatic habitats. Proper monitoring and supervision of activities at abattoirs by the regulatory bodies become inevitable in Nigeria and other developing world.

SIGNIFICANCE STATEMENT

This investigation established that the abattoir has effect on quality lower Niger River at Swale market, Niger Delta Nigeria. It is a wake up calls to the appropriate regulatory bodies especial Federal Environmental Protection Agency, Nigeria and the Department of petroleum resources (DPR) and Standard organization of Nigeria to intervene to stem the indiscriminate disposal of abattoir waste products in to the river in order to protect the aquatic life and the downstream communities that rely on the water for domestic and agricultural purposes.

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