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Bacteriological Assessment of a Tidal Creek Receiving Slaughterhouse Wastes in Bayelsa State, Nigeria

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Authors' contributions

This paper was carried out by both authors. Author EIS conceived the idea. Author SCI collected the samples, carried out the laboratory analysis and wrote the initial draft of the manuscript. Author EIS edited the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Wastes from abattoir arise from undigested ingesta, bones, horns, hairs and aborted fetuses, blood, gut contents, urine and water are discharged into surface water close to an abattoir in Yenagoa metropolis, Nigeria. This study investigated the effects of abattoir wastes on a tidal creek in Bayelsa state, Nigeria. Triplicate samples were collected from 5 stations viz: A (about 200 m upstream of the abattoir activity), B (about 100 m upstream of the abattoir activity), C (about 10 m radius of the abattoir waste disposal point), D (about 100 m downstream of the abattoir activity) and E (about 200 m downstream of the abattoir activity). Standard bacteriological method was employed for the analysis of the water samples. Results showed that total heterotrophic bacteria, total coliform and fecal coliform ranged from 0.74 – 8.43 x 10^6 cfu/ml, 8.10 – 206.67MPN/100 ml and 5.03 – 170.00 MPN/100ml respectively. Analysis of variance showed that there were no significance difference ($P>0.05$) among the various location apart samples around the effluent disposal area, which was significantly higher ($P<0.05$) compared to other locations. The bacteria populations were higher than the limits specified by World Health Organization/Food and Agricultural Organization and Standard Organization of Nigeria for drinking water. The bacteria diversity tentatively identified includes *Pseudomonas, Enterobacter, Micrococcus, Proteus, Salmonella, Klesbsiella, Bacillus, Citrobacter,*

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Shigella species, *Staphylococcus aureus* and *E. coli.* The similarity interaction between the various sampling locations with respect to bacteria isolate ranged from 50.00% to 72.73%, being similar based critical level of significance = 50%. The findings showed that abattoir effluents are having impact on bacteriological quality of tidal creek of Ikoli, Bayelsa state. Hence the need for sustainable management processes of the effluents prior to discharge.

Keywords: Anthropogenic activities; microbes; tidal creek; water pollution.

1. INTRODUCTION

Inadequate waste management is a threat to environmental sustainability. According to Chukwu et al. [1], indiscriminate and poor waste disposal techniques constitute environmental hazards. Nearly all activities of human in the environment lead to wastes generation [2,3]. The impacts of wastes on the receiving environment viz: soil, water and air depend on several factors including physical nature, composition and source of the wastes. Some sectors that generate wastes includes abattoir [4], food processing such as oil palm [5], cassava processing, pharmaceutical, paint, textile, oil and gas industries among others.

The abattoir sector is an essential constituent of the livestock business that typically provides meat supply for over 150 million people in Nigeria [6]. Abattoir sector is also source of livelihood to several families [6]. But in developing nation like Nigeria, the sector is less developed [6]. Most of the waste that is generated in abattoir is majorly discharged into the environment with little or no treatment [1]. According Chukwu et al. [1], Ogamba et al. [4], many abattoirs in Nigeria dispose their effluents into aquatic ecosystem (creek, streams and rivers).

Surface water contamination by effluents generated from slaughterhouses or abattoirs is a major concern. This is because they released substances toxic into the environment which in turn may affect the food web [7]. Authors have reported that surface water is source of habitats to several biodiversity including macrophytes such as water hyacinths [4,8–10], aquatic reptiles and mammals, planktons (zooplanktons and phytoplankton) [11], fishes (shelled and fin fish) [12,13]. Typically, the characteristics of slaughterhouse effluents vary from day to day depending on the number, types of stock being processed and the processing techniques [14]. The composition of the slaughterhouse wastes also depend on the source. For instance, Adeyemo et al. [15] reported that abattoir activities generates organic wastes with relatively high suspended solid and dissolved solid containing liquid and fat which are mostly from condemned meat, undigested ingesta, bones, horns, hairs and aborted fetuses (solid wastes) and blood, gut contents, urine and water (liquid i.e. effluents).

Typically, fecal matters associated with abattoir effluents could alters the water quality parameters including physicochemical [4,7,16] and microbial parameters leading to the introduction of pathogens causing diseases such as viruses, bacteria and protozoa [7]. Furthermore, Ojo and Alamuoye [14] also reported that unsustainable management of slaughterhouse wastes could leads to transmission of zoonotic diseases such as colibacillosis, salmonellosis, brucellosis and helminthes in humans.

In coastal region and or communities aligning surface water, its contaminations occur resulting from several anthropogenic activities of human. Some of the anthropogenic activities include sewage deposal unto surface water through pier toilet system [2,3,17], municipal wastes. Furthermore, surface water contamination by abattoir effluents abound. In some of the communities aligning surface water most economic activities such as marketing and slaughterhouse is located close to the water bodies.

In Bayelsa state, several studies have been carried out in surface water resources. But most of the study majorly focused on physicochemical characteristics [4,8,9,10,18–22]. Information on the microbiological characteristics of the water bodies in the region is scantly reported when compared to the general physicochemical analysis. Specifically in Ikoli creek, a tidal surface water in Bayelsa state, it have been widely studied with regard to the physicochemical characteristics [4,18], as well as the sediment characteristics [23]. But literature on the bacteriological quality is scarce. Hence this study focused on the bacteriological assessment of a tidal creek receiving slaughterhouse effluents in Bayelsa state, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

Several creeks exist in Bayelsa state. Within the Yenagoa metropolis, Ikoli creek exists. The creek is a tributary of River Nun [4]. Several vegetation including grasses, shrubs and trees are found around the creek [4,24]. Several economic activities including dredging, fishing, washing, swimming are also carried in the creek [4,24]. Effluents resulting from Swali abattoir are also discharged into the water [4]. Two predominant seasons are peculiar in the region including wet (April to October) and dry season (November to March of the following year). The mean temperature of the region ranged from 24 - 33ºC all year round [4].

2.2 Sampling Stations and Collection

The water samples were collected in 5 different stations viz: A (about 200 m upstream of the abattoir activity), B (about 100 m upstream of the abattoir activity), C (about 10 m radius of the abattoir waste disposal point), D (about 100 m downstream of the abattoir activity) and E (about 200 m downstream of the abattoir activity). The water samples were collected using sterile bottles in June 2013. The samples were labeled according and transported to the laboratory in ice pack.

2.3 Bacteriological Examination of the Water Samples

2.3.1 Examination of total and feacal coliform

Three tube method of most probable number previously described by Pepper and Gerba [25], Benson [26] Akubunenyi et al. [27] was used to enumerate the total and fecal coliform test (through presumptive, confirmatory and completed test). Results indications (gas production and color change) were compared with table previously presented by Pepper and Gerba [25].

2.3.2 Enumeration of total heterotrophic bacteria density

Nutrient Agar was used to enumerate the total heterotrophic bacteria count. The medium was prepared based on manufacturers' instruction. Pour plate approach previously described by Pepper and Gerba [25] and Benson [26] was used for determine the bacteria density. After serial dilution, 1.0 ml of serially diluted sample was aseptically plated. The plates were allowed to solidify and then after incubated inverted at 37ºC for 24- 48 hours. The resultant colonies were counted and expressed as colony forming units per the water sample. The different colonies were isolated into slants prior to further analysis.

2.3.3 Tentative identification of the microbial isolates

The distinct isolates that grow on the nutrient agar were subjected to biochemical tests using the guide of Cheesbrough [28] and Benson [26]. The water samples were also streaked in Salmonella shigella agar, Blood Agar and Mannitol Salt Agar plate. The presence of swarming characteristics on blood agar suggests the presence of Proteus species. While the black and pink growth in Salmonella- Shigella indicate the presence of Salmonella and Shigella species respectively [29,30]. Yellowish pigments in Mannitol Salt Agar indicates *Staphylococcus aureus* [31]. Positive tubes based on colour change and gas production were shaked and streaked in Levine's eosin Methylene Blue (EMB) Agar and incubated at 37ºC for 24 hours. The presence of small nucleated colonies with greenish metallic sheen indicates *E. coli* [25,26]. All growth in the different media was streaked in nutrient agar from where the biochemical test was carried out. The results of the biochemical test were compared with those of known taxa using scheme of Cheesbrough [28] and Bergey's Manual of Determinative Bacteriology by Holt et al. [32]. Triple Sugar Iron Agar was also used for the identification of Salmonella. A positive tube was confirmed by presence of cracks and blackening of the medium indicate [29,33].

2.4 Statistical Analysis

Statistical Package for Social Sciences software version 20 was used for the statistical analysis, Descriptive statistics i.e. mean and standard error values were expressed. One-way analysis of variance was carried out at P = 0.05 to determine significance. Duncan multiple range test statistics was used to compare between means. Sorenson qualitative index previously described by Ogbeibu [34] was used to determine the bacteria diversity similarity between samples from different locations at critical level of significance = 50%.

3. RESULTS

Table 1 present the bacteria population in Ikoli creek. The total heterotrophic bacteria, total

coliform and fecal coliform ranged from 0.74 – 8.43 x 10^6 cfu/m, 8.10 – 206.67 MPN/100 ml and 5.03 – 170.00 MPN/100 ml. Typically there was no significance difference (P>0.05) among the different location for each of the parameters except station C (viz: 10 meter radius of the abattoir effluent disposal effluents).

Table 2 presents the bacteria diversity in the tidal creek receiving abattoir effluents in Yenagoa, Bayelsa state. The isolates identified include *Pseudomonas, Enterobacter, Staphylococcus aureus, E. coli, Bacillus, Micrococcus, Proteus, Salmonella, Klesbsiella, Citrobacter* and *Shigella* species. The bacteria diversity similarity between the different locations based on Sorenson qualitative index is presented in Table 3. The similarity interaction between the various sampling locations with respect to bacteria isolate ranged from 50.00% to 72.73%, being similar based critical level of significance = 50%.

4. DISCUSSION

Beside station C, the absence of significance variation in the station suggests uniformity in anthropogenic activities in the water bodies. The results showed that bacteria load is significantly higher in the area that the abattoir wastes are discharged into the water. This suggests that abattoir activities are having an impact of bacteria density of the tidal creek. As such, abattoir effluents have environmental pollution tendency particularly on surface water resources [14]. The findings of this study are in line with previous work that reported that abattoir effluents on surface water alter the microbial characteristic of the receiving water [7].

Furthermore, the results also showed that the bacteria population is higher than the limits of 1.0 x 10^2 cfu/ml for drinking water (for total heterotrophic bacteria) as specified by World Health Organization/Food and Agricultural Organization allowable limit of 1.0 x 10^2 cfu/ml for drinking water (for total heterotrophic bacteria) [7,29,35–39]. Total coliform exceeded 0/100 ml recommended by World Health organization [7]. The coliform also exceeded 10 cfu/ml and 0 cfu/100 ml for total coliforms and Thermo tolerant Coliform/*E. Coli/* faecal streptococcus for total and fecal coliforms respectively as specified by standard organization of Nigeria for drinking water [29,35,36,40]. The high concentration at upstream and downstream compared to World health Organization limits suggests the effects of other anthropogenic activities in the bacteriological quality of the creek.

Table 1. Bacteria density of Ikoli creek receiving abattoir wastes

Location	Total heterotrophic bacteria (10^6), cfu/ml	Total coliform, MPN/100 ml	Fecal coliform, MPN/100 ml
A	1.89±0.10a	9.17±1.09a	5.67±1.07a
B	0.74±0.11a	8.10±1.00a	5.03±1.02a
C	8.43±0.88b	206.67±49.10b	170.00±20.00b
D	2.93±1.41a	46.33±3.38a	33.67±2.33a
E	1.58±0.26a	15.00±2.30a	11.07±2.25a

Data is expressed as mean ± Standard Error; The same alphabets along the column indicate no significance difference (P>0.05) according to Duncan statistics

Table 2. Bacteria diversity in a tidal creek receiving abattoir effluents

Microbes	A	B	C	D	E
Pseudomonas sp	-	+	+	+	-
*Enterobacter*sp	+	-	+	+	-
Bacillus sp	-	-	+	+	-
Staphylococcus aureus	+	+	+	+	+
*Micrococcu*s sp	-	+	+	+	+
E. coli	+	+	+	+	+
Salmonella sp	-	-	+	-	-
Shigellasp	-	-	+	-	+
Klesbsiellasp	+	-	+	-	-
Citrobactersp	-	-	-	+	+

+ = Present; - = Absence

Station A – 200 m upstream of the abattoir activity, Station B – 100 m upstream of the abattoir activity, Station C - 10 m radius of the abattoir waste disposal point, Station D - 100 m downstream of the abattoir activity, Station E – 200 m downstream of the abattoir activity

Table 3. Similarity index of bacteria diversity found in tidal creek receiving abattoir effluents in Bayelsa state

Station interactions	Percentage similarity
Station A&B	50.00
Station A&C	61.54
Station A&D	54.54
Station A&E	50.00
Station B&C	61.54
Station B&D	72.73
Station B&E	66.67
Station C&D	75.00
Station C&E	57.14
Station D&E	66.77

These microbes found in the water have been variously reported in surface water in Nigeria. For instance, *Staphylococcus aureus, E. coli, Pseudomonas, Enterobacter, Yersia, Shigella, Bacillus, Micrococcus, Serratia, Proteus, Salmonella, Klesbsiella, Streptococcus* species are the predominant bacteria isolates found in surface water and other potable waters sources in Nigeria [35]. Seiyaboh et al. [29] also reported *Staphylococcus aureus, E. coli, Pseudomonas, Enterobacter, Corynebacterium, Bacillus, Micrococcus, Proteus, Salmonella, Shigella* species as the bacteria isolates found in river Nun at Amassoma axises in Bayelsa state.

Furthermore, the bacteria isolates found in this study are comparable to the isolates previously reported in abattoir related activities in Nigeria. For instance, Ayoade and Olayioye [41], reported *Citrobacter diversus, Erwinia chrysanthemi, Klebsiella oxytoca, Klebsiella pneumoniae, Serratiafonticola, Enterobacter aerogenes, Enterobacter intermedius*and *Escherichia coli* as the bacteria associated to abattoir environment in Ogun and Lagos state, Nigeria. Nandita et al. [42] reported *Bacillus, Pseudomonas, Lactobacillus, Listeria, Staphylococcus, Cornybacterium, Klebsiella* species and *Escherichia coli* as bacteria diversity found in abattoir situated at Agege, Lagos state. Adeyemo et al. [15] reported *Escherichia coli, Pseudomonas aeruginosa, Bacillus substilis, Enterobacter aerogenes and faecal streptococcus* as bacteria isolates associated with abattoir environment in Bodija, Ibadon, Oyo state. The occurrence of coliforms could be attributed to fact that they reside in the digestive system of animals especially warm blooded animals. Typically, coliform is used as indicator organisms.

5. CONCLUSION

This study evaluated the bacteriological quality of tidal creek receiving abattoir effluents in Bayelsa state, Nigeria. The study showed that the abattoir activities are having an impact on the tidal creek of Ikoli with respect to the bacteriological quality. The water samples had higher bacteria density compared to limits specified by World Health Organization/ Standard Organization of Nigeria limits for drinking water. This suggests the impact of abattoir effluents and other anthropogenic activities on water quality of the creek. Therefore, there is the need for sustainable wastes management strategies of the abattoir effluents through treatment prior to discharge.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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