

IMPACT OF ABATTOIR ACTIVITIES ON THE PHYSICOCHEMICAL AND BACTERIOLOGICAL PROPERTIES OF SOIL SAMPLES FROM CHOBA SLAUGHTER, RIVERS STATE, NIGERIA

ABSTRACT

Slaughtering and processing of animal products at abattoirs generate different waste that may be transported into the nearby water bodies through runoff and other processes. Evaluating the soil characteristics within the abattoir will provide critical information regarding the soil health, for environmental management and health care planning. The aim of the study was therefore to assess the impact of abattoir activities on soil physico-chemical and bacteriological properties. The soil sampling involved five (5) different points, representing regions where the live animals were kept, where the animals were slaughtered, where the animal hides were roasted, where the waste bones were stacked, and a control sample collected 20 meters away from the abattoir site. The result of the physicochemical parameters showed that all the sample points were either higher or lower than that of the control soil sample. Statistical analyses however showed that there was a statistically significant difference ($p < 0.05$) between the nitrate concentration in the region used for roasting of animal hides and the control sample. The result of Total Heterotrophic Bacterial Count (THBC) showed that the highest value of 7.2×10^8 cfu/g was obtained from the location where the animals are slaughtered, while the least value of 1.0×10^3 cfu/g was from the control soil sample. The other bacterial counts varied between 0.8×10^5 cfu/g and 5.0×10^6 cfu/g; 4.3×10^4 cfu/g and 1.0×10^5 cfu/g; 3.7×10^4 cfu/g and 5.6×10^4 cfu/g, for the Total Coliform Count (TCC), Fecal Coliform Count (FCC), Salmonella and Shigella Counts (SSC), respectively. A total of 28 bacterial isolates were characterized and identified to belong to seven genera, and their percentage prevalence showed that *Staphylococcus* spp., *Bacillus* spp., and *E. coli* were the most occurring, with a frequency of 21.7% each, followed by *Salmonella* spp. (13.1 %), *Klebsiella* spp. (8.7 %), *Serratiamercescens* (8.7 %) and *Shigella* spp. (4.4 %). The result of the response of the bacterial isolates to the conventional antibiotics revealed that all the isolates were sensitive to most of the antibiotics tested. This study has shown that abattoir activities have significant influence on the bacteriological and physicochemical characteristics of the soil, thereby accentuating the need for proper waste management.

Keywords: Abattoir activities, bacteriological properties, physicochemical, soil samples, slaughter.

1. INTRODUCTION

An abattoir is a specialized facility approved and registered by the regulatory authority for inspection of animals, hygienic slaughtering, processing and effective preservation, storage and dressing of meat produced for human consumption. It is a special facility designed and licensed for receiving, holding, slaughtering and inspecting meat animals and meat products before release to the public

for consumption [1]. Abattoir aims at optimizing the recovery of edible portions from the meat processing cycle for human consumption [2]. However significant quantity of waste are generated from the animal products as well as due to the day to day activities of humans. These waste may include highly organic waste with relatively high levels of suspended solid, liquid and fats. The exact composition of the abattoir waste cannot be known since it constitute several components which is detrimental to the receiving soil.

Various organs of cattle like muscles, blood, liver and kidney have been reported to contain trace metals; also feces of life stock consists of mucus, bacteria, cellulose fibers, paunch manure which is very acidic in nature and others [3]. Additional reports have been made on the effect of abattoir waste on soil including, increased concentration of trace metals, increased population of decomposers, loss of aesthetic values, excessive soil nutrient enrichment and increase toxin accumulation as well as large accumulation of sulfide, amine and organic acids [4]. Due to the protein content of slaughtered animal as well as the need to satisfy the protein need of the populace, there is an increased level of meat production done in an unhygienic or unhealthy manner, resulting in large amount of generated and deposited waste on the soil environment (lithosphere) with several impact/effects. Furthermore, this polluted soil could serve as a receptacle for many microorganisms including pathogenic ones, resulting in serious public health problems, including disease outbreak. Also, if there are no regular monitoring, this could lead to the alteration of the soil physical and chemical properties, serving as a medium for the pollution of other ecosystems such as the atmosphere and the hydrosphere.

Abattoirs waste just like any other waste can be detrimental to human and the environment if definite precautions are not taken. Some slaughter houses are littered with non-meat products and wastes that needs to be recycled into useful bye-products for further agricultural and other industrial uses. This constitutes public health risks and nuisance in most slaughter houses spread across markets, thereby causing air, soil and water pollution as well as infestation of flies and other disease vectors [5]. For hygienic reasons, abattoir use large amount of water in processing operations; this produces large amount of waste water. When the slaughter wastes are not properly managed and discharged, especially into water ways, as such practices can introduce enteric pathogens and excess nutrients into surface water. The numerous wastes produced by abattoir operation, not only pose a significant challenge to effective environmental management but also are associated with decrease air quality of the environment, potential transferable antimicrobial resistance patterns and several infectious agents that can be pathogenic to human [6].

Ground water qualities in vicinity of the abattoir are adversely affected by seepage of abattoir effluent as well as water quality of receiving stream that is located away from the abattoir [7]. Abattoir generally use large quantities of water for measuring meat and cleaning cutlasses used for cutting meat and they are usually located near water bodies in order to gain access to water for processing [8]. Contamination of river body and land from abattoir wastes could constitute a significant environmental and health hazard [5].

Air and water qualities within the residential areas are also affected by abattoir activities especially where modern or effective waste disposal system is not practiced. Medical experts have associated some diseases with abattoir activities including pneumonia, diarrhea, typhoid fever, asthma, wool sorter diseases, respiratory and chest diseases [9]. Pathogens present in animal carcasses or shed in animal wastes may include rotaviruses, hepatitis E virus, *Salmonella* spp., *Escherichiacoli* O157:H7, *Yersiniaenterocolitica*, *Campylobacterspp*, *Cryptosporidiumparvum*, *Mycobacterium*spp and *Giardialambli*a[10]. These zoonotic pathogens can exceed millions to billions per gram of faeces and may infect humans through various routes such as contaminated air, contact with livestock animals or their waste products, exposure to potential vectors (such as flies, mosquitoes, water fowl, and rodents), or consumption of food or water contaminated by animal waste [11].

This study sort to evaluate the various activities relating to cattle slaughtering and processing in this region, with the aim of assessing the contributions of abattoir activities to the soil physico-chemical and bacteriological properties. Data from the study is expected to be useful in environmental monitoring and other social, environmental health and safety awareness purposes.

2.0 MATERIALS AND METHOD

2.1 Description of study area

The study was carried out at Choba slaughter, located close to Choba Market, at the bank of new Calabar River, within latitude 4051'25.01"N and longitude 701'18.07"E. It is a conventional open abattoir with slaughter slabs for killing and processing of animals such as cow, goats, and pigs on daily bases for the local market. An average of 10 cows are slaughtered manually per day on the concrete slab.

2.2 Period and Method of Sample collection

The study was carried out between January and March 2021. A total of fifteen (15) soil samples from five (5) different points were collected in triplicates at monthly interval, for the three months period of study. Soil samples were collected into sterile polythene bags using soil auger at a depth of 0 -15cm. The samples were labelled properly and transported aseptically to the laboratory for both physico-chemical and microbiological procedures.

2.3 Description of sample collection points

The top soil samples were collected from five different points within the abattoir site, to cover the areas where different activities are carried out.

Sampling point A: The region where the live animals are kept

Sampling point B: The region where the animals are slaughtered

Sampling point C: The region where the animal hides are roasted

Sampling point D: The region where the waste bones are stacked

Sampling point E: The region where no activities are carried out (control).

2.4 Determination of the Physico-chemical properties of the soil samples

Parameters such as temperature, pH, nitrate nitrogen, electric conductivity, total organic carbon, and calcium were determined using the methods from APHA (1998) [12].

The temperature of the soil at the various locations were determined *in situ* at a depth of 0-10cm, using a digital thermometer (Pen Style Digital Thermometer). The pH was measured using a calibrated multi-parameter (HANNA HI 9828) pH meter with 10:25 (w/v) soil to water ratio. The nitrate nitrogen was determined by the brucine method, based on the reaction of the nitrate ion with brucine sulfate in a 13 N H₂SO₄ solution at 100°C and the absorbance of resultant colour measured at 410 nm wavelength. Conductivity was measured by adding the fresh soil samples into a 25ml clean 100 ml beaker, followed by the addition of distilled water up to 75 ml, stirred for 10 minutes, and allowed to stand for 32 minutes. The total organic carbon and calcium contents were determined using the rapid oxidation method and the Atomic Adsorption Spectrophotometer (AAS), respectively.

2.5. Microbiological analysis of the soil samples

The enumeration and isolation of bacteria from the soil samples were done following a serial tenfold dilution of the samples (1g in 9ml of distilled water) with dilution factors from 10⁻¹ to 10⁻⁶ using sterile physiological saline (8.5g of NaCl in 1L of distilled water) as diluents. Aliquots (0.1ml) were plated in duplicates on Nutrient agar (NA), MacConkey agar (MCA), Eosin Methylene Blue (EMB) and Salmonella Shigella Agar (SSA) plates, using spread plate method which was done by adding aliquots on already prepared plates and using flamed glass spreader to spread the already inoculated bacteria. The plates were inverted and incubated at 37°C for 24 hours and 44.5 °C for EMB plates (faecal coliform count). The colonies formed on the plates were counted and described morphologically and biochemically. The colonies formed on EMB was used for the enumeration of the population of *E. coli*; MacConkey for other coliforms and SSA for *Salmonella* and *Shigella* species. Colonies formed on nutrient agar was used to estimate the total heterotrophic bacteria count (THBC). The plates yielding counts of 30-150 colonies (cfu/g) were recorded. Colony counts were multiplied by the dilution factor to give the number of organisms per gram (cfu/g) of the soil samples, using the formula given below [13]. Representative discrete colonies were purified by sub-culturing on freshly prepared sterile nutrient agar plates and incubated at 37°C for 24 hours to obtain pure culture.

$$\text{cfu/g} = \text{Number of colonies} \times (\text{dilution used} \times \text{volume plated})^{-1}$$

2.6. Characterizations and identification of the isolates.

The bacterial isolates were examined for colonial morphology as well as for cell morphology and biochemical characteristics.

This was carried out to group bacteria into gram positive and gram negative. A smear was made from a 24hours culture on properly labeled grease free glass slides. This was achieved by dropping one to two drops of water on the slide and emulsifying with a loop full of bacteria on the grease free glass slide. The smear was stained using the Gram's staining techniques [14]. Purple or Violet colour showed gram positive while pink or red colour showed gram negative.

2.7. Preservation of pure culture.

The pure cultures of the isolates were stored in 10 % (v/v) glycerol suspension at -4°C in bijou bottles to prevent damage of the pure cultures for further analysis.

2.8 Preparation of standard bacterial suspension

A 24 hours old pure culture of the test organism, was emulsified in sterile nutrient broth tubes and adjusted to an equivalence of 0.5 McFarland's turbidity standard prepared by adding 99.4ml of 1% v/v solution of sulphuric acid and 0.6ml of 1% w/v Barium Chloride solution [14].

2.9. Antibiotics sensitivity testing by the agar disk diffusion (Kirby Bauer disk diffusion) method

A sterile swab stick was dipped into the tube containing the bacterial suspension and its turbidity was equivalent to 0.5m McFarland turbidity. The swab stick was pressed against the tube above the fluid level to remove excess broth. Using Mueller-Hinton agar plates the isolates and conventional multiple antibiotics discs were incubated for 24hrs as previously reported [15 - 17]. The diameter of each zone of inhibition was measured in ml using a ruler on the underside of the plate and recorded for reference purpose [18].

2.10 Statistical Methods

1. A One-way Analysis of Variance (ANOVA) was used to check for significant difference between each of the different samples and the control sample. The mean separation was analyzed using Tukey High significant difference (HSD).

2. Percentage prevalence was calculated using the formula:

$$P = \left(\frac{F_i}{\sum F_i} \right) \times 100$$

Where;

P = prevalence of the isolate (%)

F_i = Frequency of respective isolates

$\sum F_i$ = Summation of frequency of respective isolates

3. The percentage sensitivity to an antibiotic was calculated using the formula:

$$S (\%) = N_s / T_i$$

Where;

N_s = Number of Isolates sensitive to the drug

T_i = Total number of isolates.

3.0 RESULTS

3.1 PHYSICO-CHEMICAL CHARACTERISTICS OF THE DIFFERENT SOIL SAMPLES FROM THE ABATTOIR SITE

The results of the physicochemical parameters as presented in Table 1, showed that the highest temperature was recorded at sample point C, where the animal hides are roasted with a value of 30.3°C. While the lowest temperature (27.5°C) was recorded at point B, where the animals are slaughtered. The results of the pH varied between 7.52 and 8.56 with the highest at sampling point E where no activity was carried out (Control), with the least pH obtained from sample point B, the region where the animals are slaughtered. The least conductivity of 183±2.8 µs/cm was obtained at sample point E (control) with point A, where the live animals are kept having the highest electrical conductivity of 277±2.8 µs/cm.

The results of the analysis for nitrate nitrogen had the least value of 54.53mg/kg obtained from sample point B, the region where the animals are slaughtered, while where the animal hides are roasted had the highest value of 258.75 (mg/kg).

The Total Organic Carbon (TOC) varied between 4.14% and 4.80% with the least obtained from the point E, the control sample, while the highest was recorded at Point C, where the animal hides are roasted.

For Calcium (Ca), the results showed that Point C had the highest value (5092.55(mg/kg)) and point B had the least value (2571.25(mg/kg)), respectively (Table 1).

Statistical analysis however revealed that there was a significant statistical ($p < 0.05$) difference between the nitrate concentration in the region where hides are roasted and the control sample, with other sample points showing no significant difference ($p > 0.05$).

Table 1: MEAN PHYSICOCHEMICAL PARAMETERS OF SOIL SAMPLES FROM THE ABATTOIR SITE

Parameter	A	B	C	D	E	P-value
Temp (°C)	28.9±2.8 ^a	27.5±3.1 ^a	30.3±3.1 ^a	28±2.8 ^a	27.9±2.8 ^a	0.8738
pH	7.9±2.8 ^a	7.5±3.1 ^a	8±2.8 ^a	8.5±3.1 ^a	8.6±3.1 ^a	0.9948
Conductivity (µs/cm)	257±2.8 ^a	192±2.8 ^a	220±.5 ^a	277±2.8 ^a	183±2.8 ^a	0.1274
Nitrate (mg/kg)	57.97±0.0 ^a	54.53±3.1 ^a	25873.74±28.6 ^b	56.88±2.8 ^a	52.63±2.8 ^a	<0.0001*
TOC (%)	4.75±0.2 ^a	4.2±0.3 ^a	4.8±1.8 ^a	4.14±0.0 ^a	4.5±0.3 ^a	0.8933
Ca (mg/kg)	2938.5±28.3 ^a	2571.25±28.3 ^a	5092.55±2831.6 ^a	4197.8±2.8 ^a	4008.7±0.3 ^a	0.3876

*Pair of means with different superscript (a – b) in each row are significantly different

Key:

- A-The region where the live animals are kept
- B-The region where the animals are slaughtered
- C-The region where the animal hides are roasted
- D-The region where the waste (bones) are stacked
- E-The region where no activities are carried out (control)

3.2 BACTERIAL POPULATION IN THE ABATTOIR SOIL SAMPLES

The result of Total Heterotrophic Bacterial Count (THBC) showed that the highest was recorded at sample point B (where the animals are slaughtered), having a value of 7.2×10^8 cfu/g. The control sample on the other hand had the least count (THBC) of 1.0×10^8 cfu/g (Table 2).

The result of the Total Coliform Count (TCC) also showed that the region where the animals are slaughtered (Sampling point B) had the highest count (50×10^5 , i.e. 5.0×10^6 cfu/g) while control soil, Point E had the least value of 0.8×10^5 cfu/g.

The result of the Fecal Coliform Count, FCC also had the highest (10×10^4 (i.e. 1.0×10^5) cfu/g) obtained from sample point B, where the live animals are slaughtered, and the least bacterial count of 4.3

10^4 cfu/g was obtained from sample point D, where the bones are piled. However, sample Point C (where animal hides are roasted) as well as the control sample (E), showed no growth.

The result of the Salmonella and Shigella Counts (SSC) showed the highest growth at sampling point A, where the live animals are kept with a value of 5.6×10^4 and least growth at sampling point D, where waste bones are heaped, with a value of 3.7×10^4 . However, sampling points B (on the soil around the slab where the animals are slaughtered), sampling point C (areas where the hides are roasted) and sampling point E (control) showed no growth (Table 2).

Statistical analysis however revealed no significant statistical difference ($p < 0.05$) between each point sampled and that of the control.

TABLE 2: Mean Counts for Total Heterotrophic Bacteria (THBC), Total Coliform (TCC), Fecal Coliform (FCC) and Salmonella Shigella (SSC) - (cfu/g)

ID	THBC $\times 10^8$	TCC $\times 10^5$	FCC $\times 10^4$	SSC $\times 10^4$
A	4.5 ± 0.3^a	7.2 ± 0.3^a	5.3 ± 0.3^a	5.6 ± 3.1^a
B	7.2 ± 3.1^a	50 ± 28.3^a	10 ± 1.4^a	—
C	5 ± 2.8^a	4.8 ± 2.8^a	—	—
D	3.5 ± 0.3^a	10 ± 1.4^a	4.3 ± 0.3^a	3.7 ± 0.3^a
E	1.0 ± 0.3^a	0.8 ± 0.3^a	—	—
P-value	0.7261	0.6426	0.5533	0.1864

*Pair of means with different superscript (a) in each column are significantly different

Key:

A-The region where the live animals are kept

B-The region where the animals are slaughtered

- C-The region where the animal hides are roasted
- D-The region where the waste (bones) are stacked
- E-The region where no activities are carried out (control)

3.3 CHARACTERIZATION AND IDENTIFICATION OF BACTERIAL ISOLATES.

The bacterial groups isolated from the soil were identified based on their microscopy, cultural and biochemical attributes.

Table 3 shows the cultural characteristics of the isolates. The elevation of the isolates was either flat (*Escherichia coli*), raised (*Bacillus spp.*) or smooth, for the rest of the isolates.

Also, in Table 3, the biochemical characteristics of the isolates is shown. All the isolates were observed to be catalase positive and fructose positive. In the same manner all the isolates were urease negative and negative for Voges-Proskauer. While *Escherichia coli* was indole positive, the rest of the isolates were found to be indole negative. Also, the motility result showed that only *Shigella* was negative.

Table 3 Cultural and Biochemical Characteristics of the different bacterial genera

Isolate	Shape	Color	Elevation	opacity	GRM	MOT	OXI	Citrate	CAT	IND	VP	MRT	UR	SUC	GLU	LAT	Probable Organism
1	Rod	Pink	Flat	Opaque	-	+	-	-	+	+	-	+	-	+	AG	A G	<i>Escherichia coli</i>
2	Rod	Creamy	Raised	Opaque	+	+	+	+	+	-	-	-	-	+	A	-	<i>Bacillus Spp</i>
3	Cocci	Yellow	Smooth	Translucent	+	+	+	+	+	+	-	-	-	+	A	-	<i>Staphylococcus spp.</i>
4	Rod	Pink-Red	Smooth	Opaque	-	+	-	+	+	-	-	+	-	+	A	-	<i>Klebsiella spp.</i>
5	Rod	Pale	Raised	Opaque	-	+	-	-	+	-	-	+	-	-	A	-	<i>Salmonella spp.</i>
6	Rod	Pale with black center	Raised	Opaque	-	-	-	-	+	-	-	+	-	-	A	-	<i>ellaspp</i>
7	Rod	Red	Raised	Opaque	-	+	-	+	+	-	+	-	+	A	A	-	<i>Serratia escens</i>

3.4 PREVALENCE OF THE BACTERIAL ISOLATES IN THE ABATTOIR SITE

The prevalence of the bacterial species is as shown in (Figure 1). The result showed that *Staphylococcus* spp., *Bacillus* spp., and *E. coli* were the highest, showing a frequency of 21.7%, each, as they occurred in all the five (5) sample locations. *Shigella* spp. was however the least occurring (4.4 %). It also followed that the other bacterial species had variations in their frequency of occurrence. *Salmonella* spp. had a prevalence of 13.1 %, occurring in four (4) samples; *Serratiamercescens* had a prevalence of 8.7 %, occurring in two (2) samples; *Klebsiella* spp. had a prevalence of 8.7 %, occurring in two (2) (Figure 1).

3.5 ANTIBIOTIC SUSCEPTIBILITY PATTERN OF THE BACTERIAL ISOLATES

The results of the response of the bacterial isolates to the commercial conventional antibiotics as presented in Figure 2 – 3, and Appendix II, showed the isolates were sensitive to most of the antibiotics used. It further revealed that while all the Gram positive isolates (100 %) were sensitive to six (i.e 60%) of the antibiotics, (CH, CPX, E, LEV, CN and RD) 5.3 % were each resistant to Streptomycin (S) and Ampiclox (APX), based on the standards of CLSI.

The Gram Negative isolates showed similar pattern as 100 % of the isolates were susceptible to eight (i.e 80%) of the antibiotics, (PEF, CN, CPX, SXT, S, PN, CEP, and OFX) with only 11.1 % of the isolates resistant to Augmentin (AU) alone (Figure 3).

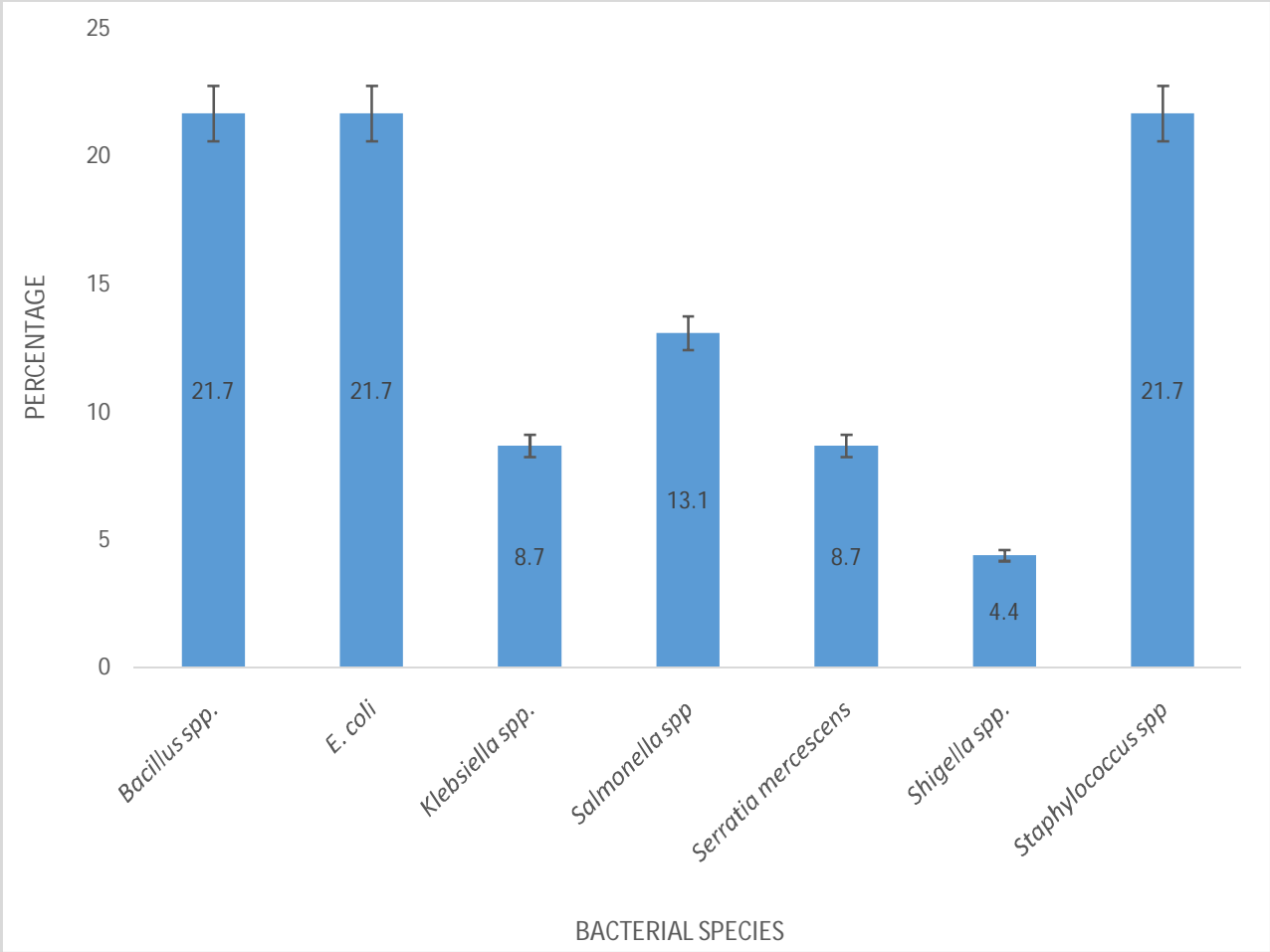


Figure 1:Prevalence of bacterial species in various soil samples at the abattoir site

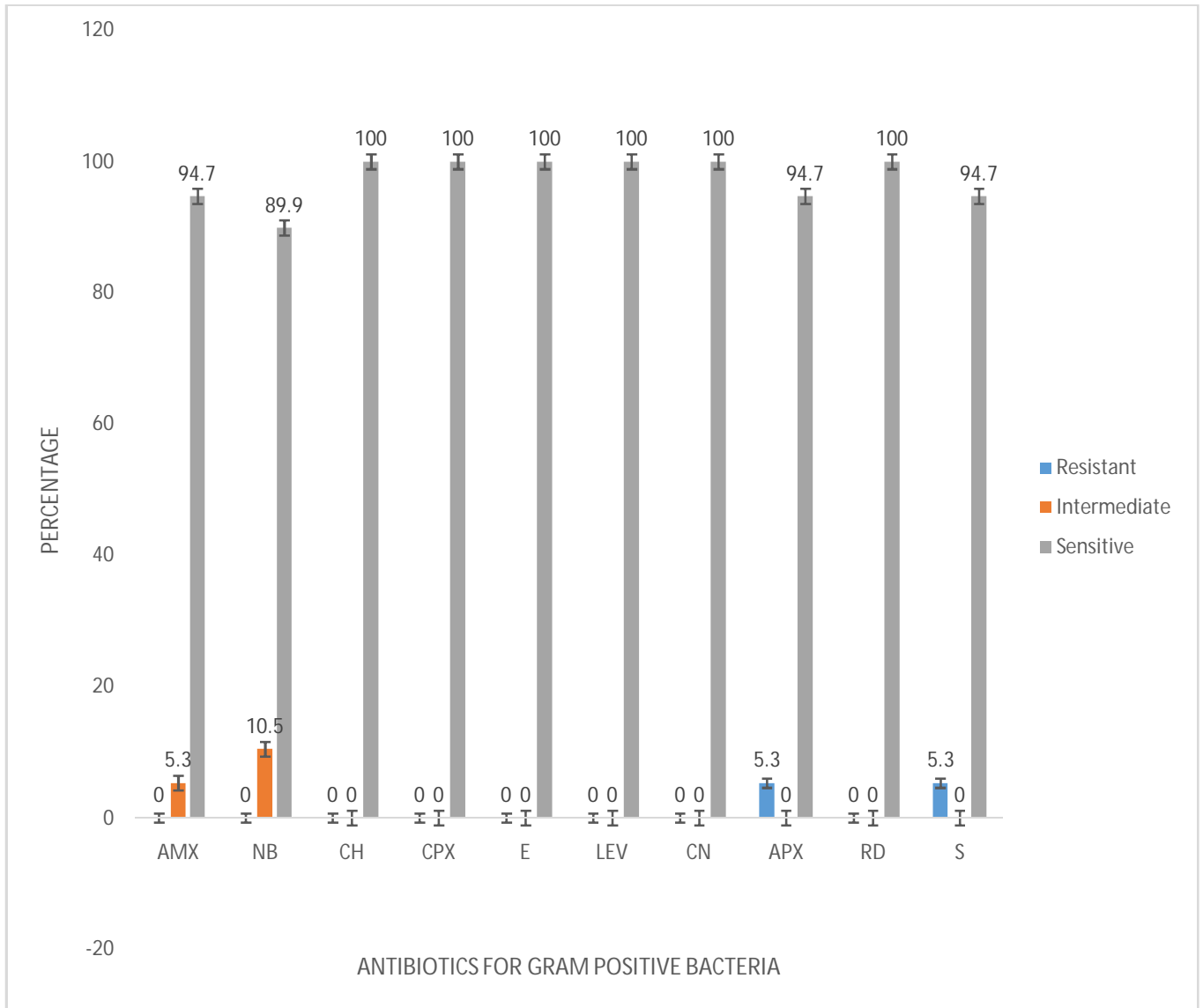


Figure 2: Antibiotics Sensitivity Pattern for Gram Positive Bacteria

KEY:

CPX: Ciproflox, CN: Gentamycin, AMX Amoxil, S: Streptomycin, RD: Rifampicin, E: Erythromycin, CH: Chloramphenicol, APX: Ampiclox, LEV: Levofloxacin, AU: Augmentin, SXT: Septrin, PN: Ampicillin, CEP: Ceporex, OFX: Tarivid, PEF: Reflaxine, NB: Norfloxacin, NA: Nalidixic acid.

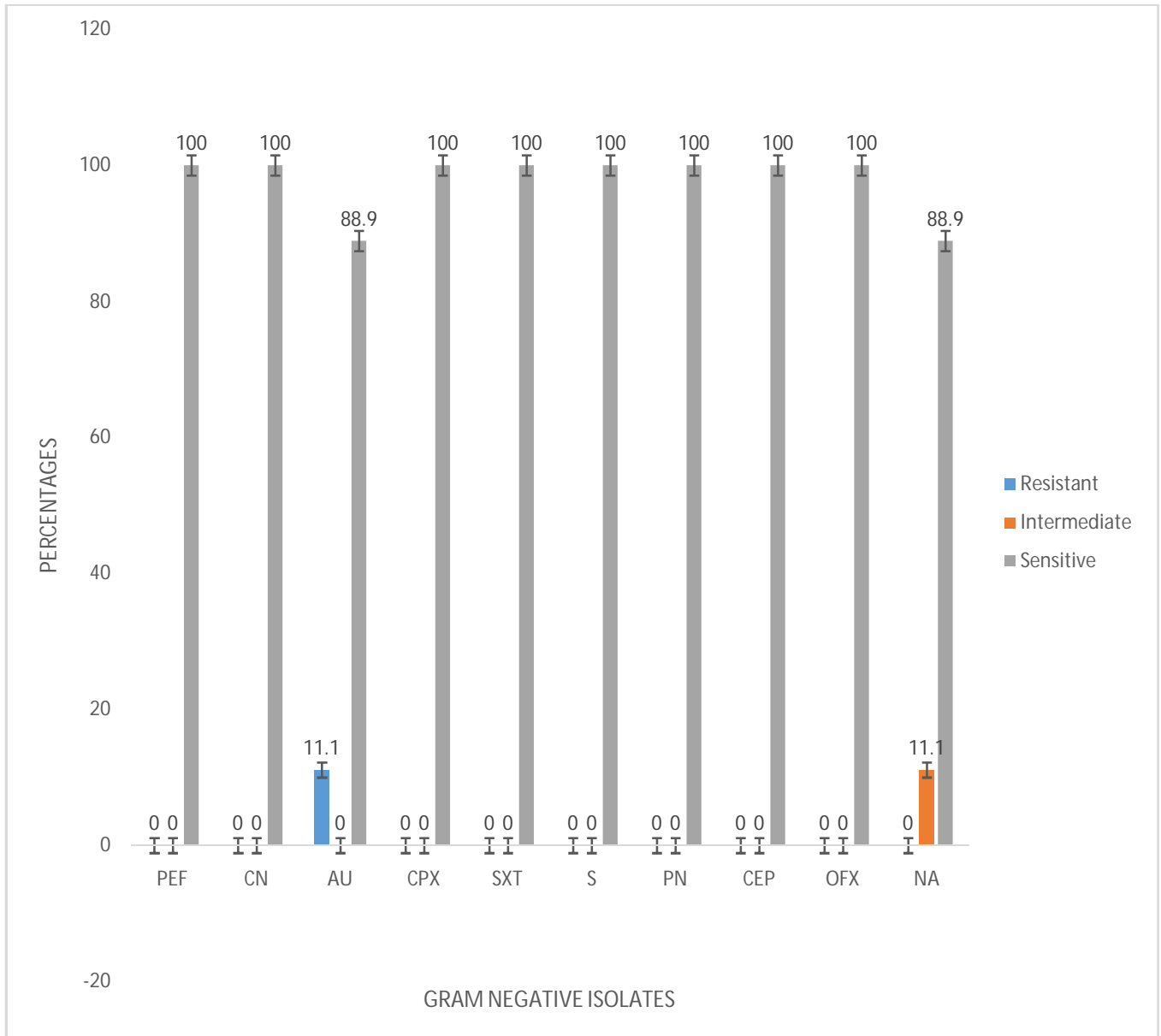


Figure 3: Antibiotics Sensitivity Pattern for Gram Negative Bacteria

KEY:

CPX: Ciproflox, CN: Gentamycin, AMX Amoxil, S: Streptomycin, RD: Rifampicin, E: Erythromycin, CH: Chloramphenicol, APX: Ampiclox, LEV: Levofloxacin, AU: Augmentin, SXT: Septrin, PN: Ampicillin, CEP: Ceporex, OFX: Tarivid, PEF: Reflacin, NB: Norfloxacin, NA: Nalidixic acid.

4.0 DISCUSSION

Due to the dependence on meat as a major protein source, the number of abattoirs in cities and rural communities is currently on the increase. This leads to an increase in waste generation which in turn impact on the physical, chemical and biological components of the environment. This present study has

presented the physicochemical and bacteriological effect of various abattoir activities at the Choba Slaughter in Rivers State.

The results of the physicochemical parameters as observed showed that the highest temperature was obtained from the region where the animal hides are burnt or roasted while the lowest temperature was recorded at the area where the animals are slaughtered. The difference in the temperature may be as a result of the heat generated during the roasting process.

The study with respect to the acidity and alkalinity, showed that the control had the highest pH value albeit the rest samples were within the neutral to alkaline range. This implies that these abattoir processes and associated waste reduced the pH towards neutrality, which may if not checked further reduce it towards an acidic range. This observation collaborates with the findings of previous researchers [19; 20] who also reported lower pH values compared to the control sample, and concluded that abattoir activities have the potential of influencing (lowering) the pH of the soil which will in turn give a concomitant effect on other parameters of the soil. Furthermore, from the study it was observed that abattoir activities influenced the conductivity, nitrate nitrogen content and total organic carbon percentage of the soil, as the control sample recorded the least value for these parameters.

High values of Electrical Conductivity mean that there are pollutants such as chloride, sodium, calcium etc. It is an indicator of water quality and soil salinity. The increase in conductivity of the abattoir soils could be ascribed to the build-up of wastes such as bones, hairs, flesh and blood, salts in abattoir effluents between the soil openings [21]. The observation of high levels of EC in abattoir soils than in the control soil could be ascribed to low cation exchange capacity (CEC) of the control soil and variations in rates at which metallic salts and organic matter complexes are formed [22].

The region where the animal hides are roasted as well as where the bones are stacked were also observed to have higher calcium content than other points and the control. Metals ions are known to influence the acidity. This implies that these waste materials such as bones, hides could be partly responsible for the higher conductivity as well as the differences in pH (compared to the control), observed in this study. Statistical analysis using a One-way Analysis of Variance (ANOVA) revealed a significant statistical difference ($p < 0.05$) between the nitrate content in the region where the hides are roasted and that of the control sample. This shows that burning of hides has the most significant environmental impact compared to other abattoir activities. The high nitrate concentration noted in this study serves as contaminant of concern as it can lead to underground water pollution via leaching, and impacting on water quality. Also, surface water quality can also be affected by this elevated nitrate level of the soil caused by this abattoir activities. This could be through runoff following rainfall, causing eutrophication of the nearby receiving water body [23].

The population of the different bacterial groups present in the soil sample was investigated and it was reported that the Total Heterotrophic Bacterial Count (THBC) had the highest obtained at sample point B (where the animals are slaughtered), with the control sample on the other hand having the least count. The population of the other bacterial groups (TCC, FC, and SSC) investigated followed similar fashion as that of the THBC. Statistical analysis however indicated that there was no significant statistical difference between each point sampled and the control.

The findings from the above indicate that these abattoir activities influence bacterial growth in the soil by either serving as exogenous sources of soil bacterial population or by altering other edaphic conditions that influence autochthonous bacterial proliferation in soil.

In a similar work by researchers [24], it was reported that the total bacterial population obtained from the contaminated abattoir soil was more than that in the soil without wastewater contamination. This could be regarded as destabilization of the soil ecological balance arising from contamination. Also, previous reports have proposed extensive microbial diversity (including species richness and species evenness) with population estimated between approximately 4×10^3 to 10^4 species per gram of uncontaminated soil [24]. It could be adduced that the higher population of bacteria observed in an impacted was possibly as a result of having more of bacteria that were able to withstand lower pH conditions.

Resistance enables bacteria to escape from being killed by antibiotics and reduces the ability to treat infections [26]. The response of the bacterial species to the different conventional antibiotics noted (as presented in Figure 2 – and 3; Appendix II and III), in this study, and it was discovered that the isolates were sensitive to most the antibiotics used. The study revealed a high rate of sensitivity of the bacterial isolates to the antibiotics tested. This high rate of sensitivity could be explained based on the fact that prior exposure of the isolate to these antibacterial drugs play a role in their resistance [27; 28].

5.0 CONCLUSION

The study on impacts of abattoir activities on the bacteriological and physico-chemical properties of soil within the abattoir environment has revealed the variable effects associated with the different abattoir activities. With respect to the physicochemical parameters, burning of hides was observed to cause a significant increase in the nitrate concentration of the soil within the abattoir environment. This could lead to serious environmental health problems if these activities are devoid of control measures.

The impact of the various abattoir practices on the soil bacterial community structure was also noted in this study. The study reported the enteric organisms as the least occurring, except for *Escherichia coli* that occurred at par with *Staphylococcus* and *Bacillus* species. Also, the control sample had the least count for all the bacterial groups (Total Heterotrophic Bacteria, Total Coliform, Fecal Coliform, *Salmonella* and *Shigella* species) evaluated. This implies that abattoir activities lead to increase in the population of soil bacterial community, including those with potential to cause disease in man.

It is therefore important to setup regulatory standards to monitor abattoir activities in order to maintain a healthy environment by promoting good hygienic and safe environmental practices in areas dealing with animal slaughtering and processing.

REFERENCES

1. Along DO. Meat and Milk Hygiene in the Tropics. *Farmose Press, Ibadan, Nigeria*.2005;77- 86.
2. RMAA (Red Meat Abattoir Association. Waste Management in Red Meat Abattoir, Pretoria, South Africa, 2010; 40
3. Navena V, Joy PP. Microbiology Laboratory Manual. *Pineapple Research Station (Kerala Agricultural University), Vazhakulam.CMuvattupuzha, Ernakulam, Kerala.P*
4. Adeyemo OK, Ayodeji IO, Aiki-Raji CO. The water Quality and the Sanitary Conditions in a Major Abattoir (Bodija) in Ibadan. *AJ, Biomed. Res*.2002; 51-55.
5. Osibanjo O, Adie GU. Impact of Effluent from Bodija Abattoir on the Physicochemical Parameters of Oshunkaye Stream in Ibadan city, Nigeria. *AJ Bio-Technology*.2007; 6: 1806-1811.
6. Meadows JH. Livestock Legacy. *Environmental Health Perspective*.1995; 103(12): 1096-1100.
7. Sangodoyin AY, Agbawhe OM. Environmental Study on Surface and Ground Water Pollutants from Abattoir Effluents. *Bio-resource Techno*.1992; 41: 193-200.
8. Amisu KO, Coker AO, S.L.W. On Isokpehi RD. *Azotobacterbutzlieria* strains from poultry abattoir effluent in Nigeria. *African Medical Journal*.2003; 218-221.
9. Bello YO, Oyedemi SS. Impact of Abattoir Activities and Management in Residential Neighborhoods, Nigeria. *Journal of Social Science*.2009; 19: 121-127.
10. Sobsey MD, Khatib LA, Hill VR, Alocilja E, Pillai S. Pathogens in Animal Wastes and the Impacts of Waste Management Practices on their Survival,Transport, and Fate. *White paper for the National Center for Manure & Agricultural Waste Management*.2002
11. Schlech WF, Lavigne PM, Bortolussi RA. Epidemic listeriosis-evidence for Transmission by food. *The New England Journal of Medicine*.2005 ;(308) 203-206.
12. APHA. Standard Methods for Examination of Water and waste water. American Public Health Association, Washington, DC. 1998.
13. Sampson, T., Barika, P.N.,Peekate, L.P. andAkani, N.P. Prevalence and antibiogram of *Escherichia coli* isolated from edible cockle (*Seniliasenilis*) in Rivers State, Nigeria. *International Research Journal of Public and Environmental Health*.2020; 7 (5). 149-156
14. Cheesbrough M. District Laboratory Practice in Tropical Countries.*2nd Edition University press, University of Cambridge, Edinburg, Cambridge, United Kingdom*.2005; 38(39):194-201.
15. Sampson, T., N. P. Akani and O. Aniwoko. Molecular Characterisation and Antibiogram of Vaginal Flora from Students Attending a Tertiary Institution in Port Harcourt, Rivers State, Nigeria. *International Journal of Pathogen Research*. 2021; 7(1), 17-27.

16. Sampson, T., N. P. Akani and I. O. Hakam. Molecular Characterization and Detection of Antibiotic Resistance Genes in *Pseudomonas species* Isolated from *Typanotonusfuscatus*. *Journal of Advances in Microbiology*, 2020; 20 (6): 37-45
17. Sampson, T, J. Alexander, and C.J. Incidence of *Staphylococcus aureus* Wound Infection amongst Patients Attending University of Port Harcourt Teaching Hospital, Rivers State, Nigeria. *Saudi Journal of Pathology and Microbiology*. 2022; 7(7): 307-312
18. Clinical and Laboratory Standard Institute. Performance Standards for Antimicrobial Susceptibility Testing, twenty-five informational supplement. *CLSI document M100-S21 (ISBN1-562387421)*. *Clinical and Laboratory Standard Institute, 940 West valley road, suite 1400, wayne, Pennsylvania. 19087 USA*. 2017; 30(1), 68-70.
19. Sumayya BU, Usman BU, Aisha U, Shahida A, Mohammad A, Yakubu MS, ZainabM. Determination of Physicochemical Qualities of Abattoir Effluent on Soil and Water in Gandu, Sokoto State. *Journal of Environmental Science, Toxicology and Food Technology*. 2013; 4(4): 47-50
20. Rabah AB, Oyeleke SB, Manga SB, Hassan LG, Ijah UJJ. Microbiological and physicochemical Assessment of soil contaminated with Abattoir effluents in Sokoto Metropolis. *Nigeria Science World Journal*. 2010; 5(3): 1-4
21. Radha S, Nithya VJ, Babu RH, Sridevi A, Narasimha G, Prasad NBL. Effect of Abattoir Waste Disposal on Soil Physico-chemical, Biological properties, and Enzyme activities. *Asian Journal of Microbiology, Biotechnology and Environmental Sciences*. 2011; 13(4): 673-676
22. Dan E, Fatunla K, Shuaibu S. Influence of Abattoir Wastes on Soil Microbial and Physicochemical Properties. *International Journal of Advance Research and Innovation*. 2018; 6 (4): 253-261
23. Wemedo, S. A., Sampson, T. and B. Dick (2021). Evaluating the Nitrate to Phosphate Ratio and Other Physicochemical Characteristics of Different Water Sources in Yeghe Community, Rivers State, Nigeria. *Asian Journal of Environment & Ecology*. 15(1), 1-9
24. Adesemoye AO, Opere BO, Makinde SCO. Microbial content of abattoir waste water and its contaminated soil in Lagos, Nigeria. *Afr. J. Biotech.* 2006; 5(20): 1963-1968.
25. Borneman J, Skroch PW, O'Sullivan KM, Palus JA, Rumjanek NG, Jansen JI, Neinhuis J, Triplett EW. Molecular Microbial Diversity of an Agricultural soil in Wisconsin. *Applied and Environmental Microbiology*. 1996; 62:1935-1943.
26. Spellberg B, Guidos R, Gilbert D. The Epidemic of Antibiotic-Resistant Infections: A Call to Action for the Medical Community from the Infectious Diseases Society of America. *Clinical Infectious Disease*. 2008; 46:155-64.
27. Sampson T, Esheyigba AP, Baridam SS. Bacteriological Assessment of Toilet Seats in a Nigerian University. *Journal of Advances in Microbiology*. 2019; 19(4): 1-11.

28. Akani NP, Hakam IO, Sampson T. Prevalence and AntibioqramSS of *Pseudomonas aeruginosa* isolated from West African Mud Creeper (*Tympanotonus fuscatus*). *South Asian Journal of Research in Microbiology*.2019; 5(2), 1-8.

UNDER PEER REVIEW