An Evaluation of Microbiological and Physicochemical Characteristics of Abattoir Soils in the Niger Delta

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Abstract: **Indiscriminate dumping of waste substances/chemicals into the environment has resulted in environmental pollution, which is one of the most important concerns in our world today. Soil samples from different Abattoirs in Bayelsa and Rivers States in the Niger Delta were evaluated for their microbiological and physicochemical properties. Soil samples collected from a region not known for abattoir activities served as control. Microbiological parameters of soil samples were analyzed using standard microbiological techniques while physicochemical parameters were analyzed based on APHA standard analytical methods. Results of mean values of microbial counts for total heterotrophic bacteria, total hydrocarbon utilizing bacteria, total coliform, total heterotrophic fungi and hydrocarbon utilizing fungi of the soil samples ranged from 6.0×10^5 CFU/g to 8.0×10^7 CFU/g, 4.8×10^4 to 3.8×10^5, 1.2×10^3 to 8.0×10^5, 1.3×10^3 to 2.4×10^5 and from 1.0×10^2 to 1.6×10^3CFU/g, respectively. Kruskal-Wallis H test showed that there was no significant difference ($P\geq0.05$) among bacterial counts and among fungal counts of the different abattoirs soils.Bacteria identified from the abattoir soil samples and percentages of occurrence were: *Bacillus* sp (20.16%), *Escherichia coli* (12.34%), *Streptococcus* sp (10.28%), *Staphylococcus* sp (22%), *Pseudomonas* sp (16.04%), *Micrococcus* sp (9.46%), *Salmonella* sp (13.16%), *Enterobacter* sp (2.88%) and *Proteus* sp (4.11%). Percentage occurrence of hydrocarbon utilizing bacteria was *Bacillus* sp (27%), *Escherichia coli* (17%), *Staphylococcus* sp (11.47%), *Pseudomonas* sp (22%), *Micrococcus* sp (3%), *Enterobacter* sp (3%) *and Proteus* sp (6%). Fungi identified and percentages of occurrence were; *Penicillium* (43.3%), *Aspergillus* sp., (26.8%), *Fusarium* sp., (11.6%) *Geotrichum* sp., and *Mucor* recorded (9.2%) each. Percentages of occurrence of hydrocarbon utilizing fungi were *Aspergillus* sp (35%), *Penicillium* sp (45%), *Fusarium* sp (10%) and *Geotrichum* sp (10%). The range of means of physicochemical parameters were: pH: 6.3-7.06, EC: 53-1573, TOM: 0.538-6001, TOC: 0.312-3939, TN: 0.091-0.341, NO_3: 0.1-2.1, SO_4: 0.1-2.7, PO_4: 0.06-0.81, salinity: 328-1075 and Cl^-:10-130. The abattoir soils are highly contaminated and could serve as reservoir for pathogens. Treatment of waste before disposal is highly recommended.**

I. INTRODUCTION

The Abattoir act defined abattoir as any premises (slaughter house but not a location on a farm) used for or in connection with the slaughter of animals whose meat is intended for human consumption and that abattoir effluents or waste are the residual material obtained from the abattoir after the slaughter of animals such as cattle, sheep, goats, and other livestock (Chukwu and Anuchi, 2016). The abattoir sector in Nigeria is a significant part of the livestock industry which provides domestic meat to over 150 million people as well as job opportunities for the workforce. In contrast to industrialized nations, where the facilities employed in the treatment of slaughterhouse wastes before discharge into the environment are abundant, abattoir industries are less established in developing countries like Nigeria (Nafarnda *et al*., 2012). Activities carried out in abattoirs usually lead to production of large wastes which are mostly not properly managed. In Africa, reports have shown that these wastes have a high potential to cause serious environmental problems to the receiving environment (Ebong *et al*., 2020). It was also reported in a previous study that abattoir operation which is believed to highly relevant to man since it provides meat for human consumption and other useful byproducts could also be a source of hazards to the public health due to the amount of waste it generates (Dankaka *et al*., 2018). It was also reported that the complex nature of the abattoir wastes could be very detrimental to any environment where these wastes are discharged, especially since there are traces of metals in organs, blood, kidneys and liver of livestock including high microbial community in faecal matters (Dan *et al.*, 2018). Charles and Okereke (2015) also noted that the high mineral contents in abattoir effluent or wastewater pose serious challenge to environmental safety. Abattoir waste when discharged on soil environment could have serious impact not just to the concentration of metals in the environment but also to micro and macroflora of that environment where it is exposed to. According to Ediene and Iren (2017) concerns about heavy metals in soils are not just limited to their toxicity to living organisms inhabiting the soil but also because failure to alleviate heavy metal build-up and persistence in soil may result in immobilization within different organic and inorganic colloids and mobilization into flora and fauna, and subsequently become available in food chain with deleterious health effects. Additional reports have been made on the effect of abattoir wastes on soil including increase concentration of trace metals, increase in population of decomposers, loss of aesthetic value, excessive soil nutrient enrichment and increase in toxin accumulation, as well as large accumulation of sulphides, mercaptans, amines and organic (Dan *et al.*, 2018).

Furthermore, random disposals of abattoir effluents into soils have been reported to accumulate metals in receiving soils, impact negatively on soil organisms by making them unable to readily adapt to or degrade heavy metals because metals slow down the rate of growth, activities and reproduction of functional microbial population in the soil (Ediene and Iren, 2017).

II. MATERIALS AND METHOD

Materials and Methods

Sampling Location

Soil samples (500g) made up of three composite samples were collected from each abattoir with the aid of a hand soil auger at about 0-15cm depth. The soil samples were collected into clean sterile containers and plastic bags for microbiological and physicochemical analyses, respectively. The soil samples were collected from four abattoirs in Yenagoa Local Government Area of Bayelsa State and from two abattoirs in Obio-Akpor Local Government Area of Rivers State. The control samples were collected from Azikoro, a community without any known history of abattoir activities as at the time of this study. The samples on collection were aseptically transported in ice-packed coolers to the Microbiology laboratory of the Rivers State University and were analyzed immediately.

Sample preparation

Samples for microbiological analysis were analyzed immediately while samples for physicochemical assay were air-dried to constant weight at 25ºC for few days, crushed to smoothness with mortar and pestle before it was sieved through a 2mm wire mesh.

The map coordinates of the abattoir locations are as stated below:

Location	Northing (N)	Easting (E)
Igbogene	5^0 2' 17.8188"	6^0 24'14.958"
Tombia	4^0 57' 17.8092"	6^0 20'53.2428"
Opolo	4^0 56'52.764"	6^0 20'3.984"
Swale	4^0 53'42.9576"	6^0 16'39.7164"
Rumuokoro	4^0 52' 11.64"	7^0 01' 026"
Rukpokwu	4^0 57' 10.908"	6^0 21' 20.7432"
Azikoro (Control)	^{0} 4 57' 13.77"	^{0} 6 21' 19.5048"

Isolation, Enumeration and Characterization of Microorganisms

Total Heterotrophic Bacteria (THB)

This was determined with the nutrient agar using the pour plate technique as described by Prescott *et al.* (2011). Ten grams (10g) of soil samples was weighed into 250ml conical flask containing 90ml sterile normal saline to give an initial 10^{-1} dilution. With the aid of sterile pipette, 1ml was taken from this dilution into the test tube containing 9ml of sterile normal saline to achieve 10^{-2} dilution. This sequence was repeated until dilution 10^{-6} was obtained. 1ml aliquot of 10^{-6} dilution was transferred aseptically unto sterile petri dishes and 10ml of molten sterile agar cooled to about 45^{o}C was added aseptically, swirled and allowed to solidify. Samples were plated in duplicates. Plates were incubated in an inverted position at 35 ± 2^{o}C for 24 hours after which viable colonies were counted.

Total Coliform Bacteria (TCC)

This was determined with MacConkey Agar using the spread plate technique as described by Prescott *et al.* (2011). Ten grams (10g) of soil samples was weighed into 250ml conical flask containing 90ml sterile normal saline to give an initial 10^{-1} dilution. One ml was taken from this dilution into the test tube containing 9ml of sterile normal saline to achieve 10^{-2} dilution. This sequence was repeated until dilution 10^{-6} was obtained. Aliquot (0.1ml) of 10^{-4} dilution was transferred aseptically unto the surface of pre-dried sterile petri dishes. Plates were spread using sterile bent glass rod, and were incubated in an inverted position at 35 ± 2^{o}C for 24 hours after which viable colonies were counted.

Total Hydrocarbon Utilizing Bacteria (THUB)

The Vapour Phase Transfer method of Mills and Colwell (1978) was adopted to determine the population of hydrocarbon utilizing bacteria. Aliquots (0.1ml) of the serially diluted samples were inoculated on mineral salt agar media using the spread plate technique as described by Odokuma (2003). Sterile filter paper discs soaked in filter-sterilized crude oil which served as the only carbon source in the mineral salt agar was placed aseptically to the cover of the inoculated agar plates. The plates were incubated for 5 days at 35 ± 2^{o}C after which viable colonies were counted. After the incubation period, mean of the colonies were recorded.

Total Heterotrophic Fungi Count (THF)

This was determined using the Potato Dextrose Agar (PDA**)** onto which 1% of lactic acid was added to suppress bacterial growth (Okerentugba and Ezereonye, 2003). The spread plate technique as described by Prescott *et al.* (2011) was adopted. An aliquot (0.1ml) of the appropriate serially diluted samples were inoculated in duplicates onto sterile pre-dried PDA plates and then spread evenly with a sterile glass spreader. The plates were incubated at 25^{o}C for about 5 days (Douglas and Robinson, 2018) after which the colonies were counted and the mean of the count recorded accordingly.

Total Hydrocarbon Utilizing Fungi (THUF)

The Vapour Phase Transfer method of Mills and Colwell (1978) was adopted to determine the population of hydrocarbon utilizing fungi. Aliquots (0.1ml) of the serially diluted samples were inoculated on mineral salt agar media added with 1% lactic acid to suppress bacterial growth (Okerentugba and Ezereonye, 2003), using the spread plate technique as described by Odokuma (2003). Sterile filter

paper discs soaked in filter-sterilized crude oil which served as the only carbon source in the mineral salt agar was placed aseptically to the cover of the inoculated agar plates. The plates were incubated at 25^{o}C (Douglas and Robinson, 2018) for about 5 days. After the incubation period, mean of the colonies were recorded.

Purification of Isolates

After the incubation periods, morphologically distinct and discreet colonies were streaked on respective agar plates to obtain pure cultures. Pure isolates of total heterotrophic bacteria and total hydrocarbon utilizing bacteria were obtained by picking (with sterile wire loop) distinct culturally and morphologically different colonies from the various media plates and streaked on pre-dried NA plates while pure cultures of fungal isolates were streaked on pre-dried PDA plates. Plates for bacteria were incubated at 35 ± 2 ^{o}C for 24 hours while the fungal plates were incubated at 25^{o}C for about 5 days.

Identification of Bacterial Isolates

Pure bacteria isolates were identified by the method described by Cheesebrough (2005). Pure bacterial isolates were subjected to Biochemical tests which include 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. Procedure for the respective biochemical tests were carried out according to standards (Cheesbrough, 2005). Bacterial isolates were identified with reference to the Bergey's Manual of Determinative Bacteriology (Holt *et al*, 1994).

Identification of Fungal Isolates

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 Barnett and Hunter (1998). 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 Barnett and Hunter (1998). The yeast isolates were further identified using Gram-staining, Sugar fermentation, oxidation and fermentation tests.

Physicochemical Parameters

The physicochemical parameters of soil samples were analyzed based on the APHA-standard methods for the examination of water and wastewater (APHA, 2012).

Determination of pH

The Hanna HI pH meter (Model 8424, USA) was used. The meter was switched on and then standardized with two buffer solutions of higher (10) and lower (4) pH by dipping the electrode in the buffer solutions. Twenty grams (20g) of air dried and sieved samples was transferred in to 250ml beaker and 100ml of distilled water was added. The mixture was stirred with a glass rod and allowed to stand for 30minutes. The electrode of the calibrated pH meter was inserted into the slurry and pH values was read.

Determination of Salinity

Soil salinity was taken from the sample above. The salinity probe was calibrated in a '0' (zero) salinity water. The probe was then placed in the soil slurry to read the salinity values.

Determination of Electrical Conductivity

A calibrated (0.01M KCl) conductivity meter was inserted into the slurry obtained from soil samples above and the values taken were read and recorded.

Determination of Phosphate

Available phosphate was determined using the method of Bray and Kurtz (1945). Fifteen millilitres (15ml) of 1M solution of Ammonium fluoride and 25ml of 0.5M HCl were added into a 500ml volumetric flask. 460ml of distilled water was added to make up the mark. One gram (1g) of air-dried soil sample was weighed into centrifuge tubes and 7ml aliquot of the extracting solution was added. It was later placed on an orbital shaker and shaken for 5minutes and then centrifuged at 2000rpm for 10minutes. After which 2ml aliquot of the clear supernatant were transferred into 20ml test tube, 5ml distilled water added followed by 2ml of ammonia solution. The contents were mixed well. Finally, 1ml of stannous chloride was added and mixed again. The colorimeter was set at 660^{o}nm and absorbance values were taken. The amount of phosphate in the soil was determined from the standard curve prepared with phosphate standard solutions.

Determination Of Nitrate

Extraction procedure: 5.0g of air-dried soil was transferred into shaking bottle and ¼ teaspoon (about 0.25g) of activated carbon and 20ml 0f extraction solution (110g Na-acetate + 30ml of 99.58% acetic acid, diluted to 1 liter) was agitated I minute before filtration. One milliliter aliquot of the soil extract was transferred to a sample vial and mixed. 0.5ml of brucine reagent (2.5g brucine sulphate in 100ml glacial acetic acid) was added, followed rapidly by the addition of 2ml sulphuric acid. The solution was mixed for about 30seconds and allowed to stand for 5minutes.

The solution was mixed again before 2ml distilled water was added with continuous mixing for about 30seconds. Afterwards, water was added to make solution up to 10ml mark of the sample vial. The vials were left to air cool for about 15minutes (to allow the test solution form a brownish colour). The solution was read for nitrate value at an absorbance measured at 400 nm using the HACH DR 890 Colorimeter.

Determination of Sulphate

Turbidimetric method as described by APHA (2012) was used. One hundred milliliter of the sample was measured into

a 250ml Erlenmeyer flask followed by addition of 20ml buffer solution and then stirred, while stirring a spoonful of $BaCl_2$ crystals was added. This was stirred for 60 seconds at a constant speed. After stirring, the solution was poured into the absorbance cell of photometer and turbidity measured at 420nm. SO_4^- was estimated by comparing turbidity reading with a standard working sulphate concentration from 0.01mg/ml – 0.1mg/ml treated as sample above, with turbidity measured at 420nm using distilled water as blank.

Calculation:

SO_4^{2-} = Absorbance of sample x Gradient of the standard graph.

Soil samples: 5g of air dried and sieved soil sample was weighed into a centrifuge tube and 25ml of extracting solution (K_2PO_4 solution containing 500ppm P) was added. The soil solution was agitated for 30minutes on a mechanical shaker before the suspension was filtered through a Whatman filter paper (Ensminger, 1954). 10ml of sample was pipetted into a 25ml volumetric flask and made up to volume with distilled water. Iml of a gelatin-$BaCl_2$ reagent (0.6g gelatin in 200ml hot distilled water + 2g $BaCl_2$) was added, making the volume up to mark and mixed. The content is left to stand for 30minutes (the test solution formed a whitish precipitate) and was measured at 420nm (Tabatabai, 1974) using a HACH DR 890 colorimeter.

Determination of Chloride

The Silver – Nitrate Titration method of APHA (2012) was used. Twenty-five milliliter of the sample was measured into 100ml conical flask. Two drops of potassium dichromate were added and then titrated with silver nitrate until the appearance of a brick red colour which is the end point. The titre volume was recorded.

$$\text{Amount of Chloride (Mg/l)} = \frac{\text{Titre (ml) x 100}}{\text{Vol. of sample (ml)}}$$

Determination of Total Kjeldahl Nitrogen

Ten grams (10g) of air-dried soil samples were weighed into 500ml macro kjeldahl flask, 20ml of distilled water was added. The flask was slowly heated until the frothing ceased. Thereafter the mixture was heated strongly to boil for 5 hours. The mixture was then cooled and 100ml of distilled water added to the flask. The digest was quantitatively transferred into another kjeldahl flask

Determination of Total Organic Carbon and Total Organic Matter

The method of Walkley and Black (1934) was used to determine the soil Organic Matter. Two grams (2)g of air-dried soil placed in a conical flask. Ten milliliters (10ml) of 1N $K_2Cr_2O_7$ solution was added and mixed. Then 10ml of concentrated H_2SO_4 was carefully added and mixed thoroughly by slight rotation. The mixture was allowed to cool for half an hour with occasional slight shaking. (If the colour of the mixture appears green then add an additional 10 ml of 1N $K_2Cr_2O_7$ solution. Green colour is an indication that all oxidizing agent added is used up to oxidize organic carbon). Then 10 ml H_3PO_4 (85%) and 0.2 g NaF in sequence was added. Then add 3 ml diphenylamine (Dissolve 0.25 g indicator into 10 ml dw and slowly add 50 ml concentrated H_2SO_4 into it) indicator prior to titration. The mixture appears deep violet in colour. Titrate excess $K_2Cr_2O_7$solution left in the flask with $FeSO_4.7H_2O$ solution. A lank titration was run (This step is essential to standardize $FeSO_4.7H_2O$ solution against standard $K_2Cr_2O_7$ solution).

TOC in soil (%) = [(B-T) × S × 0.003 × 1.3 × 100] ÷ W

Where:

B = Amount of $FeSO_4$ required in blank titration.
T = Amount of $FeSO_{4\ required}$ in soil titration.
S = Strength of $FeSO_4$ (from blank titration).
W = Weight of the soil.
TOM in soil (%) = % organic C × 1.724

Statistical Analysis

The mean and standard deviations of the microbial counts were computed. The log counts were used in plotting the graph. Also, the frequencies of microorganisms across the abattoir sites were determined. The Analysis of variance (ANOVA) was used in checking for significant difference in the microbial counts across the abattoir samples while Kruskal Walis H test was used in separating the means. All analysis was done using SPSS (version 27).

III. RESULT

The result of the mean values of the total heterotrophic bacterial counts, total hydrocarbon utilizing bacterial counts, total coliform counts, total heterotrophic fungal counts and total hydrocarbon fungal counts of the soil samples were: 6.0×10^5 CFU/g to 8.0×10^7 CFU/g, 4.8×10^4 to 3.8×10^5 CFU/g, 1.2×10^3 to 8.0×10^5 CFU/g, 1.3×10^3 to 2.4×10^5 CFU/g and from 1.0×10^2 to 1.6×10^3 CFU/g, respectively (Fig. 1). The control soil had the least total heterotrophic bacterial, total hydrocarbon utilizing bacterial, total coliform, total heterotrophic fungal and total hydrocarbon fungal counts. The highest and lowest mean total heterotrophic bacterial count of 8.0×10^7 CFU/g and 1.2×10^7 CFU/g were recorded in abattoir soil samples from Swale and Opolo abattoir samples respectively. The highest and lowest mean total hydrocarbon bacterial count of 3.8×10^5 CFU/g and 1.6×10^5 CFU/g were obtained in abattoir soil samples obtained from Tombia and Rukpokwu abattoir samples respectively. Kruskal-Wallis H test showed that there was no statistically significant difference ($P\geq0.05$) in the counts for the total heterotrophic bacteria, hydrocarbon utilizing bacteria and coliform. The mean count of total heterotrophic fungal load of 2.4×10^5 CFU/g was the highest recorded from samples collected from Tombia and Swale abattoirs. The least total heterotrophic fungal load of 1.8×10^5 CFU/g was obtained in Rumuokoro soil samples. Kruskal-Wallis H test showed that there was no

statistically significant difference (P≥0.05) in the counts for the total heterotrophic fungal and hydrocarbon utilizing fungal counts.

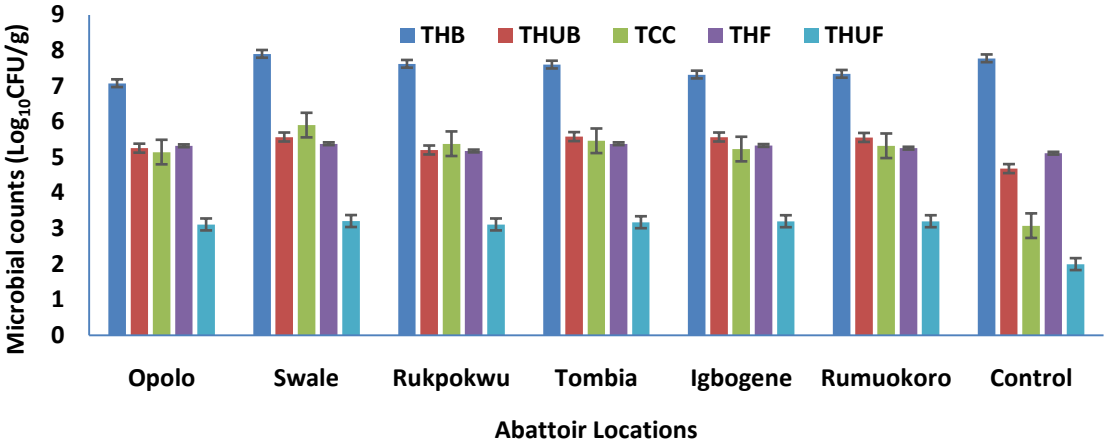

Fig. 1: Microbial load of the different Abattoir Soil samples

Key: THB = Total heterotrophic bacteria; THUB = total hydrocarbon utilizing bacteria; TF = total fungi; THUF = total hydrocarbon utilizing fungi; TCC = total coliform

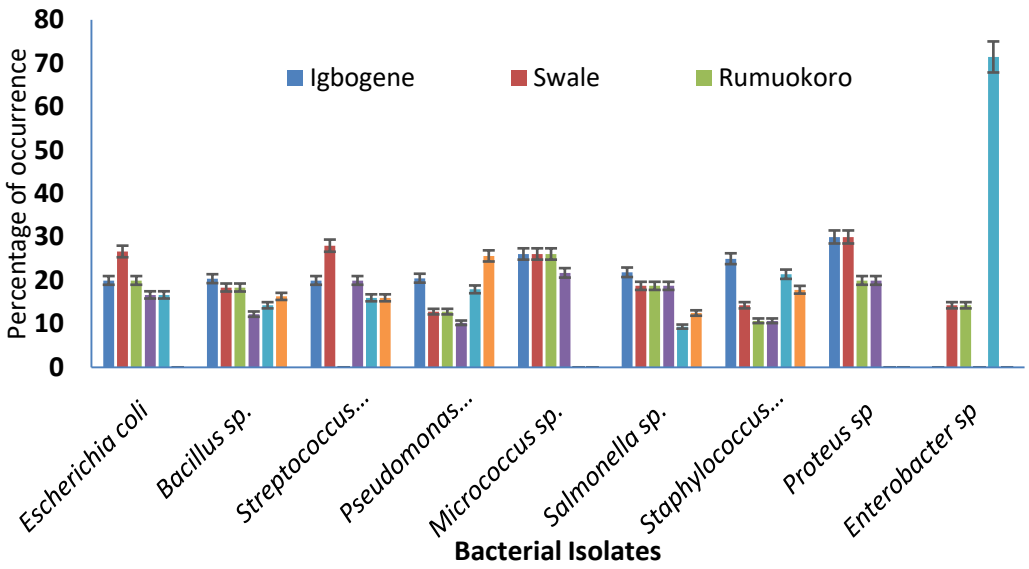

Fig. 2: Frequency of occurrence of bacteria isolated from the Abattoir Soils

The distribution of the bacteria isolated from the soil is presented in Figure 2. The bacterial isolates were: *E. coli*, *Bacillus*, *Streptococcus*, *Pseudomonas*, *Micrococcus*, *Salmonella*, *Staphylococcus*, *Proteus* and *Enterococcus* species. *Escherichia coli*, *Bacillus* sp, *Pseudomonas* sp, *Salmonella* sp and *Staphylococcus* sp were isolated from all samples. *Streptococcus* sp was isolated in all the abattoir locations except in Rumuokoro abattoir *Enterobacter* sp and *Proteus sp* were obtained in three abattoir locations each. The most abundant bacteria specie was *Bacillus* sp with 20.16% of occurrence. While the percentages of occurrence of other isolates include; *Escherichia coli* (12.23%), *Streptococcus* sp (10.28%), *Staphylococcus* sp (11.52%), *Pseudomonas* sp (16.04%), *Micrococcus* sp (9.46%), *Salmonella* sp (13.16%), *Enterobacter* sp (2.88%) and *Proteus* sp (2.88%). Hydrocarbon utilizing bacteria isolated from soil sample occurs in the percentages: *Bacillus* sp (27%) *Escherichia coli* (17%), *Staphylococcus sp* (11.47%), *Pseudomonas sp* (22%), *Micrococcus sp* (3%), *Enterobacter* sp (3%) *and Proteus* sp (6%).

The distribution of characterized fungal isolates in soil samples from the assessed abattoirs is presented in Figure 3. Tentative fungi species identified include *Aspergillus* sp. *Penicillium* sp, *Fusarium* sp. *Geotrichum* sp and *Mucor* sp. *Aspergillus niger* was found in all abattoir soil samples except in Opolo abattoir sample. *Fusarium* sp was found in all soil samples except in Rumuokoro and Opolo abattoir soils. *Penicillium* sp was the only fungal isolate found in all soil samples, Swale soil recorded the highest count while Rumuokoro soil had the least count. *Geotrichum* sp was isolated from the soil samples obtained from Tombia, Swale and Rupokwu. While *Mucor* sp was present in samples obtained from Igbogene and Rukpowu abattoirs. The percentages of occurrence showed that *Penicillium* sp was the most frequently isolated with a percentage occurrence of 43.3%, *Aspergillus* sp had a percentage occurrence of 26.8%, *Fusarium* sp recorded 11.6% while *Geotrichum* sp and *Mucor* sp had a percentage occurrence of 9.2% each. The percentage of occurrence of hydrocarbon utilizing fungi were *Aspergillus* sp (35%), *Penicillium* sp (45%), *Fusarium* sp (10%) and *Geotrichum* sp (10%).

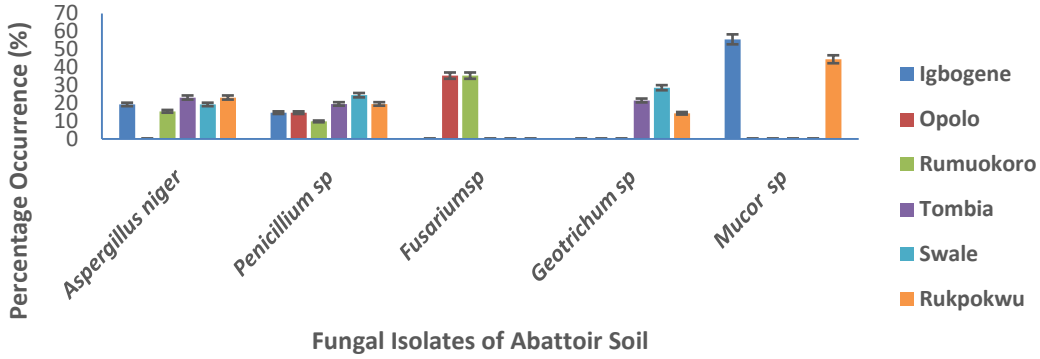

Fig. 3: Frequency of occurrence of Fungi isolated from the Abattoir Soils

Results of physicochemical prameters of the soil samples are presented in Table 1. The pH values ranged from 6.67 to 7.06 (Rukpokwu and Igbogene soils respectively). Electrical conductivity ranged from 205µScm^{-3} (Rukpokwu) to 1573µScm^{-3} (Rumuokoro). Total Organic Matter assessed recorded highest value in Swale abattoir with a mean value of 5866mg/kg and least in Opolo (1888mg/kg value). Total Organic Carbon (TOC) ranged from 1092 in Opolo soils to 3939mg/kg in Swale. Total Nitrogen values were between 0.3 to 0.091mg/kg (Rumuokoro and Tombia, respectively). Concentration of Nitrate ranged from 0.7 to 2.1 mg/kg (Rumuokoro and Igbogene, respectively). Sulphate concentration varied from 1.0mg/kg to 2.7mg/kg. Highest Phosphate value of 0.81mg/kg was obtained in Rumuokoro soil samples while the least value of 0.24mg/kg was obtained in Rukpokwu soil. The salinity of the soil samples was highest in Swale soil (1075 mg/kg) and least in Rumuokoro (642 mg/kg). Assessment of Chloride indicated that the highest mean value of 340mg/kg was obtained in Rumuokoro samples and the least mean value of 30mg/kg obtained in Swale samples.

Table 1 : Mean Values of Physicochemical Constituents of Abattoir Soil Samples with range in parenthesis

	Igbogene	Opolo	Rumuokoro	Tombia	Swale	Rukpokwu	Control	WHO Limit
pH	7.06 (6.9–7.18)	6.88 (6.86-7)	6.33 (6.29–6.4)	6.71 (6.65 – 6.8)	6.68 (6.65-6.7)	6.67 (6.6 – 6.71)	6.90 (6.8–6.91)	6 -9
Electrical Conductivity (µScm^{-3})	1288 (1282 - 1292)	1573 (1570 - 1577)	1397 (1391-1401)	656 (1652 - 1660)	1086 (1070-1098)	205 (201 – 207)	53 (49 - 59)	1250
TOM (mg/kg)	2360 (2330- 2350)	1888 (1820- 1892)	6001 (5996-6004)	4251 (4125- 4348)	5866 (5823-5874)	2562 (2558-2565)	0.538 (0.538-0.55)	
TOC (mg/kg)	1365 (1320- 1402)	1092 (1021- 1147)	3471 (3412-3502)	1239 (1232- 1244)	3939 (1475- 1490)	1482 (3935- 3943)	0.312 (0.33-0.344)	
TN (mg/kg)	0.118 (0.111 - 0.2)	0.094 (0.092-0.098)	0.3 (0.28-0.31)	0.091 (0.089-0.093)	0.128 (0.124-0.13)	0.341 (0.334-0.344)	0.312 (0.3 - 325)	
NO_3 (mg/kg)	0.9 (0.7-1.1)	1.2 (1.1-1.4)	2.1 (1.8-2.5)	1.2 (1.10\-1.3)	1.4 (1.2-1.6)	0.7 (0.4-1.1)	<0.1 (0.1 – 0.1)	
SO_4 (mg/kg)	1.3 (1.4-1.1)	1.5 (1.1-1.8)	2.7 (1.8-2.5)	1.8 (1.5-2.0)	1.8 (1.8-1.8)	1.0 (0.9-1.1)	<0.1 (0.1-0.1)	250

PO_4 (mg/kg)	0.31 (0.3-0.33)	0.38 (0.31-0.48)	0.81 (0.79-0.85)	0.61 (0.58-0.64)	0.71 (0.68-0.75)	0.24 (0.21-0.26)	0.06 (0.04-0.09)	5
Salinity (mg/kg)	732	874	642	823	1075	695	328	
Cl^- (mg/kg)	40 (34 - 45)	60 (57 - 62)	340 (338-342)	90 (87 - 93)	130 (126-132)	30 (26 - 36)	10 (8 - 14)	250

Keys: TOC= total organic carbon, TOM= total organic matter, TN= total nitrogen, NO_3= nitrate, SO_4= sulphate, PO_4= phosphate, Cl^- = Chloride

IV. DISCUSSION

This present study has revealed the microbiological and physicochemical constituents of some abattoir soils in the Niger Delta. Microbial counts in the abattoir soil were higher than those recorded for control soil. There was significant difference between counts in abattoir soils and control soil. Bacterial load was highest in Swale soil samples and this could be due to greater slaughtering activities of Swale abattoir as compared to slaughtering activities in other abattoirs. Abundance of *Bacillus* species observed in contaminated soils may not be surprising as these organisms are indigenous to soil environment and are known to persist in such environment (Atlas and Philip, 2005). However, the presence of *E. coli*, *Salmonella*, *Shigella* and *Micrococcus* in abattoir soils may be attributable to discharge of the content of animal bowels onto the soil. Findings in this current study agreed with that of Adesemoye *et al.*, (2006) as well as Ogbonna and Igbenijie (2006) who also recorded similar microorganisms in their study. This study also confirmed presence of hydrocarbon utilizing bacteria belonging to the genera; *Bacillus*, *Escherichia*, *Micrococcus*, *Proteus*, *Pseudomonas*, and *Staphylococcus* in these environmental samples. Fungal genera in this present study; *Aspergillus*, *Fusarium*, *Geotrichum*, *Mucor* and *Penicillium* marched with those reported by Abolagba and Igbinevbo (2010).

The capability of fungi to also degrade hydrocarbons is of immense importance in bioremediation procedures. Four of the obtained five genera which include *Aspergillus*, *Fusarium*, *Geotrichum*, and *Penicillium* sp demonstrated hydrocarbon utilizing potentials. Some of these organisms have earlier been reported as hydrocarbon bio-degraders by April *et al*. (2000). Hydrocarbon-utilizers isolated from the abattoir effluent by Goddey and Umaru (2014) included *Candida* sp, *Rhodotorula* sp., *Fusarium* sp., *Penicillium chrysogenus and Aspergillus niger*. Amaku and Obire (2014) also demonstrated the ability of *Aspergillus*, *Penicillium*, *Mucor*, *Rhizopus* and *candida* species isolated from Forcados effluent to biodegrade hydrocarbons.

The pH is an abiotic factor that affect microbial metabolic activities in that it affects the functioning of enzymes, hormones and proteins. pH is also a major factor in all chemical reactions associated with formation of, alteration and dissolution of chemical (Yao and Btme, 2001). The pH of abattoir soil samples examined in this study was slightly alkaline and was also within WHO permissible limit of 6.0 – 9.0. Electrical conductivity is the measure of a material's ability to allow the transport of an electric charge. It is measured by the presence of total concentration of ions, temperature of the system, etc. The conductivity of the abattoir soils were higher than those recorded for the control soil. The EC of samples from Rukpokwu abattoir (which have no active abattoir activity at the time the samples were collected) was low and within standard. This low value in EC indicates low organic matter deposition and decomposition in the soil. The obtained high values might also be as a result of decomposition and mineralization of organic matter within the abattoir environment. The conductivity levels of the abattoir soils which ranged from 205-1573 μScm^{-3} were above the maximum conductivity values of 1250 μScm^{-3} as described by the European Economic Community (EEC) in all active abattoirs.

Total Organic Carbon (TOC) is the amount of carbon found in an organic compound. It is a measure of determining the level of organic contamination within an environment. The report of Sverdrup *et al.* (2003) indicated that high organic carbon increases growth of microorganisms which leads to the depletion of oxygen. The values of TOC and TOM recorded in this study showed that abattoir soils examined had high organic carbon content. This may be as a result of indiscriminate dumping of animal wastes, dung and other organic matter within the environment. This finding agreed with that of Neboh *et al.* (2013). Neboh *et al.* (2013) found out high percentage organic carbon and organic matter values on effluent contaminated soil than on uncontaminated soil. This is because of the fact that waste from abattoir typically contains compounds that are characterized by high organic level (Nafarnda *et al*., 2006).

Concentrations of sulphate, phosphate and nitrate detected in abattoir soils examined were below WHO permissible limits. Natural environment contains chlorine in varying degrees with chlorine value increasing as mineral content increases. Chlorides are inorganic compound resulting from the combination of the chlorine gas with metal. Some common chlorides include sodium chloride (NaCl) and magnesium chloride ($MgCl_2$). Chlorine alone as (Cl_2) is highly toxic and it is often used as a disinfectant. The levels of chloride concentration in the abattoir soils were below WHO permissible limit in all the abattoirs except Rumuokoro soil sample (which is a relatively large abattoir with high slaughtering capacity) and lowest in Rukpokwu (which is an inactive abattoir). Physicochemical parameters obtained during this study indicate that the abattoir activities have negative impact on the immediate environment, thus abattoir activities constitute a major source of pollution. This

observation has been recorded by other researchers who worked on the influence/impact of abattoir activities on the environment (Adesemoye *et al*., 2006; Adeyemo *et al.*, 2002).

V. CONCLUSION

Based on the findings in this current study, the abattoir soils are highly contaminated with bowel organisms and the microorganisms from this source could pose serious health risks especially if it contaminates processed meat or ready to eat foods. The high EC, TOC and TOM values is indicative of unregulated disposal of untreated abattoir effluent in the environment thereby constituting environmental pollution. Such pollution disrupts soil biodiversity and balance, endangers humans via bioaccumulation of pollutants through the food web and can also contribute to epidemy. Consequently, it is recommended that indiscriminate dumping of untreated abattoir wastes unto the soil and adjoining water bodies be prohibited by the law and proper waste disposal facilities be made available in the abattoirs.

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