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Biophysical Quality of Abattoir Soil Environment—A Case Study of Trans-Amadi Abattoir in Port Harcourt in Nigeria

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ABSTRACT This study was aimed at determining the biophysical quality of Trans-Amadi Abattoir soil environment. Composite soil sample produced from soil collected from three different sampling points within the abattoir and a control sample collected about 400m away from the abattoir. These sampling points were identified using Global Positioning System (Model GPS78). After collection, samples were transported to the laboratory in a cooler packed with ice blocks. These samples were then analysed physically and biologically using standard microbiological procedures. Results show that THBC, TFC, THUB, THUF, TCC, SSC and TVC were higher in the test sample than the control sample. The predominant bacterial isolated were *Pseudomonas sp., Bacillus sp., Vibrio sp., Escherichia coli., Salmonella sp.* etc, while *Rhizopus sp., Aspergillus sp., Penicillum sp., Candida sp*. etc. were the predominant fungi genera isolated. Studies on physicochemical analysis of samples revealed higher values for pH, BOD, COD, SO_3^{2-}, conductivity, SO_4^{2-}, PO_4^{3-} and NO_3^- as compared to the control, while temperature of the control sample was observed to be slightly higher than that of test sample. Total organic carbon however was equal in the two samples. Analysis for cation showed higher levels of Na^+, Mg^{2+}, Ca^{2+} and K^+ in the test sample. Though mercury was below detectable level in both samples, other metals such as Zn, Fe, Mn, Pb, Cu, Cr, Cd and Ni however appeared higher in the test sample than the control sample. This study has revealed the effect of abattoir wastes on the biophysical properties of abattoir soil environment.

Keywords: Abattoir, water body, heavy metals, waste water, physicochemical properties

Introduction

Due to the existing malnutrition problems among the developing and under-developed nations of the world, there is an increasing demand for animal proteins (FAO, 2000). Animal slaughtering for public consumption is normally done in the abattoir. Abattoir is simply a place where animals such as cattle, cow, goats and other animals meant for human consumption are killed, dressed and distributed, (Ayodele and Olufunmilayo, 2012). Apart from consumption, other part of animals killed in abattoir are also distributed as raw materials to industries that require them for production purposes. On a general note, the slaughterhouse of animals forms an important component of livestock industry (Nafarnda *et al*. 2012).

Outside the known functions of serving as a killing, dressing and distribution point for animals used as food as well as raw materials, abattoir also perform the function of reduction of unemployment to the populace (Nafarnda *et al*. 2012). However, the existence of abattoir cannot be complete without its shortfalls of environmental pollution (Hinton *et al.* 2000; Benka-Coker and Ojior, 1995). Abattoir industry generates both solid and liquid wastes (Ogunnusi and Dahunsi, 2014) that affect the environment adversely if not properly managed (Rabah *et al*. 2010). Ayodele and Olufunmilayo (2012); and Adesemoye *et al*. (2006) noted that pollution arises from activities in meat production as a result of failure in adhering to Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP).Unlike the developed nations, wastes generated from abattoir constitute environmental pollution problems in most developing and under-developed nations of the world due to lack of the needed facilities to properly manage the wastes efficiently. For instance, in Nigeria, solid waste products from abattoir are disposed using the disposal bin system, open air incineration or buried in the ground, while the liquid wastes are drained into the surrounding soil or washed into the water bodies near the abattoir (Ogonnaya, 2008). Ayodele and Olufunmilayo (2012); Rabah *et al*. (2010); Amisu *et al*. (2003); Laukova *et al*. (2002); Hinton *et al*. (2000); and Edward (1990) noted the effects of draining wastewater source into the soil, surface water and ground water. The present study focused on the biophysical properties of abattoir soil environment using Trans-Amadi abattoir as a case study, all with the intention of determining the pollutional strength of abattoir wastes.

Materials and Methods

Study area

This study was carried out in abattoir located at Trans Amadi, Port Harcourt, Nigeria. Port Harcourt is located on longitude 4º 48.442´-4 49.444´N and latitude 007º 02.303´- 007º 03.545´E. The climate of Port Harcourt falls within the sub equatorial climate belt. Temperature and humidity are high throughout the year. The wet season and dry season are the two distinct seasons of the area under study, with 70% of the annual rain fall between April and August, September to November tend to have about 22% of the rain fall while December to March are the driest months in the area under study.
Trans-Amadi abattoir is the largest abattoir in Port Harcourt town. There is high level of operation including killing of animals such as cow and goat, e.t.c in the abattoir. This high level of operation is always associated with release of both solid and liquid wastes which are likely to have high pollutional strength, hence can affect the surrounding abattoir environment including abattoir soil environment. As a result of this, there is need to ascertain the effects of abattoir wastes on the environment, hence this study.

Identification of sampling points and sample collection

Surface soil samples were collected from four different sampling points coded A, B, C and D. These points were identified using Global Positioning System (Model GPS 76). At these points, soil samples were collected from the depth of 0-15cm using soil auger. "A" is the point where cow dung is deposited, point B is where hide and skin are roasted, while point C is along waste water channel. 500g of bulked composite soil from soil samples collected from points A, B and C was prepared using the method of Ekundayo and Obuekwe (1997). Soil sample from point D, which was 400m from Trans-Amadi abattoir served as the control sample. These soil samples were collected into sterile labelled polyethylene bags and transported to the laboratory in a cooler packed with ice blocks for analysis.

Table 1. Identification of sampling stations, points coordinates and sample types in the study areas.

Sampling station	Sampling points	Sampling co-ordinates Northing (N)	Sampling co-ordinates Easting (E)	Types of Samples
Trans-Amadi Abattoir	A	04º 48.886′	007º 2.707′	Soil (Test sample)
	B	04º 48.782′	007º 2.608′	Soil (Test sample)
	C	04º 48.615′	007º 2.405′	Soil (Test sample)
	D	04º 48.442′	007º 2.303′	Soil (Control)

Processing of soil samples

Soil samples for the study were processed using the method of Adesemoye *et al*. (2006). Ten grams of each soil sample was added to 90ml of sterile distilled water to get an aliquot. One milliter each of the aliquot formed was serially diluted using ten-fold serial dilution method as described by Prescott *et al*. (2005).

Microbiological analysis

Total heterotrophic bacterial count, total coliform count (TCC), total *Salmonella-Shigella* count, total *Vibrio* count, and total fungal count were determined using methods of Prescott *et al*. (2005). The method of Mills and Colwell (1978) was adopted for total hydrocarbon utilizing bacterial count and total hydrocarbon utilizing fungal count. Fungi and yeast representative isolates were identified following the methods of Barnett and Hunter (1972). Bacterial isolates were identified by carrying out series of biochemical tests as stipulated by Holt (1982).

Determination of physicochemical properties

pH was determined with the help of pH meter (Model 291 MK2).Temperature was done with mercury in glass thermometer. Conductivity was measured with the help of conductivity meter (Jenwey 4010 UK). Biological oxygen demand (BOD), chemical oxygen demand (COD), phosphate, nitrate, chloride, alkalinity and sulphate were determined following methods described by APHA (1995). Atomic Absorptions Spectrophotometry (AAS) as described by APHA (1995) was used for determination of heavy metals.

Results

Results obtained from the analysis and presented in Table 2 indicate that abattoir test soil samples recorded higher total heterotrophic, total fungal and total hydrocarbon utilizing bacterial counts of 2.8×10^7cfu/g, 1.3×10^7cfu/g and 3.2×10^6cfu/g, respectively against 2.2×10^7cfu/g, 1.0×10^7cfu/g and 2.5×10^6cfu/g obtained from control sample. Analysis further show that total hydrocarbon utilizing fungal and total coliform ranged between 1.0×10^6-2.0×10^6cfu/g and 1.4×10^7-2.5×10^7cfu/g, respectively. *Salmonella-Shigella* count had range of 4.0×10^6-9.5×10^6cfu/g while total Vibrio count had range of 3.0×10^6-6.0×10^6cfu/g.

Table 2: Microbial counts of abattoir soil environment

Total viable counts (cfu/g)	Test soil sample	Control soil sample
THBC	2.8×10^7	2.2×10^7
TFC	1.3×10^7	1.0×10^7
THUB	3.2×10^6	2.5×10^6
THUF	2.0×10^6	1.0×10^6
TCC	2.5×10^7	1.4×10^7
SSC	9.5×10^6	4.0×10^6
TVC	6.0×10^6	3.0×10^6

Legend: THBC: Total Heterotrophic bacterial Count; TFC: Total Fungal Count; THUB: Total Hydrocarbon Utilizing Bacteria; THUF: Total Hydrocarbon Utilizing Fungi; TCC: Total Coliform Count; SSC: *Salmonella-Shigella* Count; and TVC: Total *Vibrio* Count.

Table 3 shows bacterial and fungal genera isolated and characterized using morphological properties, biochemical tests and microscopic examination methods. These identified isolates from test sample include *Pseudomonas sp., Bacillus sp., Staphylococcus sp., Klebsiella sp., Vibrio sp., Salmonella sp., Escherichia coli., Proteus sp., Shigella sp., Rhizopus sp., Aspergillus sp., Penicillum sp., Fusarium sp., Candida sp.,* and *Saccharomyces sp.* Above organisms were also isolated from control sample except *Staphylococcus sp., Klebsiella sp., Proteus sp., Rhizopus sp., Fusarium sp.* and *Candida sp.*

Table 3: Identification of Isolates from Samples.

Samples	**Identified Organisms**
Test soil sample (obtained from points within the abattoir).	*Pseudomonas sp., Bacillus sp., Staphylococcus sp., Klebsiella sp., Vibrio sp., Salmonella sp., Escherichia coli., Proteus sp., Shigella sp., Rhizopus sp., Aspergillus sp., Penicillum sp., Fusarium sp., Candida sp.,* and *Saccharomyces sp.*
Control soil sample (obtained about 400m away from the abattoir)	*Pseudomonas sp., Bacillus sp., Vibrio sp., Salmonella sp., Escherichia coli., Shigella sp., Aspergillus sp., Penicillum sp., Saccharomyces sp.*

Table of physicochemical properties (Table 4) revealed that pH ranged from 8.20-8.37, temperature levels ranged from 26.20-27.30ºC. BOD level ranged between 1800.00-2101.50 mg/kg, COD levels ranged from 3605.01 - 4120.00 mg/kg. TOC ranged from 0.01- 0.96 mg/kg while conductivity levels were between 900.2- 998.00 µs/cm. SO_4^{2-} ranged from 956.30- 1033.34 mg/kg. PO_4^{3-} levels ranged between 36.09-49.50mg/kg. NO_3^- was between 40.65- 52.94 mg/kg. Chloride ranged from 120.00-160.00 mg/kg.

Table 4: Physicochemical characteristics of abattoir soil environment

Parameter	Test soil sample	Control soil sample
pH	8.37	8.20
Temperature (0^oC)	27.30	26.20
BOD (mg/kg)	2101.50	1800.00
COD(mg/kg)	4120.00	3605.01
TOC (mg/kg)	0.96	0.01
Conductivity (μs/cm)	998.00	900.2
SO_4^{2-} (mg/kg)	1033.34	956.30
PO_4^{3-} (mg/kg)	49.50	36.09
NO_3^- (mg/kg)	52.94	40.65
Cl^- (mg/kg)	160.00	120.20

Legend: COD=Chemical Oxygen Demand; TOC=Total Organic Carbon; BOD=Biological Oxygen Demand.

Cation concentration as presented in Table 5 show that Na^+ level ranged from 39.45-45.70 mg/kg. Mg^{2+} ranged from 17.01-18.00 mg/kg. Ca^{2+}levels were between 20.29-32.50 mg/kg while K^+ levels ranged from 0.143-0.263 mg/kg.

Table 5: Cation concentration of abattoir soil environment

Parameter (mg/kg)	Soil	Control
Na^+	45.70	39.45
Mg^{2+}	18.00	17.01
Ca^{2+}	32.50	20.29
K^+	0.263	0.143

Table 6 shows that test soil sample recorded higher level of Zn (716.00mg/kg) than the control sample (500.30mg/kg). Fe and Mn levels of 610.00mg/kg and 3.02mg/kg, respectively were obtained from test samples as against 405.10mg/kg and 2.10mg/kg, respectively obtained from control sample. Result also revealed that levels for Pb, Cu, Cr, Cd, Ni from test soil samples were 9.20mg/kg, 58.80mg/kg, 7.50mg/kg, 3.25mg/kg and 3.14mg/kg, respectively as against 7.06mg/kg, 35.50mg/kg, 5.06mg/kg, 2.10mg/kg and 3.01mg/kg, respectively obtained from control sample. There was however no detectable level of Hg in both test and control samples.

Table 6: Heavy metal concentration of abattoir soil environment

Parameter (mg/kg)	Test soil sample	Control soil sample
Zn	716.00	500.30
Fe	610.00	405.10
Mn	3.02	2.10
Pb	9.20	7.06
Cu	58.80	35.50
Cr	7.50	5.06
Cd	3.25	2.10
Ni	3.14	3.01
Hg	0.00	0.00

Discussion

Microorganisms are ubiquitous and act as soil indicators. They also perform other functions such as decomposition of organic matter, facilitating biogeochemical cycles among others. Results of microbial counts presented in Table 2 shows that test soil sample had higher load of all microbial groups monitored than the control sample. This trend of results is in agreement with statistical analysis (t-test) that revealed significant difference at 0.05 confidence limit between microbial loads of test sample and that of control sample. The observed high values of microbial counts in this study is also in line with works of Nafarnda *et al.*(2012); Rabah *et al.*(2010) and Adesemoye *et al.*(2006). The observed higher THBC (2.8×10^7cfu/g) in the abattoir soil

sample could be as a result of wastes and nutrients released during slaughtering of cows and other animals which then encouraged the multiplication of the organisms. Destabilization of soil ecological balance due to contamination of abattoir wastes (Rabah *et al.* 2010; Adesemoye *et al.* 2006) and possibility of soil not being washed off wastes due to absence of rain (since samples were collected during dry season) could be the cause of the higher THBC observed in the soil sample. Higher TFC of 1.3×10^7cfu/g in test soil against 1.0×10^7cfu/g observed in the control could be due to favourable environmental conditions which enhanced fungal growth within the abattoir. THUB and THUF loads were also noticed to be higher, this could be attributed to hydrocarbons released during abattoir operations such as roasting of meat with either tyer or wood. Higher TCC, SSC and TVC of 2.5×10^7cfu/g, 9.5×10^6cfu/g and 6.0×10^6cfu/g, respectively could be as a result of faecal contamination (Prescott *et al.*2005). This faecal material can be of human or animal origin. This is obvious since cow dung and animal droppings are always littered around the abattoir.

High presence of *Klebsiella sp., Vibrio sp., Salmonella sp., Escherichia coli.,* and *Shigella sp.* around the test sampling points may be connected with high rate of cattle defecation near the sites and introduction of other abattoir wastes. The presence of these isolates in this study gives credence to the findings of Ezereonye and Ubalua (2005). The presence of *Bacillus sp.* is possible since it is a soil inhabitant. The presence of *Pseudomonas* around the abattoir is possible since it has been reported to be an agent of meat spoilage (Freazier and Westhoff, 2003). Isolation of fungi such as *Rhizopus sp., Aspergillus sp., Penicillum sp., Fusarium sp., Candida sp.,* and *Saccharomyces sp.* from abattoir environment has been reported by Adesemoye *et al.* (2006). Their presence in abattoir soil is possible since genera such as *Aspergillus sp., Penicillum sp.* have been implicated in the degradation of hydrocarbons (Hill, 1982).

Physiochemical characteristics of the studied samples presented in Table 4 clearly show that test soil and control soil samples had pH level that are in alkaline range, though that of test sample was slightly higher (8.37). This could probably be due to some chemicals used in the abattoir that are finally released to the soil. The observed higher temperature of the abattoir soil sample (27.2^oC) is in line with report of Adesemoye *et al.*(2006) on microbial content of abattoir waste water and its contaminated soil in Lagos, Nigeria. BOD is a measure of oxygen required for degradation of organic materials and oxidizes inorganic materials (WHO, 1996). BOD of the studied soil sample (2101.50mg/kg) was higher than that of control (1800.00mg/kg). This trend of result could be attributed to the organic and inorganic wastes generated in the abattoir. COD is sometimes used to measure the organic matter present in a given environment. It is one of the most important parameter in water monitoring (APHA, 1995). The observed COD value (4120.00mg/kg)

of the abattoir soil sample was higher than that of control sample (3605.01mg/kg). This could be due to wastes generated in the abattoir. Sverdrup *et al.*(2003) noted that high organic carbon content consequently increases the growth of microorganisms which then lead to the depletion of oxygen supplies. The observed low TOC of 0.01mg/kg in both samples could be attributed to the rapid decay and mineralization of animal wastes and other organic materials in the soil samples leading to the liberation of the microbial constituents in animal wastes. Conductivity of abattoir soil (998.00µs/cm) was higher than that of control sample (900.2µs/cm). This could be due to high concentration of nutrients in the abattoir soil as a result of evaporation. Phosphate, sulphate and nitrate are among the nutrients needed by organisms for growth. Abattoir soil sample had higher SO_4^{2-} (1033.34mg/kg), PO_4^{3-} (49.50mg/kg) and NO_3^- (52.94mg/kg) against 956.30mg/kg, 36.09mg/kg and 40.65mg/kg, respectively from control soil sample. This could be a s result of higher release and accumulation of these nutrients in the abattoir soil.

Sodium, magnesium, calcium and potassium are important elements required for the optimal growth and productivity in animals. Higher level of these elements in abattoir soil could be as a result of constant and incessant release of these elements through abattoir activities and their accumulation over time.

Heavy metals have received much attention with regard to accumulation in the soil. Metals such as zinc (Zn), iron (Fe), manganese (Mn), lead (Pb), copper (Cu), chronium (Cr), cadmium (Cd) and nickel (Ni) were observed to have higher levels of 716.00mg/kg, 610.00mg/kg, 3.02mg/kg, 9.20mg/kg, 58.80mg/kg, 7.50mg/kg, 3.25mg/kg and 3.14mg/kg, respectively. This could be attributed to the release of these metals alongside with abattoir wastes and their ability to accumulate more on the soil. Mercury, however was below detectable level in both samples. This could be attributed to the absence of sources of this metal around the environments sampled.

Conclusion

Though the effect of abattoir activities on the environment has long been reported by different authors but the present study has revealed particularly the effect of abattoir wastes on biological and physicochemical properties of abattoir soil. Although abattoir operation could be very useful to man in the provision of meat and other byproducts, it could as well pose health risk with respect to the wastes generated. This study has shown a negative impact of abattoir wastes on the soil. Based on this finding, the abattoir management should incorporate a waste management plan for abattoir operations.

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