Elemental and Bacterial Profile of Soils Contaminated by Effluent Originating from Zangon-Shanu Abattoir, Zaria: A Preliminary Investigation

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Abstract: **Elemental and microbial properties in contaminated abattoir soils was collected at distances 500m apart and designated as A (distance of 500m from the abattoir), B (1000m from the abattoir), C (1500m from the abattoir) and X (Control soil). Preliminary results revealed samples have favorable pH and temperatures (7.47, 6.60, 7.39, 7.32 and 25 °C, 40 °C, 23 °C and 31 °C) which agrees with set environmental limits by the National Environmental Standards and Regulations Enforcement Agency (NESREA). Elemental analysis revealed % Nitrogen of 1.12, 1.4 and 0.39 and 0.56 for samples A, B, C and X respectively, no limit was set for this parameter. Phosphorus contents recorded were above the NESREA limit, except for sample B. No limit was set for Potassium. Cadmium, Copper, Zinc, Chromium and Iron levels were above the NESREA limit, Mg was below the set limit. The result of viable bacterial count in the soil samples analyzed shows high values which ranges between 3.0×10^6cfu/mL as compared to the relatively low count of 2.4×10^4 cfu/mL in the control soil. Among the bacteria isolated, *Escherichia coli* had the highest frequency of occurrence of 27%. *Klebsiella pneumonia* was the least isolated bacteria with a percentage distribution of 9%. Other bacteria isolated and their respective percentage distribution in the soil samples include *Enterococci faecalis (11%), Bacillus species (12%), Pseudomonas aeruginosa (11%), Staphylococcus aureus (13%)* and *Salmonella typhi (17%)*.**

Key words: **abattoir, bacteria, effluent, NESREA, soil and wastewater.**

I. INTRODUCTION

Abattoir operations represent a major contributor of characteristic highly organic and inorganic wastes which includes but not limited to sulphates, phosphates, etc., with relatively high levels of suspended solid, liquid and fat. The solid waste includes condemned meat, undigested food materials, bones, hairs and aborted fetuses; with all these coming together to provide a thriving environment for the survival of varieties of both pathogenic and non-pathogenic microorganisms (Sumayya *et al*., 2013).

Adesomoye *et al.*, (2006) reported that the liquid waste in slaughter houses characteristically comprise dissolved solids, blood, gut contents, urine and water. As a result of inadequate waste treatment facilities, wastes from abattoir are deposited on the land or channeled into water resource leading to pollution. Report also suggests that pollution in many countries arises from activities in meat production resulting from a failure in adhering to Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP**)** (Akinola and Olotu, 2009). In essence, slaughter activities, if not properly controlled, may pose dangers to the farmers, butchers, the environment as well as the consumers (Ire *et al*., 2017).

Industrial activities are consistent culprits in heavy metal pollution, elevated levels of heavy metals in tissues of animals in a polluted environment may be attributed to grazing activity on contaminated pastures (Okada *et al*., 1997). Swarup *et al*. (2005) assessed the Lead (Pb) burden and status of Copper (Cu), Cobalt (Co), Zinc (Zn) and Iron (Fe) in the blood of goats reared around a primary Pb-Zn smelter and inferred from the study that goats reared around a primary Pb-Zn smelter had higher blood lead levels that also affected blood copper and cobalt concentrations in a dose-dependent manner (Nwude *et al*. (2010). Blood has been reported also in many research quarters to be a major medium of transfer of heavy metals into milk, while investigating blood levels Cadmium (Cd), Pb, Co, Zn, Cu and Fe in cows at the slaughter house, Awka abattoir, Nigeria at three different seasons; results obtained showed blood had various levels of concentration for Pb, Cd, Co, Zn, Cu and Fe. There were significant correlations between the levels of Cd and Cu, Cd and Zn and Co and Zn studied (Nwude *et al*., 2010).

In another study by Osu and Okereke, (2015) the total contents of five heavy metals; Fe, Zn, Cd, Pb and Cu in soils and some widely consumed vegetables from farms near abattoirs in Umuahia, Nigeria was evaluated. The results revealed substantial amount of the heavy metals deposits onto vegetables near both abattoirs. Similarly, Edori and Kpee, (2017) investigated metal contamination of soils from three abattoirs (Agip, Iwofe and Mile III) in Port Harcourt for heavy metal contamination using atomic absorption spectrophotometer. Data documented showed Fe to be most available in the soils, followed by Zn. The least observed metal in all the sampled soils was Cd.

Assessment of seasonal variation in the concentration of the heavy metals Chromium (Cr), Manganese (Mn), Nickel (Ni), Co, Cu, Fe, Pb and Zn in Abattoir dump site soil at Yauri, Nigeria, was undertaken during the two major seasons in Nigeria, to determine the environmental pollution status of the soil at the dump site. The analytical results revealed the presence of metals in samples collected at the wet and dry seasons, with measured concentrations above the literature levels of typical soil (Yahaya *et al*., 2009).

Tortora *et al*, (2007) reported that following the discharge of untreated waste water into the soil, element previously absent or present in minute quantities will be introduced into the environment, leading to the magnification of these chemicals and thus altering the physicochemical nature of soils and waters in the vicinity. Some of these chemicals may be toxic to the microbial, floral and faunal communities of the soils and waters.

Wastewaters from abattoirs mostly absorb into surrounding soil environment, while the remaining is channeled through the abattoir drainages into connecting rivers. Water from the river is useful for irrigation farming along the river banks. The possibility of zoonotic diseases such as *E. coli*, *Bacillosis*, *Salmonellosis*, *Brucellosis* and *Heliminthes* amongst the consumers of produce from such irrigated field cannot be ruled out. However, there is need to determine the distribution of soil bacteria along the bank of effluent channel of abattoirs, since abattoir effluent wastewater has a complex composition and can be very harmful to the environment.

II. MATERIALS AND METHODS

Collection and Preparation of Sample

About 20g of soil samples were collected from the Zango Abattoir at points 'A', 'B' and 'C' 500m apart and along the effluent channel leading to River Kubani. The samples were collected using sterile Scalpel and transferred into sterile polythene bags. The collected samples were labelled alphabetically with respect to the distance from the abattoir. A control soil sample is collected 500 away from the abattoir and the effluent channel into sterile polythene bags and labeled 'X'. All the samples collected were transported to the laboratories of NILEST for analysis.

Physicochemical Analysis of Soil samples

The physicochemical qualities of the soil samples were determined using standard methods for analysis of soil according to Udo *et al.*, (1985) and the Association of Official Analytical Chemists (AOAC, 1990). Soil temperature was determined in-situ using a handheld thermometer.

A crushed portion of the air dried soil sample was thoroughly mixed with water in the ratio of 1:1 by volume and used for determination of pH of the soil. The electrometric API-RP 45 EPA method was adopted using a JENWAY 3015 pH/conductivity Meter.

A 5g portion of the air-dried soil sample was digested in aqua-regia prior to heavy metal analysis following methods previously reported (Odu *et al*., 1985). The filtrate was made up to 100 mL with deionized water and the concentrations of the heavy metals, Fe, Pb, Cu, Cd, Ni and Cr were determined using Atomic Absorption Spectrophotometer (AAS) (Perkin Elmer Analyst 200) following the standard procedures as given in APHA (1995). The above parameters were subsequently determined in the water sample, in addition, Dissolved Oxygen (DO) and Biochemical oxygen demand (BOD) was also evaluated following standard procedures.

Isolation, enumeration and identification of Bacteria

For each of the collected stock sample, ten-fold serial dilution was performed up to 10^{-6}. About 0.2 ml of the last dilution was inoculated into sterile nutrient agar, McConkey agar and Blood agar using pour plate technique. The inoculated plates were incubated at 37^0C for 24 to 48 hours. Colonies growing on each plate were counted per plate using a colony counter, these were used to estimate the bacterial load, calculated and recorded as the total colony forming unit per milliliter (cfu/mL) of each sample.

Method of Cheesbrough, (1999) was adopted for characterization of the bacterial isolates. The primary cultures were purified unto sterile nutrient agar plates to obtain the pure isolates. Each pure isolate was smeared on clean grease-free slide, heat-fixed then gram stained. The gram stained slides were examined under 100× oil immersion objective lens to identify the gram status and micromorphology of the isolates. The pure isolates were further characterized using series of biochemical tests. The characterized organisms were identified by comparing the results obtained with Bargey's Manual of determinative bacteriology (Holt *et al.*, 1994)

III. RESULTS

Table 1: Physico-Chemical properties of soil contaminated soil and control soil

Parameters	Soil Samples				NESREA limit
	A	B	C	X (control)	
pH	7.47	6.60	7.39	7.32	6.00-9.00
Temperature (^{0}C)	25	40	23	31	40
Nitrogen (%)	1.12	1.4	0.39	0.56	Not available
Phosphorous (mg/kg)	396.11	218.11	1448.10	111.32	5.00
Cadmium (mg/kg)	5.4	5.4	1.6	1.7	0.003
Copper (mg/kg)	40.2	31.4	7.8	62.1	1.0
Lead (mg/kg)	215.6	184.4	59.4	252	0.01
Potassium (mg/kg)	950	250	65	723.1	Not available
Zinc (mg/kg)	290.2	190.9	62.4	340.4	5
Chromium (mg/kg)	477.4	509.7	58.1	427.6	Less than 1

Calcium (mg/kg)	109.0	45.9	149.5	61.4	200.00
Magnesium (mg/kg)	137.1	101.0	71.0	121.9	200.00
Iron (mg/kg)	2788.2	2764.5	646.2	3121.6	0.3
Organic matter (mg/kg)	12	3.20	4.3	2.11	Not available

Table 2: Microbial loads of soils along effluent discharge channel of Zangon-Shanu abattoir

SOIL SAMPLES	Bacterial load (cfu/mL)
A : 500m from the abattoir	6.0×10^{-6}
B : 1km from the abattoir	4.3×10^{-6}
C : 1.5km from the abattoir	3.0×10^{-6}
X : Control soil*	2.4×10^{-4}

* Control soil sample collected 1km away from the abattoir and away from the effluent channel

Table 3: Distribution of Bacteria Isolated from the soil samples obtained along the Zango abattoir effluent channel and the control sample of soil obtained at a distance away from channel.

S/No	Organisms isolated from the contaminated soil samples	Frequency of occurrence	Percentage distribution	Organisms isolated from control soil sample	Frequency of occurrence	Percentage distribution
1	*Escherichia coli*	20	27	*Escherichia coli*	6	43
2	*Enterococci faecalis*	8	11	*Pseudomonas aeruginosa*	2	14
3	*Klebsiella pneumonia*	7	9	*Staphylococcus aureus*	3	21
4	*Bacillus species*	9	12	*Bacillus species*	3	21
5	*Pseudomonas aeruginosa*	8	11			
6	*Staphylococcus aureus*	10	13			
7	*Salmonella species*	13	17			

IV. DISCUSSION

Table I presents result of physicochemical characteristics of various soils studied for this work. The temperature measured indicated that there was no great temperature fluctuation within the analysed samples and control, these temperatures fall within the NESREA permissible limit. The pH recorded for all samples was near neutral. These two factors were found to be within the optimal requirement of most potentially pathogenic species and are great influences in the qualitative and quantitative abundance of microorganisms in the contaminated soil (Yusuf and Sonibare, 2004).

Although there was no great difference in the values obtained for temperature, nitrogen and cadmium in the contaminated and control soils, their values fall below the permissible limit. Significant difference existed in the values obtained for magnesium, copper, lead, potassium zinc chromium, phosphorous, iron, dissolved oxygen, biochemical oxygen demand and organic matter for the contaminated soil and that of the uncontaminated soil. The values for Temperature, pH, Calcium, Magnesium and BOD are below the limits of National Environmental Standards and Regulations Enforcement Agency, while Phosphorous, Cadmium, Copper, Lead, Zinc, Chromium, Dissolved oxygen and Iron are above the Limit.

The high bacterial loads, the isolated pathogenic bacteria as well as the high levels of the elements and heavy metals obtained in the sampled soils indicates that all such may easily be transferred or deposited on crops produced from the vast irrigation farms which span along the river bank. This is supported by the findings of Osu and Okereke, (2015), whose research revealed substantial amount of the heavy metals deposits onto vegetables near the abattoirs studied.

This study shows that the distribution of bacteria decreases as one drift away from the abattoir, an implication that bacteria is being lost or deposited onto the soil as the effluent is channeled down to the river Kubanni. The high bacterial count obtained revealed also that the study soil had a much higher bacterial load than the control soil and there was a significant difference between the counts in the contaminated (study soil) compared to the uncontaminated (control) soil. This may be as a result of the higher nutrients found in the effluent that could be deposited in the soil could thereby be easily utilized by the organisms therein as compared to the uncontaminated soil. It may also be attributable to the destabilization of the soil ecological balance as a result of the contamination due to the discharged of the abattoir wastewater into the soil ecosystem. This evaluation is in agreement with the reports of Adesemoye *et al.* (2006).

The abundance of species of *Bacillus* observed in the contaminated soil may not be surprising as these organisms are indigenous to the soils in abattoir environments and are known to persist in such environment (Atlas and Bartha, 2007). The presence of *E. coli* and *Enterococcus faecalis* in the contaminated soil is indicative of fecal coliforms. The presence of the coliforms and some pathogens in high numbers in the water sampled beyond the limits for effluents and irrigation water set by National Environmental (Surface and Groundwater Quality Control) Regulations (FRN Gazette, 2011) further implicates the water as risky and potentially unfit for use as irrigation water. The high coliform presence

may be attributable to the high load of animal excreta in the wastewater.

Although there was no great difference in the values obtained for temperature, nitrogen and cadmium in the contaminated and control soil, a significant difference existed in the values obtained for magnesium, copper, lead, potassium zinc chromium, phosphorous, iron, dissolved oxygen, biochemical oxygen demand and organic matter for the contaminated soil and that of the uncontaminated soil. The values for Temperature, pH, Calcium, Magnesium and BOD are below the limits of Federal Ministry of Environment, while Phosphorous, Cadmium, Copper, Lead, Zinc, Chromium, Dissolved oxygen and Iron are above the Limit.

The high bacterial loads, the isolated pathogenic bacteria as well as the high levels of the elements and heavy metals obtained in the sampled soils indicates that all such may easily be transferred or deposited on crops produced from the vast irrigation farms which span along the river. This is supported by the findings of Osu and Okereke, (2015), whose research revealed substantial amount of the heavy metals deposits onto vegetables near the abattoirs studied.

V. CONCLUSION

The study evaluated the biophysical properties of soil samples contaminated with abattoir wastes vis-à-vis the pollution strength of the wastes.

Although abattoir operation could be very beneficial to man in that it serves as a standard means of obtaining meat for human consumption and other useful by-products, the outcome of this research shows that it can be very hazardous to public health with respect to the waste that is generated, especially where such waste is not adequately handled or treated before discharge. The high pollution strength of the abattoir wastes as revealed in this study further confirmed the dangers associated with discharging untreated wastes to the environment, thus the need for adequate treatment to ensure decontamination.

Following the bacteria species isolated, the possibility of zoonotic diseases such as *E. coli*, *Bacillosis*, *Salmonellosis*, as well as pneumonia may be imminent amongst the consumers of produce from such irrigated fields around the abattoir.

There is little doubt that documented results of environmental contamination emanating from abattoir wastes is evidence enough to implicate the studied abattoir as having the potential for generating large quantities of waste, with evaluated metal concentrations exceeding the Federal Ministry of Environment's Limit, thus contributing significantly to pollution problems in the environment. The study indicates a negative impact of abattoir activities on the soil that receive wastes from abattoirs which is probably because effective waste disposal system is not practiced by abattoir operators. The high bacterial loads in the soil samples analyzed is indicative of health risks to animals and humans around the abattoir.

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