Spatiotemporal Variation of Abattoir Operation on Soil Quality Dynamics in Umuahia South, Abia State, Nigeria

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ABSTRACT: Heaps of abattoir wastes are commonly sighted in most abattoirs in Nigeria which constitute serious environmental and public health hazards. The study aimed at assessing the spatiotemporal variation of abattoir operation on soil quality in Umuahia South, Abia State, Nigeria. A total of nine composite samples were collected from three different locations at graded distance. Conventional analytical methods were employed for the determination of physico-chemical parameters. The results indicate that the mean pH value was 5.90, organic carbon 1.31% and 2.27% organic matter respectively. Mean values of 2.10 g/kg and 3.66 mg/kg were observed for total nitrogen and available phosphorus respectively. The exchangeable cations were observed to be 0.53Cmol/kg, 2.31Cmol/kg, 0.49Cmol/kg and 0.67Cmol/kg for Potassium, Sodium, Calcium and Magnesium respectively. The mean cation exchange capacity was 8.70Cmol/kg, mean percentage base saturation was 46.04% and mean of electrical conductivity was 5.96, Mean values of 5.06, 1.70%, 2.94%, 2.81g/kg, 5.28mg/kg, 0.63Cmol/kg, 3.17Cmol/kg, 0.50Cmol/kg, 0.51Cmol/kg, 8.64Cmol/kg and 55.29%, percentage organic carbon and organic matter, total nitrogen, available phosphorus, exchangeable potassium, sodium, calcium and magnesium, cation exchange capacity and percentage base saturation, electrical conductivity respectively. This study reveals that the possible source of contaminants is due to the unhygienic manner of handling meat in abattoirs and concludes that the results obtained indicated that the quality of the soil is negatively affected by the activities of the abattoir. Regular inspection of abattoirs and strict enforcement of law is hereby recommended.

The continuous drive to increase meat production for the protein needs of the ever-increasing world population has some pollution problems attached. Pollution arises from activities in meat production as a result of failure in adhering to Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) (Akinro *et al.*, 2009). Consideration is hardly given to safety practices during animal transport to the abattoir, during slaughter and during dressing (Singh and Neelam, 2011). Abattoir waste can be defined as waste or waste water from an abattoir which could consist of the pollutants: internal organs, carcasses, animal faeces, blood, fat, hides, carcass trimmings, paunch content and urine. Abattoir waste just like any other waste can be detrimental to humans and the environment if definite precautions are not taken. In the Nigerian livestock industry, slaughter houses are littered with non-meat products and wastes that need to be recycled into useful by-products for further agricultural and other industrial uses (Osibanjo and Adie, 2007). This constitutes public health risks and nuisance in most slaughter houses spread across

Nigerian markets, producing air, soil, and water pollution as well as infestation of flies and other disease vectors. For hygienic reasons abattoirs use large amount of water in processing operations; this produces large amount of waste water. The major environmental problem associated with this abattoir waste water is the large number of suspended solids and liquid waste as well as odour generation (Gauri, 2006). This situation has been reported by Nwachukwu, (2006) which observed that the establishment and management of abattoirs and wastes in Nigeria have always been regarded as social services by all the three tiers of government. Each of these government authorities has for many years neglected its function and has been apathetic about taking over responsibilities (Nwachukwu, 2006).

Effluent from slaughterhouses has also been known to contaminate both surface and groundwater because during abattoir processing, blood, fat, manure, urine and meat tissue are lost to the wastewater streams (Bello and Oyedemi, 2009). In Nigeria, many abattoirs

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dispose their effluents directly into streams and rivers without any form of treatment and the slaughtered meat is washed by the same water. Leaching into groundwater is a major part of the concern, especially due to the recalcitrant nature of some contaminants (Muhirwa *et al*.,2010).

The processes of adsorption and trapping by fine sandy materials, clays and organic matter can remove pathogenic organisms and some dissolved organic matter during passage of polluted water through the soil, thus reducing the microbial load. However, if there is too high departure of conditions from normalcy, beyond the carrying capacity of the natural process, diversity of autochthonous species could diminish while count of individual species that are able to survive may increase with possibility of grave consequences on groundwater (Osemwota, 2010). Adeyemo *et al*., (2009) observed that facilities for waste recovery, treatment, and reuse are either inadequate or non-existent in most Nigerian abattoirs. Thus, wastes are indiscriminately and improperly discharged and constitute environmental hazards. Leachates from their serial decomposition processes have the potential to pollute nearby surface water, with enteric pathogens and excess nutrients which may percolate into the underlying aquifers and contaminate hand-dug wells. Blood constitutes the highest pollution load of all the components of abattoir effluents, followed by fat. Blood, one of the major dissolved pollutants in abattoir waste water, has the highest COD of any effluent from abattoir operations (Aniebo *et al*., 2009).

The major characteristics of abattoir wastes are high organic strength, sufficient organic biological nutrients, adequate alkalinity, relatively high temperature (20 to 30°C) and free of toxic material. Abattoir wastewaters with the above characteristics are well suited to anaerobic treatment and the efficiency in reducing the BOD ranged between 60 and 90% (Chukwu, 2008). The high concentration of nitrates in the abattoir wastewater also shows that the wastewater could be treated by biological processes. Due to the economic situation of Nigeria, little interest has been shown to the effects of wastes from abattoirs to the environment (Singh and Neelam, 2011). It is also important to note that for one to understand the methods of handling and disposing waste there is need for a vivid knowledge of the basic characteristics of the waste in question and its quantity (Chukwu *et al.,* 2011).

This study aimed at assessing the spatiotemporal variation of abattoir operation on soil quality and

address the possible ways of managing abattoir activities in Umuahia South, Abia Sate, Nigeria.

MATERIALS AND METHOD

*Study Area***:** Umuahia South is located within the lowland rainforest zone in Nigeria (Keay, 1989). On an altitude of 148m above sea level. It lies on latitude 05^0 $25'$ N and longitude 07^0 $30'$ E. Umuahia South has loamy sandy to sandy loam soil and a mean top soil pH of 4.7. It has the following mean climatic data: rainfall of 2230mm with a double peak rainfall pattern in July and a September, mean maximum and minimum temperature of 32^0C and 23^0C respectively, relative humidity range of 66-80% (NRCRI, 2002), Umuahia South has an area of 140 km² and a population of 138,570 (National Population Census, 2006).

Soil sampling method: Soil sampling was carried out according to the methods of Zaku (2006). A total of nine composite samples were collected from three different locations. Three composite and replicates samples each were collected from the sampling locations at a depth of 0 to 15cm, and at a distance interval of 10m, 20m and 30m with a control 100m meter away.

Soil Sample Analysis: Preliminary routine laboratory practices of air drying, crushing and sieving were done. Soil pH was determined using 1:1 soil to distilled water, and measured with a glass electrode pH meter (Bates, 1954). Percentage Organic Carbon (OC) and Organic Matter (OM) were determined using Walkley-Black method (Walkley and Black, 1934). Total nitrogen (N) was determined using micro Kjedhal digestion distillation method (Bremner and Mulvaney, 1982). Available phosphorus (P) was determined using Bray-1 method (Bray and Kurtz, 1945). Exchangeable cation was determined using ammonium acetate (NH_4OA_C) extraction solution method; sodium (Na) and potassium (K) were measured using Flame Photometer, calcium (Ca) and magnesium (Mg) were measured using EDTA titration. Cation exchange capacity (CEC) was determined using 1N neutral ammonium acetate (NH_4OA_C) solution. Percentage base saturation (PBS) was determined.

Statistical Analysis: Significance difference between means of various abattoir waste sites was tested at P ≤ 0.05 level of significance, using the Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Table 1, The Physicochemical properties of the old effluent discharging area samples reveals that mean pH value of 5.90 organic carbon 1.31% and 2.27%

organic matter respectively. Mean values of 2.10 mg/kg and 3.66 mg/kg were observed for total nitrogen and available phosphorus respectively. The exchangeable cations were observed to be 0.53Cmol/kg, 2.31Cmol/kg, 0.49Cmol/kg and 0.67Cmol/kg for Potassium, Sodium, Calcium and Magnesium respectively. The mean cation exchange capacity was 8.70Cmol/kg, mean percentage base saturation was 46.04% and mean of electrical conductivity was 5.96. Table 2 reveals the chemical

properties of the new effluent discharging area samples. The results indicated the mean values of 5.06, 1.70%, 2.94%, 2.81mg/kg, 5.28mg/kg, 0.63Cmol/kg, 3.17Cmol/kg, 0.50Cmol/kg, 0.51Cmol/kg, 8.64Cmol/kg and 55.29%,5.96 for pH, percentage organic carbon and organic matter, total nitrogen, available phosphorus, exchangeable potassium, sodium, calcium and magnesium, cation exchange capacity and percentage base saturation, electrical conductivity respectively.

Table 1: Physicochemical properties of old abattoir effluent discharging area samples

Treatment	10 meters	20 meters	30 meters	Control	Mean/S.E
Sand	75.97	77.63	79.63	93.3	77.74±1.06
Silt	20.7	23.7	28.57	1.45	24.32±2.27
Clay	6.55	6.67	5.89	5.98	6.37±0.26
PH	5.91	6.1	5.74	6.09	5.90±0.103
%OC	1.21	1.08	1.65	0.78	1.31±0.17
OM	2.09	1.87	2.85	1.34	2.27±0.29
N	2.08	2.24	1.99	0.89	2.10±0.73
P	3.49	3.92	3.56	2.99	3.66±0.13
K	0.54	0.55	0.5	0.58	1.59±0.015
Na	2.22	2.47	2.24	3.09	2.31±0.08
Ca	0.5	0.48	0.5	0.64	0.49±0.0067
Mg	0.74	0.51	0.77	0.51	0.67±0.082
CEC	8.62	8.8	8.69	7.23	8.70±0.052
PBS	46.4	45.57	46.14	68.43	46.04±0.25
EC	4.8	5.61	5.87	3.26	5.43±0.32

Table 2: Physicochemical properties of new abattoir effluent discharging area samples

Treatment	10 meters	20 meters	30 meters	Control	Mean/S.E
Sand	72.45	80.33	90	88.6	80.93±5.08
Silt	15.67	18.04	21.5	2.04	18.40±1.69
Clay	5.88	5.9	5.77	6.03	5.85±0.040
PH	5.22	5.46	4.49	6.09	5.06±0.29
%OC	1.85	1.35	1.92	0.78	1.70±0.18
OM	3.18	2.22	3.32	1.34	2.95±0.35
N	2.04	3.44	2.94	0.89	2.81±0.41
P	5.64	5.22	4.98	2.99	5.28±0.19
K	0.72	0.51	0.58	0.58	0.63±0.062
Na	2.8	3.55	3.16	3.09	3.17±0.211
Ca	0.46	0.53	0.51	0.64	0.50±0.021
Mg	0.56	0.45	0.51	0.51	0.51±0.032
CEC	8.51	8.86	8.55	7.23	8.64±0.11
PBS	52.64	57.67	55.56	68.43	55.29±1.46
EC	6.61	5.87	5.41	3.26	5.96±0.35

Table 3: Mean Physicochemical properties of the control, old and new effluent discharging area samples

Location	Sand	Silt	Clay	PH	OC%	OM	N	P	K	Na	Ca	Mg	CEC	PBS	EC
Old	77.74	24.32	6.37	5.9	1.31	2.27	2.1	3.66	0.53	2.31	0.49	0.67	8.7	46.04	5.96
New	80.93	18.4	5.85	5.06	1.7	2.94	2.81	5.28	0.63	3.17	0.5	0.51	8.64	55.29	5.96
Control	90.95	1.75	6.01	6.09	0.78	1.34	0.87	2.99	0.58	3.09	0.64	0.51	7.23	68.43	3.26
LSD	2.84*	NS	NS	0.65*	0.52*	0.89*	0.82*	0.81*	NS	0.57*	0.06*	NS	0.27*	3.03*	0.23*

Table 3 reveals the mean chemical properties of the control, old and new effluent discharging area samples. The low pH values on both old and new effluent discharging areas indicated that abattoir effluent had the ability to lower the pH value of soils. The control samples had the mean value of 6.09, which is not statistically different (P <0.05) from 5.90 observed from old effluent discharging area samples, but statistically different (P <0.05) with 5.06 for the

new effluent discharging area samples. High percentage organic carbon and organic matter were observed from the samples taken from effluent discharging areas. The results indicated significant difference between the effluent discharging areas and the control area. Both old and new effluent discharging area samples were statistically similar, but were different from the control samples (P <0.05). Control samples had mean value of 0.78% and 1.34% for

organic carbon and organic matter respectively, which is lower than and statistically different with 1.31% and 1.70%, and 2.27% and 2.94% for old and new effluent discharging areas respectively.

There is significant (P <0.05) difference between the samples in terms of total nitrogen content. Higher mean values of total nitrogen were observed on samples from the effluent discharging areas. There was significant difference (P <0.05) between the samples. The results indicated phosphorous has significant difference between new effluent discharging area and the other areas. Abattoir effluent discharge had effect on exchangeable calcium and sodium, but showed no significant effect on exchangeable potassium and magnesium. 3.17Cmol/kg, 3.09Cmol/kg and 2.31Cmol/kg were the mean exchangeable magnesium values for new abattoir effluent discharging area samples, control area samples and old effluent discharging area samples respectively. These are statistically different from one another (P <0.005). The cation exchange capacity of the soil samples with mean 8.64Cmol/kg was observed for new effluent discharging area, which was statistically the same with 8.70Cmol/kg for the old effluent discharging area samples. Significant effect of effluent discharge was observed on the percentage base saturation. base saturation of 68.43% and electricity conductivity of 5.43 was observed for the control area samples, which was higher than and statistically different from 55.29% and 46.04% for new and old effluent discharging areas and the same in EC with mean of 5.96 respectively. Results shows mean of three replicates in old and new site area indicates significant difference from control (p<0.05).In assessing the impacts abattoir waste generation on the soil physicochemical properties in different level of distances from 10m, 20m and 30m, the result showed significant differences (p≥0.5). The pH of the abattoir waste on soil samples (Table 3) was observed to decrease significantly (p<0.05) compared to control soil samples. The observed decrease in pH is associated with decaying of organic matter in abattoir which alters the soil pH. This is in line with report of Omole and Ogbiye (2013) that Soil acidity radically affects nutrient availability of plants which presently affects seed germination and crop yield. Increase in soil acidity with decreasing distance to the abattoir site is in accordance with the findings of Iwuagwu and Ugwuanyi (2014) and Nnaji *et al.,* (2016) who observed a decrease in soil pH of abattoir sites effluents when discharged is acidic but gradually becomes alkaline as biodegradation takes place (Hemming, 1997). The low pH values on both old and new effluent discharging areas indicated that abattoir effluent had the ability to lower the pH value of soils. This is in line with the findings of Rabah *et al.* (2010),

whose results revealed lower pH on abattoir effluent contaminated soil, and high pH on uncontaminated soil. (Johnbosco *et al*., 2009; Odoemelan, and Ajunwa, 2008). The new effluent discharging area had the highest nitrogen mean value of 2.81mg/kg than the old effluent discharging and control sample area. This is attributed to the washing away of faeces that is known to contain undigested protein, excess nitrogen from digested protein (Omole and Longe, 2008), high total nitrogen content of the soil enhances microbial proliferation and promotes plant growth (Norton *et al.*, 2002). The new effluent discharging area on available phosphorous had 5.28mg/kg than the old effluent discharging area and control area. This is consistent to the findings of Rabah *et al.* (2010), who reported similar high mean available phosphorus value of 5.60mg/kg for abattoir effluent contaminated soil and 5.20mg/kg for uncontaminated soil (Neboh *et al.*, 2013). The two-exchange magnesium means values prove to be statistically different. These conforms to the findings of Rabah *et al.* (2010) and Neboh *et al.* (2013), who also reported higher cation exchange capacity values for abattoir effluent contaminated soil (Thomas, 1982). Electrical exchange means values prove to be statistically different with the mean value of 7.22Cmol/kg observed for the control area samples. Electrical conductivity mean values were 5.43 and 5.96 and the control is statistically lower with 3.26 respectively. Electrical conductivity (EC) is a measure of the amount of salts in soil and it may be inferred that the higher mean EC value in the soil means higher deposition of dissolved ions from the effluent (Akinro *et al.,* 2009).

Conclusion: The results obtained indicated that the quality of the soil is negatively affected by the activities of the abattoir. The mean soil pH value of the control samples was 6.09, which falls within the limits given by the Federal Ministry of Environment. Higher exchangeable sodium (Na^+) value was observed on the new effluent discharging area samples. Excess level of sodium ions in the soil disperses fine particles into pores, thereby reducing water penetration and blocking root access. The study recommends that regular inspection of abattoirs and strict enforcement of law be made to reduce environmental contamination.

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