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IMPACT OF ABATTOIR EFFLUENT ON SOIL CHEMICAL PROPERTIES IN YOLA, ADAMAWA STATE, NIGERIA

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ABSTRACT
Despite increasing population pressure in Nigeria which resulted in increase in agricultural intensification very little attention has been paid to the soil quality. This research work was carried out to evaluate the impact of abattoir effluent on soil chemical properties in Yola, Adamawa State located on latitude 90201N and longitude 120301E. Discharging abattoir effluent to the surrounding soil had significant (P <0.05) effect on some soil chemical properties. The results revealed significant effects of abattoir effluent on soil pH, percentage organic carbon and organic matter, total nitrogen, available phosphorus, exchangeable sodium and calcium, cation exchange capacity and percentage base saturation. The results showed no significant effects on exchangeable potassium and magnesium. Highest mean values of 6.09, 0.64 Cmolkg-1 and 68.43% were observed on control samples for pH, exchangeable calcium and percentage base saturation respectively. Highest mean values of 1.70%, 2.94%, 2.81gkg-1, 5.28mgkg-1 and 3.17Cmolkg-1 were observed on samples taken from new effluent discharging area for percentage organic carbon and organic matter, total nitrogen, available phosphorus, and exchangeable sodium respectively. The highest mean value of 8.70Cmolkg-1 was observed on samples taken from the old effluent discharging area for cation exchange capacity.

Keywords: Abattoir, Chemical properties, Soil quality, Adamawa, Effluents, Organic carbon.

Contribution/ Originality

This study contributes in the existing literature, uses new estimation methodology, originates new formula and one of the very few studies which have investigated the impact of abattoir effluents on soil chemical properties and contributes the first logical analysis which documents that the quality of the soil is negatively affected by the activities of the abattoir.

1. INTRODUCTION

The continuous drive to increase meat production to meet the protein needs of the population is usually associated with some pollution problems (Hinton *et al.*, 2000). The pollution problems include air, water, food and soil pollution (Ezeoha and Ungwuishiwu, 2011). One type of waste that is of great concern to both urban and rural areas in Nigeria is the abattoir or slaughterhouse waste (Ezeoha and Ungwuishiwu, 2011). Abattoir is any premises used for or in connection with slaughter of animals whose meat is intended for human consumption, and include a slaughter house, but does not include a place situated on a farm (Abattoir Acts, 1985). Abattoirs all over the world are known to, directly or indirectly, pollute environment through the various processes

(Neboh *et al*., 2013). This is because less than 1% of the world's fresh water about 0.007% of the overall water on earth is readily accessible for direct human use (UNESCO, 2006).

Abattoirs are usually located near water bodies in order to gain access to water for processing (Neboh *et al*., 2013). Yola abattoir is not an exception, as it is located near River Chouchi (Akindawa *et al*., 2009). Large amounts of waste water used by the abattoir drains into the surrounding environment (Amisu *et al*., 2003). These wastes typically contain fat, grease, hairs, feathers, manure, grit, undigested feed, blood, bones (Nafarnda *et al*., 2006; Osibanjo and Adie, 2007). Organic and inorganic solids, and salts and chemicals added during processing operations (Leoh, 1974), urine and aborted foetus (Akindawa *et al*., 2009).

In ruminant animals, the first stomach or paunch contains undigested materials called paunch manure, which contains long hairs, whole grains and large fragments (Ezeoha and Ungwuishiwu, 2011). The excreta poses undigested feed, mostly cellulose-fibre, undigested protein, excess nitrogen from digested protein, residues from digested fluids, waste minerals, worn-out cells from intestinal linings, mucus, bacteria and foreign matter such as dirt consumed, calcium (Ca), magnesium (Mg), iron (Fe), phosphorus (P), sodium (Na) *et cetera* (Robinson *et al*., 1971). These could increase the levels of nitrogen (N), phosphorus (P) and total solids in receiving environments considerably (Omole and Longe, 2008) or introduce certain elements such as iron (Fe), lead (Pb), zinc (Zn) and calcium (Ca). Present in minute quantity, and make them the leading chemicals, thus, altering the physicochemical nature of the soil (Tortora *et al*., 2007). Some of these chemicals may be toxic to the microbial, floral and faunal community of the soil (Rabah *et al*., 2010).

The resultant consequences could be the degradation of soil fertility due to accumulation of certain nutrients and heavy metals that may lead to low productivity in the surrounding farm lands, in addition to the damages and destruction of aquatic lives (Rabah *et al*., 2010). Over the years Nigeria has witnessed an increased in population which resulted to increased in agricultural production with increased in cultivable area of production. The general aim of this research is to examine the effect of abattoir effluent on soil quality looking at the possible causes and the remedies in order to make possible recommendations to improve the soil quality.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

Yola metropolis Adamawa State is in North-Eastern part of Nigeria (Akindawa *et al*., 2009). It lies between latitudes 7°N and 11°N of the equator, and 11°E and 14°E of the Greenwich Meridian shares national boundaries with Gombe (West), Yobe (North-West), Borno (North) and Taraba (South-East) States. It also, shares international boundary with Republic of Cameroun by the East and South. The town is located along the Benue valley, with a population of 392,845 (Census, 2006). The climate is tropical, characterized by dry and wet seasons. The dry season lasts from November to March, while the wettest months are August and September, with an average annual rainfall of 759mm. The relative humidity of the area drops from 82% to 92% between June and October to about 25% to 36% between November and December. The annual temperature ranges from 24.1°C to 45°C The Vegetation is that of Sub-Sudan vegetation marked by short grasses with short trees (Brown *et al.*, 2005).

2.2. Soil Sampling

Soil sampling was done according to the methods of Zaku (2006). A total of nine composite samples were collected from three different locations. The locations were control area, old effluent discharging area and new effluent discharging area. Three composite samples each were collected from the sampling locations at a depth of 0 to 15cm, and at an interval of two weeks each from the sampling dates. One composite sample each was collected from the three sampling locations on each sampling date. The samples were placed in sterile polythene bags and transported to the laboratory for processing (Rabah *et al.*, 2010).

2.3. Laboratory 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 were determined using ammonium acetate (NH_4OAC) extraction solution method; sodium (Na) and potassium (K) were measured using Flame Photometer, calcium (Ca) and magnesium (Mg) were measured using EDTA titration (Page *et al.*, 1982). Cation exchange capacity (CEC) was determined using 1N neutral ammonium acetate (NH_4OAC) solution. Percentage base saturation (PBS) was determined using the formula below:

$$\text{Base Saturation} = \frac{\text{Ca} + \text{Mg} + \text{Na} + \text{K}}{\text{CEC}} \times 100$$

2.4. Data Analysis

The data generated was subjected to Analysis of Variance (ANOVA), using Statistical Package for Social Science (SPSS) 17.0.

3. RESULTS AND DISCUSSION

The chemical properties of the control samples are presented in Table 1. The results revealed the mean pH value of 6.09, percentage organic carbon 0.78% and 1.34% organic matter respectively. The total nitrogen was 0.89gkg^{-1} and available phosphorus was 2.99mgkg^{-1}. The mean exchangeable cation values were observed to be 0.58Cmolkg^{-1}, 3.09Cmolkg^{-1}, 0.64Cmolkg^{-1} and 0.51Cmolkg^{-1} for K, Na, Ca and Mg respectively. The mean cation exchange capacity of 7.22Cmolkg^{-1} and percentage base saturation of 68.43% were observed.

The chemical properties of the old effluent discharging area samples were presented in Table 2. The results indicated the mean pH value of 5.90 organic carbon 1.31% and 2.27% organic matter respectively. Mean values of 2.10gkg^{-1} and 3.66mgkg^{-1} were observed for total nitrogen and available phosphorus respectively. The exchangeable cations were observed to be 0.53Cmolkg^{-1}, 2.31Cmolkg^{-1}, 0.49Cmolkg^{-1} and 0.67Cmolkg^{-1} for Potassium, Sodium, Calcium and Magnesium respectively. The mean cation exchange capacity was 8.70Cmolkg^{-1} and mean percentage base saturation was 46.04%.

Table-1. Chemical properties of control area samples

Sample	pH	OC	OM	N	P	K	Na	Ca	Mg	CEC	PBS
			%	gkg^{-1}	mgkg^{-1}			Cmolkg^{-1}			%
1	6.21	0.88	1.52	0.92	2.91	0.46	3.41	0.60	0.50	7.23	68.05
2	5.96	0.69	1.19	0.86	2.46	0.77	2.88	0.69	0.52	7.34	68.66
3	6.10	0.76	1.31	0.90	3.61	0.52	3.00	0.63	0.50	7.10	68.59
Total	18.27	2.33	4.02	2.68	8.98	1.75	9.29	1.92	1.52	21.67	205.30
Mean	6.09	0.78	1.34	0.89	2.99	0.58	3.09	0.64	0.51	7.23	68.43

The chemical properties of the new effluent discharging area samples were presented in Table 3.The results in Table 3 indicated the mean values of 5.06, 1.70%, 2.94%, 2.81gkg^{-1}, 5.28mgkg^{-1}, 0.63Cmolkg^{-1}, 3.17Cmolkg^{-1}, 0.50Cmolkg^{-1}, 0.51Cmolkg^{-1}, 8.64Cmolkg^{-1} and 55.29% 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 respectively. The mean chemical properties of the control, old and new effluent discharging area samples were presented in Table 4.

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. The results revealed that there is significant difference between the pH values of the soil samples. 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. These findings conform with that of Neboh *et al.* (2013). They 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 (Coker *et al.*, 2001; Nafarnda *et al.*, 2006).

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. Significant difference was found statistically (P <0.05) between the samples. The new effluent discharging area had the highest mean value of 2.81gkg^{-1} which was the same as 2.10gkg^{-1} for the old effluent discharging area, but statistically different with 0.89gkg^{-1} for the 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 microbial activities such as decomposition of organic residues. High total nitrogen content of the soil enhances microbial proliferation and promotes plant growth (Norton *et al.*, 2002).

Table-2. Chemical properties of old effluent discharging area samples

Sample	pH	OC	OM	N	P	K	Na	Ca	Mg	CEC	PBS
			%	gkg^{-1}	mgkg^{-1}			Cmolkg^{-1}			%
1	5.91	1.21	2.09	2.08	3.49	0.54	2.22	0.50	0.74	8.62	46.40
2	6.10	1.08	1.87	2.24	3.92	0.55	2.47	0.48	0.51	8.80	45.57
3	5.74	1.65	2.85	1.99	3.56	0.50	2.24	0.50	0.77	8.69	46.14
Total	17.75	3.94	6.81	6.31	10.97	1.59	6.93	1.48	2.02	26.11	138.11
Mean	5.90	1.31	2.27	2.10	3.66	0.53	2.31	0.49	0.67	8.70	46.04

Effluent discharging area samples had higher available phosphorus content than control samples. The results indicated significant difference between new effluent discharging area and the other areas. The new effluent discharging area had 5.28mgkg^{-1}, which was higher than and statistically different from 3.66mgkg^{-1} and 2.99mgkg^{-1} for old effluent discharging area and control area respectively. This is consistent to the findings of Rabah *et al.* (2010), who reported similar high mean available phosphorus value of 5.60mgg^{-1} for abattoir effluent contaminated soil and 5.20mgg^{-1} for uncontaminated soil. The high concentration of available phosphorus on the effluent discharging area is ideal (Neboh *et al.*, 2013).

Abattoir effluent discharge had effect on exchangeable calcium and sodium, but showed no significant effect on exchangeable potassium and magnesium. The control area samples revealed high mean exchangeable calcium value of 0.64Cmolkg^{-1}, which was statistically different from 0.50Cmolkg^{-1} and 0.49Cmolkg^{-1} for new and old effluent discharging area samples respectively. The level of sodium ions when in excess disperses fine particles into pores, thereby reducing water penetration and blocking plant root access, whereas high levels of calcium salt reduces risk of soil erosion (Neboh *et al.*, 2013). 3.17Cmolkg^{-1}, 3.09Cmolkg^{-1} and 2.31Cmolkg^{-1} 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 indicated significant effect of effluent discharge on soil. 8.64Cmolkg^{-1} was observed for new effluent discharging area, which was statistically the same with 8.70Cmolkg^{-1} for the old effluent discharging area samples.

The two mean values prove to be statistically different with the mean value of 7.22Cmolkg^{-1} observed for the control area samples. 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 soils. Significant effect of effluent discharge was observed on the percentage base saturation. base saturation of 68.43% 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 respectively.

Table-3. Chemical properties of new effluent discharging area samples

Sample	pH	OC	OM	N	P	K	Na	Ca	Mg	CEC	PBS
			%	gkg^{-1}	mgkg^{-1}			Cmolkg^{-1}			%
1	5.22	1.84	3.18	2.04	5.64	0.72	2.80	0.46	0.56	8.51	52.64
2	5.46	1.35	2.22	3.44	5.22	0.51	3.55	0.53	0.45	8.86	57.67
3	4.49	1.92	3.32	2.94	4.98	0.58	3.16	0.51	0.51	8.55	55.56
Total	15.17	5.11	8.83	8.42	15.84	1.81	9.51	1.50	1.52	25.92	165.87
Mean	5.06	1.70	2.94	2.81	5.28	0.63	3.17	0.50	0.51	8.64	55.29

Table-4. Mean chemical properties of the control, old and new effluent discharging area samples

Area	pH	OC	OM	N	P	K	Na	Ca	Mg	CEC	PBS
			%	gkg^{-1}	mgkg^{-1}			Cmolkg^{-1}			%
Control	6.09	0.78^{b}	1.34^{b}	0.89^{b}	2.99^{b}	0.58	3.09^{a}	0.64^{a}	0.71	7.22^{b}	68.43^{a}
Old	5.90	1.31^{a}	2.27^{a}	2.10^{a}	3.66^{b}	0.53	2.31^{b}	0.49^{b}	0.67	8.70^{a}	46.04^{c}
New	5.06	1.70^{a}	2.94^{a}	2.81^{a}	5.28^{a}	0.63	3.17^{a}	0.50^{b}	0.51	8.64^{a}	55.29^{b}
LSD	0.655	0.521	0.893	0.819	0.812		0.569	0.064		0.271	3.034
Significance	*	*	*	*	*	ns	*	*	ns	*	*

Values assigned with different letters on same columns are statistically different ($P < 0.05$).

4. CONCLUSION AND RECOMMENDATION

In Yola abattoir, soil chemical properties were analyzed from the soil around the effluent discharging areas. 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 of the pH range 6.00 to 9.00 given by the Federal Ministry of Environment (FEPA, 1991), whereas the pH values of the two effluent discharging areas were found to be below the standard. The low pH values of the contaminated soils indicated the presence and prevalence of micronutrients in the soil, some of which are hazardous to the microbial community of the soil as well as the plants. Higher exchangeable sodium 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. Lowest values of exchangeable calcium were found on the samples from the effluent discharging areas. This is said to make the soil of the areas more prone to erosion risks. It is therefore recommended that the National Directorate responsible for waste management in collaboration with Regional and State offices, further develop documents to make provision for appropriate guidelines including research outcomes on improved waste recover and promoting researches into cleaner technology and recovery of higher value products from the wastes discharged out of abattoirs.

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