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Physicochemical and Mineral Compositions of Wastewater and Soils from Two Selected Abattoirs in Warri, Delta State, Nigeria

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Abstract: This study was carried out to evaluate the physicochemical and mineral compositions of abattoir wastewater and contaminated soils from two selected abattoirs in Warri, Delta State and therefore to assess the impact of abattoir activities on the surrounding soil environment. The pH values of the abattoir wastewater (8.2 ± 0.04 and 8.0 ± 0.14) and contaminated soil (7.28 ± 0.31 and 7.75 ± 0.21) were higher than the control at 6.4 ± 0.01 and 6.6 ± 0.01 (control water) and 5.4 ± 0.02 and 4.2 ± 0.01 (uncontaminated soil). The BOD and COD values for abattoir A wastewater (110 ± 2.82 mg/L and 2.64 ± 2.82 mg/L) and abattoir B (398.5 ± 2.10mg/L and 351 ± 1.41 mg/L) were higher than the WHO standard. All the minerals were below the WHO standard except iron with mean concentration of 0.73 ± 0.17 mg/L and 1.35 ± 0.61 mg/L for abattoir wastewater A and B respectively. The abattoir waste contaminated soils A and B had higher values compared with the controlled soils. The soils A and B had higher values compared with the control soils. The soils A and B have values for organic carbon (16381.25 ± 1.78 mg/L and 12863.1 ± 0.88 mg/L), sulphate (2166.8 ± 1.72 mg/L and 3700.5 ± 0.70 mg/L), chloride (4501 ± 1.41 mgL and 2101.5 ± 2.12 mg/L), iron (855.9 ± 0.34 mg/L and 1287.5 ± 2.12 mg/L), lead (27.94 ± 0.42 mg/L and 16.87 ± 0.50 mg/L), manganese (66.32 ± 2.22 mg/L and 44.17 ± 1.12 mg/L) and phosphorus (75.13 ± 1.24 mg/L and 79.01 ± 1.40 mg/L). The continuous discharge of the abattoir wastewater into the surrounding soils led to the pollution of the soil. Adequate treatment of the wastewater before discharge and proper waste disposal systems are necessary.

Keywords: Wastewater, Abattoir, Soil, Physicochemical Mineral

Introduction

Inability to effectively and efficiently manage the vast amount of waste generated by various anthropogenic activities especially in developing countries has created problems in our environment. The continuous drive to increase meat production for the protein needs of the ever increasing world population has resulted in pollution problems (Eni *et al.*, 2014). Consideration is hardly given to safety practices during animal transport to the abattoir, during slaughter and during dressing (Singh and Neelam, 2011). An abattoir or a slaughter house is defined as a place approved and registered by the controlling authority for the hygienic slaughtering and inspection of animals, processing and effective preservation and storage of meat products for human consumption (Bello and Odeyemi, 2009). Abattoirs generate large amounts of solid waste and effluents such as rumen contents, blood and wastewater (Mbajiuka *et al.*, 2014). The large amount of wastewater produced in the abattoir during processing operations is a major environmental problem as the wastewater contains suspended and dissolved solids, blood gut contents, urine and water (Gauri, 2006; Hassan et al, 2014). This constitutes public health risks as it may result in air, soil and water pollution as well as infestation of flies and other disease vectors (Chukwu *et al.*, 2011).

In the Nigerian livestock industry, slaughterhouses 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). Effluent from the slaughterhouses are 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 Odeyemi, 2009). The discharge of the untreated abattoir wastewater into the soil release certain elements and heavy metals leading to alteration of the physicochemical nature of the soil (Tortora *et al.*,

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2007). These elements may be toxic to the microbial, floral and faunal communities of the soil (Rabah et al. 2010). When contaminated wastewater logs in the soil, it results in the depletion of soil oxygen, making oxygen less available (Eze *et al.*, 2013). This study is to determine the physicochemical and mineral compositions of the abattoir wastewater from two abattoirs in Warri, Delta State and then assess the impact on the soils receiving the wastewater.

Materials and Methods

Collection of Wastewater and Soil Samples

The two selected abattoirs for the study were the Hausa Quarters abattoir (Abattoir A) and the Warri Main Market abattoir (Abattoir B) both located in Warri, Delta State (Lat 50^o 31'N and Long 50^o 45'N). Sterile bottles were used to collect the wastewater as it flowed into drainage in the abattoirs. Control water samples were collected from the boreholes located in the abattoir vicinity. The soil samples contaminated with abattoir wastewater were collected with a soil auger into sterile plastic bags. Control soil was collected 50m away of the abattoir. The samples were properly labeled and taken to the laboratory for analysis.

Physicochemical and Mineral Analyses

The pH of the soil and water samples was determined using a Hach pH meter (APHA, 2005). Temperature was determined by dipping the bulb of the mercury-in-glass thermometer into the soil suspension and water samples (APHA, 2005). Conductivity and turbidity were carried out using a Hach Conductivity meter and Turbidity meter respectively (APHA, 2005). Total organic carbon in the soil samples and oil and grease were determined by the method of ASTM (2003). Alkalinity, sulphate, nitrate, BOD, COD, TSS, TDS and chloride concentrations in the samples were determined using the method of APHA (2005). The mineral compositions were determined by the method of APHA (2005). Magnesium, iron, zinc, lead, copper, mercury, manganese and phosphorus concentrations were determined by using atomic absorption spectrophotometer while potassium, calcium and sodium were determined by using flame emission spectrophotometer..

Results

The mean physicochemical and mineral compositions of the wastewater and soil samples were higher than the control. In Table 1 is presented the mean physicochemical composition of the abattoir wastewater samples. The abattoirs A and B had mean values for pH (8.2 ± 0.04 and 8.0 ± 0.14), turbidity (21.0 ± 0.57 NTU and 19.3 ± 1.27 NTU), temperature (28.6 ± 0.14^{o}C and 29.2 ± 0.14^{o}C), TSS (2083 ± 2.82 mg/L and 738.5 ± 2.12 mg/L), TDS (655.5 ± 2.12mg/L and 922 ± 2.82 mg/L) higher than the control water samples from the abattoir A and B with pH (6.4 ± 0.01 and 6.6 ± 0.01), turbidity (11.15 ± 0.25 NTU and 11.35 ± 0.01 NTU), temperature (27.5 ± 0.01^{o}C and 29.4 ± 0.01^{o}C), TSS (168 ± 1.00 mg/L and 205 ± 1.20 mg/L), TDS (472 ± 0.05 mg/L and 401.2 ± 0.03 mgLl). Abattoir wastewater B and higher values for the parameters tested except for sulphate, TSS, turbidity and pH.

Table 1: Mean Physicochemical Compositions of Abattoir Wastewater Samples

Parameters	Units	Abattoir A	Abattoir B	Control	
				A	B
pH		8.2 ± 0.04	8.0 ± 0.14	6.4 ± 0.01	6.6 ± 0.01
Turbidity	NTU	21 ± 0.57	19.3 ± 1.27	11.15 ± 0.25	11.35 ± 0.05
Temperature	^{o}C	28.6 ± 0.14	29.2 ± 0.14	27.5 ± 0.01	27.4 ± 0.01
Total suspended solids	mg/L	2083 ± 2.82	738.5 ± 2.12	168 ±1.00	205 ± 1.20
Total dissolved solids	mg/L	655.5 ± 2.12	922 ± 2.82	472 ± 0.05	401.2 ± 0.03
BOD	mg/L	110 ± 2.82	398.5 ± 2.10	12 ± 0.01	6.4 ± 0.01
COD	mg/L	264 ± 2.82	351 ± 1.41	68 ± 0.01	84.4 ± 0.05
Conductivity	µs/cm	1004.2 ± 2.70	1413.7 ± 2.39	726.15 ± 1.50	617.2 ± 1.00
Sulphate	mg/L	76.3 ± 2.97	58.2 ± 1.84	24.83 ± 1.40	41.08 ± 0.05
Chlorides	mg/L	163 ± 1.41	473 ± 1.40	79 ± 0.02	38 ± 0.07
Oil/Grease	mg/L	8.1 ± 0.42	13.6 ± 1.13	0.78 ± 0.01	1.2 ± 0.01
Nitrate	mg/L	27.6 ± 1.69	33.4 ± 2.69	21.08 ± 0.50	8.05 ± 0.04
Alkalinity	mg/L	158.5 ± 2.40	261.5 ± 2.12	106 ± 0.07	226 ± 1.00

The mean mineral compositions of the abattoir wastewater A and B and the control is presented in Table 2. Sodium concentration was highest in abattoir A and B with mean values of 10.8 ± 0.42 mgL and 9.01 ± 0.69 mg/L. Mercury concentration was lowest at 0.001 ± 0.000 mg/L in both abattoir A and B wastewater samples. All values for the minerals were lower than the WHO (2006) discharge limit except for iron with value for abattoir A (0.73 ± 0.46 mg/L) and abattoir B (1.35 ± 0.60mg/L) higher than the WHO limit of 0.3 mg/L.

Table 2: Mean Mineral Compositions of Abattoir Wastewater Samples

Parameter (mg/L)	Abattoir		Control	
	A	B	A	B
Sodium	10.8 ± 0.42	9.01 ± 0.69	8.3 ± 0.10	5.64 ± 0.01
Potassium	2.62 ± 0.11	3.07 ± 0.01	1.05 ± 0.01	1.05 ± 0.01
Calcium	4.23 ± 0.14	7.3 ± 1.27	0.61 ± 0.01	1.04 ± 0.02
Magnesium	2.5 ± 0.14	0.12 ± 0.00	2.18 ± 0.01	0.11 ± 0.02
Iron	0.73 ± 0.16	1.35 ± 0.60	1.44 ± 0.02	1.57 ± 0.01
Zinc	0.3 ± 0.16	0.15 ± 0.02	0.17 ± 0.01	0.3 ± 0.01
Lead	0.003 ± 0.001	0.0025 ± 0.0007	0.08 ± 0.01	0.002 ± 0.000
Copper	0.14 ± 0.01	0.14 ± 0.02	0.16 ± 0.01	0.09 ± 0.01
Mercury	0.001 ± 0.001	0.001 ± 0.000	0.001 ± 0.001	0.001 ± 0.000
Manganese	0.02 ± 0.01	0.02 ± 0.01	0.04 ±0.01	0.07 ± 0.01
Phosphorus	3.4 ± 0.28	2.27 ± 0.52	3.1 ± 0.01	1.7 ± 0.01

In Table 3 is presented the mean physicochemical and mineral compositions of the soil samples from abattoir A and B. The contaminated soil samples were higher in than the control samples. The values for the parameters were higher in the contaminated soil sample from abattoir B for pH (7.75 ± 0.21) conductivity (803 ± 2.82 mg/L μs/cm), sulphate (3700.5 ± 0.70 mg/L mg/kg), potassium (88.25 ± 1.05 mg/kg), calcium (2138 ± 2.80mg/kg, magnesium (72.10 ± 2.96 mg/kg), Iron (1287.5 ± 2.12 mg/kg), zinc (40.82 ± 1.82 mg/kg), copper (10.25 ± 0.94 mg/kg) and phosphorus (79.01 ± 1.40 mg/kg) than for abattoir A. Abattoir A had higher values for temperature (28.2°C), nitrate (250.74 ± 1.04 mg/kg), chloride (4501 ± 1.41 mg/kg), total organic carbon (16381.25 ±1.76 mg/kg), sodium (147.45 ± 1.34 mg/kg), lead (27.94 ± 0.42 mg/kg) and manganese (66.32 ± 2.22 mg/kg).

Table 3: Mean Physicochemical and Mineral Compositions of Soil Samples from Abattoirs A and B

Parameters	Unit	Soil Samples		Control Soil	
		A	B	A	B
pH		7.28 ± 0.31	7.75 ± 0.21	5.4 ±0.02	4.2 ± 0.01
Temperature	°C	28.2 ± 0.85	27.5 ± 0.71	27 ± 0.05	27.1 ± 0.03
Conductivity	μs/cm	724.5 ± 2.12	803 ± 2.82	134.2 ± 1.40	78.3 ± 1.00
Sulphate	mg/kg	2166.8 ± 1.72	3700.5 ± 0.70	46.08 ± 0.01	208.4 ± 1.00
Nitrate	mg/kg	250.74 ± 1.04	210.55 ± 0.63	234.8 ± 1.00	178.2 ± 0.57
Chlorides	mg/kg	4501 ± 1.41	2101.5 ± 2.12	186.4 ± 0.05	168.44 ± 1.00
Total Organic Carbon	mg/kg	16381.25 ±1.76	12868.1 ± 0.88	1540.44 ± 1.00	975.66 ± 0.03
Sodium	mg/kg	147.45 ± 1.34	144.25 ± 1.48	68.3 ± 0.01	28.4 ± 0.01
Potassium	mg/kg	48.17 ± 1.34	88.25 ± 1.05	12.8 ± 0.01	21.86 ± 0.02
Calcium	mg/kg	2135.92 ± 1.17	2138 ± 2.80	86.9 ± 0.02	53.2 ± 0.05
Magnesium	mg/kg	69.42 ± 1.96	72.10 ± 2.96	21.9 ± 0.01	41.08 ± 0.01
Iron	mg/kg	855.9 ± 0.34	1287.5 ± 2.12	190.6 ± 0.02	192.4 ± 0.34
Zinc	mg/kg	16.09 ± 0.18	40.82 ± 1.82	14.83 ± 0.01	28.82 ± 0.03
Lead	mg/kg	27.94 ± 0.42	16.87 ± 0.50	11.44 ± 0.20	16.24 ± 0.01
Copper	mg/kg	8.725 ± 0.98	10.25 ± 0.94	8.27 ± 0.10	9.88 ± 0.30
Mercury	mg/kg	0.001 ± 0.000	0.001 ± 0.000	0.001 ± 0.000	0.001 ± 0.000
Manganese	mg/kg	66.32 ± 2.22	44.17 ± 1.12	43.38 ± 1.50	29.48 ± 1.00
Phosphorus	mg/kg	75.13 ±1.24	79.01 ± 1.40	68.2 ± 1.00	76.9 ± 0.05

Discussion

Temperature and pH play an important role in determining the qualitative and quantitative abundance of microorganisms in contaminated soils (Rabah *et al.*, 2010). Though the pH and temperature of the abattoir wastewater and contaminated soils were within the WHO (2006) limits, they were higher than the values for the control samples. The conductivity values were below the WHO (2006) limit except for wastewater from abattoir B. The increased conductivity could be attributed to the type of wastes in the wastewater which increased the concentration of dissolved ions in the wastewater. The total dissolved solids, total suspended solids and turbidity concentrations were very high in the wastewater samples and this might have been due to the various solid wastes from the slaughtered animals (Williams and Dionbo, 2015). The very high chloride content in the wastewater and subsequently the contaminated surrounding soils was due to the slaughterhouse activities. High chloride concentration can cause toxicity in plants and reduce crop yield (Chukwu and Anuchi, 2016). Wastewater from abattoirs when released into the soil with concentration of pollutants and nutrient load above threshold level will cause soil problems including soil salinity (Anderson et al; 2006). This deposition of excess amount of nutrients causes potential effect on soil fertility and productivity affecting soil biodiversity.

The values of the COD and BOD in the wastewater were higher than the WHO (2006) recommended limit. The increase in BOD is as a result of depletion of oxygen which is utilized by the microorganisms when they break down organic matter leading to proliferation of anaerobic organisms (Matilukuro, 2003). High COD level indicates the presence of chemical oxidants in the wastewater and this causes nutrient fixation in the soil resulting in reduced rate of nutrient availability to plants (Magaji and Chup, 2012). The mineral nutrients (Ca, Mg, K, Na and P) were lower in the wastewater and contaminated soil when compared with recommended limits except calcium which were higher in the soil samples. High level of calcium salts is a reflection of increased soil conditions and when combined with phosphates could render them insoluble and unavailable to plants (Eze *et al.*, 2013).

The concentration of the heavy metals in the wastewater and contaminated soils were lower than the recommended limits except for iron. Contamination of water and soils with heavy metals is of public health significance. Most metals do not undergo microbial or chemical degradation and their total concentration in soils persist for a long time after introduction (Agyarko *et al*., 2010). Their persistence in soil may lead to increase up-take by plants and vegetables grown in the area and subsequent risk of transfer through the food chain to humans (Ubwa *et al.*, 2013). The high level of iron could be as a result of the abattoir wastes, rusted pipes tanks and metals for water storage and accumulation of deposit in the distribution system. The ground water quality in the vicinity of the abattoir can therefore be affected by the diversity of contaminants and heavy metals even at low concentrations (Vodela *et al.*, 1997). Iron concentration in high levels causes the formation of blue baby syndrome in babies and goiter in adults (Akinbule, 2006). Excess of these heavy metals is detrimental to human health. High level of mercury damages the nervous system, cause memory loss and lack of coordination (Neboh *et al.*, 2013). Excess copper in humans causes anaemia, liver and kidney damage, stomach and intestinal irritation (Neboh *et al.*, 2013). Lead poison causes inhibition of heamoglobin synthesis, dysfunction in the kidneys, reproductive systems and cardiovascular system (Ferner, 2001). Cadmium in excess causes renal dysfunction, bronchitis, gastric and intestinal disorders, liver and brain disorders (Dara, 2000). The release of the abattoir waste water into the soil and its permeability makes it to allow large quantities of contaminants and leachetes pass through it and thus having the potential of contaminating surrounding underground water (Ubwa *et al*., 2013).

Conclusion

Abattoir wastewater could constitute a significant environmental and health hazard. The level of contaminants released into the surrounding soils could also affect surface and ground waters. The contaminated soils contain pollutants and nutrients above threshold level. Some of the cows to be slaughtered even feed on the plants in the vicinity before they are killed. Therefore, abattoir wastes should be properly treated before discharge.

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