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Physicochemistry and Heavy Metal Characteristics of Waste Products from Abattoir Activities in Port Harcourt, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author ATC designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author DNO managed the analyses of the study under the supervision of author JO. All authors read and approved the final manuscript.

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ABSTRACT

The upsurge of abattoir operations as a result of the rise in demand for meat protein has led to a corresponding increase in waste generation. These wastes are often channelled into nearby streams with little or no treatment which exposes aquatic organisms to the resultant consequences of this waste deposition. This study was thus aimed at determining the physicochemical quality of some abattoir samples in Port Harcourt city. Soil, faecal matter, wastewater, waste blood and service water samples from the Iwofe, Rumuodomaya and Trans-Amadi abattoirs were collected within a period of one year and the pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), sulphate, chloride, temperature, nitrate, ammonia and heavy metals quantities including chromium, lead, zinc, cobalt, copper and cadmium were determined using standard

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techniques. The study recorded high BOD_5 and COD values from the blood, faecal matter, soil and wastewater samples while service water samples had values within the Nigerian Standard for Drinking Water Quality limits. Seasonal variations in the physicochemical parameters of the samples collected both in the wet and dry seasons were observed. The pH values ranged from 6.2-8.5, BOD_5 of blood, faecal matter soil and wastewater ranged from 2124-4349 mg/l while the COD ranged from 2715-8820 mg/l. In Rumuodomaya, the BOD_5 and COD ranged from 2276-2727 mg/l and 2583-3245 mg/l respectively while samples from Trans-Amadi abattoir had values for BOD_5 and COD ranging from 2253-4330 mg/l and 2931-4597 mg/l, respectively. Nitrate, chromium, cadmium, zinc, cobalt, lead and copper contents in the different locations varied statistically at α-0.05 while no significant difference was observed for pH, ammonia, temperature, COD, BOD_5, sulphate and chloride contents at α=0.05. The BOD_5 and COD of waste blood, wastewater, soil and faecal matter recorded values that were above permissible limits for service water and therefore raises concern for the aquatic life being threatened by these effluents as the amount of dissolved oxygen available for them will be reduced as a pollution of the immediate environment, if these generated wastes are not treated before disposal.

Keywords: Abattoir activities; heavy metal; physicochemistry; waste products; pollution.

1. INTRODUCTION

Abattoir activities generate huge amount of wastes through slaughtering of animals or livestock and processing of meat and by-products (e.g. cow, goat, ram). The process is to optimize the recovery of edible parts from the meat processing cycle for consumption by humans [1]. However, a good quantity of secondary wastes are generated, and they appear as liquid, solid or gaseous substances which usually contains both organic and inorganic materials most of which are not suitable for consumption [2]. In most cases, slaughtering of animals is done in places with poor hygienic standard that have been polluted with blood and faecal materials, also with flies, birds and rodents invading the area afterwards thus making the meat vulnerable to spoilage and bacterial contamination. This may predispose the meat products to food poisoning in humans [3].

Other sources of abattoir wastes are from the processing of the carcass, animal pens, bleeding, offal and by-products processing [4]. In several cases during processing, liquid wastes such as urine, water, blood, gut contents and solid wastes like bones, undigested material and in some cases aborted foetuses are also generated [5]. In Port Harcourt, these wastes are washed unto the soils which are subsequently washed into rivers through runoffs or storm-water during flash floods or torrential rainfalls. For example, wastes products from such activities in Trans-Amadi is channeled into River Okpoka, a feeder of the Bonny River [3]. Contaminated soils serve as both a reservoir for contaminants or a source of contaminants to the water column and organisms that live there. Because of the porous soil structures and permeable nature of the subsurface geologic formation and the shallow depth of water table of the Niger Delta region, the ground water bodies eventually becomes highly vulnerable to leachates from these wastes which find its way into boreholes, rivers, lakes, wells and other water bodies. The consequence is that water quality becomes deplorable and polluted and unfit for human consumption. Leachates containing dissolved organic and inorganic elements and compounds such as magnesium, potassium, sulphate, ammonium, calcium, sodium and heavy metals such as copper, cadmium, nickel, chromium, zinc and lead may also contaminate the environment thus altering the physicochemistry of the environment [6-8].

Results of abattoir effluent pollution of the environment affect the physicochemistry and microbiology of the ground and surface waters. This may further result in the production of methane gas, carbon dioxide and organic acids due to the decomposition of abattoir wastes leading to greenhouse effect, thus defacing the aesthetic value of the environment [9-10]. These effluents therefore, decrease the quality of air in the environment in addition to making effective environmental management a serious challenge [3]. These elements,. some of which are toxic to soil microflora may find their way into the environment leading to an increase in the quantity of these chemicals and subsequently, may cause changes in the status of the soil [6]. Depletion of oxygen content due to the accumulation of waste products in water may result to nutrient over-enrichment of the receiving environment [11]. Eventually when these wastes decompose and are washed into rivers, increased biological productivity due to the overabundance of nutrients such as nitrogen and phosphorus, thereby blocking light penetration which may lead to reduction in dissolved oxygen content causing eutrophication of rivers, estuaries, lakes and marine waters [9,10,12] and thus results in ecological imbalance in the receiving body of water [13].

These wastes also deposit certain heavy metals that may be toxic and alter the physicochemistry of both soil and water bodies, since these wastes are often times emptied into water bodies (which in some cases are sources of water for drinking and other domestic purposes) with little or no pre-treatment to reduce the quantity of the pollutants. These elements in water may lead to chronic illnesses which may affect the respiratory or nervous systems. This study was thus aimed at determining the physicochemistry of wastes generated in abattoirs.

2. MATERIALS AND METHODS

2.1 Sampling Area

Samples for this study were collected from abattoirs within Port Harcourt which is one of Nigeria's busiest and most populous cities. The abattoirs included the Rumuodomaya, Iwofe and Trans-Amadi abattoirs. Trans-Amadi is an industrial layout in the city and hosts many of the companies in Port Harcourt city and has the largest abattoir. Its effluents are drained into the Okpoka Creek. The Creek passes through Woji, Oginigba and Azubiae where activities such as dredging, bathing, fishing, disposal of excreta, swimming and navigation are carried out. The Iwofe abattoir was established not too long ago (less than three years) while Rumuodomaya abattoir is much older than the Iwofe abattoir. Inhabitants of these areas are mainly traders, artisans, civil servants, fishermen and farmers. Table 1 shows the Global Positioning System (GPS) coordinates of the sampling points while Fig. 1 is a map showing the three sampling locations. The samples were collected within one year covering both dry and wet seasons.

2.2 Sample Collection

Water sample: water used in servicing the abattoir was collected using sterile bottles. The taps were allowed to run for 30 seconds from the water source before the samples were collected.

Faecal matter: Using sterile spoons, the cow faecal matter was scooped from the intestine of the animal aseptically and put in sterile sample bottles.

Blood sample: Using sterile syringes, waste blood sample from the cow was collected as it gushed out through the vein during slaughtering. Blood for physicochemical analyses were collected using sterile 1 L sample bottles.

Wastewater sample: One litre sterile sample containers were used to collect the wastewater as the carcasses were washed.

Table 1. Sampling points, GPS coordinates and types of samples

Sampling stations	Sampling points	Sampling coordinates		Samples
		Northing	Easting	
Iwofe abattoir	1	004° 48.598´	006° 57.517´	Blood
	2	004° 48.592´	006° 57.501´	Soil
	3	004° 48.601´	006° 57. 525´	Service Water
	4	004° 48.594´	006° 57.518´	Faecal matter
	5	004° 48.598´	006° 57.517´	Waste water
Rumuodomaya abattoir	1	004° 52.118´	006° 59.580´	Blood
	2	004° 52.102´	006° 59.571´	Soil
	3	004° 52.124´	006° 59. 602´	Service Water
	4	004° 52.120´	006° 59.582´	Faecal matter
	5	004° 52.118´	006° 59.580´	Waste water
Trans-Amadi abattoir	1	004° 48.442´	007° 02.303´	Blood
	2	004° 48.434´	007° 02.293´	Soil
	3	004° 48.456´	007° 02.319´	Service Water
	4	004° 48.444´	007° 02.301´	Faecal matter
	5	004° 48.442´	007° 02.303´	Waste water

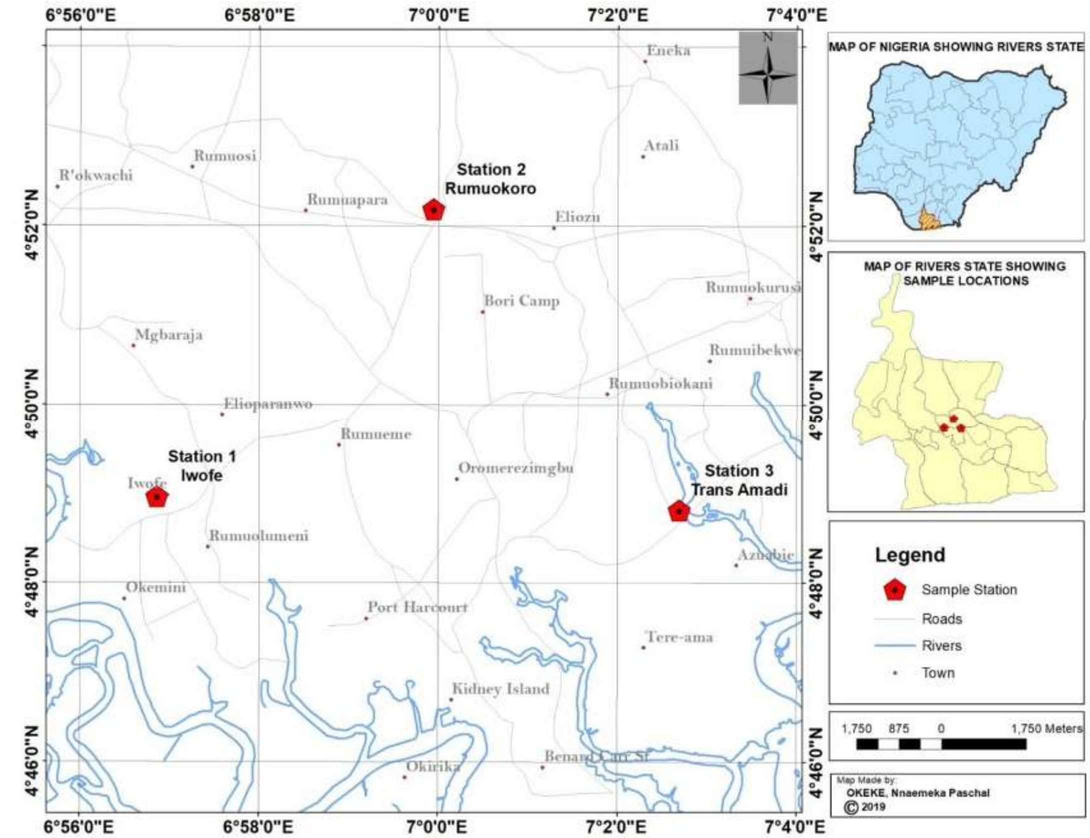

Fig. 1. Map of Port Harcourt Metropolis showing the sampling points

Soil sample: Composite soil samples measuring 500 g were collected in sterile sample bottles with the aid of a hand soil auger at 0-15 cm depth.

2.3 Physicochemical Analyses

The physicochemical parameters of the collected samples analysed included pH, temprerature, nitrate, ammonia, chloride, sulphate, BOD, COD, lead, zinc, copper, cobalt, chromium and cadmium and these analyses were carried out using standard procedures listed in Table 2.

3. RESULTS

Results of the spatial variation of physicochemical parameters for blood, service water, faecal matter, soil and wastewater samples analyzed are presented in tables. The values obtained for service water were within the National Standard for Drinking Water Quality (NSDWQ) limits (pH ranging from 6.8-8.5, nitrate ≤50 mg/l, ammonia ≤1.5 mg/l, BOD^5 ≤5-7 mg/l, sulphate ≤100 mg/l and temperature <40°C). The study recorded high BOD^5 and COD values from the blood, faecal matter, soil and wastewater samples while service water samples had values within the NSDWQ standard. Table 3 shows the variation in the physicochemical parameters of the samples collected both in the wet and dry seasons from Iwofe abattoir. The pH values ranged from 6.2-8.5, BOD^5 of blood, faecal matter soil and wastewater ranged from 2124-4349 mg/l while the COD ranged from 2715-8820 mg/l; the parameters varied in the seasons. Table 4 shows the values of the physicochemical parameters of samples from Rumuodomaya abattoir studied. The BOD^5 and COD ranged from 2276-2727 mg/l and 2583-3245 mg/l, respectively. Quantitative variation was observed in the two seasons as well as in those in samples from Trans-Amadi abattoir (Table 5). Samples from Trans-Amadi abattoir had values for BOD^5 and COD ranging from 2253-4330 mg/l and 2931-4597 mg/l, respectively. Table 6 shows the mean and standard deviation of each of the samples collected in the three locations. There was no significant difference in most of the samples analysed at a confidence interval of

95%; however, nitrate values for wastewater and service water varied significantly. Ammonia contents across the locations varied significantly with a mean value of 0.21. Chromium, zinc, cobalt, lead and copper contents of waste blood and service water in the different locations varied statistically; that of Cadmium for all the samples varied significantly.

4. DISCUSSION

Abattoir effluents often consist of blood, wash water (wastewater), intestinal contents and urine. The physicochemical characteristics of the samples showed variation in the samples. An alternative method of blood disposal from abattoirs involves dispensing them into water which is later recovered as concentrates and used as livestock feed, fertilizer and in pharmaceutical industries because of its high protein and nitrogen content which is about 18% [2,14]. The values obtained for service water was compared with the Nigerian Standard for Drinking Water Quality (NSDWQ). Temperature is often determined by weather conditions. The temperature of the samples analysed in this study ranged from 26.4-32ºC for cow blood samples from Rumuodomaya and faecal matter from Iwofe abattoirs, respectively. This is in agreement with a study by Ire et al. [15] who recorded temperature values ranging from 27-30ºC in abattoir effluents from Port Harcourt. A similar study by Edori and Iyama however recorded higher temperature values ranging from 31.6-36.2ºC in soil samples [16]. The pH refers to the basicity or acidity of a sample and ranges from 0-14. The service water samples recorded a mean pH of 6.65 which is weakly acidic while the waste blood had a strong alkaline value of 7.63. This parameter is known to play a major role in the activities of microorganisms in any medium in terms of tolerance for optimum conditions. The waste blood samples were weakly alkaline while the water samples were weakly acidic. The difference in pH values between the service water samples and wastewater samples is in consonance with studies by Chukwu et al. who reported high pH in wastewater samples and low pH for service water from boreholes [17]. The pH values recorded in this study ranged from 5.90 for service water from Trans-Amadi to 8.64 for blood from Rumuodomaya abattoir. This is in consonance with a similar study by Ire et al. but differs with the reports of Edori and Iyama whose pH values ranged from 6.55-7.21 and 4.19-4.79 respectively in different abattoirs [15,16]. Increased rate of wastes decomposition has been linked to low pH [18], while accumulation of particles and dissolved materials contributes to increased pH [19]. The toxicity of ammonia is often increased at a high pH; whereas a low pH increases the toxicity of hydrogen sulphide and cyanide [20]. The toxicity of microbial poisons in water is also affected by pH changes [21]. pH is important as it determines the functioning of almost all hormones, enzymes and proteins controlling growth, metabolism and development and also in chemical reactions linked with the alteration, formation and dissolution of minerals [22,23].

The life of any body of water depends to a large extent upon its ability to maintain a certain amount of dissolved oxygen, which is needed to maintain aquatic life. For example, without dissolved oxygen, fish suffocate and normal aquatic organisms are destroyed. This situation creates an imbalance in the ecosystem. Biochemical Oxygen Demand refers to the quantity of oxygen needed by bacteria for the

Table 2. Analytical method used for physicochemical parameters

S/N	Parameter	Method	Reference
1	pH	Jenway pH meter (model 291 MK2)	APHA (1995)
2	Temperature	Mercury-in-glass thermometer	APHA (1995)
3	Nitrate	Spectrophotometry	APHA (1995)
4	Ammonia	Direct nesslerization	ASTM (2007)
5	Chloride	Argentometry	APHA (2017)
6	Sulphate	Turbidimetry	APHA (1995)
7	Biochemical Oxygen Demand	Azide modification	APHA (1995)
8	Chemical Oxygen Demand	Dichromate reflux	APHA (1995)
9	Lead	Atomic absorption spectrophotometry	APHA (1995)
10	Zinc	Atomic absorption spectrophotometry	APHA (1995)
11	Copper	Atomic absorption spectrophotometry	APHA (1995)
12	Cadmium	Atomic absorption spectrophotometry	APHA (1995)
13	Cobalt	Atomic absorption spectrophotometry	APHA (1995)
14	Chromium	Atomic absorption spectrophotometry	APHA (1995)

Table 3. Mean seasonal physicochemical quality of samples from Iwofe Abattoir

Parameters	Blood		Service water		Faecal matter		Soil		Wastewater	
	RS	**DS**	**RS**	**DS**	**RS**	**DS**	**RS**	**DS**	**RS**	**DS**
pH	6.40±0.40	6.50±0.85	6.52±0.95	6.36±0.82	5.40±0.92	6.60±0.35	7.70±0.56	8.50±0.25	6.20±0.56	6.90±0.68
Nitrate (mg/l)	3.08±0.08	3.12±0.05	2.8±0.03	2.05±0.04	36.2±0.15	34.4±0.27	27.5±0.92	26.2±0.09	2.95±0.07	2.72±0.03
Ammonia (mg/l)	0.72±0.03	0.67±0.02	0.54±0.08	0.46±0.01	17.1±0.07	16.3±0.41	13.7±0.41	13.2±0.06	0.63±0.03	0.55±0.08
BOD_5 (mg/l)	4394±1.89	4349±1.59	2.3±0.24	2.4±0.05	2915±2.95	2124±305	2580±5.35	2496±2.95	3125±3.92	3061±1.93
Sulphate (mg/l)	38.20±0.58	35.40±0.70	2.5±0.08	2.3±0.00	66.4±0.15	67.2±0.05	96.6±0.38	93.5±0.43	13.9±0.23	14.4±0.54
Chloride (mg/l)	26.4±0.89	25.6±0.93	0.24±0.07	0.24±0.09	106.2±0.13	104.5±0.69	292.7±1.55	294.5±0.41	22.3±0.46	20.9±0.23
Temperature (°C)	28±1.50	30.9±2.00	25.8±2.46	27.4±2.50	32.7±0.55	32.8±0.50	27.8±1.85	30.5±1.50	26.4±2.50	27.3±2.23
COD (mg/l)	4820±2.24	4722±4.52	4.79±0.21	4.73±0.20	3985±3.25	3824±4.65	2715±6.35	2644±7.55	3797±3.54	3413±4.21
Chromium (mg/l)	0	0	0.7±0.01	0.69±0.02	0	0	0.05±0.01	0.05±0.00	0	0
Cobalt (mg/l)	0	0	0	0	0	0	0	0	0	0
Cadmium (mg/l)	0.9±0.01	0.87±0.02	0.7±0.04	0.69±0.06	0	0	0.82±0.02	0.81±0.04	0.68±0.03	0.62±0.05
Copper (mg/l)	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00	0	0	0.006±0.01	0.007±0.01	0.001±0.00	0.001±0.00
Lead (mg/l)	0	0	0	0	0	0	0	0	0	0
Zinc (mg/l)	0.42±0.05	0.38	0	0	0.004±0.001	0.003±0.00	0.001±0.00	0	0.31±0.01	0.27±0.05

RS= Rainy Season
DS= Dry Season

Table 4. Mean seasonal physicochemical quality of samples from Rumuodomaya abattoir

Parameters	Blood		Service water		Faecal matter		Soil		Wastewater	
	RS	**DS**	**RS**	**DS**	**RS**	**DS**	**RS**	**DS**	**RS**	**DS**
pH	8.60±0.37	8.60±0.04	7.40±0.21	7.60±0.02	6.60±0.03	6.90±0.95	8.34±0.30	8.47±0.05	6.60±0.93	7.50±0.55
Nitrate (mg/l)	0.06±0.01	0.02±0.00	0.03±0.01	0.02±0.00	28.1±0.26	27.8±0.00	26.9±0.53	25.7±0.22	0.02±0.00	0.04±0.02
Ammonia (mg/l)	0.9±0.08	0.7±0.03	0.25±0.04	0.24±0.04	14.0±0.04	13.4±0.07	13.3±0.08	12.7±0.08	0.37±0.06	0.41±0.01
BOD_5 (mg/l)	2528±2.55	2518±3.75	1.85±0.30	1.84±0.37	2303±3.75	2276±0.45	2606±4.95	2727±3.75	2638±5.55	2657±4.75
Sulphate (mg/l)	76±1.25	74.7±0.79	3.6±0.04	3.4±0.07	58.6±0.82	60.2±1.05	111±0.39	112±1.21	24.7±0.69	24.9±0.25
Chloride (mg/l)	0.39±0.06	0.23±0.04	0.16±0.09	0.14±0.02	100±1.25	100.1±0.56	277±0.72	272±0.50	25.6±0.31	27.4±0.21
Temperature (°C)	31±0.25	30.4±0.15	25.6±0.45	27.3±0.05	29±0.55	30±0.05	27.2±1.5	29.8±1.00	29.5±0.55	28.4±0.65
COD (mg/l)	3245±7.35	3325±3.95	5.4±0.02	4.95±0.25	3365±6.55	3195±3.95	2613±3.60	2583±3.45	3100±7.25	2827±3.57
Chromium (mg/l)	0	0	<0.001	<0.001	0	0	0.15±0.02	0.16±0.04	0	0
Cobalt (mg/l)	0	0	0	0	0	0	0	0	0	0
Cadmium (mg/l)	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00	0	0	0.29±0.01	0.27±0.07	0.001±0.00	<0.001
Copper (mg/l)	0.001±0.00	0.001±0.00	0.001±0.00	<0.001	0	0	0.006±0.01	0.002±0.01	<0.001	<0.001
Lead (mg/l)	0.74±0.03	0.75±0.03	0.005±0.00	0	0	0	0.023±0.00	0.014±0.00	0.2±0.01	0.15±0.02
Zinc (mg/l)	0.001±0.00	0.001±0.00	0.001±0.00	<0.001	0.004±0.02	0.005±0.01	0.02±0.00	0.01±0.01	0.13±0.04	0.12±0.02

RS= Rainy Season
DS= Dry Season

Table 5. Mean seasonal physicochemical quality of samples from Trans-Amadi abattoir

Parameters	Blood		Service water		Faecal matter		Soil		Wastewater	
	RS	**DS**	**RS**	**DS**	**RS**	**DS**	**RS**	**DS**	**RS**	**DS**
pH	6.30±0.47	6.50±0.10	5.80±0.05	6.20±0.39	7.30±0.55	7.20±0.02	7.40±0.05	8.30±0.08	6.60±0.41	6.70±0.03
Nitrate (mg/l)	3.5±0.25	2.9±0.03	0.01±0.00	0.01±0.00	32.6±0.09	30.9±0.27	27.5±0.01	26.7±0.25	1.13±0.09	1.07±0.06
Ammonia (mg/l)	0.87±0.04	0.75±0.01	0.01±0.00	0.01±0.00	18.4±0.03	17±0.19	11.6±0.05	10.4±0.79	0.45±0.06	0.35±0.03
BOD_5 (mg/l)	4330±4.62	4140±6.24	3.8±0.05	3.1±0.04	2412±4.75	2253±4.21	2733±0.93	2618±5.65	2809±8.25	2732±6.75
Sulphate (mg/l)	23.4±0.04	22±0.15	1.78±0.03	1.85±0.08	56.8±0.28	54±0.44	125.2±0.23	124.2±0.49	21.2±0.56	19.8±0.02
Chloride (mg/l)	982±2.52	980±2.05	8.1±0.25	8.2±0.02	86±1.30	83±0.4	315.8±0.55	299.7±0.92	28.1±0.60	23.2±0.94
Temperature (°C)	31.6±0.53	31.8±0.50	24.9±0.50	27.1±0.25	30.4±0.71	30.7±0.75	27.7±35	29.9±0.35	26.8±0.65	27.3±0.50
COD (mg/l)	4392±4.85	4597±8.35	6.3±0.05	5.6±0.03	3400±9.24	3300±7.25	3105±5.25	2931±9.24	3450±6.25	3270±3.58
Chromium (mg/l)	0.01±0.00	<0.01	0.001±0.00	0.001±0.00	0	0	0.33±0.04	0.26±0.02	0	0
Cobalt (mg/l)	0	0	0	0	0	0	0	0	0	0
Cadmium (mg/l)	0	0	0	0	0	0	0.89±0.04	0.89±0.05	0	0
Copper (mg/l)	0.5±0.01	0.4±0.06	0	0	0	0	0.05±0.01	0.03±0.01	0.31±0.02	0.32±0.04
Lead (mg/l)	0.23±0.06	0.27±0.02	0	0	0	0	0.24±0.04	0.25±0.06	0.13±0.07	0.07±0.01
Zinc (mg/l)	1.4±0.02	1.1±0.07	0.001±0.00	0.01±0.00	0.04±0.00	0.03±0.01	0.027±0.02	0.029±0.02	0.23±0.03	0.23±0.48

RS= Rainy Season
DS= Dry Season

Table 6. Mean and standard deviation of physicochemical parameters for the three locations

Parameter	Blood	Service water	Faecal matter	Wastewater	Soil
pH	7.63±1.06[a]	6.65±0.82[a]	6.89±0.33[a]	6.92±0.19[a]	8.34±0.12[a]
Nitrate	2.03±1.75[b]	0.64±1.09[b]	31.18±2.89[a]	1.26±1.35[b]	26.50±0.60[a]
Ammonia	0.73±0.06[a]	0.21±0.22[b]	15.43±1.69[a]	0.45±0.11[a]	11.99±1.55[a]
Chromium	0.003±0.006[b]	0.0007±0.001[b]	0.00±0.00	0.00±0.00[b]	0.14±0.12[a]
Cobalt	0.00±0.00[b]	0.00±0.00[b]	0.00±0.00	0.00±0.00[b]	0.00±0.00[b]
Cadmium	0.29±0.50[b]	0.23±0.40[b]	0.00±0.00	0.21±0.37[b]	0.66±0.37[b]
Lead	0.35±0.38[b]	2.73±4.73[b]	0.00±0.00	0.13±0.12[b]	0.09±0.14[b]
Zinc	0.52±0.60[b]	0.001±0.001[b]	0.013±0.017[b]	0.19±0.06[a]	0.012±0.013[b]
BOD_5	3653.3±1004.85[a]	2.39±0.58[a]	2181.67±68.25[a]	2800.00±264.58[a]	2513.33±16.07[a]
Sulphate	43.41±28.55[b]	2.55±0.80[a]	60.67±6.66[a]	19.31±4.84[a]	110.00±15.00[a]
Chloride	335.4±558.39[b]	3.12±5.10[b]	95.00±8.89[a]	23.00±2.00[a]	295±15.00[a]
Copper	0.22±0.37[b]	0.004±0.01[b]	0.00±0.00	0.11±0.20[b]	0.016±0.02[b]
Temperature (°C)	29.83±0.76[a]	25.50±0.50[a]	30.97±1.38[a]	27.00±0.50[a]	29.78±0.66[a]
COD	4345.8±111.7[a]	4.91±0.13[a]	3280±180.7[a]	3597.1±38.9[a]	3868.3±104.08[a]

a= means with this superscript have no significant difference at α=0.05
b= means with this superscript differ significantly at α=0.05

breakdown of decomposable organic matter into simpler substances in a sample. Research has shown that the higher the quantity of decomposable organic matter, the higher the BOD_5. Abattoir wastes are known sources of materials that have high oxygen demand [24].The higher BOD_5 of the blood samples reported is in agreement with the study by Adesemoye *et al* and Rabah et al., who also posited that whole blood has a high biochemical oxygen demand (BOD_5) and this could serve as a rich source of protein for the proliferation of microorganisms if it is not sterile [25,26]. The high BOD_5 and COD observed in the faecal matter, soil and wastewater samples indicate a corresponding high microbial biomass which can stimulate pollution. Similar results have been reported by Chukwu et al. who analysed these samples from abattoirs in Minna, Niger State [17]. In a similar study carried out in Rumuokoro, Emenike and Ogbogoro abattoirs in Port Harcourt, high BOD_5 and COD of 2500 mg/l and 5240 mg/l, respectively were recorded in the abattoir effluents [15]. Treatment of these effluents and processing of the blood into blood meal (a huge protein source) also reduces the quantity of wastes generated and this may help reduce organic pollution [2].

Heavy metals including copper, chromium, lead and zinc present in the abattoir samples were also reported by Dauda et al. in wastewater from an abattoir in Minna, Nigeria [27]. The inhalation of smoke from vehicle exhausts and roasting of cow skin during processing of the meat in the abattoir and consumption of meat and its products may led to the presence of lead (Pb) in the cow blood as these cattles are moved from one place to another in search of green pastures. Also possible air droplet contamination during sample collection may have also contributed to their presence. Quantities found in water may be as a result of anthropogenic activities such as the disposal of lead-containing wastes as well as smoke from burnt fuels.

Student t-test analyses carried out showed that significant differences were observed in the nitrate, zinc and copper values of the analysed samples across the three locations. These variations may be as a result of the difference in sanitary conditions and water quality of the abattoirs. No significant differences were observed in the BOD_5 and COD of the analysed samples; this may be as result of these livestock having a common origin before they are sent to the different abattoirs. The slight differences observed in the physicochemical parameters monitored during the wet and dry season may be associated with the continuous rainfall observed even during the dry which has made it difficult to differentiate between wet and dry seasons.

5. CONCLUSION

Physicochemical analyses of abattoir samples contaminated with abattoir-generated wastes were carried out in this study to determine the strength of pollution by the waste substances. The blood, faecal matter, soil and wastewater samples collected from Iwofe, Rumuodomaya and Trans-Amadi abattoirs in Port Harcourt city were analysed. From this study, faecal matter, blood, soil and wastewater samples recorded high BOD_5 and COD when compared with the service water samples. Subsequently, deposition of these untreated wastes into the environment is capable of altering the natural condition of the soil and nearby streams leading to organic pollution. The heavy metal concentration of the samples were low, however, continuous generation of waste materials from abattoir activities and disposal of these wastes indiscriminately may increase the quantity of heavy metal concentrations overtime thereby exposing aquatic animals to high concentrations of these metals and possibly cause lethal effects. These results show the danger associated with the deposition of untreated abattoir wastes into the environment as a potential source of pollution and may eventually result in the ecological imbalance of the receiving water bodies. Therefore proper management and treatment of these wastes is important in reducing pollution of natural environments.

CONSENT AND ETHICAL APPROVAL

Approval for this research was obtained from the Department of Microbiology of the Rivers State University as well as a consent from the abattoir authorities.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. RMMA (Red Meat Abattoir Assoiction). Waste Management in Red Meat Abattoir, Pretoria, South Africa; 2010.
2. Tamenech B, Tamirat H. Review of abattoir waste management. Global Veterinaria. 2017;19(2):517-524.
3. Nwanta JA, Onunkwo JI, Ezenduka VE, Phil-Eze PO, Egege SC. Abattoir operations and waste management in Nigeria: A review of challenges and prospects. Sokoto Journal of Veterinary Sciences. 2008;7(2):61-67.
4. Chukwu O. Analysis of groundwater pollution from abattoir wastes in Minna, Nigeria. Research Journal of Dairy Services. 2008;2(4):74-77.
5. Fearon J, Mensah SB, Boateng V. Abattoir operations, waste generation and management in the Tamale metropolis: Case study of the Tamale slaughterhouse. Journal of Public Health and Epidemiology. 2014;6(1):14-19.
6. Tortora G, Funke BR, Case CL. Microbiology: An Introduction. 9thEdition. Benjamin/Cummings Publishing Company Inc, California; 2007.
7. Aderemi AO, Oriaku AV, Adewumi GA, Otitoloju AA. Assessment of groundwater contamination by leachate near a municipal solid waste landfill. African Journal of Environmental Science and Technology. 2011;5(11):933-940.
8. Christensen TH, Kjeldsen P, Bjerg PL, Jensen DL, Christensen, J.B. and Baun, A. Biogeochemistry of landfill leachate plumes. Applied Geochemistry. 2001;16: 659–718.
9. Abiade-Paul CU, Kene IC, Chah KF. Occurrence and antibiogram of Salmonellae in effluent from Nsukka Munincipal abattoir. Nigerian Veterinary Journal. 2006;1:48-53.
10. Adeyemo OK. Unhygienic operations of a city abattoir in South Western Nigeria, environmental implication. African Journal of Biomedical Research. 2002;5:51–55.
11. Nwachukwu MI, Akinde SB, Udujih OS, Nwachukwu OI. Effect of Abattoir wastes on the Population of proteolytic and lipolytic bacteria in a Recipient water Body (Otamiri River). Global Research Journal of Science. 2011;1:40–42.
12. Perry RH, Green DW, Maloney JO. Perry's chemical engineers' handbook. — 7th ed. McGraw-Hill, New York; 2007.
13. Mahdieh E, Amirhossein M. Water quality assessment of Bertam River and its tributaries in Cameron Highlands, Malaysia. World Applied Sciences Journal. 2006;7(6):769-766.
14. Aniebo AO, Wekh SN, Okoli IC. Abattoir blood waste generation in River state and its environmental implications in the Niger Delta. Toxicological and Environmental Chemistry. 2009;91:619-625.
15. Ire FS, Amos MO, Ossia-Ndidi LN. Microbiological and physiochemical assessment of abattoir effluents and receiving water bodies in Port Harcourt. Journal of Pharmaceutical, Clinical and Biological Sciences. 2017;5(1):34-39.
16. Edori OS, Iyama WA. Assessment of physicochemical parameters of soils from selected abattoirs in Port Harcourt, Rivers State, Nigeria. Journal of Environmental Analytical Chemistry. 2017;4(3):1-5.
17. Chukwu O, Adeoye P, Chidiebere I Abattoir wastes generation, management and the environment: A case of minna, North Central Nigeria. International Journal of Biosciences. 2011;1(6):100-109.
18. Chetana SA, Somasekhar RK. Ecological study on the riverine ecosystem of Karnataka and physicochemical characteristics of river Cauvery. J. Environ. Pollut. 1997;4(1):57–63.
19. Ekhaise FO, Omoigberale MO. Bacteriological and Physicochemical Qualities of Ebutte River in Ebutte Community, Uhunmwonde Local Government Area, Edo State, Nigeria J. Appl. Sci. Environ. Manage. 2011;15(4): 663-673.
20. Ibiebele DD, Powel CB, Shou PM, Isoun M, Murday M, Selema MD. Establishment of baseline data for complete monitoring of petroleum-related aquatic pollution in Nigeria. In:Proc. Int. Seminar on Petroleum Industry and the Nigeria. Environment, Port Harcourt. NNPC Publ. 1993;159-164.
21. Okonko IO, Adejoje OD, Ogunnusi TA, Fajobi E, Shittu OB. Microbiological and physicochemical analysis of different water samples used for domestic purposes in Abeokuta and Ojota, Lagos Nigeria. African J Biotechnol. 2008;7(5):6717-6721.
22. Yao W, Byme RH. Spectrophotometric determination of fresh water pH using Bromocresol purple and phenol red. Environ Sci Technol. 2001;35:1197-1201.

23. Ogbonna DN, Ideriah TJK. Effect of Abattoir Waste Water on Physico-chemical Characteristics of Soil and Sediment in Southern Nigeria Journal of Scientific Research & Reports. 2014;3(12):1612-1632.
24. Ezeoha SI, Ugwuishiwu BO. Status of abattoir wastes research in Nigeria. Nigerian Journal of Technology. 2011; 30(2):143-148.
25. Adesemoye AO, Opere BO, Makinde SCO. Microbial content of abattoir wastewater and its contaminated soil in Lagos, Nigeria, African Journal of Biotechnology. 2006; 5(20):1963-1968.
26. Rabah AB, Ijah UJJ, Manga SB, Ibrahim ML. Assessment of Physico-chemical and Microbiological qualities of Abattoir Wastewater in Sokoto, Nigeria. Nigerian Journal of Basic and Applied Sciences. 2008;16(2):149–154.
27. Dauda DR, Duro D, Ijah UJJ. Physicochemical and microbiological qualities of the abattoir wastewater in part of Minna, Niger State. Advances in Life Science and Technology. 2016;51:17-25.

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