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Abattoir Waste and Public Health Implications in Port Harcourt Metropolis

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ABSTRACT

This study assessed the impact of abattoir waste discharge on surface water quality in Port Harcourt Metropolis, Rivers State, Nigeria. The samples for the study were gotten from the point source into the aquatic environment. The physiochemical, microbiological characteristics and heavy metals concentration of surface water were analyzed and compared to the World health organization limits for discharge and use. The observed physicochemical and bacteriological parameters were Temperature(29 0^c), pH (7.4), Salinity (74), Total Suspended Solids (178), Total Dissolved Solids (151), Total Alkalinity (7.89), Chloride (36), Nitrate (3.3), Phosphate (0.3), Sulphate (4.9), Dissolved Oxygen (4.7), Chemical Oxygen demand (149), Biological Oxygen Demand (36), Calcium (0.49), Zinc (0.09), Copper (0.004), Iron (0.35), Chromium (0.003), Sodium (34.7), Manganese (0.030), Lead (0.0003), Cadmium (0.18), Potassium (8.45), Nickel (0.021), Silver (0.002) and Total Coliform bacteria(2.45/100ml) using the standard procedure in the Standard Methods for the Examination of Water and Wastewater Part 1000. It was observed that the Salinity, BOD, Iron, Cadmium and Total coliform exceeded the limits set by the world health organization. The spatial pollutant concentration varied from sample point to another. Despite that, continuous discharge of these wastes into the stream however, may in no distant time, pose a threat to human health. The study highlights significant health concerns such as the spread of waterborne diseases (e.g., cholera, typhoid) and zoonotic diseases (infections transferred from animals to humans). These risks are exacerbated by improper waste management practices, including unregulated discharge into public water systems. The paper thus concludes by recommending that a mechanism be put in place for the treatment of these abattoir wastes before they are then properly disposed.

Key words: Wastewater Treatment, Effluent, Slaughterhouse Waste, Public Health Implication and Soil Contamination.

Introduction

Water pollution has now become a global problem due to the ever-increasing population of the earth which constantly are in need of fresh water (Alfonso-Muniozguren et al., 2018; Gil-Pulido et al., 2018; Meng et al., 2018). This water pollution has birthed various regulations and discharge limits established for national and global standards. There has been an increasing study on the treatment of wastewater before discharge into the water bodies some of which were studied by (Akyol, Taner, Demirbas, & Kobya, 2013; Badejo, Omole, Ndambuki, & Kupolati, 2017; Emenike, Omole, Ngene, & Tenebe, 2017; Ogbiye, Omole, Ade-Balogun, Onakunle, & Elemile, 2018; Ogbiye, Onakunle, & Omole, 2018). The recycling of wastewater is an increasingly popular option in water management to reduce pressure on water supplies due to the exponential growth in population (Zahedi et al., 2018). Water can be used for numerous purposes and there are no limits to its usage; In Nigeria, the environmental regulator known as the National Environmental Standards and Regulations Enforcement Agency (NESREA) postulated some acts which form the guiding rules for water and wastewater use and discharge (FEPA, 1991).

The meat industry which consists of various forms of processing which include abattoir, abattoir is one of the largest consumers of water (Angelakis, Snyder, Angelakis, & Snyder, 2015; GerbensLeenes & Mekonnen, 2013) with over 2000 Gm3 of water required per year for the animal production (Mekonnen & Hoekstra, 2011). This high volume of water for the meat production yields considerably equal amount of wastewater to be discharged. The wastewater discharged vary in pollution content ranging from organic to inorganic pollutants. The need for regular surveillance, pre-treatment and treatment of water bodies is of utmost importance in this generation so as to maintain the sustainability of the environment (Khan, Gani, & Chakrapani, 2016; Nkansah, Donkoh, Akoto, & Ephraim, 2019; Tyagi et al., 2013). Abattoir sludge which originates from high strength wastewater (Eryuruk, Tezcan Un, & Bakır Ogutveren, 2018) needs to be properly disposed of. This abattoir waste contains several compositional elements such as potential pathogens, biodegradable organic compounds and odor producing elements (Alfonso-Muniozguren et al., 2018; Eryuruk, Tezcan Un, & Bakır Ogutveren, 2018; Ozdemir, Yetilmezsoy, Nuhoglu, Dede, & Turp, 2018).

The discharge of untreated wastewater into surface water bodies such as streams, rivers, lakes and oceans result in the pollution of such water environments. This pollution of surface water bodies, resulting from anthropogenic activities, is a growing concern worldwide (Zhai, 2014, Hillel, *et., al* 2015). The elevated levels of nutrients (nitrogen and phosphorus) in surface water due to pollution accelerate the growth of oxygen-depleting microbes, destroy the aquatic ecosystems and result in eutrophication (Zhang, *et., al.* 2015). Eutrophication causes many adverse effects on the water body including increased biomass of phytoplankton and macrophyte vegetation, increased blooms of gelatinous zooplankton (marine environment), growth of benthic and epiphytic algae, increased toxins from bloom-forming algal species, loss of commercial and sport fisheries, reduced carbon available to food webs, increased taste and odour problems, reduced species diversity, increased treatment costs prior to human use, and decreased aesthetic value of the water body (Smith, 2009, Badruzzaman, *et. al.,* 2012).

In Nigeria, many streams and rivers get polluted as a result of the discharge of untreated wastewater and other organic wastes directly into them (Jaji, *et al,* 2007; Obire, *et al.,* 2008; Osibanjo, *et. al.* 2011). Thus, river pollution is becoming a central issue in water management in Nigeria (Arimoro, 2009). One of the major sources of river pollution is livestock production activities (Kato, *et. al*, 2009) especially in terms of nutrient pollution (Burkholder, *et. al* 2007). Animal faeces and urine can be a source of pollution if not properly managed. If the animals are not housed, there may also be issues of erosion and sediment transport into surface waters due to their grazing activities. The runoff of animal wastes into surface water poses a great risk of pollution (Khaleel, *et. al* 2008). The waste from abattoirs, where the animals are slaughtered, pose another risk due to its high biochemical oxygen demand (BOD), nutrients and pathogens content (Matsumura, 2008; Keskes, *et al.* 2012).

The location of abattoirs in Nigeria tends to be near water bodies for easy access to guaranteed water for processing activities (Adeyemo, *et. al*. 2002; Akan, *et. al*. 2010). The wastewater generated from the various abattoir activities abattoir wastewater typically comprises water generated from cleaning operations, animal blood, dissolved solids, oil and grease, gut contents, and urine (Adeyemo, *et. al.* 2002; Del Nery, *et. al.* 2007). The contamination of surface water from abattoir wastewater constitutes significant environmental and health hazards (Omole, 2008) due the elevated levels of biodegradable organic matter, sufficient alkalinity, and adequate phosphorous, nitrogen and micronutrient concentrations (Del Nery, *et. al.* 2007).

The Choba community abattoir, like most in Obio Akpor LGA of Rivers State, discharges its waste directly into a nearby water course, the New Calabar River. This discharge of untreated abattoir waste, potentially has grave impact on the livelihood of those dependent on the water body. However, the abattoir is not the only identified source of potential pollution, as within the vicinity are operations likely to introduce contamination, such as industrial activity, and the indiscriminate disposal of human, domestic as well as market waste. While some organic waste can be diluted in the river to very low concentration and subsequently self-cleansed by natural biological processes in the river, high strength wastes like abattoir wastewater may take a longer time to degrade. Some waste may not biodegrade at all depending on the chemical oxygen demand (COD) to BOD ratio (Mutamim, et. al 2013).

Material and Method

Port Harcourt is the largest city of Rivers State and it is the capital city. Some have alleged that Port Harcourt started a long time ago as a fishing settlement (Mmon and Fred-Nwagwu, 2013) while some others claimed that it was part of the farmland of Diobu village. Port Harcourt is located in the humid tropics of the southern part of Nigeria (Ukpere, 2005). The city is located geographically within latitude $4^{\circ}45^{1}$ and $4^{\circ}55^{1}$ North and Longitude $6^{\circ}55^{1}$ and $7^{\circ}05^{1}$ East. The modern Port Harcourt is now very extensive, and it will be difficult for one to ascertain the actual dimension of the city. It consists of the former European quarters now called Old Government Residential Area (GRA) and New Layout areas (i.e Port Harcourt Local Government Area); the main city that now covers the entire Obio-Akpor and part of Eleme and Oyigbo Local Government Areas. The Greater Port Harcourt region, spans into eight Local Government Areas which included Port Harcourt, Okrika, Obio-Akpor, Ikwerre, Oyigbo, Ogu-Bolo, Etche and Eleme. The population of the study comprise of all the thirty (30) abattoirs in the study area: Choba, Alakahia, Rumuosi, Rumuokoro, Eliozu, Rumuodara, Trans-Woji/Mother cat, Okuru, Azabie, Emenike, Mile 3, Iwofe, Rukpoku SAR road, New Rumuolumeni slaughter, Sandfield, Eagle Island, Agip, Mgbuoshimini, Nembe waterside, Naval base, Taverna farms & butchery, Egbelu, Rumuokparali, Endorsement, Eliozu Timber, Pipeline, Yam zone, Rukpoku and Eneka slaughter house. All their latitudes and longitudes were taken using the Global Positioning System (GPS) to enhance easy production of the base map of the study area (Fig. 1).

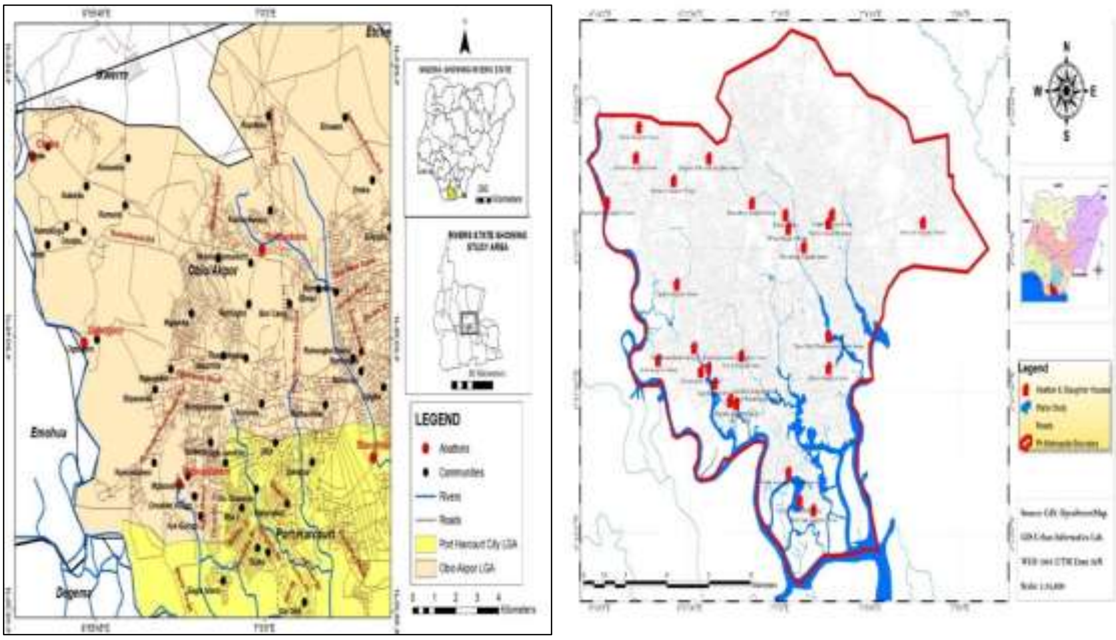

Fig. 1 and 2 Abattoir locations in Port Harcourt Metropolis.

Table 1 Names of abattoir and slaughter houses in Port Harcourt metropolis

s/n	Name of abattoir	Location	GPS	
			Latitude	Longitude
1.	Choba slaughter house	Choba waterside market	4.910773	6.926590
2.	Alakahia slaughter house	Alakahia	4.887802	6.923930
3.	Rumuosi slaughter house	Wazobia Max Rumuosi	4.879943	6.447090
4.	Rumuokoro slaughter house	Rumuokoro market	4.869830	6.999508
5.	Eliozu slaughter house	Ist market	4.859452	7.023642
6.	Rumuodara slughter house	Rumuodara market	4.852642	7.032825
7.	Trans-Woji/Mother cat slaughter house	Eze Gbaka-gbaka	4.815963	7.049248
8.	Okuru slaughter house	Emma Estate off Trans-Amadi by industrial layout	4.803204	7.048670
9.	Auabie slaughter house	Trans-Amadi industrial layout	4.865048	7.051056
10.	Emenike slaughter house	107 Emenike street/Iloabuchi, Mile 2 Diobu Ph	4.788375	6.989544
11.	Mile 3 slaughter house	Mile 3 market	4.807315	6.992902
12.	Iwofe slaughter house	Opposite IAUE main gate	4.806141	6.939941
13.	Rukpoku SAR road slaughter house	SARs Market	4.886862	6.971325
14.	New Rumuolumeni slaughter house	Aker Junction, Apabkolo Ameachi	4.810235	6.961488
15.	Sandfield slaughter house	Island road Diobu	4.788076	6.984940
16.	Eagle Island slaughter house	Eagel island	4.788105	6.984938
17.	Agip slaughter house	Agip waterside	4.795058	6.974780
18.	Mgbuoshimini slaughter house	Tech farm, Ahia-oglogo	4.801658	6.970897
20.	Nembe waterside slaughter house	Borokiri	4.758568	7.022716

21.	Naval base slaughter house	Nowa market, naval base Borokiri	4.743151	7.038698
22.	Taverna farms & butchery	148 Bonny Street, Borokiri	4.747161	7.030026
23.	Egbelu slaughter house	Egbelu market	4.835658	6.949791
24.	Rumuokparali slaughter house	Rumuokparali waterside market	4.868358	6.904681
25.	Endorsement slaughter	Nkpor	4.799530	6.965708
26.	Eliozu Timber	Eliozu fly over	4.863744	7.020213
27.	Pipeline slaughter house	Rumukwurushi tank by white house	4.860509	7.048213
28.	Yam zone slaughter house	Iriebe	4.860946	7.109156
29.	Rukpoku slaughter house	Rukpoku pipeline	4.889543	6.974535
30.	Eneka slaughter house	Eneke farm road	4.893263	7.024530

The sample size for the study was statistically determined. This may primarily affect the required accuracy of the estimate and the likelihood of their variability which will, of course, set against the limitation of time available for the conduct of the survey. However, in order to obtain adequate samples for the research study from which inference about the population could be drawn; accidental sampling method will be used. According to Singh and Masuku (2014), the basic principle guiding the selection of sample size is that the smaller the populations, the bigger the sampling ratios for an accurate sample. Singh and Masuku also opines that larger population permit smaller sampling ratios for equally good samples. Hence, it is this principle that 40% of the sample frame will be as the sample size for the study.

Table 2 Sample Size Determination

Total number of Abattoir	Sampling frame	Sample size
All abattoirs in the study area	30	16

Grab samples was collected along the effluent flow path from the abattoir. The description of sampling points and the corresponding activities that was carried out are indicated in Table 3. Water samples was collected into 1L clean plastic containers and glass bottles (for oil and grease), at points with reduced human interference on quality status. Sampling was carried out between the hours of 13.15 and 14.30pm, when pollution load is expected to be highest. However, only two samples were collected from each sampling area. The total linear distance along the stream trajectory divided by the sampling intervals gives the sampling frame for each location.

Table 3 Description of sapling points.

Sampling Point	Description	Surrounding Activities
Upstream (Station 1)	A point (about 100m) before the introduction of abattoir waste	Residential area, human waste disposal, fishing
Midstream (Station 2)	Point of effluent discharge	Slaughter house, market, lairage furnace / processing section
Downstream (Station 3)	A point (about 100m) after the effluent mixes with the receiving water body	Uncultivated land, domestic waste dumpsite. Defunct oil servicing company, market

All bottles were washed with distilled water prior to usage. At each sampling location, water sample was collected in a plastic container of one liter. Before taking the water sample, the bottles were rinsed three times with the sample water at the point of collection to prevent any likely contamination from the containers that was used for the samples. Two different bottles were used to collect two water samples from each location. One of the bottles was used for physico chemical analysis while the other for microbiological analysis. All samples were labeled with the following information; (i) sample location (ii) date of collection (iii) time of collection and (iv) analysis required. The water sampling was collected in both dry (January) and rainy (July) seasons of 2024. This double sampling is to reflect seasonal changes in water quality. Water samples was collected at various points, with varying proximity to the point of discharge. Unstable parameters such as pH and temperature measurements were recorded in situ, using a 3015-pH meter by Jenwes and a portable mercury in glass centigrade thermometer respectively. The analytical methods for the determination of the parameters was from the American Public Health Association (APHA) series of standard methods of examination of water and effluent, 20th edition (1998). The amount of salts dissolved in water was measured by silver nitrate titration. Chloride, BOD_5, COD content in effluent was determined by titrimetric method of analysis, using various reagents. The dissolved solids and total suspended solids in effluent sample was determined using the gravimetric method. The amount of oxygen found in wastewater sample (DO) was determined using the Winkler's titration method, and nitrate concentration in sample determined using the Brucine method, as described by Allen, 1974. Phosphate concentration in effluent sample was determined in accordance with the colorimetric method, APHA 424E with samples analysed at a wave length of 480nm. The turbidimetric method (based on APHA 3111 D) was used for the determination of sulphate in surface water. Oil and grease (TPH) were determined in effluent using the spectrophotometry method, and heavy metal concentration of surface water samples was determined using the atomic absorption spectrophotometer method. Samples for heavy metal testing was acidified with nitric acid to avoid precipitation, while bottled samples (for oil and grease analysis) was preserved by acidifying with H_2SO_4.

The parameters includes: temperature (T), turbidity (NTU), pH, total alkalinity (TA), total hardness (TH), electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), calcium (Ca), magnesium (Mg), sulphate (SO4), nitrate (NO3), and chloride (Cl). The heavy metal analysis was carried out using hydrochloric acid digestion. Metal ion concentrations was determined using an atomic absorption spectrometer (model Philips PU 9100) with a hollow cathode lamp and a fuel-rich flame (air acetylene). These parameters analyzed included zinc (Zn), nickel (Ni), copper (Cu), chromium (Cr) and lead (Pb). The microbiological analysis of the water samples was performed by the determination of total coliform, according to the modified methods.

Results and Discussions

Physico-chemical, microbiological characteristics and heavy metals concentration of surface water in the study area

The results reveal a significant effect of abattoir processes (discharge of untreated effluent / solid waste, surface runoffs), on the various determined water quality parameters. The oxygen availability as well as metal concentrations varied with proximity to effluent point source, and observed trends in relationships between analyzed physical/chemical properties were also evident. The table 4 - 5 presents the result on the physical, chemical and heavy metal analysis of parameters used in determining the impact of abattoir waste on surface water quality.

Table 4 Physical properties of effluent discharged in the area samples

Parameter	Sampling points					Mean	Range
	Choba	Rumu-okoro	Egbule/ Ogbogoro	Slaughter	Mgbu-osumini		
Temp. ^{0}C	29	28	28	29	28	28.4	28-29
pH	7.2	7.4	7.8	7.9	7.3	7.52	7.2-7.9
Salinity	50	67	101	61	89	73.6	50-101
Total Suspended Solids mg/l	138	140	320	180	152	186	138-320
Total Dissolved Solids mg/l	110	120	240	160	121	150.2	110-160

Effect of Abattoir Effluents on the Physical Properties of the River

The pH of the abattoir wastewater samples was basic with its values ranging from 7.2-7.9. The Total Suspended Solids (TSS) of the samples ranges from 138-320mg/l and its mean value is 186mg/l while the total dissolve solids range from 110-160mg/l and its mean value is 150.2mg.

Table 5 Chemical properties of effluent discharged in the area samples

Parameter	Sampling points					Mean	Range
	Choba	Rumu-okoro	Egbule/ Ogbogoro	Slaughter	Mgbu-osumini		
Total acidity mg/l	27	31	20	24	12	22.8	12-31
Total alkalinity mg/l	80	73	82	78	95	81.6	73-95
Chloride mg/l	28	33	25	48	42	35.2	25-48
Nitrate mg/l	2.6	2.6	3.8	1.8	2.1	2.6	1.8-2.6
Phosphate mg/l	0.4	0.2	0.2	0.3	0.1	0.2	0.1-0.4
Sulphate mg/l	6.1	3.4	5.8	3.0	2.5	4.2	2.5-6.1
Dissolved Oxygen	4.8	4.3	4.7	4.0	4.1	4.4	4.0-4.8
Chemical Oxygen	76	74	316	227	64	151.4	52-316

Demand mg/l							
Biological Oxygen Demand mg/l	48	42	35	25	31	36.2	25-48

Effect of Abattoir Effluents on the Chemical Properties of the River

Phosphate in the sample ranged from 0.1-0.4mg/l with a mean value of 0.2mg while Nitrate in the wastewater samples ranged from 1.8-2.6mg/l with a mean value of 2.6mg/l. This result was in line with (Akan et al., 2010) findings on the chemical properties of abattoir wastewater samples in Maiduguri, Nigeria. Nitrate in water bodies could cause Blue Baby syndrome, increased phosphate can also cause excessive aquatic plant growth and algal bloom. The presence of water hyacinth was observed in large quantities on the Egbelu/Ogbogoro River.

The dissolved oxygen ranged from 4.0-4.8mg/l and its mean was 4.4mg/l. For Biochemical oxygen demand (BOD), it ranges from 25-48mg/l and the mean was 36.2mg/l. Biochemical Oxygen Demand values at the discharge point could be attributed to the low Dissolved Oxygen level, since low Dissolved Oxygen will result in high Biochemical Oxygen Demand and this is a strong indication of pollution (Tekenah et al., 2014). The chemical oxygen demand of the wastewater samples ranges from 52-76mg/l and its mean value is 67.6mg/l.

Relationship between Total Dissolved Solids and Dissolved Oxygen

An inverse linear correlation was observed between Total Dissolved Solids and Dissolved Oxygen in that as the Total Dissolved solids increase, the dissolved oxygen falls with a correlation of r = - 0.92. This was in line with (Adie and Osibanjo, 2007) findings.

Relationship between Total Dissolved Solids and Chemical Oxygen Demand

Total Dissolved Solids (TDS) and Chemical oxygen demand (COD) is seen to have a linear correlation in that as Total Dissolved Solids increases, Chemical Oxygen Demand likewise increases at a correlation of r = 0.99.

Relationship between Total Dissolved Solids and Biochemical oxygen Demand

The relationship between the Total Dissolved Solids and Biochemical Oxygen Demand is a linear correlation indicating that as Total Dissolved Solids (TDS) increases, Biochemical Oxygen Demand (BOD) also increases. The correlation is at r = 0.99, which is close to what is seen in previous study of (Ojekunle and Lateef, 2017).

Heavy metal concentrations in the study area River due to abattoir effluent discharge

Heavy and trace metals are of importance in water, living organisms require varying amounts of some of these metals (Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni and Zn) as nutrients (macro or micro) for proper growth. Other metals (Ag, Al, Cd, Au, Pb and Hg) have no biological role and hence are non-essential (Akpor and Muchie, 2011). Their presence in wastewater is due to discharges from residential dwellings, groundwater infiltration, and industrial discharges. From (Table 6), Sodium was the metal with the highest concentration in the wastewater samples, ranging from 22.8-37.5mg/l and a mean value of 31.4mg/l. The metal with the least concentration was lead which had a mean value of 0.0004mg/l and ranged from -0.0004-0.0016mg/l. The accumulation of these metals in wastewater depends on many local factors, such as way of life and awareness of the impact on the environment through the careless disposal of wastes (Bhattacharya and Bolaji, 2010).

Table 6 Concentration of Heavy metals in Abattoir wastewater samples

Parameter	**Sampling points**					**Mean**	**Range**
	Choba	Rumu-okoro	Egbule/ Ogbogoro	Slaughter	Mgbu-osumini		
Calcium mg/l	0.47	0.52	0.37	0.42	0.39	0.43	0.37-0.47
Zinc mg/l	0.08	0.09	0.06	0.10	0.09	0.08	0.06-0.10
Copper	0.002	0.003	0.006	0.001	0.004	0.003	0.001-0.006
Iron mg/l	0.33	0.31	0.34	0.35	0.29	0.32	0.29-0.35
Chromium mg/l	0.008	0.001	0.003	-0.002	-0.005	0.001	-0.002-0.008
Sodium mg/l	37.5	35.2	22.8	26.7	34.8	31.4	22.8-37.5
Manganese mg/l	0.029	0.026	0.030	0.021	0.030	0.027	0.021-0.030
Lead mg/l	0.0006	0.0	0.0	0.0016	0.0	-0.0004	-0.0004-0.0016
Cadmium mg/l	0.183	0.162	0.170	0.142	0.018	0.135	0.018-0.183
Potassium mg/l	9.058	8.123	8.862	8.355	3.059	7.491	3.059-9.058

Nickel mg/l	0.223	0.113	0.221	0.190	0.032	0.156	0.032-0.223
Silver mg/l	0.0	0.0	0.0	0.0	0.0	0.00	0.00

Effluent effects on surface water oxygen (O_2) availability

Surface water oxygen availability from all analysed sites were observed to follow a trend throughout the experiment. The biological and chemical oxygen demand as well as level of dissolved oxygen recorded, were generally high. (Fig. 4). The chemical oxygen demand was generally observed to be highest and the dissolved oxygen lowest, showing no significant difference between sampled sites.

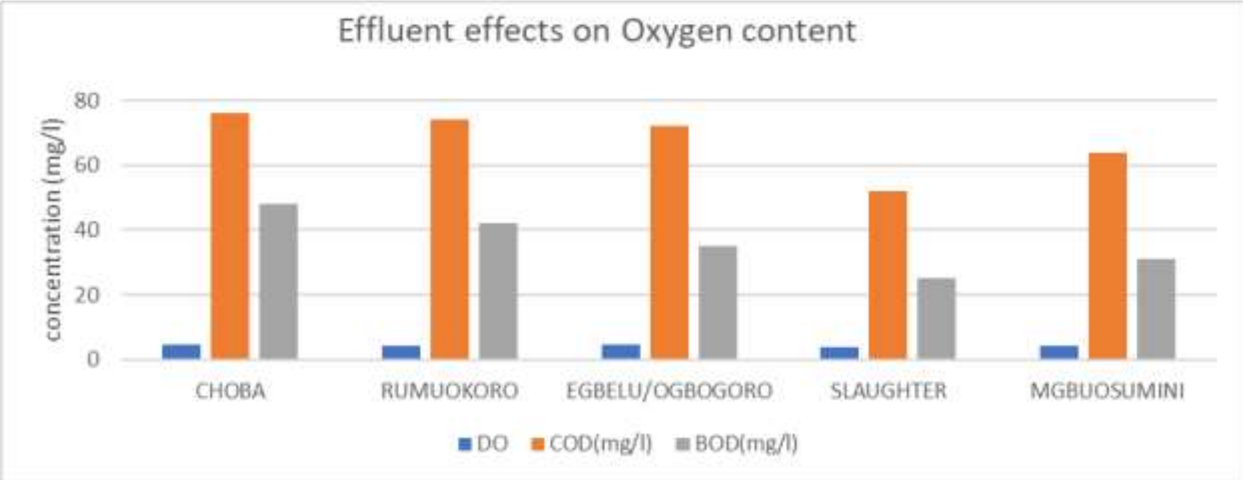

Figure 4 Effluent effects on Oxygen content

Effect of Effluent waste on river heavy metal concentration (Ca, Zn, Cu, Fe, Mg, and Ni)

Heavy metal concentration as observed from the various analysed sites varied throughout the experiment. Concentrations observed, were generally lower at Mgbuosumini, except calcium, sodium and potassium concentrations which were recorded to be highest, fig. 5. These variations maybe owing to the age of the abattoir as is just a less than a year old. Similarly, the salt content, total as well as suspended solids, and chloride concentrations recorded varied decreasingly across the sample areas. However, Sodium and Potassium concentration was very high and was excluded.

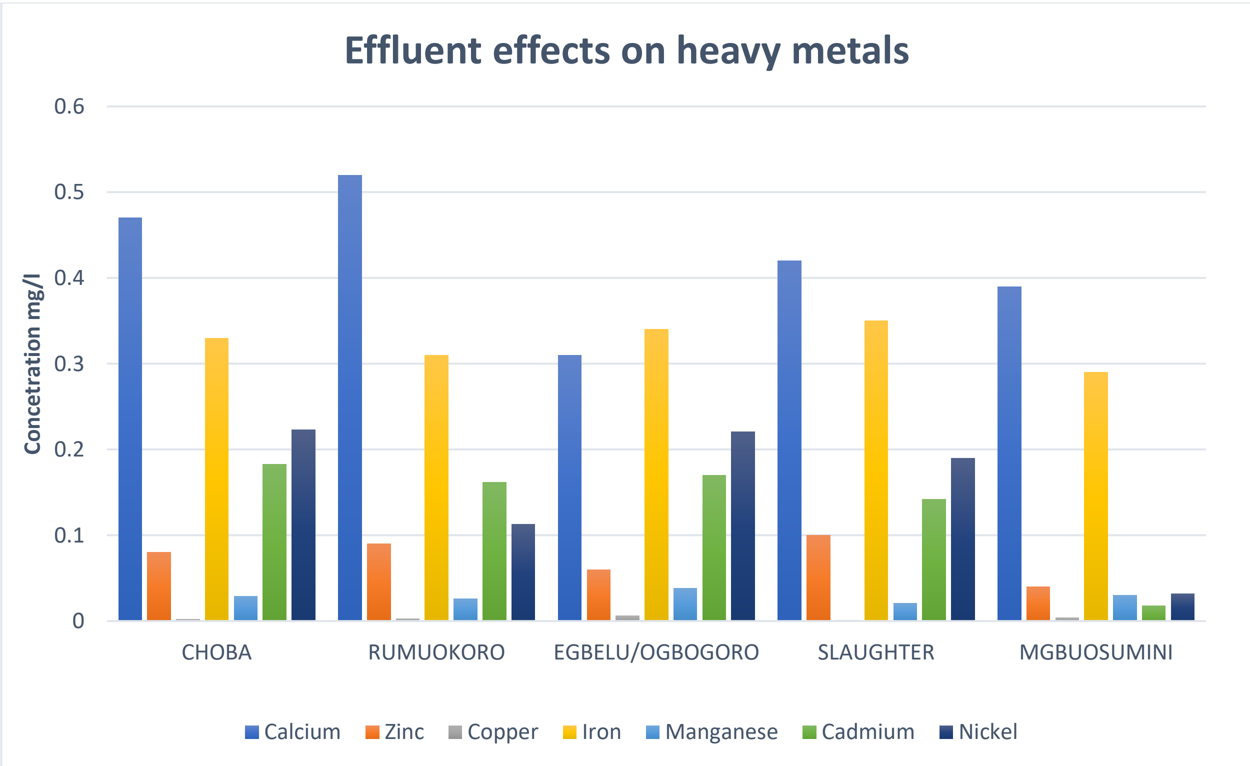

Figure 5 Effluent effects on heavy metals

Microbiological analysis of the effluent

Bacteria are the most common microbial pollutants in wastewater. They cause a wide range of infections, such as diarrhoea, dysentery, skin and tissue infections, etc. The tests for total coliform and faecal coliform nonpathogenic bacteria were used to indicate the presence of pathogenic bacteria. Table 6 showed that the Total Plate count ranged from 120 to a too numerous to count (TNTC) range. This implies that the presence of microorganisms in the samples were too loaded hence making it difficult to count them. The presence of coliform in the water sample was also recorded and it could be attributed to abuse of the water by dumping of animal waste into it. Escherichia coli have been implicated in diseases such as diarrhoea, urinary tract infections, respiratory illness, pneumonia etc.

Table 6 Microbiological analysis of Abattoir waster sample

S/N	SAMPLING POINTS	THBC	E.*coli*	TOTAL COLIFORM
1	CHOBA	3.6 x 10^6 cfu/ml	17/100ml	140/100ml
2	RUMUOKORO	5.7 x 10^5 cfu/ml	21/100ml	140/100ml
3	EGBELU/OGBOGORO	3.2 x 10^6 cfu/ml	16/100ml	2.20/100ml
4	SLAUGHTER	3.7 x 10^7 cfu/ml	17/100ml	920/100ml
5	MGBUOSUMINI	2.0 x 10^6 cfu/ml	23/100ml	350/100ml
	TOTAL	APHA 9215 C	ASTM D5392-93	APHA 9222B

Descriptive Analysis of various Results from Different Sample Points

Descriptive analysis of various results from different sample points conducted are presented in Table 7.

Table 7 Descriptive analysis of the Laboratory Results.

Parameters (mg/l)	Range	Mean	Std. deviation	Coefficient of variation	Statistical Significance
Temperature ^{0}C	28-29	28.4	0.13	0.45	Insignificant
Ph	7.2-7.9	7.52	0.50	8.70	Insignificant
Salinity	50-101	73.6	14.4	50	Significant
TSS mg/l	138-320	186	76.26	49.60	Significant
TDS mg/l	110-160	150.2	89.42	56.23	Significant
Total acidity mg/l	12-31	22.8	0.11	0.35	Insignificant
Total alkalinity mg/l	73-95	81.6	17.4	82.23	Significant
Chloride mg/l	25-48	35.2	8.02	51.04	Significant
Nitrate mg/l	1.8-2.6	2.6	0.35	21.07	Insignificant
Phosphate mg/l	0.1-0.4	0.2	0.14	32.09	Insignificant
Sulphate mg/l	2.5-6.1	4.2	0.65	13.36	Insignificant
Dissolved Oxygen	4.0-4.8	4.4	0.70	13.59	Insignificant
COD	52-316	213.50	124.93	58.52	Significant
BOD	25-48	36.2	4.02	64.64	Significant
Calcium mg/l	0.37-0.47	0.43	0.17	45.92	Insignificant
Zinc mg/l	0.06-0.10	0.08	0.03	50	Significant
Copper	0.001-0.006	0.003	0.09	36	Insignificant
Iron mg/l	0.29-0.35	0.32	0.19	39.58	Insignificant
Chromium mg/l	-0.002-0.008	0.001	0.09	28.23	Insignificant
Sodium mg/l	22.8-37.5	31.4	3.7	62.09	Significant

Manganese mg/l	0.021-0.030	0.027	0.14	32.37	Insignificant
Lead mg/l	-0.0004-0.0016	-0.0004	0.07	9.03	Insignificant
Cadmium mg/l	0.018-0.183	0.135	0.04	6.36	Insignificant
Potassium mg/l	3.059-9.058	7.491	0.46	8.04	Insignificant
Nickel mg/l	0.032-0.223	0.156	0.17	45.06	Insignificant
Silver mg/l	0.00	0.00	0.00	0.00	

Comparison of water pollutants across the study area

The result of the mean values of the water samples was compared with the FEPA recommended limits, with a view of finding the deviation from the acceptable standards. This was to determine whether the abattoir effluent has already affected the water quality of the stream, to an extent that it may be injurious to human health.

Table 8: Comparison of the analysed samples with the FEPA acceptable limits

PARAMETERS (mg/l)	**Mean values**	**FEPA Limit**	**Deviation**	**Remark**
Temperature ^{0}C	28.4	<40	11.6	WL
pH	7.52	6-9	-1.52 – 1.48	BL
Salinity	73.6	0.1	73.5	AL
TSS	186	1500	-1314	BL
TDS	150.2	1500	-1349.8	BL
Chloride	35.2	250	-214.8	BL
Nitrate	2.6	50	-47.4	BL
Phosphate	0.2	3	-2.8	BL
Sulphate	4.2	100	-95.8	BL
Dissolved Oxygen	4.4	7.5	-3.1	BL
COD	67.6	80	-12.4	BL
BOD	36.2	30	6.2	AL
Calcium	0.43	20	-19.57	BL
Zinc Zn^{2+}	0.08	5	-4.92	BL
Copper CU^{2+}	0.003	1.0	-0.997	BL
Iron Fe^{2+}	0.32	0.3	0.02	AL
Chromium	0.001	0.1	-0.09	BL
Sodium	31.4	NR	NR	NR
Manganese	0.027	150	-149.9	BL
Lead Pb^{2+}	-0.0004	0.01	$9.6x10^{-03}$	BL
Cadmium Cd^{2+}	0.135	0.003	0.132	AL
Potassium	7.491	200	-192.5	BL
Nickel	0.156	3.0	-2.84	BL
Silver	0.00	≥0.10		

WL= Within limit; BL =Below limit; AL = Above limit

Temperature is within the FEPA range, while pH, TSS, TDS, Cl, NO_3, PO_4^{3-}, SO_4^{2-}, DO, COD, Ca^{2+}, Zn^{2+}, Cu^{2+}, Cr^{3+}, Mn, Pb^{2+}, K and Ni, are below the FEPA recommended limit. On the other hand however, salinity, BOD, and Cd are above the FEPA acceptable limit. Apart from people defecating along the river bank, the abattoir's borehole is not functioning, so the animal slaughtered are taken to the river for washing, thus adding to the quantity of wastes. The following can be further deduced from the results in table 4.5.

The temperature of the samples ranged between 28 – 29ºC. This is in compliance with the FEPA effluent permissible limit of 40oC. The pH values of the samples ranged from 7.2 – 7.9, which places the values below the FEPA acceptable limit, and within those of Adeyemo, et al. (2002), and Osibanjo and Adie (2007), which were 7.0 -8.3, and 6.92-8.18, respectively. This implies that the pollution level of this study is relative when compared with their own study area.

Salinity of the samples range between 50 – 101mg/l. This clearly shows that it is highest at the meeting point of the abattoir effluent and the stream. These figures are higher than FEPA limit for portable water and higher than FAO recommended limit for agricultural purposes such as irrigation. (Chukwu, 2005).

The total dissolved solids (TDS) of the samples were quite low, compared to recommended limits (FEPA 1991), which is 1500 mg/l. The figures of the different sample points however show that effluent have dilution effect on TDS as there is progressive decrease from the upstream section through the point the effluents enters the stream to the 2 other points down stream. Dissolved oxygen in the samples range between 4.0 – 4.8mg/l, which is very much higher than the result of Chukwu, et al (2008); and still within FEPA limit of 7.5 mg/l. Most Game fish required at least 4-5mg/l level of DO to thrive.

The COD values ranged between 52-316mg/l. This could probably be due to the rate of dilution of the pollutants that led to the increase at point 3, and decrease at point 4. The recommended FEPA standard is 80 mg/l. It was discovered however that at the point of entry of the abattoir effluent into the stream, COD was 54mg/l, but much higher at the other sample points. High level of COD indicates the presence of chemical oxidants in the effluent while low COD indicates otherwise. High COD could likely cause nutrient fixation in the soil resulting to reduce rate of nutrients fixation in the soil resulting to reduced rate of nutrient availability to plants. Chemical oxidants affect water treatment plants by causing rapid development of rust (Chukwu et al., 2008).

Iron concentration in the collected samples range between 0.24-0.35mg/l and it is above the recommended level of 0.3mg/l by FEPA, if water is to be used for drinking purposes. This implies that if the abattoir discharges its wastewater into other water bodies used for drinking purposes downstream, it could be a contaminant and hence, hazardous to human health. In order to verify whether or not there was significant difference in the concentration of heavy metals at the different sample points, the results relating to heavy metals was subjected to the Analysis of Variance (ANOVA), and the calculated value when compared to the table value, indicate that there are actually significant differences. This further implies that there is significant difference in the concentration of some of the pollutants taken at different sampling points. Secondly, in order to verify whether the heavy metals concentration in the sampled water significantly varies with the FEPA approved limits, the data in Table 4.5 was subjected to the student t-test, and the result indicated that there was indeed significant variation.

Comparison of the concentration of water pollutant across the study area

The comparison of the concentrations of water pollutant is shown in Table 9 whereby it is revealed that Rumuokoro and Mgbosimini experienced higher concentrations of Zn and the least was experienced in Slaughter. The situation with Cu concentration revealed the highest concentration in Ogbogoro and the smallest was in Slaughter. Furthermore, it is shown that Fe was the highest with respect to concentration among the selected heavy metals ranging from 0.29 in Mgbuosimini mg/l to 0.35 mg/l in Slaughter. It is further shown that a minimum of 0.31 mg/l of Fe was obtained in each of Rumuokoro, Choba and Ogbogoro. Considering Cr, it is revealed from the analysis that the highest being in Choba was 0.008 mg/l and the least was found in Rumuokoro. It is thus shown that Mn was higher in Choba and Rumuokoro while the least Mn was discovered in Ogbogoro and Mgbuosimini. Furthermore, the analysis showed that Pb was very low in the study location; however, higher concentrations were found Slaughter and Choba. Cd concentrations ranged from 0.018 mg/l in Mgbuosimini to 0.183 mg/l in Rumuokoro. In a similar development, Ni concentrations ranged from 0.032 mg/l in Mgbuosimini to 0.223 mg/l in Choba.

The Kruskal Wallis analysis showed that significant variation existed in the concentrations of Cu (p=0.009); Fe (p=0.017); Cr (p=0.016); Pb (p=0.011); Cd (p=0.012) and Ni (p=0.010) among the study locations at p<0.05. The analysis thus otherwise showed that there was no significant variation in the concentration of Zn (p=0.065) and Mn (p=0.339) among the study locations. Thus, majority of the water pollutants showed significant variation with respect to their concentration in different study locations and this may be attributed to the level of human activities taking place at the upper course of the river and together with the abattoir activities taking place at the study locations.

Table 9: Heavy Metal Pollutants in the Selected Surface Water

Parameters	Zn mg/l	Cu mg/l	Fe mg/l	Cr mg/l	Mn mg/l	Pb mg/l	Cd mg/l	Ni mg/l	Ag mg/l
Rumuokoro	0.09	0.003	0.31	0.001	0.026	0	0.162	0.113	0
Choba	0.08	0.002	0.33	0.008	0.029	0.0006	0.183	0.223	0
Ogbogoro	0.06	0.006	0.34	0.003	0.03	0	0.17	0.221	0
Mugbuosimini	0.09	0.004	0.29	0.005	0.03	0	0.018	0.032	0
Slaughter	0.1	0.001	0.35	0.002	0.021	0.0016	0.142	0.19	0

Discussion of Findings

Effluent from the abattoir varied from animal blood, urine, wash water as well as the content of the intestines of the slaughtered animals. Study has shown that blood from animal blood contains high oxygen demand (Ezeoha, 2000). The wastewater from abattoirs contains high organic material, blood, animal waste, and other contaminants that can severely degrade water quality when not properly treated. Therefore, the release of such into the surface water will reduce the dissolved oxygen in the aquatic environment. Disposing of untreated wastewater into local rivers and drains can lead to water pollution, affecting ecosystems and potentially harming aquatic life. It also increases the risk of soil contamination, especially in densely populated areas like Port Harcourt. The presence of paunch from ruminant animals contains the highest pollution load and breed more decomposers, more of which are pathogenic (Olarewaju and Olufayo, 2004). Presence of pathogens poses health challenge to humans during recreation activities. Eutrophication in stream channels reduces the size of receiving stream channels thereby causing flooding. Offensive odors generated within the abattoir environment and breed site for mosquitoes owing to remains of solid wastes, feces, carcass among others constitute environmental health problems. Physico-chemical test show that oxygen concentration as well as metal concentrations varied with proximity to the effluent points sources. The pH of the samples were basic ranging from 7.2-7.9, total suspended solid of the samples ranges from 138-320mg/l while total dissolved solids ranges from 110-160mg/l. The study highlights significant health concerns such as the spread of waterborne diseases (e.g., cholera, typhoid) and zoonotic diseases (infections transferred from animals to humans). These risks are exacerbated by improper waste management practices, including unregulated discharge into public water systems.

Summary

The major source of surface and groundwater pollution is indiscriminate discharge of untreated abattoir effluents directly into the surface water bodies resulting in serious surface contamination. This loss of water quality is causing health hazards and death of human beings. This problem is aggravated by inadequate awareness, scarce financial resources, lack wastewater treatment facilities, and the inefficient ineffective environmental laws. One issue discussed is the lack of adequate enforcement of environmental regulations governing wastewater disposal in the region. Many abattoirs operate without proper waste treatment facilities, which worsens the public health risks. The concentration of the heavy metal's verification like Cd, Pb, Cu reported above indicate that there is significant difference in the concentration of the pollutants taken at different sample points.

Furthermore, the concentration of heavy metals in the sample water was discovered to be significantly higher than the permissible limits of WHO standard, 2006. Although some of the results like EC and TDS are slightly in line with permissible limits of WHO standard, 2006. However, our environment is under threat if the present habit of discharging untreated abattoir wastes continues. The toxic level of harmful materials can aggravate due to the continuous generation of the effluents. This calls for concern, as most of the analysed values were above the recommended standards, which obviously signals danger to human health and that of plants life. Residents living in abattoir vicinity may in no distant time begin to experience severe consequences of pollutants from abattoir activities located in their neighbourhood.

Conclusion

The heavy metals verification as reported above indicates that indicate that there is significant difference in the concentration of the pollutants taken at different sample points. Furthermore, the concentration of heavy metals in the sampled stream water was discovered to be significantly different from the National and International standards. This calls for concern, as most of the analysed values were above the recommended standards, which obviously signals danger to human health, and also, plants. Though the water quality was generally still above recommended standards, it is however under threat if the present habit of discharging untreated abattoir wastes continues. Residents living in abattoir vicinity may in no distant time begin to experience severe consequences of pollutants from abattoir activities located in their neighbourhood.

Recommendation

In view of the findings of this work, and in addition to the fact that the abattoir is located in the heart of the town, and also, in view of the fact that the discharge of untreated abattoir wastes may continue unabated, the following recommendations are hereby made:

Efforts should be made to commence activities towards the relocation of the abattoir to an area away from residential areas.

Immediate steps should be taken to put in place machinery that will enable treatment of the abattoir wastes before they are disposed.

Aggressive public awareness and enlightenment on possible impacts of pollution from abattoir wastes should be embarked upon by relevant agencies.

Liquid wastes generated from the abattoir should be converted to biogas for cooking while solid wastes as organic manure for farming in which case, government or private individuals can establish biogas plants (based on the number of animals slaughtered daily and volume of wastes generated).

There should be regular monitoring activities of the two streams to ensure its safety for domestic, industrial and agricultural uses.

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