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Impact of abattoir waste effluent on water bodies: A Case Study of Ugwuoba Abattoir Activites on Ezu River, Enugu state, Nigeria

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Abstract
The discharge of high-strength wastewater into water bodies results in deterioration of water quality of the receiving water. This study investigated the impact of abattoir waste effluents of Ugwuoba abattoir on Ezu River, Ugwuoba Enugu State, Nigeria. The study examined the physicochemical and bacteriological parameters of the water samples and its health impacts on Gariki residents and environs, and also compared the values with the WHO and FEPA standards. Six sampling points (designated as Points 1, 2, 3, 4, 5 and 6) each located 30-40m apart, from the abattoir facility to the course of the river were selected for the study. Physicochemical and bacteriological analyses were done using standard methods for the examination of water and wastewater and multiple tube fermentation methods respectively. The physicochemical results obtained showed that pH (6.66–7.78), salinity (29.80–40.84 PSU), electrical conductivity (148.10–274.76 uS/cm), total dissolved solids (23.90–112.40 mg/L), chloride (2.02–10.01 mg/L), sodium (7.60–9.88 mg/L), calcium (4.99–6.08 mg/L), nitrate (0.00–4.36 mg/L) except at P1 (22.7 mg/L), chemical oxygen demand (48.0–234.7 mg/L) except at P1 (234.70 mg/L) and all heavy metals were within the WHO and FEPA standards, whereas the colour (411–980 PCU), turbidity (20.53–87.33 NTU) and biological oxygen demand (117.8–280 mg/L) were above the standards. Bacteriological analysis results showed that the total coliform count ($2.6x10^3$ – $8.2x10^4$ MPN/100mL), faecal coliform count ($2.3x10^2$ – $4.6x10^4$ MPN/100mL) and total bacterial count ($2.8x10^3$ – $5.2x10^5$ CFU/mL) were above the WHO and FEPA standards. Seven bacterial isolates were identified: *Escherichia coli*, *Vibrio cholerae*, *Salmonella* spp., *Shigella* spp., *Klebsiella* spp., *Pseudomonas* spp. and *Staphylococcus aureus*. Using IRSA, 80% of the residents frowned at the foul odours from the abattoir facility and 65% complained about frequent water-related diseases suffered by them, especially diarrhoea and dysentery. The water is, therefore, deemed not potable and poses hazards to public health if consumed without treatment. Blood collection should be adopted in order to reduce the effluent concentration and abattoir staff should be properly trained on safe environmental practices.

Keywords: Ugwuoba abattoir effluents, Ezu river, water quality, physicochemical and bacteriological parameters

Introduction

Pollution of water bodies is one of the global public health challenges of the 20th and 21st centuries, and has become a threat to sustainable development of water resources management. In Nigeria, surface water pollution is associated with agricultural and irrigation water runoff, industrial effluent, cold-room effluent, domestic wastes and abattoir effluent (Adewolo *et al*., 2012; Omole *et al*., 2018) [23]. Abattoir waste effluent discharges are major components of water pollution in Nigeria and other developing countries. The abattoir industry is an important component of the livestock industry in Nigeria, providing domestic meat supply to over 200 million people and also employment opportunities for millions of people (Ogbomida *et al*., 2016) [20]. However, majority of the activities going on in most abattoir sites in Nigeria are not properly monitored and facilities for the treatment of abattoir effluents before discharge into nearby water bodies are lacking. Abattoir activities are generally known to pollute the receiving environment such as water and land from their various processes either directly or indirectly (Bala *et al*., 2016) [5]. The main abattoir activities include butchering, removal of the hide, intestine management, rendering, trimming, processing and cleaning activities (Ezeoha and Ungwuishiwu, 2011) [12].

The physical and chemical indices of water are indicators of how suitable, safe and potable the water body would be for human and animal consumption, and plants usage (Elemile *et al*., 2019) [11]. Most rural dwellers believe that potable water is based on its physical observations and once it is adjudged so, it has little or no effect on their health. Pollution of water can increase or decrease the levels of physicochemical parameters such as the pH, electrical conductivity, total dissolved solids, total suspended solids, turbidity, biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates, sodium, calcium, etc, which can have detrimental effects on the end users of the water (Adesina *et al*., 2018) [3]. Abattoir effluents are one of the major contributors to surface water pollution in Nigeria, and physicochemical properties in water body are adversely affected.

Heavy metals are also known to affect the colour and taste of a water body when in high concentrations, and have detrimental effects if consumed without proper treatment. The harmful effect of heavy metals in human and animals depends on their dosage, rate of emission and period of exposure. Some of the heavy metals that have received more attention in water for the last two decades are mercury (Hg), lead (Pb), cadmium (Cd), arsenic (Ar), nickel (Ni) and copper (Cu) (Ogunlade *et al*., 2021) [21].

Polluted water is home to millions of pathogenic microorganisms which are responsible for various water-related diseases such as typhoid fever, cholera, diaarhoea, dysentery, giardiasis, etc (WHO, 2007). Although chemical composition of water may affect the safety, taste and appearance, bacterial contamination cannot be detected by appearance, taste or smell. This can only be detected by testing the water sample for the presence of indicator organisms, *E. coli* and other coliform organisms present in the water samples. Ideally, drinking water should not contain any pathogenic organism, and should be free from bacteria indicative of faecal pollution (WHO, 2011). Inappropriate disposal procedures of abattoir waste effluents from slaughterhouses could lead to zoonotic diseases such as salmonellosis, brucellosis, helminthiasis, cholera, dysentery. The pollution of water bodies from abattoir effluents may result in substantial environmental and public health hazards (Neboh *et al*., 2013) [19].

Assessing the water quality of a receiving watershed from abattoir waste effluent would help to determine the level of contamination in the water. Waste effluent from Ugwuoba abattoir facility discharged into Ezu River is a threat to the natural water parameters of the water body, as it leads to uncontrolled increase in organic and nutrient loads of the water body, which can alter the physicochemical and bacteriological parameters. The study, therefore, was conducted to examine the impact of abattoir waste effluent from Ugwuoba abattoir site into Ezu River, and also its health implications on Gariki residents of Ugwuoba, Enugu State, Nigeria.

Materials and methods

Study area

Ugwuoba, a town in Oji River Local Government Area of Enugu State, Nigeria, is located on top of a hill and lies within the rainforest region of Nigeria with 1000mm-1500mm rainfall annually. It has GPS coordinates of 6º15'0" North and 7º14'0" East. Geographically, it is bounded in the South by Amansea/Mamu River; in the East by Achi/Nkwele-Inyi town; in the West by Ebenebe/Ezeagu and in the North by Nachi/Oji River. Ugwuoba abattoir site is located along Enugu-Onitsha Express road, near Ezu River and was established in 1995 by the then Oji River LGA Council. The abattoir is located on the hilltop of Agungu village, where Hausa/Fulani cattle herders and sellers reside, otherwise known as *Gariki*. The Ezu River is used for fishing, domestic use, car wash, recreation, transportation, etc.

Study design

The design was based on Investigative Survey Research Approach (ISRA) as described by Chukwu (1994) [6]. Data were obtained from series of visits to the abattoir facility, which involved inspection and witnessing of processing operations, interviewing relevant and competent staff of the abattoir and residents of the area, and collection of waste effluent from the Ugwuoba River for laboratory analyses.

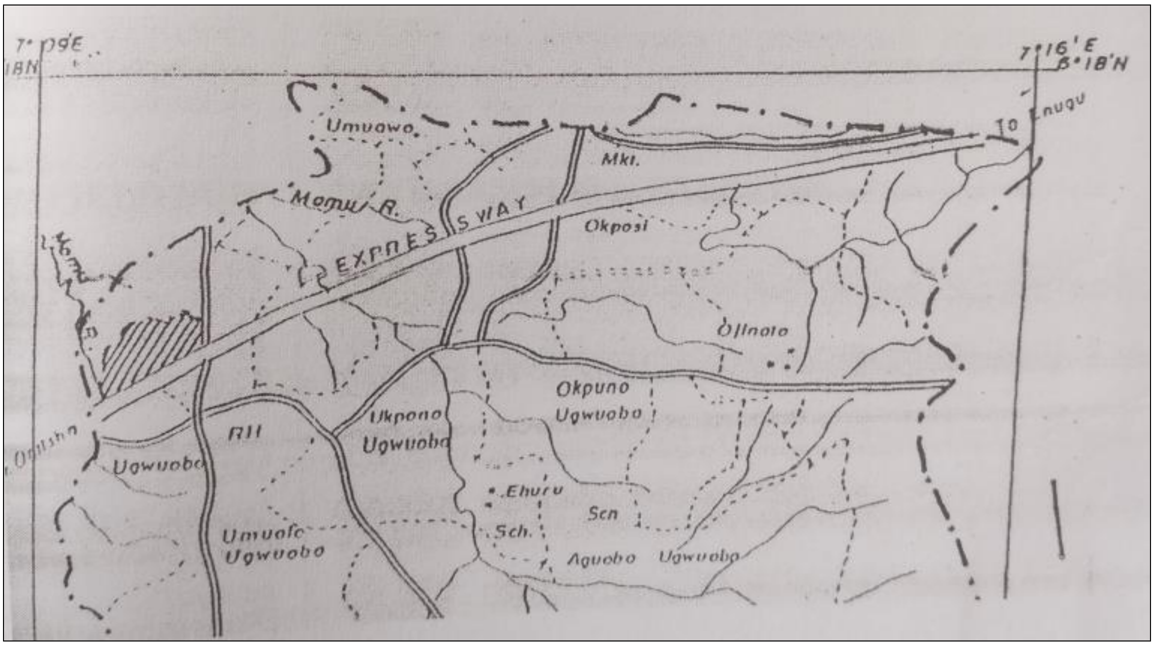

Fig 1: Map showing Ugwuoba abattoir facilityand Ezu river, along Onitsha-Enugu express way, Enugu State, Nigeria

Field survey and sampling

The field survey was carried out for two days and covered a distance of about 300m along Enugu/Anambra States boundary and Gariki market in Ugwuoba community. A point source/mixing zone of pollution caused by the abattoir effluent discharge into the river was identified. The sampling was done based on various distances affected by the pollution and water samples were collected from six points along the stream that drains the abattoir.

Sampling design

The sampling was designed to cover six different point sources, taken at three fixed monitoring stations as points 1, 2, 3, 4, 5 and 6. Point 1 was taken as the point where effluent sample passes before entering the river. Point 2 was the upstream of the river before effluent discharge (40m to point 3). Point 3 was the point where all effluent discharges directly into the river (mixing zone). Point 4 was the downstream of the river, 30m from the mixing zone. Point 5 was 30m from point 4, while point 6 was 20m away from point 5.

Sample collection

The collection was done between the hours of 8.00am and 10.00am when the discharge of effluent into the river usually occurred. All samples for laboratory analyses were dispensed into thoroughly cleaned 1L plastic water cans, which were previously washed with detergents and rinsed with distilled water. Each water can was rinsed with the appropriate quantity of sample before final sample collection. The water samples were placed in a cooler box filled with ice cubes and protected from direct sunlight and then taken to the laboratories for analyses. Upon arrival at the laboratory, the samples were preserved in a refrigerator with temperature between 0 and 4 ºC, before they were analyzed for selected physicochemical and bacteriological parameters. Samples for heavy metals analysis were preserved in 5% v/v nitric acid.

Determination of physicochemical parameters

The following physicochemical parameters were determined using the standard procedures in American Public Health Association (APHA, 2017) [4]: pH, salinity, colour, electrical conductivity (EC), turbidity, total dissolved solids (TDS), biological oxygen demand (BOD), dissolved oxygen (DO), chemical oxygen demand (COD), nitrate, sodium and calcium.

Heavy metals such as lead (Pb), cadmium (Cd) and copper (Cu) were determined using hydrochloric acid digestion. Metal ion concentrations were determined using an atomic absorption spectrophotometer (AA-6300 SHIMAOZU Model) with a hollow cathode lamp and a fuel-rich flame (air acetylene).

Bacteriological analysis

The water samples were analyzed for their bacteriological qualities using multiple tube fermentation method as described by APHA and AWWA (2017). This analysis involved presumptive, confirmatory and completed tests.

Data statistical analysis

Data were analyzed using the SPSS software version 21.0 and parameters of all the water samples from the sampling points were compared using ANOVA. Duncan's multiple range comparison tests were used to establish the difference between the average values of parameters that were measured at various points, using a 5% significance level ($p < 0.05$). All data obtained were presented as descriptive statistics and compared with the guideline limits set by the World Health Organization (WHO) and the Federal Environmental Protection Agency (FEPA) for effluent and wastewater sample.

Results and discussion

The results of the physicochemical, heavy metal and bacteriological analyses of the water samples collected from Ezu River, Ugwuoba at Point 1, Point 2, Point 3, Point 4, Point 5 and Point 6 are shown in the tables below.

Physicochemical parameters of the water samples

The physicochemical parameters of the effluents reflect diversity in the characteristics of the effluents before discharge (Points 1 and 2), and during and after discharge (Points 2-6). The results of the physicochemical parameters of the water samples from Ezu River as a result of abattoir waste effluent into it and the WHO and FEPA limits are shown in Table 1.

pH

From the table, the pH levels obtained ranged between 6.66 and 7.78, with Point 1 having the highest value (7.78) and Point 3 having the least value (6.66). The values obtained were within the limits set by the WHO and FEPA for livestock effluent (6.5-8.5). Water with a pH value outside the specified range may cause nutritional imbalance and have adverse effect on the growth of aquatic lives (Elemile *et al*., 2019) [11] and not palatable to drink. The values were higher when compared with the reports of other researchers. Adelowo *et al*., 2012 [2] reported pH range of 5.7-6.7. Water generally becomes more corrosive with decreasing pH. Similarly, Magaji and Chup (2012) [16] reported 6.0-7.2, with well water closest to the abattoir house having the highest (7.2). The results of the pH values in this study could be attributed to the large size of the abattoir facility and many activities occurring at the site.

Table 1: Physicochemical characterization of Ugwuoba abattoir effluents discharged into Ezu River

Parameter	Sampled Points							
	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	FEPA Limit	WHO Limit
pH	7.78	6.81	6.66	6.78	7.00	6.80	6.5–8.5	7.0–8.5
Salinity (PSU)	40.84	32.30	32.10	32.00	32.20	29.80	100	100
Colour (PCU)	980	411	560	461	420	407	NS	<50
EC (µS/cm)	274.76	149.70	152.40	150.20	149.30	148.10	500	500
Turbidity (NTU)	87.33	20.53	39.41	34.30	32.98	24.20	1	1
TDS (mg/L)	112.40	24.80	48.30	24.60	23.90	24.10	500	600
Chloride (mg/L)	10.01	0.00	4.99	3.22	2.95	2.02	250	250
Sodium (mg/L)	9.88	8.47	8.08	8.00	7.89	7.60	200	50
Calcium (mg/L)	4.99	5.29	5.90	5.70	6.08	6.01	50	100
Nitrate (mg/L)	22.70	0.00	4.36	2.34	0.00	0.00	50	50
DO (mg/L)	71.60	78.00	82.00	87.00	90.28	90.40	NS	NS
BOD (mg/L)	280.00	181.30	121.50	137.60	124.20	117.80	5	25
COD (mg/L)	234.70	77.33	60.00	52.30	50.10	48.00	100	50

NS = Not Stated

Salinity

Salinity is the measure of the concentration of compounds of salts in a solution. This is as a result of the effect of the salt concentration on the settling velocity and aggregation of suspended particles (Igbinosa and Uwidia, 2018) [14]. In this study, salinity ranged between 29.80 Psu and 40.84 Psu, with Point 1 having the highest value (40.84 Psu) and Point 6 having the least value (29.80 Psu). The values were within the WHO and FEPA standard limits. It could be deduced from the table that salinity levels decrease as the abattoir effluent flow deeper in the river and mixes well (Points 5 and 6). Sources of salt compounds in the effluent could be traced to the detergents used by butcher-men to wash hides and skins of cattle and goats, and also from artificial fertilizers used by local farmers in nearby gardens and farms. Bala *et al*., 2016 [5], reported similar decrease in salinity levels from points of heavy concentrations (67.52 Psu) to a point of less concentration (where effluent discharges have mixed with water samples well) (28.53 Psu). Other researchers such as Akanga *et* al., 2016; Omole *et al*., 2018 [23] and Elemile *et al.,* 2019, reported that salinity levels were highest from the first point of contact with water body.

Electrical Conductivity (EC)

This is a method for obtaining an estimate of dissolved solids in water samples. In this study, the values of EC ranged between 148.10 µS/cm and 274.76 µS/cm, with Point 1 having the highest value of 274.76 µS/cm and Point 6 having the least value of 148.10 µS/cm. There were significant differences in the EC values and they were within the WHO and FEPA maximum permissible limits of 500 µS/cm and 400 µS/cm. The results agreed with the reports of Tekenah *et al*. (2014) [26] and Abubakar and Tukur (2014) [1], where EC values were within the maximum permissible limits and were highest at the point of discharge of effluents into the water body. The results in this study indicated that the water samples are not salty because the concentration of salts dissolved in the water was as little as possible. Magaji and Chup (2012) [16] reported that consumption of water high in EC, above maximum permissible limit, over a period of time can affect the endocrine functions in man and can cause total brain damage.

Turbidity

Turbidity refers to the optical determination of water quality (Wetzel, 2001). Turbid water appears murky or otherwise coloured, which affects the physical appearance of the water. In this study, turbidity ranged between 24.20 NTU and 87.33 NTU, with Point 1 having the highest value and Point 6 having the least value. The values were above the WHO permissible limit, with Point 1 having great potentials to be deleterious. The high value of Point 1 could be attributed to its close proximity to the direct source of abattoir effluent. From Points 4 to 6, the effluent has mixed with the water body evenly and this provided a sort of natural purification of the effluent in the river, and also, some of the pollutants are dissolved as they enter the river. The results obtained in this study agreed with the reports of Neboh *et al*., 2013 [19]; Bala *et al*., 2016 [5]; Igbinosa and Uwidia, 2018 [14], where turbidity levels ranged between 45.55 NTU to 225.8 NTU and were above maximum permissible limit. Turbidity measurements are frequently used as an indicator of water quality with regards to its clarity and estimated total suspended solids in water. High levels of turbidity can impede photosynthesis by preventing penetration of sunlight into the river, which in turn would result in decreased dissolved oxygen output and decrease in plant survival (Adesina *et al*., 2018) [3].

Total dissolved solids (TDS)

The total dissolved solid (TDS) is a measure of the total ions in solutions or compounds. In this study, TDS ranged between 23.90 mg/L and 112.40 mg/L and the values were within the WHO and FEPA permissible limits. Point 1 had the highest TDS value (112.40 mg/L) while Point 5 had the least value (23.90 mg/L). There were significant differences in the values of the TDS, although they were within the standard limit of 500 mg/L. The values obtained for TDS in this study agreed with the reports of previous studies on abattoir effluent into streams, rivers lakes, etc in many parts of the developing countries such as Nigeria. Neboh *et al*., 2013 [19], reported TDS values between 185.50 mg/L and 258.7 mg/L; Bala *et al*., 2016 [5], reported 148-201 mg/L; Omole *et al*., 2018 [23] recorded 220.25 – 290.13 mg/L while Okoye *et al*., 2022a [22] reported between 311–401 mg/L and 114.7–268 mg/L. The implication of a high TDS is that the water becomes ‘undrinkable’ and it can corrode water storage tanks and containers.

Chloride (Cl^-)

The chloride values ranged between 10.01 mg/L and 2.02 mg/L, with samples from Point 1 having the highest value (10.01 mg/L), while the least value from Point 6 (2.02 mg/L). Surprisingly, there was no trace of chloride in Point 2. The values of Cl^- fall within the WHO and FEPA permissible limit. Although chloride ions are harmless at low levels, water samples with high concentrations of Cl^- could damage plants if used for irrigation or gardening. It could also give drinking water an unpleasant taste if consumed (WHO, 2011). Adelowo *et al*., 2012 [2] reported low levels of Cl^- in the water samples of a river in Ogbomosho, where abattoir effluents are being discharged. There were cases of indiscriminate faecal droppings from animals and humans around the study site. Igbinosa and Uwidia (2018) reported traces of chloride in water samples of Ikpoba River, around Benin City, Edo State, Nigeria, where abattoir effluents are being discharged and attributed it to septic tank waste waters, animal feeds and use of artificial fertilizers. Similarly, Abubakar and Tukur (2014) [1] reported chloride detection from the water samples of a Yola stream in Adamawa State, Nigeria.

Sodium and Calcium

The values obtained for sodium (Na^+) and calcium (Ca^{2+}) ranged between 7.60 mg/L and 9.88 mg/L and 4.99 mg/L and 6.08 mg/L respectively. These values were within the WHO and FEPA standards, and agreed with the reports of several other researchers. Drury *et al*. (2011) [10] reported Ca^{2+} and Na^+ values as 10.58 mg/L and 17.25 mg/L respectively in the study of wastewater treatment effluent and its influence on bacterial communities in benthic regions. Similarly, Okoye *et al*. (2022a) [22] reported that calcium levels ranged between 18.67 mg/L and 19.00 mg/L.

Nitrate

The value for the nitrate ranged between 0 and 22.70 mg/L, with Point 1 having the highest value (22.70 mg/L), while three other points had 0.00 mg/L. The values were within the WHO permissible limit of 50 mg/L, but Point 1 exceeded the FEPA limit of 10 mg/L. The results agreed with Adesina *et al*. (2018) and Ogunlade *et al*. (2021) [21] where nitrate levels were within the standard limit. There were significant differences in the values as some points had no trace of nitrate. Several researchers have reported that high values of nitrate in water could result to excessive aquatic plant growth and algal bloom (Tekenah *et al*., 2014; Chukwu and Anuchi, 2016) [26, 8], and in the Blue-baby syndrome in children and pregnant women (Nazir *et al*., 2015) [18].

Dissolved Oxygen (DO)

The value for DO ranged between 71.60 mg/L and 90.40 mg/L with water samples from Point 6 having the highest value of 90.40 mg/L while Point 1 had the least value of 71.80 mg/L. These values were above the WHO and FEPA standard limits for DO in wastewater effluent, and it increased from Points 1 to 6. The result agreed with Abubakar and Tukur (2014) [1] and Aboyomi and Taiwo (2018) where DO values from abattoir effluent were above WHO standard limit. Similarly, Neboh *et al*., 2013, [19] reported increase in DO levels as the effluent flowed from one point to the next and further away from the abattoir facility. The levels of the DO indicate the degree of pollution by organic matter from the water body and in this study, were above the standard limits, which have not adversely affected the quality of aquatic life in the water body. The DO levels below 5.0 mg/L adversely affect aquatic biological life, while a concentration below 2.0 mg/L may lead to death for most fishes (Uwidia *et al*., 2017; Ogunlade *et al*., 2021) [27, 21].

Biological oxygen demand (BOD)

The BOD is the most commonly used index in water quality management (Chukwu, 2008) [7] and it represents the amount of oxygen required for the biological decomposition of organic matter under aerobic condition. The BOD values ranged between 117.8 mg/L and 280.0 mg/L, with Point 1 having the highest value while Point 6 had the least value. The values were above the WHO and FEPA permissible limits. This agreed with the reports of Ogunlade *et al*. (2021) [21], where BOD values obtained from wastewater samples associated with abattoir effluent were also above (527 mg/L – 640 mg/L) the standard limit. The high BOD values could be attributed to the percolation of abattoir effluent loaded with biodegradable compounds and nearness of the abattoir facility to the water body. Ezeoha and Ungwuishiwu (2011) [12] and Abubakur and Tukur (2014) also reported high BOD values from water samples polluted with abattoir effluents. Both the BOD and COD are important water quality parameters, and are very essential in water quality assessment. Therefore, the more organic material is present in the abattoir effluent, the higher the BOD and COD.

Chemical oxygen demand (COD)

The values for the COD ranged between 48.0 mg/L and 230.70 mg/L, with Point 1 having the highest value and Point 6 having the least. A closer look at the table showed that the COD values decreased sharply from Points 2 to 6, probably due to the rate of dilution of the pollutants as it flows. The table also showed that the values were all within the WHO and FEPA standards except at Point 1. This could be attributed to the presence of chemical oxidants in the effluent, probably from detergent used in washing tides and skins of cattle and goats, and motorcycles. Though BOD and COD measured the amount of organic compounds of water, COD is less specific, such that it measures all compounds that can be oxidized chemically (Omole *et al*., 2018) [23]. Bala *et al*. (2016) [5] reported that COD values of abattoir effluents impacted the groundwater quality of Keffi, North Central, Nigeria, but were within the WHO standard. Similarly, Saidu and Musa (2012) [25] and Neboh *et al*. (2013) [19] reported that COD values associated with abattoir wastewater were within the WHO and FAO standards.

Concentration of Heavy metals

The concentration of heavy metals (Pb, Cu and Cd) in Ugwuoba abattoir effluent of Ezu River is shown in Table 2. The results showed that the concentration of Pb in effluent sample ranged between 0.00 and 0.19 mg/L, with some points not traced at all. The values obtained were above the WHO and FEPA limits of 0.03 mg/L and 0.01 mg/L respectively. This can be attributed to the activities going on around the abattoir facility such as washing and combustion of motor vehicles and motorcyclists, faecal droppings from cattle and burning of oils in the abattoir. Other researchers: Nazir *et al*. (2015) [18]; Chukwu and Anuchi (2016) [8]; Uwidia *et al*. (2017); Aboyomi and Taiwo (2018) and Igbinosa and Uwidia (2018) [14] all reported that the Pb levels were above the standard limit.

Table 2: Heavy metals analysis of Ugwuoba abattoir effluent in Ezu River water samples

	Sampled Points							
Parameters	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**	**FEPA Standard**	**WHO Standard**
Lead (mg/L)	0.00	0.13	0.16	0.19	0.17	0.00	0.01	0.03
Copper (mg/L)	0.00	0.00	0.08	0.04	0.00	0.01	1.00	3.00
Cadmium (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00	NS	0.20

NS = Not Stated

The Cu levels in the effluent sample ranged between 0.01 mg/L and 0.08 mg/L, although some studied points had no trace of the metal. The values obtained were within the WHO and FEPA standard limits. There was no trace of Cd in the effluent samples analyzed in this study, and therefore, the threats posed by high Cd values in water samples used for irrigation purposes had been mitigated. Cd contamination poses a risk on consuming farm products (vegetables) and kinds of seafood in such area (Ogunlade *et al*., 2021) [21].

Bacteriological analysis of the effluent water samples

Table 3 shows the bacteriological analysis of Ugwuoba abattoir effluent in Ezu River water samples from points 1 to 6 and the values were presented as total coliform (TC), faecal coliform (FC) in MPN/100mL and the total bacterial counts (TBCs) in CFU/mL. Bacterial concentrations for TC and FC ranged between 2.6×10^3 MPN/100mL and 8.2×10^4 MPN/100mL respectively. The TBC of the abattoir effluent in Ezu River ranged between 3.08×10^2 CFU/mL and 5.2×10^5 CFU/mL. These values were above the WHO and FEPA standards for effluent discharge into water bodies and the presence of faecal coliforms showed faecal contamination of the water samples.

Table 3: Bacteriological analysis of Ugwuoba abattoir effluent in Ezu River water samples

	Sampled Points					
Parameters	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**
TC (MPN/100mL)	$4.8x10^3$	$6.4x10^4$	$8.2x10^4$	$7.8x10^3$	$6.2x10^3$	$2.6x10^3$
FC (MPN/100mL)	$3.4x10^3$	$4.1x10^3$	$4.6x10^3$	$3.8x10^4$	$3.4x10^2$	$2.3x10^2$
TBC (CFU/mL)	$3.25x10^3$	$2.54x10^3$	$5.2x10^5$	$4.2x10^3$	$2.8x10^2$	$3.08x10^2$

The bacteria isolated from the water samples of these points showed varying degrees of contamination, with Point 3 having the most form of bacterial contamination while Point 6 had the least form of contamination. Several other researchers like Chukwu, 2008; Josiah *et al*., 2014 [15]; Bala *et al*., 2016 [5]; Adesina *et al*., 2018 [3] and Elemile *et al*., 2019 [11] reported the presence of high microbial loads in abattoir effluent in water bodies. The following enteric bacterial isolates were identified using Gram staining technique and various biochemical tests: *Escherichia coli*, *Vibrio cholerae*, *Salmonella* spp., *Shigella* spp., *Klebsiella* spp., and *Pseudomonas* spp. and *Staphylococcus aureus*. There was more bacterial contamination on Point 3 compared to other points. Nafarnda *et al*. (2012) [17] reported similar presence of bacterial isolates from the water samples polluted from abattoir effluents. The impact of this microbial load on the water quality has led to the many public health hazards such as diseases, unsafe water, faced by Gariki residents and environs.

Conclusion and Recommendations

The study revealed that the values of physicochemical, heavy metals and bacteriological parameters investigated were either higher than the WHO and FEPA limits or within the limits, with Point 1 being the most polluted point and point 6, the least polluted point. The contaminated water samples could pose significant health and environmental threats to the Gariki dwellers and environs, who rely on the Ezu river as their source of domestic water, recreation and agriculture. Adequate pretreatment system should be constructed through a constructed lined drain before discharge of the abattoir effluent is made into the Ezu River. Determination of specific pathogenic microorganisms in abattoir effluent and their health impacts is recommended. Furthermore, continuous monitoring by environment and public health staff is recommended to control discharge of abattoir effluent into the river and public enlightenment should be carried out. Abattoir staff at Ugwuoba abattoir site should be trained in environmental safe practices as well as occupational health procedures, to ensure reduction in diseases implosion and transmission.

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