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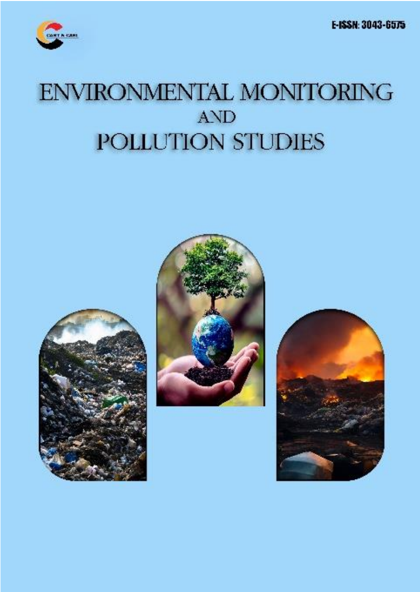

Physicochemical, Heavy Metals and Microbial Pollution of Surface Water Around Choba Abattoir in Rivers State, Nigeria

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Abstract

Abattoir operations generate numerous waste and microbial organisms that pollute the environment and severely threaten human health and quality of life. The study assessed the physicochemical, heavy metals and microbial pollution of surface water around Choba abattoir in Rivers State, Nigeria. Surface water was collected from the selected waterbody and tested for physicochemical parameters (pH, turbidity, conductivity, total dissolved solid, Nitrate, phosphate and sulphate), heavy metals (lead, cadmium, nickel, copper, iron, zinc and manganese) and microbial quality (total and faecal coliform) based on American Public Health Association standard. The findings revealed that the pH (6.6-7.0), COD (3.38-5.06 mg/l), BOD (2.13-3.38 mg/l), Nitrate (2.5-3.5 mg/l), and all heavy metals are within WHO limit for the surface water except for Cd (0.005-0.008 mg/l), while the microbial quality exceeded the WHO limit. The study concluded that the concentration of the surface water parameters indicated that the water is of a poor quality that could negatively impact human and aquatic organisms; hence, all types of waste should be treated before discharge into any media of the environment to avoid the pollution of such media.

Keywords: Abattoir, Heavy Metals, Physicochemical Parameters, Microbial Quality, Pollution

Introduction

Abattoir operations generate numerous waste and microbial organisms that pollute the environment and seriously threaten human health and quality of life (Abdullahi et al., 2023). Sadly enough, most abattoirs in Nigeria are characterised by poor design, obsolete facilities and deteriorating environment. The challenges posed by poor abattoir waste management on public food safety and quality of life in Nigeria have recently become a source of concern. So many studies have been carried out on the poor state of abattoirs in developing countries like Nigeria (Fearon et al., 2014; Oruonye, 2015; Abubakar and Bello, 2023; Abdullahi et al., 2023). The numerous wastes produced by abattoir operations not only pose a significant challenge to effective environmental management but also are associated with decreased air quality of the environment, potential transferable antimicrobial resistance patterns, and several infectious agents that can be pathogenic to humans (Oruonye, 2015; Daramola & Olowoporoku, 2017; Akpanama & Ekenta, 2022).

The abattoir industry remains an essential sector in the livestock industry, providing jobs for the populace and meat for people in general. The waste produced during meat processing is usually disposed of into water bodies without adequate care for environmental laws and situations. Allison et al. (2020) attributed the deterioration of the Mini Whuo River in Rivers State to disposing of human and animal wastes into the water body. Abattoir waste harms organisms and their surroundings if precautions are neglected (Terrumun and Oliver, 2015; Igbinosa & Uwidia, 2018). Adeyemo (2002) reported that abattoir waste piled up within the environment causes pollution and produces methane gas that aggravates the greenhouse effect. Yahaya and Agbendeh (2015) reported that the discharge of animal blood into the water would deplete the dissolved oxygen of the aquatic environment. Terrumun and Oliver (2015) reported that abattoir wastes are dangerous due to their high organic matter content, trace heavy metals, salts, bacteria, viruses, and other microorganisms. The indiscriminate discharge of paunch manure will reduce the dissolved oxygen of the water body and increase the composition of microorganisms in the water body (Terrumun & Oliver, 2015).

The waste from abattoir operations, often separated into solids, liquids, and fats, could be highly organic (Akankali et al., 2022). The solid part of the waste consists of condensed meat, undigested ingest, bones and hairs. On the other hand, the liquid aspect consists of dissolved solid blood, gut content, urine and water, while the fat waste consists of fats and oils (Elemile et al., 2019). Onojake (2011) suggested that abattoir wastewater is a typical source of pollution and creates serious environmental concerns. Studies have considered the influence of abattoir operations and waste discharge on the surface water qualities based on the water physicochemical, heavy metals and microbial parameters (Akanni et al., 2019; Adeyemo et al., 2019; Ogunlade et al., 2021; Akankali et al., 2022; Iyiola et al., 2022) and the present study further contributed to the aspect of pollution studies by assessing the physicochemical, heavy metals and microbial pollution of surface water around Choba abattoir in Rivers state, Nigeria to further established the effect of abattoir waste on surface water.

Materials and Methods

Study Area

The study was undertaken at Choba slaughter (Abattoir) house close to Choba Market, at the bank of the new Calabar River, within latitude 4°51'25.01" N and longitude 7° 1'18.07"E. The Choba slaughter (Abattoir) house is found within the Obio/Akpor Local Government Area of Rivers State, located approximately between latitude 4°45"N through 4°56"N and longitude 6°52"E through 7°6"E. It has a general elevation of less than 15.24m above mean sea level (Oyegun & Adeyemo, 1999). Ikwerre LGA bounds it to the north, Port Harcourt LGA to the south, to the east, Oyigbo LGA and to the West, Emohua LGA. It is one of the major centres of economic activities in Nigeria and a major city in the Niger Delta, said to be the wealthiest LGA in Rivers State. The abattoir is an open operating system with an average kill (slaughter) of 10 cows per day and animals such as goats and pigs daily for the local market.

Data Collection

Three major sampling points were identified based on their contribution to the abattoir operation. The three sampling points established were classified into three groups: upstream, midstream and downstream of the river, with equidistance of 150m from each other. Water samples for physicochemical parameters were collected into sterilised plastic bottles (1 litre). The plastic bottle and glassware used for sampling collection were soaked in 1M nitric acid overnight and then washed with tap water and deionised water to ensure quality assurance (Adeyemo et al., 2019). The bottle was tied to a rope before being suspended on a pole and lowered into the water against the flow. Glass bottles were used for water sample collection of heavy metals parameters. The samples for Biological Oxygen Demand and Chemical Oxygen Demand (COD) were collected with 200ml amber bottles, which were initially sterilised. The collected samples were instantly wrapped in foil papers (soil), placed in an icebox (water), appropriately labelled and taken to the laboratory (Analytical Concept Limited) for analysis.

Data Analysis

The collected samples were analysed for relevant physicochemical and major ions parameters according to internationally accepted procedures and standard methods (American Public Health Association standard- APHA, 2012. The laboratory analysis procedure and quality control were similar to those described by (Afolabi et al., 2023). Heavy metals were determined by the ASTMD 4691 method of Atomic Absorption Spectrophotometry (Perkin Elmer Analyst 400) (Adeyemo et al., 2019). The biological/bacteriological analysis of the study was done for parameters such as total coliform, which indicates the presence of various microscopic organisms in the water. Through “plate count Agar” incubated at 37ºC for 72 hours while monitoring and maintaining all laboratory standards, the biological content analysis was carried out to indicate the amount of biological organism in 100mg/L.

To ascertain the quality of the outcome from various analyses, standard procedures and laboratory quality assurance were strictly followed while samples were analysed in triplicates, and the mean was estimated for accuracy and precision. All analyses were subjected to a high-quality reagent from Analytical Concept Limited, and all instruments such as Pyrex glassware and containers for the analysis were washed adequately in deionised water, then soaked overnight with a 10% HNO3 in 1% HCl solution and later washed with

with deionised water and desiccated.

Results

The nearby surface water connected to the abattoir operations was analysed for its physiochemical, heavy metals, and microbiological quality based on designated points: upstream (US), midstream (MS), and Downstream (DS). The outcome is presented in Table 1.

Physicochemical Parameters

The pH value of the surface water ranged from 6.6 at DS, 6.7 at MS to 7.0 at US, with a mean pH value of 6.76 and a control value of 6.5, while all the values are within the World Health Organisation (WHO) permitted limit of 8.5. The temperature ranged from 29.9 °C in the US to 30.0 °C at both the DS and MS, with an average temperature of 29.96 °C. The turbidity of the surface water ranged from 1 NTU at the US, 2 NTU at MS, to 3 NTU at DS, with an average turbidity of 2 NTU, while the turbidity was above the WHO permitted limit of 1.67 NTU at MS and DS. The surface water salinity ranged from 3370 mg/l at MS to 3560 mg/l in the US, with a mean value of 3470 mg/l. The hardness of the surface water ranged from 2100 mg/l at MS to 2400 mg/l in the US, with a mean value of 2257 mg/l. The Total dissolved solids (TDS) of the sample ranges from 3710 mg/l at MS, 3880 mg/l at DS, to 3900 mg/l at US, with a mean concentration of 3830 mg/l and a control value of 222 mg/l. All the TDS concentrations across the stream's points are above the WHO permitted limit of 500 mg/l except at the control. The conductivity of the sample ranged from 6740 µs/cm at MS, 7050 µs/cm at DS to 7090 µs/cm at US, with a mean concentration of 6960 µs/cm. All the conductivity concentrations across the stream's points are above the WHO-permitted limit of 1000 µs/cm. The surface water's Biological Oxygen Demand (BOD) ranged from 2.13 mg/l at MS, 3.25 mg/l at US to 3.38 mg/l at DS with a mean value of 2.92 and control value of 10mg/l. Surface water's Chemical Oxygen Demand (COD) ranged from 3.19 mg/l at MS, 4.88 mg/l at US, and 5.06 mg/l at DS, with a mean value of 4.37. The Nitrate concentration of the surface water ranged from 2.5 mg/l at MS, 3.0 mg/l at DS, to 3.5 mg/l at US, while the mean concentration was 3.0 mg/l and a control value of 0.25. The phosphate concentration of the surface water ranged from 0.56 mg/l at MS, 0.68 mg/l at DS, and 0.81 mg/l at US, while the mean concentration was 0.68 mg/l. The Sulphate concentration of the surface water ranged from 60 mg/l at MS, 80 mg/l at DS, to 100 mg/l at US, while the mean concentration was 80 mg/l and the control value was 75 mg/l.

Heavy Metals Concentration

The concentration of heavy metals such as Lead (Pb), Nickel (Ni), Iron (Fe) and Manganese (Mn) for the surface water was <0.001 across all the sampling points and all within the WHO-permitted limits.

The Potassium concentration of the surface water ranged from 10.68 mg/l at US, 12.71 mg/l at DS, to 13.49 mg/l at US, while the mean concentration was 12.29 mg/l.For Cadmium (Cd), the concentration ranged from < 0.001 mg/l at DS, 0.005 mg/l at the US, to 0.008 mg/l with a mean value of 0.006. The Cd concentration at the US and MS exceeded the WHO permitted limit of 0.003. For Zinc (Zn), the concentration ranged from 0.017 mg/l at DS, 0.019 mg/l at the US to 0.148 mg/l with a mean value of 0.06 while the Zn concentration across the sampling points is within the WHO permitted limit of 3.

Microbiological Quality

All samples showed no presence of E. Coli; however, the Total Coliform (TC) of the surface water ranged from 93 MPN/100ml at US, 1100 MPN/100ml at DS to ≥2400 MPN/100ml at the MS and the control point has >800 MPN/100ml. The surface water's faecal coliform (FC) ranged from 23 MPN/100ml at DS, 43 MPN/100ml at US to 93 MPN/100ml at the MS and the control point had 12 MPN/100ml. The surface water's Hydrocarbon Utilizing Bacteria (HUB) ranged from 0.1 x 102 cfu/ml at DS to 0.2 x 102 cfu/ml at US and MS.

Discussion

The pH reported is alkaline (6.6 to 7.0) and within WHO standards. This outcome is similar to the pH level reported by Nasiru et al. (2016) and Akankali et al. (2022) for creek water quality influenced by abattoir activities. The reported physicochemical properties, such as COD and BOD, are within the WHO limit and less than those reported by Ogunlade et al. (2021). BOD and COD are important water quality parameters that are essential in water quality assessment. Therefore, the more organic material in the abattoir wastewater, the higher the BOD and COD. The turbidity and TDS reported are above the WHO limit and similar to those reported by Nasiru et al. (2016) for wastewater from abattoir activities. Also, the reported conductivity and hardness are above the permitted limit of WHO by more than three-fold, indicating human influence. The high concentration of turbidity, TDS, hardness and conductivity implies that aquatic organisms will be affected, such as the level of light and oxygen penetrating the waterbody is reduced. This finding is similar to the assertion of Afolabi et al. (2022), who suggested that conductivity is linked strongly to TDS-high EC values correspond to high concentrations of dissolved substances. The Nitrate, Sulphate and Phosphate reported in the study are within the WHO limit and lower than those reported by Nasiru et al. (2016) and Ogunlade et al. (2021) for wastewater from abattoir activities. The levels of nitrate in the abattoir wastewater may give rise to methemoglobinemia. Also, the nitrate levels reported in this study and phosphate levels can cause eutrophication and may pose a problem if discharged into rivers or streams.

Table 1: Physicochemical, Heavy Metal And Microbiological Quality Of Surface Water

Parameter	Upstream	Midstream	Downstream	Mean	Control	SD	WHO
pH	7.0	6.7	6.6	6.76	6.5	0.16	8.5
Temperature °C	29.9	30.0	30.0	29.96	29.8	0.04	Ambient
Turbidity, NTU	1	2	3	2	-	0.81	1.67
Salinity mg/l	3560	3370	3480	3470	-	77.89	-
Hardness mg/l	2400	2100	2270	2257	-	122.84	150
TDS, mg/l	3900	3710	3880	3830	222	85.24	500
Conductivity µs/cm	7090	6740	7050	6960		156.41	1000
TSS mg/l	-	-	-	-		-	-
BOD mg/l	3.25	2.13	3.38	2.92	10	0.56	20
COD mg/l	4.88	3.19	5.06	4.37	-	0.84	1000
Nitrate, mg/l	3.5	2.5	3.0	3	0.25	0.41	45
Phosphate, mg/l	0.81	0.56	0.68	0.68	-	0.102	5
Sulphate, mg/l	100	60	80	80	75	16.32	250
Potassium K mg/l	10.68	13.49	12.71	12.29		1.18	-
Lead (Pb) mg/l	<0.001	<0.001	<0.001		<0.001		0.01
Cadmium (Cd) (mg/l)	0.005	0.008	<0.001	0.006	<0.001		0.003
Nickel (Ni) (mg/l)	<0.001	<0.001	<0.001		<0.001		0.02
Copper (Cu) mg/l	<0.001	0.179	<0.001		<0.001		1
Iron(Fe) mg/l	<0.001	<0.001	<0.001		<0.001		0.3
Zinc (Zn^{2+}), mg/l	0.148	0.019	0.017	0.06	<0.001	0.06	3
Manganese (Mn) mg/l	<0.001	<0.001	<0.001		<0.001		0.4
E.Coli	-	-	-		-		
TC (MPN/100ml)	93	≥ 2400	1100		>800		
FC (MPN/100ml)	43	93	23		12		
HUB (cfu/ml) x 10^2	0.2	0.2	0.1		-		
HUF (cfu/ml) x 10^2	-	-	-		-		

WHO: World Health Organisation, TC: Total Coliform, FC: Faecal Coliform, HUB: Hydrocarbon Utilizing Bacteria, HUF: Hydrocarbon Utilizing Fungi

All the heavy metals reported are within WHO limits except for Cd at the upstream. The concentration reported is closely similar to those reported by Ogunlade et al. (2021) but lower than those reported by Mohammed et al. (2020). Cd can affect the kidneys, livers, skeletal and cardiovascular systems and cause eyesight and hearing loss, even at low concentrations. It also disrupts steroidogenesis and causes difficulties with the menstrual period and reproductive hormones, puberty and menstrual irregularity, stillbirths, preterm birth, and low birth weight (Nandomah and Tetteh, 2023).

The microbial concentration based on TC, FC and HUB revealed concentrations above the WHO-permitted limit and those reported by the study conducted by Ogunlade et al. (2021) and Sampson and Deele (2022). However, the concentrations were lower than those reported by Anele et al. (2023) for Rumuokoro and Tran-Amadi abattoir.

Conclusion

Abattoir operations generate numerous waste and microbial organisms that pollute the environment and severely threaten human health and quality of life. With a specific focus on the influence of abattoir operation and waste discharge to nearby surface water, several physicochemical parameters are within the WHO standard except for turbidity and TDS. All the heavy metals reported are within WHO limits except for Cd at the upstream. At the same time, the microbial concentration based on TC, FC and HUB revealed a concentration above the WHO-permitted limit. The study concluded that the concentration of the surface water parameters indicated that the water is of poor quality, which could negatively impact human and aquatic organisms. Lairage and waste disposal equipment should be provided while also ensuring that all types of waste should be treated before discharge into any media of the environment to avoid the pollution of such media.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Credit Authorship Contribution Statement

Ibegbu, C.O.: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Visualization, Project administration, Writing - original draft. **Osuji, L.C** and **Obafemi, A.A.**: Supervision, Methodology, Validation, Formal analysis, Data curation, Visualization, Review & Editing.

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