GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(Research Article)

Environmental Assessment of Heavy Metal Contamination and Physicochemical Properties in Abattoir Wastewater

Taiwo Bakare-Abidola [1,*], Jelil Olaoye [2] and Oluwafemi Sheriff Yekinni [3]

[1] *Department of Environmental Science, Georgia Southern University, Georgia, USA.*
[2] *Department of Applied Physical Science, Georgia Southern University, Georgia, USA.*
[3] *Department of Health Science, Western Illinois University, Illinois, USA.*

GSC Advanced Research and Reviews, 2025, 22(03), 092-102

Publication history: Received on 10 January 2025; revised on 24 February 2025; accepted on 27 February 2025

Article DOI: https://doi.org/10.30574/gscarr.2025.22.3.0067

Abstract

This study assessed the physicochemical properties and heavy metal contamination in abattoir wastewater and tap water from two abattoirs in Lagos State, Nigeria. Wastewater and tap water samples were collected between February and March 2018, with tap water serving as the control. Parameters analyzed included pH, temperature, and concentrations of Ca, Cd, Fe, Mn, Pb, and Zn. Results showed that pH and temperature met regulatory standards, while Pb and Zn in wastewater exceeded FMENV limits for surface water discharge. Similarly, tap water samples contained Cd, Fe, Mn, and Pb above WHO drinking water standards. The metal pollution index indicated higher contamination in Oko-Oba Abattoir wastewater (5.12 mg/L) than in Ejigbo (3.42 mg/L). Statistical analysis revealed a significant difference in Mn levels between tap water from the two abattoirs, while other parameters showed no significant variation. These findings highlight the need for effective pre-treatment and regulatory monitoring to mitigate pollution and health risks associated with abattoir wastewater discharge.

Keywords: Abattoir; Heavy Metals; Limits; Pretreatment; Wastewater; Physicochemical Parameters

1. Introduction

Abattoir operations are essential for meat production but generate large volumes of organic waste that significantly impact the environment if not properly managed. The liquid waste from abattoirs is composed of suspended solids, blood, gut contents, urine, fats, and water, while solid waste consists of discarded meat, bones, and animal fecal matter (1). In many developing countries, including Nigeria, poor waste management in abattoirs leads to the contamination of nearby water bodies, posing a threat to both public health and the ecosystem (2). The absence of modern facilities, inadequate hygiene standards, and the improper siting of abattoirs near rivers and streams exacerbate these challenges (3). The discharge of untreated wastewater containing heavy metals and microbial contaminants into surface water bodies threatens aquatic ecosystems and contributes to the degradation of water quality (4).

Abattoir wastewater contains high concentrations of organic matter, nutrients, and heavy metals, which can cause severe environmental pollution if not adequately treated before disposal (5). The organic components of abattoir waste decompose in water, leading to oxygen depletion and increased biochemical oxygen demand (BOD) and chemical oxygen demand (COD) levels, which negatively affect aquatic life (6). Studies have shown that abattoir effluent significantly increases nutrient loads, leading to eutrophication and harmful algal blooms in receiving water bodies (7). In addition to organic pollutants, abattoir wastewater is a major source of microbial contamination, including bacteria such as Escherichia coli, Salmonella, and Vibrio cholerae, which are responsible for gastrointestinal infections and other waterborne diseases (8).

* Corresponding author: Taiwo Bakare-Abidola.

Heavy metal contamination in abattoir wastewater is particularly concerning due to the toxicity and persistence of metals such as lead (Pb), cadmium (Cd), iron (Fe), manganese (Mn), and zinc (Zn) (9). These metals accumulate in the environment, leading to bioaccumulation in aquatic organisms and biomagnification along the food chain, which poses significant risks to human health (10). For instance, prolonged exposure to high levels of Pb and Cd has been linked to neurological disorders, kidney damage, and carcinogenic effects (11). A study by Osu et al. (2014) revealed that heavy metal concentrations in abattoir effluents exceeded permissible limits in several Nigerian water bodies, highlighting the urgent need for improved waste treatment strategies (12).

In Nigeria, industrial and agricultural activities contribute to the pollution of surface and groundwater resources, with abattoirs being a major source of water contamination (13). Lagos State, in particular, is home to several abattoirs that discharge untreated wastewater directly into rivers and streams, exacerbating the issue of water pollution (14). A study conducted by Ibanga et al. (2018) found that abattoir effluents in Lagos significantly increased heavy metal concentrations in surrounding water bodies, posing a risk to aquatic organisms and communities relying on these water sources for domestic use (15). Similar findings have been reported in other developing countries where inadequate wastewater treatment facilities result in the contamination of drinking water sources, leading to outbreaks of waterborne diseases (16).

The challenge of abattoir waste management in Nigeria is further compounded by weak regulatory enforcement and the lack of infrastructure for wastewater treatment. The Nigerian Federal Ministry of Environment (FMENV) has established guidelines for wastewater discharge, yet many abattoirs fail to comply due to inadequate monitoring and enforcement mechanisms (17). Studies have shown that even in cases where abattoir waste is collected for treatment, the absence of efficient treatment technologies often results in incomplete removal of pollutants before disposal (18).

Water pollution is a major global concern, particularly in regions experiencing rapid industrialization and urbanization. Studies indicate that anthropogenic activities such as industrial discharge, agricultural runoff, and improper waste disposal significantly degrade water quality worldwide (19). In developing countries, water bodies often serve as the final receptacle for untreated effluents, leading to contamination that affects both human populations and aquatic ecosystems (20). The United Nations Sustainable Development Goal (SDG) 6 emphasizes the need for clean water and sanitation, highlighting the importance of proper wastewater management to ensure safe drinking water and sustainable environmental practices (21).

A study conducted by Omokaro et al., (2024) identified industrial effluents, including those from abattoirs, as a primary source of pollution in urban water bodies (22). Similarly, a study by Hillel et al. (2015) found that unregulated wastewater discharge in developing regions has led to the depletion of freshwater resources, affecting both agricultural productivity and biodiversity (23). Water pollution not only reduces the availability of safe drinking water but also threatens food security by contaminating agricultural irrigation sources (24). The World Bank (2003) has reported that increased pollution levels, coupled with rising global water demands, pose significant challenges to water sustainability, requiring urgent interventions to improve water management practices (25).

Among various pollutants in abattoir wastewater, heavy metals pose significant environmental and health risks due to their persistence, bioaccumulation, and toxicity. In abattoirs, heavy metals can enter wastewater through contaminated animal feed, veterinary drugs, and slaughtering processes (26). The presence of heavy metals in wastewater has significant ecological and human health implications due to their non-biodegradable nature and potential for bioaccumulation (27). Studies have shown that metals such as Pb, Cd, Fe, and Zn are commonly found in abattoir effluents, often exceeding permissible limits set by regulatory agencies (28).

The toxicity of heavy metals depends on their concentration, chemical form, and bioavailability. For instance, Cd is known to interfere with calcium metabolism, leading to bone disorders, while Pb exposure is associated with neurological impairments, particularly in children (29). A study by Chanpiwat et al. (2014) on heavy metal contamination in drinking water sources found that exposure to Pb and Cd from contaminated water resulted in increased cases of renal dysfunction and cardiovascular diseases (30). Additionally, Mn toxicity has been linked to neurological disorders such as Parkinson’s disease, emphasizing the need for stringent monitoring of metal concentrations in wastewater (31).

This study aims to evaluate the physicochemical properties and heavy metal contamination of wastewater from selected abattoirs in Lagos State, Nigeria. Specifically, it seeks to determine key physicochemical parameters such as pH and temperature, assess the concentrations of selected heavy metals (Pb, Cd, Fe, Mn, Zn, and Ca) in wastewater samples, and compare the metal pollution index across different abattoirs. Additionally, the study aims to evaluate the compliance of wastewater quality with national (FMENV) and international (WHO) regulatory standards while providing recommendations for improved wastewater management to mitigate environmental pollution and associated health risks.

2. Material and method

2.1. Study area

Lagos, located in southwestern Nigeria, serves as the country's commercial hub and is home to over 18 million people, accounting for approximately 10% of Nigeria's population (32). The city has a high demand for meat, with an estimated 8,000 ruminant livestock, valued at approximately 1.6 billion Naira, consumed daily (33). To meet this demand, livestock primarily cattle are slaughtered in abattoirs and distributed across the state.

This study was conducted at Ejigbo Abattoir and Oko-Oba Abattoir, located in Agege Local Government Area, Lagos, Nigeria. Oko-Oba Abattoir is the largest of the authorized abattoirs in Lagos State, accounting for over 30% of the total meat processed for consumption in the city (33). Wastewater samples were collected from three different sections of the abattoir wastewater channels, with three samples taken from upstream, midstream, and downstream locations. The sampling points were geo-referenced using a handheld Global Positioning System (GPS) to accurately record the coordinates of each location.

A wide variety of animals, including cows, goats, sheep, and camels, are slaughtered daily throughout the year. The wastewater generated from these activities flows directly into a nearby stream without undergoing any form of treatment. Due to the largely unregulated nature of abattoir operations, this study aims to assess the physicochemical properties and heavy metal contamination (Ca, Cd, Fe, Mn, Pb, and Zn) in wastewater samples from Oko-Oba and Ejigbo Abattoirs. The findings from this research will provide critical baseline data for future wastewater management practices in abattoirs and their potential impact on the surrounding environment.

2.2. Sample Area and Collection

The study was conducted at two selected abattoirs in Lagos State, Nigeria Oko-Oba Abattoir and Ejigbo Abattoir. Wastewater and tap water (control) samples were collected weekly in replicates over a period of five weeks, from February to March 2018. Figure 1 shows the geographical location of the two abattoirs.

A total of 20 samples, comprising 10 wastewater samples and 10 tap water samples, were obtained from the two abattoirs. The geographical coordinates for Ejigbo Abattoir were recorded as Latitude 6.5350°N and Longitude 3.2910°E, while Oko-Oba Agege Abattoir was located at Latitude 6.6490°N and Longitude 3.3180°E. Control samples consisted of tap water used within the main buildings of both abattoirs.

Samples were collected in the early hours of the day, around 8:00 AM, to ensure consistency in sampling conditions. Sterile 1-liter bottles were used to aseptically collect wastewater directly from the drainage channels as it exited the slaughtering pavements. Similarly, tap water control samples were collected directly from taps within the abattoir buildings.

Immediately after collection, the pH and temperature of both wastewater and tap water samples were measured and recorded. To preserve the integrity of the samples, 5 mL of concentrated nitric acid (conc. HNO_3) was added to each sample, after which they were shaken vigorously to ensure thorough mixing. The samples were then transported immediately to the laboratory for further preparation and analysis following standard procedures outlined by the American Public Health Association (APHA, 2005).

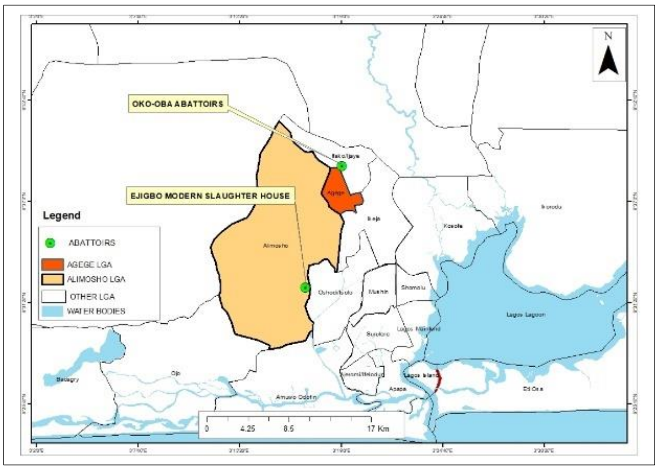

Figure 1 Map showing the Geographical locations of both Abattoirs

Figure 2 Abattoir Operation at Oko-Oba Agege Abattoir, Lagos State

Figure 3 Abattoir Operation at Ejigbo Abattoir, Lagos State

2.3. Determination of Hydrogen Ion Concentration (pH)

The pH of both wastewater and tap water samples was measured using a Beckman Coulter 360 pH/Temp/mV Meter. Prior to measurement, the pH meter was calibrated by immersing its electrode in a pH 7.0 buffer solution to ensure accuracy and functionality. For each sample, the electrode was carefully inserted, and the reading was allowed to stabilize before recording the final pH value. The pH results obtained from the analysis are presented in Tables 2.

2.4. Determination of Temperature

The temperature of both wastewater and tap water (control) samples was measured on-site using a mercury bulb thermometer (0–360°C). Temperature readings were taken immediately after sample collection to ensure accuracy and prevent any alterations due to environmental changes. The thermometer was carefully inserted into each wastewater and tap water sample, allowing it to stabilize before recording the temperature in degrees Celsius (°C). The results of the temperature measurements are presented in Tables 2.

2.5. Instrumentation and Measurements

2.5.1. Digestion of Samples and Determination of Metals in Abattoir Wastewater and Tap Water Samples

The determination of metal concentrations in wastewater and tap water samples was carried out through an acid digestion process. 100 mL of filtered wastewater and tap water samples were measured into a conical flask, followed by the addition of 10 mL of concentrated nitric acid (HNO_3). The mixture was heated on a hot plate and allowed to evaporate to near dryness, reducing the solution to less than 20 mL. Once removed from the hot plate, the solution was allowed to cool before being diluted with distilled water to a final volume of 25 mL in a volumetric flask. The digested solution was then filtered using 12.5 cm Whatman filter paper into a 25 mL volumetric flask. The final filtered solution was transferred into a 50 mL sample bottle, completing the digestion process.

The prepared samples were stored in a refrigerator prior to metal analysis. The concentrations of calcium (Ca), cadmium (Cd), iron (Fe), manganese (Mn), lead (Pb), and zinc (Zn) were determined using an Atomic Absorption Spectrophotometer (AAS) VGP Model 210 (Buck Scientific, USA) following standard procedures (34). A blank sample analysis was conducted using the same procedure, substituting 100 mL of distilled water in place of the sample and digesting it with 10 mL of concentrated HNO_3 to ensure the accuracy and reliability of the metal analysis.

2.5.2. Determination of Metals Using Atomic Absorption Spectroscopy (AAS) Technique

The concentrations of zinc (Zn), lead (Pb), cadmium (Cd), manganese (Mn), iron (Fe), and calcium (Ca) in the wastewater and tap water samples were determined using Atomic Absorption Spectroscopy (AAS). The digested samples were aspirated into the VGP Model 210 (Buck Scientific, USA) Atomic Absorption Spectrophotometer, which was used for the quantitative analysis of heavy metals. Each element was analyzed using its respective hollow cathode lamp, serving as the light source. The metals were measured under optimum operating conditions using an air-acetylene flame, which facilitated the atomization of the sample solution for accurate detection. The absorbance of each metal in the sample was recorded, and a calibration curve was prepared to determine the concentration of each metal.

The wavelengths and detection limits for each metal were set according to the manufacturer's specifications and are presented in Table 1. This ensured precision and compliance with standard analytical protocols for heavy metal determination.

Table 1 Wavelengths and Detection Limits of Each Metal Measured by Atomic Absorption Spectrophotometers

Elements	Wavelength (mm)	Detection Limit (mg/L)
Calcium	422.70	0.01
Cadmium	228.90	0.002
Iron	248.30	0.05
Manganese	279.50	0.03
Lead	283.30	0.05
Zinc	213.90	0.005

2.6. Metal Pollution Index (MPI)

To assess and compare the total metal content in wastewater and tap water (control) samples from Oko-Oba and Ejigbo Abattoirs, the Metal Pollution Index (MPI) was calculated. This index provides a quantitative measure of metal contamination levels in water samples and facilitates comparative analysis between different sampling locations.

The MPI was computed using the equation proposed by Fadeyi et al. (2011) [35], ensuring a standardized approach to evaluating heavy metal pollution in the collected samples. The calculated MPI values enabled the assessment of contamination severity in abattoir wastewater and its potential environmental and health risks.

$$MPI = (Cf_1 \times Cf_2 \ldots\ldots\ldots\ldots Cfn)^{1/n}$$

Where Cfn = Concentration of metal in the Abattoir wastewater and tap water.

n = number of metals to be determined

2.7. Statistical Analysis

All results obtained from Oko-Oba and Ejigbo abattoir wastewater and tap water samples were subjected to statistical analysis to determine the mean, standard deviation, and t-test for comparative evaluation. Statistical computations were performed using Microsoft Excel 2016 and SPSS 11.0 software.

To assess the compliance of tap water quality with regulatory standards, the World Health Organization (WHO, 2011) [36] standard limits for drinking water were used as a benchmark. Similarly, the wastewater samples were evaluated against the Federal Ministry of Environment (FMENV, 1991) [37] standard limits for wastewater discharge. This comparative analysis provided insights into the extent of contamination and the potential risks associated with abattoir wastewater and tap water quality.

3. Results

3.1. Presentation of Results

Table 2 Mean of Physio-Chemical Parameters of Tap water and Wastewater for both locations

	Oke-Oba				**Ejigbo**			
Parameters	**Tap water**		**Wastewater**		**Tape Water**		**Wastewater**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
pH	6.6	0.25	7.4	0.38	6.6	0.44	7.3	0.27
Temperature (°C)	29.6	0.89	29.6	1.52	29.3	1.30	29.8	1.64
Ca (mg/L)	38.30	8.38	83.46	12.69	29.93	4.62	77.49	13.66
Cd (mg/L)	0.13	0.10	0.23	0.18	0.16	0.13	0.22	0.20
Fe (mg/L)	1.33	0.59	14.16	5.66	1.52	0.83	9.05	5.08
Mn (mg/L)	0.81	0.14	4.45	1.59	0.42	0.14	1.56	1.47
Pb (mg/L)	0.92	0.45	1.06	0.58	0.86	0.42	0.67	0.50
Zn (mg/L)	1.38	0.92	14.05	2.30	2.05	1.59	9.99	3.92

Notes: ND, Not detected; SD, Standard Deviation; MPI, Metal Pollution Index

Table 3 Mean of Physico-Chemical Parameters and Metals Pollution Index (MPI) of the Oko-Oba Wastewater/Tapwater and Ejigbo Wastewater/Tapwater

LOCATION	Ph	Temp(°C)	Ca	Cd	Fe	Mn	Pb	Zn	MPI
Oko-Oba (tap-water)	7.4±0.38 (6.6±0.25)	29.6±1.52 (29.6±0.89)	83.46±12.69 (38.30±8.38)	0.23±0.18 (0.13±0.10)	14.16±5.66 (1.33±0.59)	4.45±1.59 (0.81±0.41)	1.06±0.58 (0.92±0.45)	14.05±2.30 (1.38±0.92)	5.12 (1.13)
Ejigbo (tap water)	7.3±0.27 (6.6±0.44)	29.8±1.64 (29.3±1.30)	77.49±13.66 (29.93±4.62)	0.22±0.20 (0.16±0.13)	9.05±5.08 (1.52±0.83)	1.56±1.47 (0.42±0.14)	0.67±0.50 (0.86±0.42)	9.99±3.92 (2.05±0.59)	3.42 (0.90)

WHO (Drinking Water)	6.5-8.5	< 40	75.0-200	0.003	0.5	0.4	0.01	3	
FMENV (Surface Water)	6.0-9.0	< 40	200	<1	20	5	0.5	<1	

Table 4 FMENV Limit for Wastewater Samples and Nigeria Background Value for Tapwater and Waste water Samples

Parameters	**Fmenv limits Surface water Discharge**	**NBV Wastewater**
pH	6.0-9.0	6.5 - 8.2
Temperature (°C)	< 40	26.0 – 34.0
Calcium (mg/L)	200	0.6 – 1.10
Cadmium(mg/L)	<1	ND – 0.81
Iron(mg/L)	20	0.08 – 4.07
Manganese(mg/L)	0.5	0.30 – 0.42
Lead(mg/L)	<1	0.01 – 0.64
Zinc(mg/L)	<1	0.15 – 6.08

Notes: NBV, Nigeria Background Value
NBV for wastewater are Osibanjo and Adie, (2007); Joseph et al., (2010); Ekanem et al., (2016) and Nasiru et al., (2016).
FMENV, Federal Ministry of Environment (1991).

Table 5 WHO Limit for Drinking Water and Nigeria Background Value for Groundwater Samples

Parameters	**WHO limit for drinking water**	**NBV Ground water**
pH	6.5-8.5	4.17 – 8.05
Temperature (°C)	< 40	27.5
Calcium(mg/L)	75.0-200	10.32 – 104.3
Cadmium(mg/L)	0.003	0.0001-1.121
Iron(mg/L)	0.5	0.001 – 2.20
Manganese(mg/L)	0.4	0.001 - 0.45
Lead(mg/L)	0.01	ND – 7.50
Zinc(mg/L)	3	0.001-0.23

Table 6 T-test Statistical Analysis of the Physio-Chemical Parameters for both locations

Parameters	**pH**	**Temp (°C)**	**Ca**	**Cd**	**Fe**	**Mn**	**Pb**	**Zn**
t_{cal} (OT vs ET)	0.53	0.54	1.66	0.53	1.11	6.99*	0.21	1.94
t_{cal} (ET vs EW)	1.98	0.89	7.38	1.43	3.56*	1.73	0.53	4.56*
t_{cal} (OW vs EW)	0.43	0.34	0.66	1.43	3.56*	1.73^{ns}	0.53	4.56*
t_{cal} (OT vs OW)	3.92*	0.00^{ns}	5.09*	2.51*	4.99*	5.03*	0.51	13.04*

O = Oko-Oba, E = Ejigbo, T= Tap water, W = Wastewater

4. Discussion

The physico-chemical analysis of Oko-Oba and Ejigbo abattoir water samples, including pH, temperature, and metal concentrations (Ca, Cd, Fe, Mn, Pb, Zn), is summarized in Tables 2–6. The pH levels of the wastewater samples from both abattoirs were within the FMENV limits for surface water discharge, with mean values of 7.4 ± 0.38 (Oko-Oba) and 7.3 ± 0.27 (Ejigbo). The tap water samples from both locations had pH values of 6.6 ± 0.25 and 6.6 ± 0.44, aligning with WHO drinking water standards. The mean temperature values of wastewater samples (29.6°C ± 1.52°C for Oko-Oba and 29.8°C ± 1.64°C for Ejigbo) also complied with FMENV limits, while tap water samples had slightly lower temperatures, remaining within WHO standards.

Heavy metal concentrations varied across the samples. Calcium levels in wastewater samples were within FMENV discharge limits (83.46 ± 12.69 mg/L for Oko-Oba, 77.49 ± 16.36 mg/L for Ejigbo), while tap water samples did not exceed WHO standards. Cadmium levels in wastewater (0.23 ± 0.18 mg/L for Oko-Oba, 0.22 ± 0.20 mg/L for Ejigbo) were within FMENV limits, but tap water samples (0.13 ± 0.10 mg/L for Oko-Oba, 0.16 ± 0.13 mg/L for Ejigbo) exceeded WHO's 0.003 mg/L limit. Iron concentrations in wastewater were acceptable per FMENV guidelines (14.16 ± 5.66 mg/L for Oko-Oba, 9.05 ± 5.08 mg/L for Ejigbo), yet tap water exceeded WHO's 0.3 mg/L limit. Manganese levels in wastewater complied with FMENV standards, while tap water exceeded WHO limits, posing a potential neurological risk. Lead levels in Oko-Oba wastewater (1.06 ± 0.58 mg/L) surpassed FMENV limits, whereas Ejigbo wastewater (0.67 ± 0.50 mg/L) remained within range. Zinc concentrations exceeded FMENV limits in wastewater but were within WHO standards in tap water.

The metal pollution index (MPI) indicated that Oko-Oba wastewater had a higher pollution index (5.12 mg/L) compared to Ejigbo (3.42 mg/L), suggesting greater contamination from slaughterhouse activities. Similarly, Oko-Oba tap water had a higher MPI (1.13 mg/L) than Ejigbo (0.90 mg/L), reinforcing the need for improved water management in these locations. The high pollution index in Oko-Oba suggests greater exposure to contaminants, potentially due to industrial and abattoir activities. The elevated levels of toxic metals, particularly cadmium, manganese, and lead, highlight significant public health risks, necessitating urgent remediation measures, such as wastewater treatment and improved water filtration systems.

The t-test analysis (Table 6) revealed non-significant differences ($p < 0.05$) in pH, temperature, calcium, cadmium, iron, lead, and zinc levels between tap water samples from both locations, except for manganese, which showed significant variation. Comparisons between Ejigbo tap and wastewater samples indicated non-significant differences for pH, temperature, cadmium, manganese, and lead, while calcium, iron, and zinc showed significant differences. Between the wastewater samples of both abattoirs, only iron and zinc showed significant variation. In contrast, comparisons between Oko-Oba tap and wastewater samples indicated significant differences for most parameters except temperature and lead. Overall, the analysis confirms that both abattoir sites experience similar pollution patterns, reinforcing the urgent need for water treatment infrastructure to mitigate heavy metal contamination.

5. Conclusion

The findings from this study indicate that zinc and lead concentrations in wastewater samples from both abattoirs exceed the limits set by the Federal Ministry of Environment, raising significant environmental and public health concerns due to their potential for bioaccumulation. In contrast, other physico-chemical parameters, including pH, temperature, calcium, cadmium, iron, and manganese in wastewater, remained within regulatory discharge limits, suggesting partial compliance with environmental standards. However, the presence of elevated manganese levels in Oko-Oba tap water, as well as excessive cadmium, iron, and lead concentrations in tap water from both abattoirs, highlights serious concerns regarding the safety of drinking water, as these values exceed WHO (2011) standards.

These results emphasize the urgent need for improved wastewater management and treatment systems in abattoirs to mitigate heavy metal contamination. The exceedance of WHO drinking water limits for several heavy metals suggests potential health risks for individuals consuming untreated tap water in these areas. Establishing proper filtration and treatment infrastructure, along with regular monitoring, is necessary to ensure compliance with both national and international water quality standards, thereby safeguarding public health and the surrounding ecosystem.

Recommendation

- Based on the findings of this study, it is recommended that wastewater from both abattoirs undergo proper treatment before being discharged into surface water to prevent heavy metal contamination and environmental degradation.

- Cleaner meat production processes should be adopted and closely monitored by relevant regulatory agencies to minimize pollution from abattoir activities and ensure compliance with environmental standards.
- Given that manganese (in Oko-Oba tap water), as well as cadmium, iron, and lead in tap water from both abattoirs, exceed WHO (2011) drinking water limits, pre-treatment of tap water used in the abattoirs is necessary to safeguard public health and prevent long-term exposure to hazardous contaminants.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Oladipo OO, Ilesanmi TM, Olaleye AC. Environmental Impact of Abattoir Waste Discharge on the Quality of Water Body and Soil in Ado-Ekiti, Ekiti State. Asian J. Biotechnol. Bioresour. Technol. [Internet]. 2022 Apr. 14 [cited 2025 Feb.6];8(2):1-6. Available from: https://journalajb2t.com/index.php/AJB2T/article/view/154

[2] Thomas AJ, Akande I, Oso OM, Oke AB, Akindamini T. Global Waste Management Practices in Abattoir: Challenges for Implementation in Nigeria. Journal of Environmental Protection. 2024 Oct 12;15(12):1022-34.

[3] Nandomah S, Tetteh IK. Potential ecological risk assessment of heavy metals associated with abattoir liquid waste: A narrative and systematic review. Heliyon. 2023 Aug 1;9(8).

[4] Akankali J, Faith CC, Davies I. Abattoir Wastes In Niger Delta: A Review Of Its Impact on Water Quality. GARDEN CITY 2021. 2021:318.

[5] Madhav S, Ahamad A, Singh AK, Kushawaha J, Chauhan JS, Sharma S, Singh P. Water pollutants: sources and impact on the environment and human health. Sensors in water pollutants monitoring: Role of material. 2020:43-62.

[6] Kayode-Afolayan SD, Ahuekwe EF, Nwinyi OC. Impacts of pharmaceutical effluents on aquatic ecosystems. Scientific African. 2022 Sep 1;17:e01288.

[7] Ogidi OI, Izah SC. Water Contamination by Municipal Solid Wastes and Sustainable Management Strategies. InWater Crises and Sustainable Management in the Global South 2024 Sep 24 (pp. 313-339). Singapore: Springer Nature Singapore.

[8] Ibe FC, Enyoh CE, Opara AI, Ibe BO. Evaluation of pollution status of groundwater resources of parts of Owerri metropolis and environs, Southeastern Nigeria, using health risk and contamination models. International Journal of Energy and Water Resources. 2020 Dec;4:357-74.

[9] Aboyeji OS, Eigbokhan SF. Evaluations of groundwater contamination by leachates around Olusosun open dumpsite in Lagos metropolis, southwest Nigeria. Journal of environmental management. 2016 Dec 1;183:333-41.

[10] Ji L, Li Y, Zhang G, Bi Y. Anthropogenic disturbances have contributed to degradation of river water quality in arid areas. Water. 2021 Nov 22;13(22):3305.

[11] Poonam T, Tanushree B, Sukalyan C. Water quality indices-important tools for water quality assessment: a review. International Journal of Advances in chemistry. 2013 Nov;1(1):15-28.

[12] Schwarzenbach RP, Egli T, Hofstetter TB, Von Gunten U, Wehrli B. Global water pollution and human health. Annual review of environment and resources. 2010 Nov 21;35(1):109-36.

[13] Fadeyibi A, Halilu A, Osunde ZD. Analysis of physicochemical properties of abattoir wastewater for irrigation in Minna, Niger State.

[14] OSU CI, Ogoko EC. BIOCONCENTRATION AND TRANSFER OF HEAVY METAL FROM SOIL INTO VERNINIA AMYDALINA, TELFERA OCCIDENDALIS, AND AMARATHUS SPINOSUS. Journal of Applied Phytotechnology in Environmental Sanitation. 2014 May 1;3(4).

[15] Moten AM, Rehman A. Study on heavy trace metal ions in industrial waste effluents in Pakistan. Enviromental-expert. com, article-909. 1998.

[16] Lee KK, Park Y, Han SP, Kim HC. The alerting effect from rising public awareness of air quality on the outdoor activities of megacity residents. Sustainability. 2020 Jan 22;12(3):820.

[17] Amakom U. Sanitation Sector Status and Gap Analysis: Nigeria. Report sponsored by the Global Sanitation Fund/Water Supply and Sanitation Collaborative Council. 2009 Sep.

[18] Aziz A, Basheer F, Sengar A, Khan SU, Farooqi IH. Biological wastewater treatment (anaerobic-aerobic) technologies for safe discharge of treated slaughterhouse and meat processing wastewater. Science of the total environment. 2019 Oct 10;686:681-708.

[19] Akhtar N, Syakir Ishak MI, Bhawani SA, Umar K. Various natural and anthropogenic factors responsible for water quality degradation: A review. Water. 2021 Sep 27;13(19):2660.

[20] Edokpayi JN, Odiyo JO, Durowoju OS. Impact of wastewater on surface water quality in developing countries: a case study of South Africa. Water quality. 2017 Jan 18;10(66561):10-5772.

[21] Baskaran V. A systematic review on the role of geographical information systems in monitoring and achieving sustainable development goal 6: Clean water and sanitation. Sustainable Development. 2022 Oct;30(5):1417-25.

[22] Omokaro GO, Idama V, Airueghian EO, Michael I. Water Resources, Pollution, Integrated Management and Practices in Nigeria–An Overview. American Journal of Environmental Economics. 2024 Apr 10;3(1):5-18.

[23] Hillel N, Geyer S, Licha T, Khayat S, Laronne JB, Siebert C. Water quality and discharge of the Lower Jordan River. Journal of Hydrology. 2015 Aug 1;527:1096-105.

[24] Lu Y, Song S, Wang R, Liu Z, Meng J, Sweetman AJ, Jenkins A, Ferrier RC, Li H, Luo W, Wang T. Impacts of soil and water pollution on food safety and health risks in China. Environment international. 2015 Apr 1;77:5-15.

[25] Ogamba CC, Bukar AA. Wastes generated, wastes management in kano abattoir, dala local government area, kano state, nigeria. Fudma Journal of Sciences. 2023 Jul 7;7(3):87-94.

[26] Nandomah S, Tetteh IK. Potential ecological risk assessment of heavy metals associated with abattoir liquid waste: A narrative and systematic review. Heliyon. 2023 Aug 1;9(8).

[27] Sharma P, Dutta D, Udayan A, Nadda AK, Lam SS, Kumar S. Role of microbes in bioaccumulation of heavy metals in municipal solid waste: Impacts on plant and human being. Environmental Pollution. 2022 Jul 15;305:119248.

[28] Agboola OE. Assessment of Physicochemical Properties and Heavy Metals Concentration of Abbatoir Effluent on Oko Oba River in Agege, Lagos Nigeria (Master's thesis, Kwara State University (Nigeria)).

[29] Huang D, Gong X, Liu Y, Zeng G, Lai C, Bashir H, Zhou L, Wang D, Xu P, Cheng M, Wan J. Effects of calcium at toxic concentrations of cadmium in plants. Planta. 2017 May;245:863-73.

[30] Chanpiwat P, Lee BT, Kim KW, Sthiannopkao S. Human health risk assessment for ingestion exposure to groundwater contaminated by naturally occurring mixtures of toxic heavy metals in the Lao PDR. Environmental Monitoring and Assessment. 2014 Aug;186:4905-23.

[31] Gouri H, Bhalla G. Neurotoxic Chemistry: Unraveling the chemical mechanisms connecting environmental toxin exposure to neurological disorders. Journal of Integrated Science and Technology. 2025 Jan 7;13(3):1064-.

[32] Ojeh VN, Balogun AA, Okhimamhe AA. Urban-rural temperature differences in Lagos. Climate. 2016 May 17;4(2):29.

[33] Fatunsin OT, Adetola A, Adetunde OT. Effects of abattoir activities on the water quality of Oko-Oba river in Agege, Lagos, Nigeria: a seasonal variation assessment. Proceedings of the Nigerian Academy of Science. 2021 Jan 1;13(2s).

[34] Nasiru A, Osakwe CE, Lawal IM, Chinade AU. Assessment of physicochemical parameters and heavy metals in Gombe abattoir wastewater. Am. J. Eng. Res. 2016;5(3):64-9.

[35] Fadeyibi A, Halilu A, Osunde ZD. Analysis of physicochemical properties of abattoir wastewater for irrigation in Minna, Niger State.

[36] Edition F. Guidelines for drinking-water quality. WHO chronicle. 2011;38(4):104-8.

[37] FEPA/FMENV, Federal Environmental Protection Agency (FEPA) Guidelines and Standards for Environmental Pollution Control in Nigeria (1991)., FEPA, Lagos, 13-94.

[38] Nasiru A, Osakwe CE, Lawal IM, Chinade AU. Assessment of physicochemical parameters and heavy metals in Gombe abattoir wastewater. Am. J. Eng. Res. 2016;5(3):64-9.

[39] Ekanem KV, Chukwuma GO, Ubah JI. Determination of the physicochemical characteristics of effluent discharged from Karu abattoir. International Journal of Science and Technology. 2016 Feb;5(2):43-51.

[40] Adeniyi A, Yusuf K, Okedeyi O, Sowemimo M. Classification and health risk assessment for borehole water contaminated by metals in selected households in Southwest Nigeria. Journal of Water Resource and Protection. 2016 Apr 12;8(4):459-71.

[41] Akanni A, Ogbiye A, Onakunle O. The Impact assessment of abattoir waste facility discharge on water in Osogbo, Nigeria. Cogent Engineering. 2019 Jan 1;6(1):1614317.

[42] Orisakwe OE, Igwilo IO, Afonne OJ, Maduabuchi JM, Obi E, Nduka JC. Heavy metal hazards of sachet water in Nigeria. Archives of environmental & occupational health. 2006 Sep 1;61(5):209-13.

[43] Ogamba CC, Bukar AA. Wastes generated, wastes management in kano abattoir, dala local government area, kano state, nigeria. Fudma Journal of Sciences. 2023 Jul 7;7(3):87-94.

[44] Laniyan TA, Bayewu OO, Ariyo SO. Heavy metal characteristics of groundwater in Ibadan South Western, Nigeria. African Journal of Environmental Science and Technology. 2013 Sep 9;7(7):641-7.

[45] Akan JC, Abdulrahman FI, Yusuf E. Physical and chemical parameters in abattoir wastewater sample, Maiduguri Metropolis, Nigeria. The Pacific Journal of Science and Technology. 2010;11(1):640-8.

[46] Osibanjo O, Adie GU. Impact of effluent from Bodija abattoir on the physicochemical parameters of Oshunkaye stream in Ibadan City, Nigeria. African Journal of Biotechnology. 2007;6(15).

[47] World Health Organization. Guidelines for drinking-water quality. World Health Organization; 2002.