# Hydro-Environmental Implications of Slaughterhouse Wastewater Disposal: Surface Water Degradation and Groundwater Vulnerability in an Urbanizing Tropical Catchment

Tolulope Oyewumi Ajao[1*]; Oluwatunmise Peter Abolarin[2]; Praise Adenike Alli[3]; Adebola Saheed Akolade[4]; Tolulope Adelola Akintunde[5]; Adekunle Dare Joseph[6]

[1,6]Department of Civil Engineering, Faculty of Engineering and the Polytechnic, Ibadan, Ibadan, Nigeria
[2,3,4,5]Department of Civil Engineering, Faculty of Engineering and Technology Lead City University, Ibadan, Nigeria.

[1](ORCID ID- 0009-0004-6152-7225)
[2](ORCID ID- 0009-0002-3884-4105)
[3](ORCID ID- 0009-0003-2491-1298)
[4](ORCID ID- 0000-0002-6654-6706)
[5](ORCID ID- 0009-0006-8398-7016)
[6](ORCID ID- 0009-0006-9750-6682)

Corresponding Author: Tolulope Oyewumi Ajao[1*]

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**Abstract: Untreated slaughterhouse wastewater represents a significant source of environmental pollution in many developing countries, posing serious risks to surface-water quality, groundwater resources, and public health. This study investigated the hydro-environmental implications of wastewater disposal from Akinyele Central Abattoir, Ibadan, Nigeria, with particular emphasis on surface-water degradation and groundwater vulnerability within an urbanizing tropical catchment. Wastewater, surface-water, and groundwater samples were collected from six strategically selected locations comprising the effluent discharge point, downstream receiving waters, and nearby wells. Physicochemical parameters including pH, temperature, electrical conductivity, turbidity, and biochemical oxygen demand ($BOD_5$), together with microbiological assessment of *Escherichia coli*, were analyzed using standard methods and compared with World Health Organization guideline values. Operational assessment indicated that the facility processes approximately 550 cattle and 450 goats daily and generates an estimated 24.05 $m^3$ of wastewater per day, equivalent to about 8,778.25 $m^3$ annually. Results revealed considerable deterioration of water quality, with $BOD_5$ values ranging from 115 to 643 mg/L and *E. coli* counts ranging from 4 to 1600 MPN/100 mL, exceeding permissible limits in all sampled locations. Surface-water samples exhibited elevated turbidity (35.9–42.1 NTU), while groundwater samples showed increased electrical conductivity values of up to 1452 µS/cm, indicating contaminant migration into subsurface water systems. The findings demonstrate that untreated abattoir effluent poses substantial threats to water-resource sustainability, ecosystem integrity, and public health. The study highlights the urgent need for effective wastewater treatment, continuous environmental monitoring, and improved waste management practices to enhance the sustainability of slaughterhouse operations in rapidly urbanizing tropical environments.**

***Keywords:*** *Abattoir Wastewater; Groundwater Vulnerability; Surface-Water Degradation; Hydro-Environmental Impacts; Tropical Catchment.*

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# I. INTRODUCTION

Water pollution remains one of the most significant environmental challenges worldwide, affecting ecosystem integrity, public health, and socio-economic development. Increasing urbanization, industrialization, agricultural intensification, and inadequate wastewater management have contributed substantially to the deterioration of surface and groundwater quality in many regions of the world. The decline in water quality has further intensified global water scarcity, as a considerable proportion of available freshwater resources become unsuitable for domestic, agricultural, and industrial uses without prior treatment (Ungureanu *et al.*, 2020; Kandou *et al.*, 2023). The growing demand for freshwater resources, coupled with increasing pollutant loads from anthropogenic activities, poses serious threats to rivers, lakes, estuaries, and groundwater systems. Water quality degradation adversely affects human health, biodiversity conservation, agricultural productivity, and industrial development. Consequently, sustainable management of wastewater has become a critical component of global water resource management strategies, particularly in developing countries where wastewater treatment infrastructure remains inadequate (Kandou *et al.*, 2023; Costa *et al.*, 2024). Among the industries contributing significantly to wastewater generation is the livestock processing sector. Abattoirs play an essential role in ensuring food security by supplying meat and meat products for human consumption while providing employment opportunities throughout the livestock value chain. However, slaughterhouse operations require substantial quantities of water for animal washing, slaughtering, carcass dressing, equipment cleaning, and facility sanitation. These activities generate large volumes of wastewater characterized by high concentrations of organic matter, nutrients, suspended solids, fats, oils, grease, and pathogenic microorganisms (Musa & Idrus, 2021; Pereira *et al.*, 2024). In many developing countries, abattoir wastewater is often discharged directly into nearby rivers, streams, drainage channels, and other receiving water bodies without adequate treatment. Such practices contribute to environmental pollution and increase the risk of waterborne diseases among surrounding communities. The improper disposal of slaughterhouse wastes can introduce pathogenic microorganisms, excess nutrients, and organic pollutants into aquatic environments, thereby degrading water quality and threatening public health (Olusola-Makinde, 2023; Abasi *et al.*, 2024). Studies have shown that abattoir effluents may contain significant populations of pathogenic microorganisms, including *Escherichia coli*, *Salmonella* spp., *Shigella* spp., and other enteric pathogens capable of causing severe gastrointestinal infections and other health complications. The contamination of both surface and groundwater resources by untreated slaughterhouse wastewater therefore represents a major environmental and public health concern, particularly in communities that rely on these water sources for domestic purposes (Olusola-Makinde, 2023; Gufe *et al.*, 2025). Like many agro-industrial operations, slaughterhouses are associated with considerable environmental management challenges. These include high water consumption, elevated organic loading, nutrient enrichment, unpleasant odors, greenhouse gas emissions, and the generation of substantial quantities of solid and liquid wastes. The wastewater generated from slaughterhouse activities is particularly problematic because of its high biochemical oxygen demand ($BOD_5$), chemical oxygen demand (COD), suspended solids, and microbial content. If discharged untreated, these pollutants can deplete dissolved oxygen in receiving water bodies, disrupt aquatic ecosystems, and impair water quality (Musa & Idrus, 2021; Pereira *et al.*, 2024). Recent investigations have further highlighted the environmental risks associated with slaughterhouse wastewater, including the accumulation of heavy metals, antibiotic-resistant bacteria, and other emerging contaminants in aquatic environments. These pollutants may persist in ecosystems and pose long-term ecological and human health risks if not properly managed (Nandomah & Tetteh, 2023; Gufe *et al.*, 2025). Furthermore, slaughterhouse wastewater has been reported to contain exceptionally high concentrations of organic matter derived from blood, animal tissues, fats, and gastrointestinal contents, making it one of the most polluting agro-industrial effluents generated globally (Pereira *et al.*, 2024). Given the increasing concerns regarding environmental sustainability and public health protection, there is a need to continuously assess the management of abattoir wastewater and its impacts on surrounding ecosystems. Given the increasing pressures of urbanization, water resource degradation, and environmental sustainability challenges in tropical catchments, there is a critical need to understand the hydro-environmental consequences of untreated slaughterhouse wastewater disposal. This study investigates the hydro-environmental implications of wastewater discharge from Akinyele Central Abattoir, Ibadan, Nigeria, with particular emphasis on surface water degradation and groundwater vulnerability. Through physicochemical and microbiological assessments, the study evaluates the extent of water quality deterioration and the potential risks posed to environmental integrity and public health within the receiving catchment.

➢ *Study Area*

This study was conducted at the Central Abattoir located in Amosun Village, within Akinyele Local Government Area, Ibadan, Oyo State, Nigeria. The study area lies approximately between latitude 7°20′N and longitude 3°05′E and forms part of the Ibadan metropolitan region, one of the largest urban centers in southwestern Nigeria. According to the National Population Commission (NPC, 2006), Ibadan had a population exceeding three million people during the 2006 national census, with subsequent growth driven by urbanization and economic expansion. The Central Abattoir is strategically located along the Ibadan–Oyo Expressway and serves as the principal slaughter facility

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for the eleven local government areas within the Ibadan metropolis. The facility was established by the Oyo State Government to centralize meat processing activities and improve sanitary conditions associated with animal slaughter and meat handling within the city (Oyo State Ministry of Agriculture, Natural Resources and Rural Development [OYSMANR&RD], n.d.). The relocation of butchers from existing slaughter facilities, including Bodija, Aleshiloye, Gege, Monatan, and Onibu-Ore abattoirs, was officially implemented in 2018 to promote hygienic meat production and strengthen regulatory oversight of slaughter operations (Independent Newspaper, 2018; Channels Television, 2018).

The abattoir occupies approximately 10 hectares of land and is equipped with facilities designed to support large-scale livestock processing operations. Available infrastructure includes cattle holding pens with a capacity of approximately 5,000 animals, lairage facilities, slaughter slabs, a dedicated goat section capable of accommodating about 300 goats, veterinary inspection units, administrative offices, and security posts (OYSMANR&RD, n.d.). These facilities were established to ensure efficient slaughter operations, proper meat inspection, environmental sanitation, and public health protection.

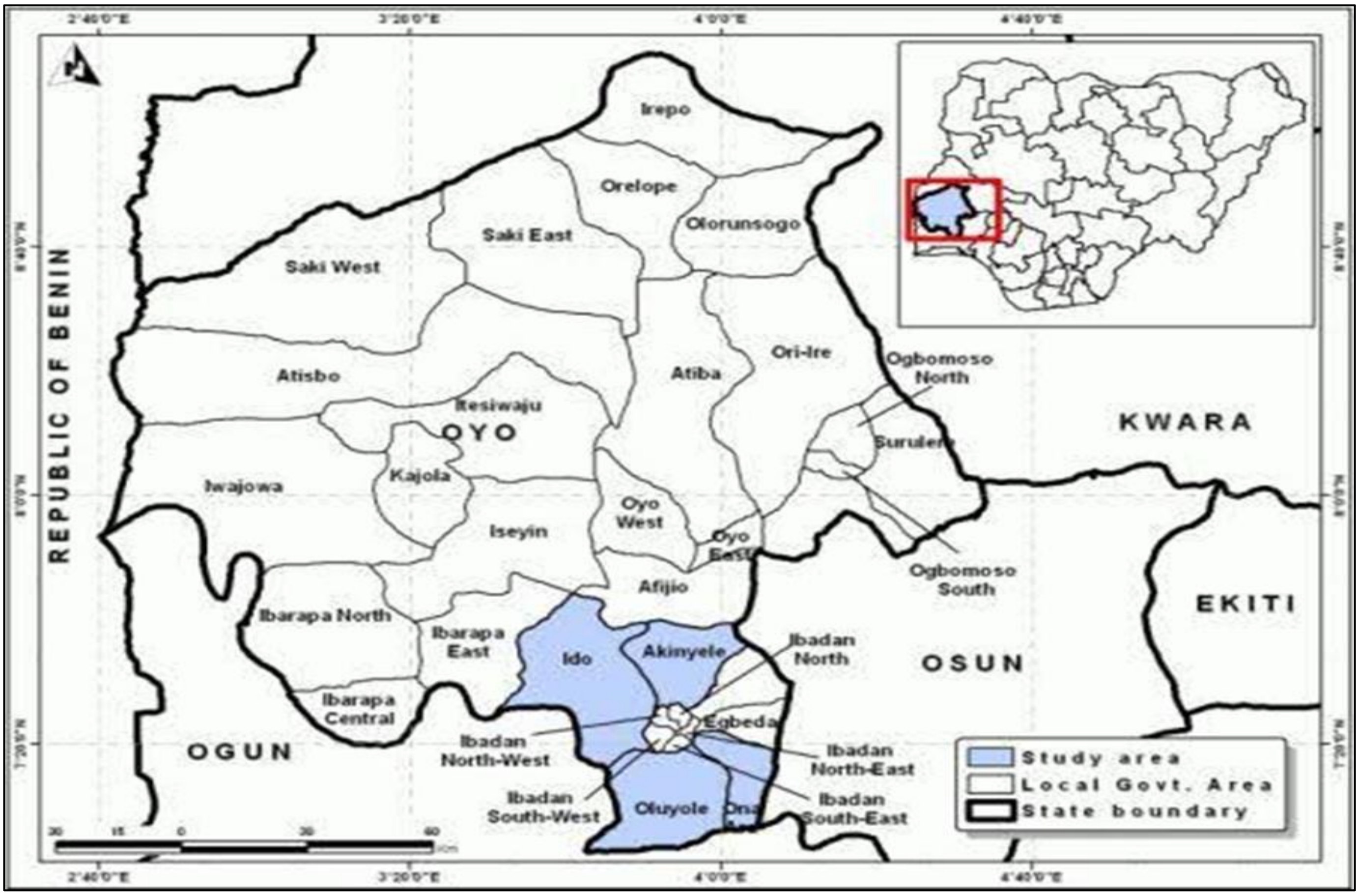

Fig 1 (Map of the Study Area Showing Akinyele Local Government Area, Oyo State, Nigeria.)
Source: Adapted from Akinosun, Olojede, Atoyebi, and Oyelere (2025), Based on National Space Research and Development Agency (NASRDA) Geospatial Data.

## II. METHODOLOGY

➢ *Sample Design and Collection*

Wastewater, surface water, and groundwater samples were collected to evaluate the hydro-environmental impacts of untreated slaughterhouse effluent disposal within the Akinyele catchment, Ibadan, Nigeria. The sampling design was developed to characterize contaminant transport pathways and assess the susceptibility of adjacent surface-water and groundwater systems to pollution arising from abattoir operations. Six strategically selected monitoring locations were established, encompassing the effluent discharge point, downstream receiving waters, and groundwater sources within the zone of potential influence. This integrated sampling approach facilitated the evaluation of spatial variations in water quality and provided insights into the extent of surface water degradation and groundwater vulnerability within a rapidly urbanizing tropical environment.

- *The Sampling Locations were Designated as Follows:*

✓ Sample A: Wastewater collected directly at the effluent discharge point of the abattoir.
✓ Sample B1: Surface water sample collected 30 m downstream from the effluent discharge point within the receiving stream.

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- ✓ Sample B2: Surface water sample collected 30 m downstream from Sample B1 (60 m from the discharge point).
- ✓ Sample C1: Groundwater sample collected from a well located within the abattoir premises.
- ✓ Sample C2: Groundwater sample collected from a well located within Akinyele Community approximately 30 m from the receiving stream.
- ✓ Sample C3: Groundwater sample collected from another well located approximately 30 m from Sample C2 and 60 m from Sample C1.

The sampling arrangement was designed to evaluate changes in water quality with increasing distance from the effluent discharge point and to determine the potential influence of abattoir wastewater on nearby groundwater resources. Similar sampling approaches have been adopted in recent studies assessing the environmental impacts of slaughterhouse wastewater on surface and groundwater quality (Pereira *et al.,* 2024; Gufe *et al.,* 2025). Prior to sample collection, all sampling containers were thoroughly washed, rinsed with distilled water, and properly labeled to prevent contamination. Wastewater and water samples were collected in clean 1-L polyethylene bottles following standard sampling protocols for environmental water quality assessment. Samples were preserved immediately after collection and transported under cooled conditions to the laboratory for analysis. Sample collection, preservation, transportation, and handling procedures were carried out in accordance with the latest Standard Methods for the Examination of Water and Wastewater (Baird *et al.,* 2023). Wastewater samples were collected during active abattoir operations over a four-hour sampling period between 09:00 and 13:00 h to obtain representative wastewater characteristics during peak slaughter activities. Samples were obtained from the influent wastewater stream, effluent discharge point, and receiving surface water body to evaluate the quality of wastewater generated and discharged into the environment.

➢ *Laboratory Analysis*

A sample volume of 1 L was collected from each sampling point for physicochemical and microbiological analyses. The collected samples were analyzed at the Public Health Laboratory, College of Medicine, University College Hospital (UCH), Ibadan, Nigeria. The parameters analyzed included pH, temperature, electrical conductivity, turbidity, biochemical oxygen demand ($BOD_5$), and *Escherichia coli* (E. coli). The analyzed parameters are presented in Table 2. These parameters were selected because they are widely recognized indicators of wastewater pollution and environmental contamination associated with slaughterhouse activities (Pereira *et al.,* 2024; Gufe *et al.,* 2025). Physicochemical and microbiological analyses were conducted in accordance with the procedures outlined in the latest edition of Standard Methods for the Examination of Water and Wastewater (Baird *et al.,* 2023). The analytical procedures ensured the accuracy, reliability, and comparability of the results obtained.

➢ *Data Analysis*

Measured values of the physicochemical and microbiological parameters were compared with the permissible limits specified by the Federal Ministry of Environment (FMEnv) and the World Health Organization (WHO) guidelines for wastewater discharge and drinking water quality. The results were presented using tables to facilitate the assessment of wastewater characteristics and the environmental impacts associated with abattoir wastewater discharge. The observed results among sampling locations were used to evaluate the extent of contamination and the potential influence of wastewater discharge on surrounding surface and groundwater resources.

## III. RESULTS AND DISCUSSIONS

➢ *Results*

Data for this study were collected during the pre-slaughter, slaughter, and post-slaughter operations at Akinyele Central Abattoir, Ibadan. The assessment focused on operational parameters including the number of animals processed daily, daily water consumption, and the volume of wastewater generated. These parameters were used to evaluate wastewater generation patterns and the environmental implications of abattoir activities (John *et al.*, 2025; Ozcan & Kucukcongar, 2026).

➢ *Number of Animals Slaughtered per Day*

Analysis of slaughter records obtained during the study period (March 2026–May 2026) showed that the abattoir processed an average of approximately 550 cattle and 450 goats per day. The number of animals slaughtered varied throughout the study period, reflecting fluctuations in market demand and seasonal consumption patterns. Increased slaughter activities were particularly observed during festive and religious celebrations such as Eid-ul-Fitr, Easter, and Christmas, which are traditionally associated with higher meat consumption. The observed slaughter rates indicate a substantial throughput capacity and suggest a corresponding increase in water demand and wastewater generation. Similar studies have reported that slaughterhouse operations generate large volumes of wastewater due to intensive washing, carcass processing, cleaning, and sanitation activities. Recent research has emphasized that slaughterhouse wastewater is characterized by high organic loads, suspended solids, fats, proteins, and nutrients, making effective management essential for environmental protection (Mohamed *et al.*, 2025; Ozcan & Kucukcongar, 2026). Table 1 presents the monthly slaughter records obtained during the study period.

➢ *Determination of Average Daily Slaughter Rate*

Daily slaughter data were obtained from the official records maintained by the Veterinary Inspection Unit of Akinyele Central Abattoir. The records documented the number of cattle and goats slaughtered each day over a three-month period (March–May 2026). Monthly averages were subsequently calculated and used to determine the average daily slaughter rate for the facility. The use of official slaughter records provided a reliable basis for estimating livestock processing capacity and assessing its relationship with water consumption and wastewater generation. Accurate

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determination of slaughter rates is essential for designing appropriate wastewater management systems and estimating pollutant loading associated with abattoir operations. Recent studies have highlighted the importance of operational monitoring in improving wastewater treatment efficiency and environmental compliance within slaughterhouse facilities (John *et al.*, 2025; Letah Nzouebet *et al.*, 2025; Cortheo *et al.*, 2026).

Table 1 Average Daily Slaughter Rate at Akinyele Abattoir

| Month | Number of Cattle Slaughtered | Average per Day | Number of Goats Slaughtered | Average per Day |
|---|---|---|---|---|
| March 2026 | 16,800 | 542 | 13,950 | 450 |
| April 2026 | 17,250 | 557 | 14,100 | 455 |
| May 2026 | 16,500 | 550 | 13,500 | 450 |
| Average | - | 550 | - | 452 ≈ 450 |

➢ *Water Consumption Rate*

Water consumption was estimated by measuring the storage capacity of the water tanks supplying the abattoir and monitoring the frequency of refilling during daily operations. The facility utilizes two overhead tanks with a combined storage capacity of 5,000 L each, resulting in an estimated daily water consumption of approximately 10,000 L/day (10 m³/day).

➢ *Determination of Water Consumption Rate*

Water consumption at Akinyele Abattoir was estimated from the storage capacity of the raw water tanks supplying the facility. Field observations showed that the abattoir utilizes two overhead water tanks, each having a storage capacity of 5,000 L. Therefore, the total water storage capacity available daily is:

Total water volume = Number of tanks × Capacity per tank

= 2 × 5,000 L

= 10,000 L/day

= 10 m³/day

Thus, the estimated daily water consumption at the abattoir is approximately 10,000 L/day (10 m³/day).

➢ *Wastewater Volume Generated*

The quantity of wastewater generated at Akinyele Abattoir was estimated using a water balance approach, which assumes that wastewater originates from animal processing activities, cleaning operations, and sanitary uses within the facility. Similar approaches have been adopted in recent slaughterhouse wastewater studies for estimating wastewater production from abattoir operations. Slaughterhouse wastewater generation is strongly dependent on the number of animals processed, water consumption patterns, and the efficiency of waste separation practices. Recent reviews have reported that a significant proportion (82–98%) of the water used in slaughterhouse operations is eventually discharged as wastewater (Kumari *et al.*, 2024; Moyo *et al.*, 2025).

The daily wastewater generation was estimated using:

$$Qw = Qc + Qg + Qh$$

Where:

- $Qw$ = total wastewater generated (L/day)
- $Qc$ = wastewater generated from cattle slaughter and processing activities (L/day)
- $Qg$ = wastewater generated from goat/sheep slaughter and processing activities (L/day)
- $Qh$ = wastewater generated from washing, cleaning, and sanitary operations within the abattoir (L/day)

The average daily slaughter rate obtained from abattoir records was 550 cattle and 450 goats. Water-use surveys in slaughter facilities indicate that small-ruminant processing consumes substantial quantities of water during evisceration and carcass cleaning, while cattle slaughter operations require larger volumes because of carcass size and washing requirements (Ibrahim *et al.*, 2025). Based on field observations and operational records at the abattoir, wastewater generated from slaughter activities was estimated using average waste and wash-water contributions of 20 L per cattle and 9 L per goat.

For cattle slaughter:

$$Qc = 550 \times 20$$

$$Qc = 11{,}000 \text{ L/day}$$

For goat slaughter:

$$Qg = 450 \times 9$$

$$Qg = 4{,}050 \text{ L/day}$$

Total wastewater generated from animal processing:

$$Qc + Qg = 15{,}050 \text{ L/day}$$

The daily water consumption at the abattoir was estimated at 10,000 L/day from the storage capacities of the water tanks supplying the facility. Assuming approximately 10% losses through evaporation, splashing, and other operational uses, the effective process wastewater contribution was estimated as:

$$Qh = 10{,}000 - 1{,}000$$

$$Qh = 9{,}000 \text{ L/day}$$

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Therefore,

$$Qw = 11{,}000 + 4{,}050 + 9{,}000$$

$$Qw = 24{,}050 \text{ L/day}$$

$$Qw = 24.05 \text{ m}^3\text{/day}$$

Thus, approximately 24.05 m³ of wastewater is generated and discharged daily from the abattoir.

The annual wastewater generation was estimated as:

$$24.05 \times 365 = 8{,}778.25 \text{ m}^3\text{/year}$$

Therefore, the total annual wastewater generation at Akinyele Abattoir was estimated as 8,778.25 m³/year. Therefore, approximately 8,778.25 m³ of wastewater is discharged yearly into Amosun river untreated.

Table 2 Laboratory Results of Analysis Conducted on Samples Collected at Different Locations in and Around the Abattoir.

| Parameter | Sample C1 | Sample C2 | Sample C3 | Sample B1 | Sample B2 | Sample A | WHO |
|---|---|---|---|---|---|---|---|
| pH | 6.80 | 6.63 | 6.42 | 5.59 | 5.73 | 5.97 | 6.5 – 9.0 |
| Electrical Conductivity (µS) | 667 | 449 | 1452 | 2.59 | 2.43 | 17.89 | 400 |
| Temperature $^{O}$C | 25.0 | 26.0 | 25.0 | 28.1 | 29.0 | 28.3 | 40.00 |
| Turbidity (NTU) | 4.02 | 2.56 | 2.98 | 35.9 | 42.1 | 38.0 | 10 |
| $BOD_5$ (Mg/L) | 123 | 115 | 136 | 456 | 521 | 643 | 2.4 |
| E.coli (MPN) | 9 | 12 | 4 | 900 | 900 | 1600 | 0 |

➤ *Discussions*

- *Physicochemical Parameters pH*

The analyzed parameters are presented in Table 2, the pH values of the analyzed samples ranged from 5.59 to 6.80. The groundwater samples (C1 = 6.80, C2 = 6.63, and C3 = 6.42) were generally closer to the WHO recommended range of 6.5–9.0, whereas the surface-water samples and raw effluent (B1 = 5.59, B2 = 5.73, and A = 5.97) exhibited slightly acidic conditions. The relatively low pH recorded in Sample A indicates the presence of acidic substances in the untreated abattoir effluent, which may originate from blood decomposition, organic waste degradation, and detergents used during carcass washing and facility cleaning. The acidic nature of the discharged effluent appears to have influenced the pH of the receiving surface water, as reflected by the lower values observed in Samples B1 and B2. Similar observations have been reported in recent studies where slaughterhouse wastewater altered the pH characteristics of receiving water bodies due to the discharge of organic-rich effluents (Pereira *et al.,* 2024).

- *Electrical Conductivity (EC)*

The electrical conductivity values reported in Table 2 ranged from 2.43 to 1452 µS/cm. Sample C3 recorded the highest EC value (1452 µS/cm), followed by C1 (667 µS/cm) and C2 (449 µS/cm), all of which exceeded the WHO guideline value of 400 µS/cm. Conversely, Samples A (17.89 µS/cm), B1 (2.59 µS/cm), and B2 (2.43 µS/cm) remained below the permissible limit. The elevated conductivity observed in the groundwater samples suggests the presence of dissolved ions and mineral constituents that may have accumulated through infiltration processes. The exceptionally high EC value observed in Sample C3 may indicate prolonged interaction between groundwater and dissolved contaminants originating from abattoir activities. According to (Pereira *et al*. 2024), elevated conductivity in areas surrounding slaughterhouses is often associated with dissolved organic and inorganic pollutants released during animal processing operations.

- *Temperature*

The analyzed parameters presented in Table 2, ranged from 25.0°C to 29.0°C, which are all below the WHO permissible limit of 40°C. The highest temperatures were recorded in Samples B2 (29.0°C), B1 (28.1°C), and A (28.3°C), whereas the groundwater samples recorded relatively lower temperatures between 25°C and 26°C. The slightly elevated temperatures observed around the discharge point may be attributed to slaughterhouse operations such as hide burning, scalding, and washing activities. Although all measured temperatures were within acceptable limits, elevated temperatures can enhance microbial activity and accelerate the decomposition of organic matter within receiving water bodies. Similar temperature ranges have been reported in recent investigations of slaughterhouse wastewater systems (Mohamed *et al.,* 2025).

- *Turbidity*

The turbidity values presented in Table 2 revealed substantial differences between surface-water and groundwater samples. Samples B1 (35.9 NTU), B2 (42.1 NTU), and A (38.0 NTU) greatly exceeded the WHO permissible limit of 10 NTU, whereas groundwater samples C1 (4.02 NTU), C2 (2.56 NTU), and C3 (2.98 NTU) remained within acceptable levels. The high turbidity observed in the raw effluent and receiving surface water indicates the presence of suspended solids, blood particles, fats, tissue debris, and other organic materials generated during slaughtering activities. Notably, turbidity increased from the discharge point (38.0 NTU) to Sample B2 (42.1 NTU), suggesting continued transport of suspended materials along the wastewater flow path. The much lower turbidity levels recorded in groundwater samples suggest that soil filtration processes may have reduced the concentration of suspended particles before infiltration into underground water sources. Similar findings have been reported by Pereira *et al.* (2024), who identified high turbidity as a characteristic feature of untreated slaughterhouse effluents.

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- *Biochemical Oxygen Demand ($BOD_5$)*

The Biochemical Oxygen Demand ($BOD_5$) values shown in Table 2 ranged from 115 to 643 mg/L, with all samples exceeding the WHO recommended limit of 2.4 mg/L. The highest value was recorded in Sample A (643 mg/L), followed by B2 (521 mg/L) and B1 (456 mg/L). Even the groundwater samples C1 (123 mg/L), C2 (115 mg/L), and C3 (136 mg/L) exhibited values far above the permissible limit. These results indicate significant organic pollution within both surface-water and groundwater systems surrounding the abattoir. The extremely high Biochemical Oxygen Demand ($BOD_5$) values observed in the effluent and receiving stream are likely attributable to the discharge of blood, fats, proteins, rumen contents, and other biodegradable organic materials. The persistence of elevated Biochemical Oxygen Demand ($BOD_5$) levels in groundwater samples further suggests contamination of underground water sources. Recent studies have consistently reported that slaughterhouse wastewater possesses exceptionally high organic loads and oxygen demand because of the large quantities of biodegradable waste generated during processing operations (Pereira *et al.,* 2024; Ozcan & Kucukcongar, 2026). The results therefore indicate that wastewater discharged from Akinyele Abattoir contributes significantly to oxygen depletion and organic pollution in the surrounding aquatic environment.

➢ *Biological Parameter*

- *Escherichia Coli (E. Coli)*

The microbiological results presented in Table 2 show that E. coli counts ranged from 4 to 1600 MPN/100 mL, with all samples exceeding the WHO guideline value of zero. The highest count was observed in the raw effluent sample (A = 1600 MPN/100 mL), followed by the surface-water samples B1 and B2, which both recorded 900 MPN/100 mL. Although lower counts were observed in groundwater samples C1 (9 MPN/100 mL), C2 (12 MPN/100 mL), and C3 (4 MPN/100 mL), their presence still indicates microbial contamination of groundwater resources. The exceptionally high E. coli counts recorded in the effluent and receiving stream suggest significant fecal contamination resulting from slaughterhouse activities, particularly the handling of intestinal contents and animal wastes. The reduction in bacterial counts observed in groundwater samples may be attributed to natural filtration processes occurring within soil layers. However, the detection of E. coli in all groundwater samples indicates that contamination has extended beyond the surface-water environment and may pose a serious public-health risk to residents relying on these wells for domestic water supply. The findings demonstrate that wastewater discharge from the abattoir has adversely affected both surface-water and groundwater quality. This observation agrees with recent studies which identify untreated abattoir wastewater as a major source of pathogenic microorganisms and antimicrobial-resistant bacteria in surrounding aquatic environments (Gufe *et al.,* 2025). The presence of E. coli in drinking-water sources is of particular concern because pathogenic strains can cause severe gastrointestinal infections, hemorrhagic colitis, hemolytic uremic syndrome, and other waterborne diseases.

# IV. CONCLUSION

The findings of this study reveal significant hydro-environmental consequences associated with the disposal of untreated slaughterhouse wastewater from Akinyele Central Abattoir, Ibadan, Nigeria. The physicochemical and microbiological characteristics of the analyzed samples indicate substantial deterioration of both surface-water and groundwater quality within the receiving catchment. Several key water quality indicators, including pH, turbidity, biochemical oxygen demand ($BOD_5$), and *Escherichia coli* concentrations, exceeded the permissible limits prescribed by the World Health Organization (WHO), demonstrating the adverse influence of abattoir effluent on surrounding aquatic systems. The elevated Biochemical Oxygen Demand ($BOD_5$) concentrations observed in both surface-water and groundwater samples reflect a high organic pollution burden resulting from the discharge of blood, animal tissues, fats, intestinal contents, and other biodegradable wastes generated during slaughtering operations. The persistence of elevated pollutant levels beyond the discharge point indicates the transport of contaminants through surface-water pathways, contributing to progressive degradation of the receiving aquatic environment. Furthermore, the detection of *E. coli* in all groundwater samples highlights the vulnerability of subsurface water resources to contamination and suggests the possible migration of microbial pollutants through soil and groundwater flow pathways. The results demonstrate that untreated wastewater disposal from slaughterhouse operations represents a significant threat to water-resource sustainability, ecosystem integrity, and public health within rapidly urbanizing tropical catchments. The contamination of both surface-water and groundwater resources is particularly concerning in communities where these water sources serve as important supplies for domestic and other beneficial uses. Continued discharge of untreated effluent may exacerbate water quality deterioration, increase the risk of waterborne diseases, and undermine long-term environmental resilience. The study further identifies critical shortcomings in existing wastewater management practices at the abattoir, particularly the absence of effective treatment infrastructure and inadequate waste segregation measures. Addressing these challenges requires the adoption of an integrated wastewater management framework that incorporates efficient wastewater treatment technologies, source separation of blood and animal by-products, routine environmental monitoring, and strict enforcement of environmental regulations. Such interventions are essential for reducing pollutant loading, limiting contaminant migration, protecting vulnerable groundwater systems, and enhancing the ecological sustainability of receiving water bodies. Consequently, this study provides valuable insights into the hydro-environmental implications of slaughterhouse wastewater disposal in developing urban environments and highlights the urgent need for sustainable wastewater management strategies to safeguard water quality, public health, and environmental sustainability in tropical catchments undergoing rapid urbanization.

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## RECOMMENDATION

The findings of this study underscore the urgent need for improved wastewater management practices at Akinyele Central Abattoir. A functional wastewater treatment system should be established to ensure that slaughterhouse effluents are adequately treated before discharge into the receiving environment. Proper segregation and management of blood, rumen contents, animal by-products, and other solid wastes generated during slaughter operations should also be encouraged to minimize the organic and microbial pollution load entering surrounding water bodies. Regular monitoring of both surface-water and groundwater quality within the catchment is essential for early detection of contamination and for safeguarding public health. Furthermore, appropriate setback distances should be maintained between wastewater disposal areas and groundwater sources to reduce the risk of contaminant migration into subsurface water systems. Environmental regulatory agencies should strengthen compliance monitoring and enforce existing wastewater discharge standards to ensure sustainable environmental practices. Continuous training of abattoir personnel on modern sanitation procedures, waste management techniques, and environmental protection practices will further improve operational efficiency and minimize adverse environmental impacts. In addition, further investigations into seasonal variations in water quality and the occurrence of emerging contaminants are recommended to support long-term environmental management. Collectively, these measures will contribute to the protection of water resources, preservation of ecosystem integrity, improvement of public health, and promotion of sustainable slaughterhouse operations within rapidly urbanizing tropical catchments.

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