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How to Manage Abattoir Wastewater through Community Service: Environmental Assessment, Heavy-Metal Risks, and Proposed Conventional Treatment Strategy

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ABSTRACT

Untreated abattoir wastewater can create environmental and public-health problems when discharged directly into surrounding land and water systems. This study assessed wastewater from the Dikumari abattoir in Damaturu, Nigeria, and interpreted the findings through a community-service perspective. Physicochemical parameters, inorganic ions, and selected heavy metals were analyzed and compared with regulatory benchmarks. The results identified turbidity and heavy-metal contamination as the main environmental concerns, while several other parameters remained within the applied limits. Based on these findings, a community-oriented management strategy was proposed, combining environmental awareness, routine monitoring, stakeholder participation, and conventional treatment involving screening, coagulation-flocculation, sedimentation, filtration, and optional disinfection. The study demonstrates how environmental assessment can support practical wastewater management and community-based environmental action.

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1. INTRODUCTION

Abattoirs play an important role in urban food systems by providing meat products, employment, and economic activities [1]. However, slaughtering and meat-processing operations also generate large quantities of liquid waste containing blood, fats, gastrointestinal contents, urine, fecal materials, suspended solids, and cleaning residues. When these wastes are discharged without adequate treatment, they can create serious environmental problems in surrounding soil and water systems. Previous studies in Nigeria have demonstrated that abattoir effluent can contribute substantial pollution loads and reduce the quality of receiving environments [2, 3].

Wastewater generated from slaughterhouse operations is generally characterized by high organic loading, suspended matter, nutrients, and other contaminants. Reviews of slaughterhouse wastewater have shown that its composition depends on animal type, slaughtering practices, water consumption, cleaning procedures, and waste-management systems [4]. High-strength wastewater can increase oxygen demand, generate unpleasant odors, promote microbial activity, and reduce the environmental quality of receiving waters. These characteristics make wastewater treatment an important component of sustainable abattoir management.

The environmental consequences become more serious when wastewater is discharged directly onto open land. In the Dikumari area of Damaturu, wastewater from slaughtering activities is released through an open drainage system onto unlined surrounding terrain. The field assessment indicates that the facility lacks adequate effluent-treatment infrastructure and that nearby land and groundwater resources may therefore be vulnerable to contamination. Such conditions demonstrate that abattoir wastewater management is not only an engineering issue but also a community and environmental-health concern.

Wastewater treatment can involve physical, biological, and integrated processes. Conventional treatment approaches include screening, sedimentation, biological degradation, anaerobic treatment, stabilization ponds, and filtration [4-7]. Appropriate technology selection depends on wastewater characteristics, treatment objectives, operating cost, technical capacity, and local infrastructure. For communities with limited resources, treatment systems should ideally be technically simple, affordable, and understandable to local operators and stakeholders.

Simple water-treatment technologies may also have value in community-oriented environmental programs. Conventional filtration systems have been demonstrated as practical approaches for improving water quality in rural areas [8]. Such technologies provide useful examples of how relatively low-complexity treatment concepts can be introduced to communities as part of environmental education and local capacity building. More advanced water-treatment approaches based on particle and catalyst technologies have also been reviewed for pollutant-removal applications [9], indicating that treatment options can range from simple filtration to more sophisticated technologies depending on local requirements and available resources. However, technical intervention alone may not be sufficient. Environmental management depends substantially on awareness, participation, behavioral change, and communication among facility operators, nearby residents, regulators, researchers, and local authorities. Community-service activities can help translate laboratory findings into understandable environmental information and practical recommendations.

This approach is particularly relevant when pollution sources are closely connected with community livelihoods and everyday economic activities.

Community empowerment has been associated with improved environmental responsibility and waste-management practices. Community-based programs addressing responsible production, waste reduction, and Sustainable Development Goals (SDGs) demonstrate that environmental problems can be addressed through a combination of education, participation, and locally appropriate interventions [10]. Public demonstration and environmental-awareness activities can further help communities understand the consequences of unmanaged waste and encourage more sustainable practices [11].

The community-service perspective is therefore especially relevant to abattoir wastewater management. Instead of limiting an assessment to the determination of pollutant concentrations, analytical findings can be transformed into educational material for abattoir workers, community members, environmental officers, and local authorities. Such communication can explain which wastewater parameters are problematic, why uncontrolled discharge is harmful, what simple treatment measures may be introduced, and how routine monitoring can support environmental protection.

Water-quality education also plays an important role in public-health awareness. Community-oriented educational activities related to water quality have demonstrated that scientific information can be communicated in ways that support health awareness and responsible behavior [12]. This connection between environmental testing and education provides a useful conceptual basis for positioning wastewater assessment as part of community service rather than as a purely laboratory-based activity.

The Dikumari abattoir in Damaturu represents an important case because untreated wastewater is discharged directly onto surrounding land. The assessment measured pH, temperature, turbidity, total dissolved solids, electrical conductivity, nitrate, fluoride, cadmium, chromium, and lead. The results indicated that turbidity and several heavy metals were major concerns, whereas a number of other physicochemical parameters remained within the regulatory values applied in the study.

This study aimed to evaluate how abattoir wastewater management can be improved through a community-service approach based on environmental assessment, public awareness, and conventional treatment. Specifically, the study sought to: (i) characterize selected physicochemical, inorganic-ion, and heavy-metal parameters of untreated wastewater from the Dikumari abattoir; (ii) compare the measured values with the regulatory benchmarks applied in the original assessment; (iii) identify the principal environmental concerns associated with untreated discharge; (iv) translate the analytical findings into community-oriented environmental-awareness and monitoring activities; and (v) propose a conventional treatment strategy involving screening, coagulation-flocculation, sedimentation, filtration, optional disinfection, and appropriate sludge management.

The novelty of this study lies in integrating physicochemical wastewater assessment with a community-service approach and a proposed conventional treatment strategy for abattoir wastewater management. Rather than limiting the study to laboratory characterization and regulatory comparison, the findings are translated into environmental-awareness activities, stakeholder-oriented recommendations, and a practical treatment sequence involving screening, coagulation-flocculation, sedimentation, filtration, and optional disinfection. This integrated approach connects environmental monitoring, community education, and feasible wastewater-management solutions for the Dikumari abattoir.

2. LITERATURE REVIEW

2.1. Abattoir Wastewater and Environmental Pollution

Abattoir operations generate wastewater containing blood, fats, suspended solids, gastrointestinal materials, urine, fecal residues, and cleaning chemicals. When discharged without adequate treatment, these materials can increase organic loading and degrade surrounding soil and water quality. Previous studies in Nigeria have reported substantial pollution loads from abattoir effluent and demonstrated negative effects on receiving aquatic environments [1-3]. The characteristics of slaughterhouse wastewater vary according to slaughtering capacity, animal type, cleaning practices, water use, and waste handling. Typical concerns include high turbidity, suspended solids, organic matter, nutrients, pathogens, and potentially toxic metals [4]. These contaminants can create environmental problems when wastewater is discharged directly into surface water, drainage channels, or permeable soils. **Table 1** summarizes the principal environmental concerns associated with untreated abattoir wastewater.

Table 1. Main characteristics and environmental implications of untreated abattoir wastewater.

WASTEWATER COMPONENT	TYPICAL SOURCE	POTENTIAL ENVIRONMENTAL IMPLICATION
Blood and organic matter	Slaughtering and carcass processing	Increased organic loading and oxygen demand
Suspended solids	Tissue, manure, gut contents, soil	High turbidity and sediment accumulation
Fats and oils	Carcass and hide processing	Surface films and reduced water quality
Nutrients	Urine, manure, organic decomposition	Nutrient enrichment of receiving environments
Heavy metals	Feed, equipment, chemicals, other sources	Soil and water contamination
Microbial contaminants	Animal waste and processing residues	Potential environmental and public-health concern

2.2. Wastewater Treatment and Sustainable Management

Sustainable abattoir wastewater management requires appropriate treatment before environmental discharge. Reviews of slaughterhouse wastewater treatment have described physical, biological, and integrated treatment technologies, including screening, sedimentation, anaerobic digestion, aerobic processes, filtration, stabilization ponds, and other combinations [4-7]. Treatment selection should consider pollutant characteristics, operating cost, land availability, energy demand, technical expertise, and maintenance requirements. For communities and facilities with limited infrastructure, low-complexity treatment systems may provide a practical starting point. Conventional filtration has been demonstrated as a relatively simple water-treatment approach for rural applications [8]. Such systems are useful not only as treatment options but also as educational examples that can help communities understand basic water-quality improvement processes.

Conventional wastewater treatment can be introduced to local stakeholders through a simple sequence of physical and chemical treatment stages. As illustrated in **Figure 1**, a conventional treatment train generally begins with screening to remove coarse materials, followed by coagulation and flocculation to aggregate smaller suspended particles. Sedimentation then allows the formed flocs to settle, while filtration provides further removal of remaining particulate matter. A final disinfection stage can be applied when microbial control is required. This stepwise treatment concept is particularly useful for community-service activities because each treatment function can be explained visually and practically to abattoir workers, facility managers, and local environmental stakeholders.

Figure 1 provides a simplified representation of how untreated wastewater can progressively undergo contaminant removal. For abattoir wastewater, screening is particularly important for removing coarse residues such as tissue fragments and other solid materials, while sedimentation and filtration can reduce suspended matter contributing to high turbidity. Coagulation-flocculation can further enhance the removal of fine particles that do not readily settle. Depending on the intended final use or discharge requirement, disinfection may be added as a polishing step. The framework is useful for community education because it demonstrates that wastewater treatment is not a single process but a sequence of complementary operations.

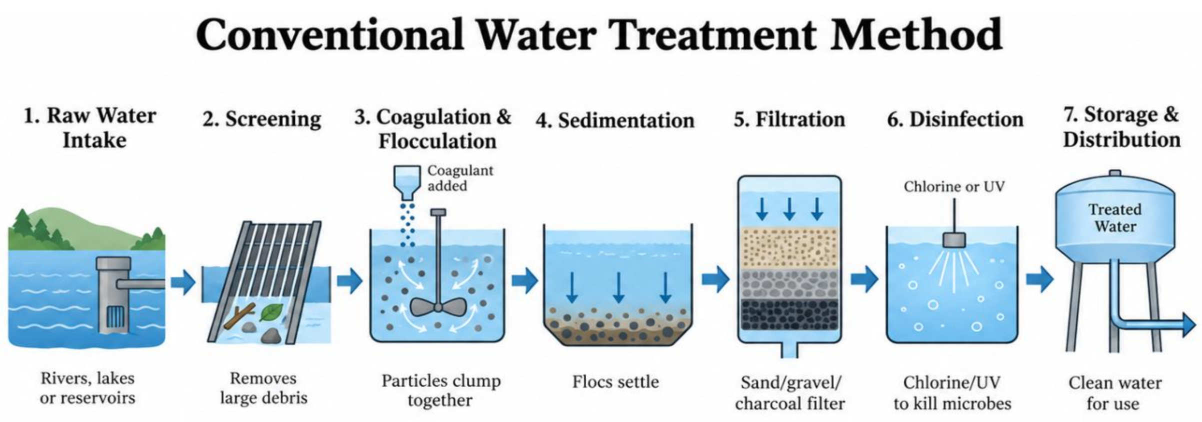

Figure 1. Simplified conventional water-treatment sequence involving screening, coagulation-flocculation, sedimentation, filtration, disinfection, and treated-water management.

More advanced treatment can involve particle-based and catalytic materials. Particle technology has been reviewed as an important element in catalyst design for water-treatment applications, particularly for improving pollutant removal and process performance [9]. Therefore, wastewater-treatment options may be viewed as a continuum from simple community-scale filtration to more advanced treatment technologies. **Table 2** summarizes treatment approaches relevant to the present community-service framework.

2.3. Heavy Metals and Environmental Health

Heavy metals in wastewater are important because they can persist in the environment and may accumulate in soil, groundwater, crops, and biological systems. In the Dikumari abattoir assessment, cadmium, chromium, and lead were among the metals analyzed. Their inclusion is particularly relevant because untreated effluent is discharged directly onto open land, creating potential pathways for environmental transport. The concentrations of cadmium, chromium, and lead exceeded the regulatory values used in the study. Therefore, the interpretation of these metals should extend beyond laboratory measurement toward environmental communication and community awareness. From a community-service perspective, heavy-metal results can be translated into simple messages concerning untreated wastewater, soil contamination, groundwater protection, safe disposal, and the importance of routine monitoring.

Table 2. Wastewater-management approaches relevant to community-based abattoir management.

TREATMENT APPROACH	MAIN FUNCTION	COMMUNITY-SERVICE RELEVANCE
Screening	Removal of coarse solids	Simple first-stage waste separation
Sedimentation	Removal of settleable solids	Low-complexity primary treatment
Filtration	Removal of suspended material	Demonstration of accessible treatment principles
Anaerobic treatment	Reduction of organic loading	Potential energy/resource recovery
Stabilization ponds	Biological wastewater treatment	Suitable where land is available
Constructed wetlands	Natural polishing of wastewater	Environmentally oriented treatment option
Catalyst-based treatment	Enhanced pollutant degradation	Advanced technology for future development

2.4. Environmental Awareness and Community Service

Environmental problems are more effectively addressed when scientific assessment is combined with community education and participation. Community-service activities can help translate technical findings into understandable information for workers, nearby residents, community leaders, and local authorities. Community empowerment has been linked with waste reduction and responsible production practices within Sustainable Development Goals-oriented programs [10]. Public demonstration and environmental education have also been used to increase awareness of environmental impacts and promote more responsible waste-management behavior [11]. These approaches are relevant to abattoir wastewater because environmental problems at slaughtering facilities involve multiple stakeholders. Wastewater management therefore requires not only treatment infrastructure but also understanding, communication, local responsibility, and institutional support. The conceptual relationship among environmental assessment, awareness, treatment, and community action will be illustrated later in **Figure 2**.

2.5. Water Quality Education and Community Capacity

Water-quality information can become more useful when incorporated into educational activities. Previous community-oriented work has demonstrated that education concerning drinking-water quality can support health awareness and responsible behavior [12]. Although the context differs from industrial wastewater, the principle is transferable: scientific information should be communicated in an accessible form. Thus, communities can understand environmental risks and possible responses. In the context of the Dikumari abattoir, laboratory measurements can therefore serve as the evidence base for community-service activities. Parameters such as turbidity, heavy metals, nitrate, fluoride, pH, conductivity, and total dissolved solids can be transformed into educational materials explaining which parameters are acceptable, which require attention, and which management practices should be prioritized.

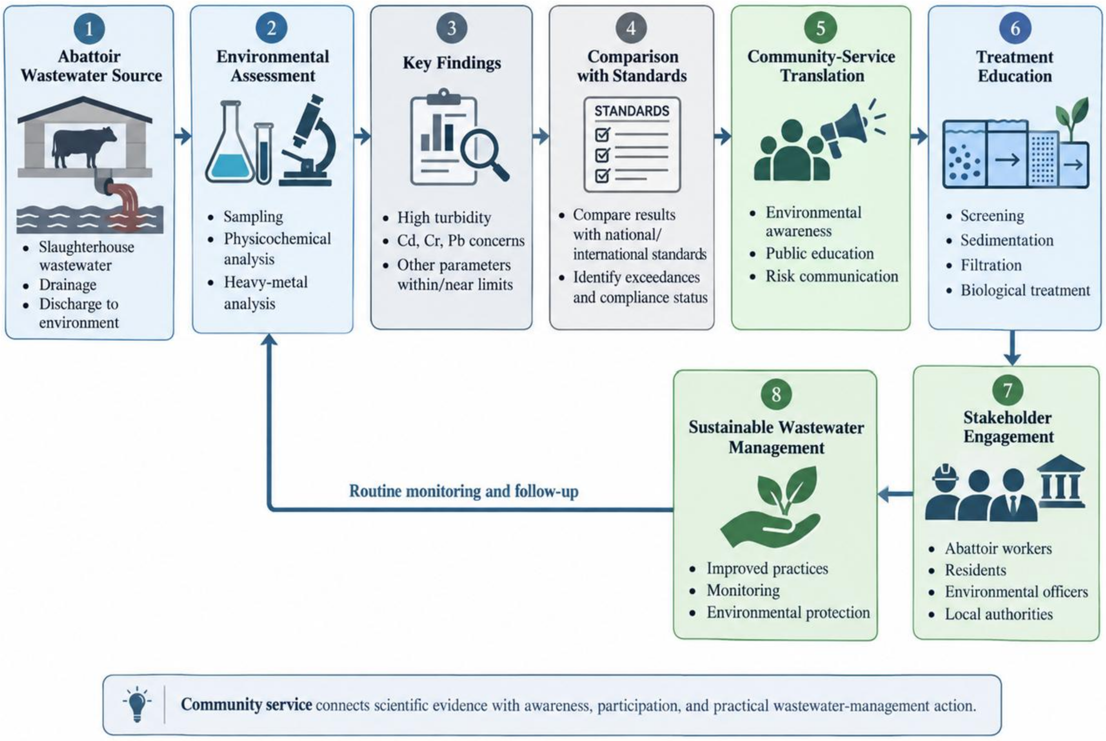

Figure 2. Community-service framework for sustainable abattoir wastewater management, integrating environmental assessment, regulatory comparison, public awareness, treatment education, stakeholder engagement, and routine monitoring.

2.6. Integrated Community-Service Perspective

Abattoir wastewater management involves several interconnected aspects. Previous studies have primarily examined pollution characteristics and environmental impacts of abattoir effluent [1-3], while other studies have focused on wastewater-treatment technologies and management strategies [4-9]. In parallel, community-oriented studies emphasize environmental education, waste reduction, public awareness, and participation [10-12]. The present study connects these technical and community dimensions by using laboratory assessment as the scientific basis for environmental communication and community service. The analytical results are used to identify priority pollutants, explain wastewater-related risks, introduce practical management options, and support stakeholder awareness. **Table 3** summarizes how these components are integrated within the proposed community-service approach.

3. METHOD

3.1. Study Design

This study used an environmental assessment combined with a community-service-oriented interpretation. The technical component involved physicochemical and heavy-metal characterization of untreated wastewater from the Dikumari abattoir in Damaturu, Yobe State, Nigeria. The community-service component used the analytical findings to identify environmental concerns, develop awareness messages, and formulate practical recommendations for wastewater monitoring and sustainable management.

Table 3. Integrated community-service framework for abattoir wastewater management.

DIMENSION	MAIN ACTIVITY	EXPECTED CONTRIBUTION
Environmental assessment	Measurement of wastewater parameters	Identification of pollution priorities
Regulatory comparison	Comparison with selected benchmarks	Understanding of compliance status
Environmental awareness	Communication of major findings	Improved stakeholder understanding
Treatment education	Introduction of treatment options	Better knowledge of practical solutions
Community participation	Engagement of local stakeholders	Shared environmental responsibility
Monitoring	Repeated wastewater assessment	Continuous environmental improvement

3.2. Study Area

The study was conducted at the Dikumari abattoir in Damaturu Metropolis, Yobe State, Nigeria. The facility includes slaughtering and bleeding areas, carcass-dressing sections, gut-emptying areas, and hide-washing channels. Liquid wastes from these activities converge into an open drainage channel and are discharged onto unlined surrounding land. The location was selected because untreated wastewater is discharged directly into the surrounding environment, creating a relevant setting for linking environmental assessment with community awareness and sustainable management. **Figure 1** illustrates the study location from the national to the local scale. As shown in **Figure 1(a)**, Yobe State is located in northeastern Nigeria. **Figure 1(b)** further identifies Damaturu Local Government Area within Yobe State, while **Figure 1(c)** provides a more detailed representation of the study area and the position of the Dikumari abattoir relative to Damaturu and surrounding settlements. This spatial information provides the geographical context for the wastewater sampling and subsequent environmental assessment conducted in this study.

3.3. Wastewater Sampling

Wastewater samples were collected at the principal discharge outlet during peak morning operational activity. Sterile, acid-washed borosilicate bottles were used for sample collection. Sampling was conducted before wastewater dispersed onto the surrounding ground. The sampling procedure was designed to represent untreated wastewater leaving the active abattoir operation.

3.4. Field Measurement of Physical Parameters

Physical parameters were measured directly at the sampling location. The evaluated parameters included pH, temperature, electrical conductivity, and total dissolved solids. Portable and benchtop instruments described in the experimental protocol were used for these measurements. Turbidity was also included as an important indicator of suspended particulate loading because the wastewater contained visible blood, tissue materials, manure, and other process residues. The analyzed physical parameters are summarized in **Table 4**.

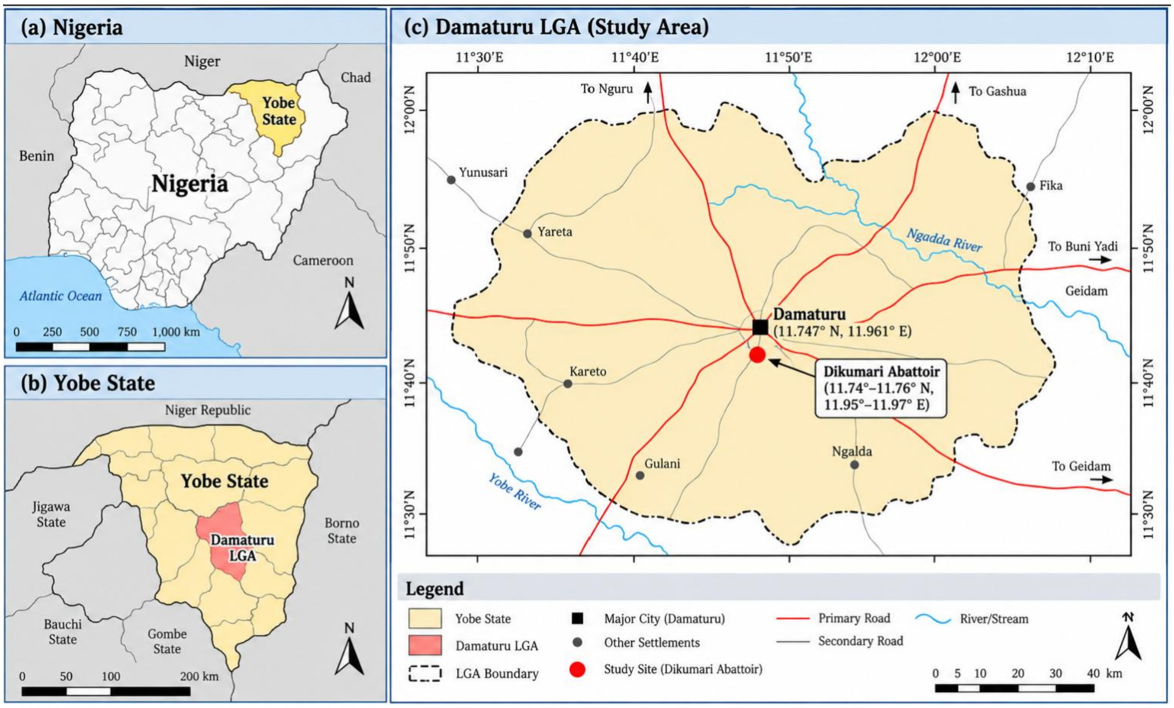

Figure 3. Geographical location of the Dikumari abattoir study area in Damaturu, Yobe State, Nigeria: (a) location of Yobe State within Nigeria; (b) location of Damaturu Local Government Area within Yobe State; and (c) detailed location of the Dikumari abattoir study site within Damaturu.

Table 4. Physical parameters evaluated in the wastewater assessment.

PARAMETER	UNIT	ENVIRONMENTAL RELEVANCE
pH	-	Acidity or alkalinity of wastewater
Temperature	°C	Thermal characteristics
Turbidity	NTU	Suspended particulate loading
Total dissolved solids	mg/L	Dissolved material content
Electrical conductivity	µS/cm	Ionic content of wastewater

3.5. Laboratory Analysis of Inorganic Ions and Heavy Metals

Samples intended for metal analysis were preserved by acidification with nitric acid. Wastewater aliquots were subsequently digested using concentrated nitric acid before instrumental analysis. Cadmium, chromium, and lead were determined together with nitrate and fluoride using the analytical procedures and instruments reported in the experimental protocol. Digital colorimetry and spectrophotometric techniques were applied in accordance with the stated standard analytical procedures. **Table 5** summarizes the chemical parameters included in the analysis.

Table 5. Chemical parameters evaluated in the wastewater assessment.

PARAMETER GROUP	PARAMETER	MAIN INTERPRETATION
Heavy metal	Cadmium (Cd)	Potential toxic-metal contamination
Heavy metal	Chromium (Cr)	Potential environmental contamination
Heavy metal	Lead (Pb)	Potential toxic-metal contamination
Inorganic ion	Nitrate (NO_3^-)	Nutrient and water-quality indicator
Inorganic ion	Fluoride (F^-)	Inorganic water-quality parameter

3.6. Regulatory Comparison

Measured wastewater values were compared with the regulatory benchmark values applied in the study. The comparison was used to distinguish parameters that were within the selected limits from those that exceeded them. The purpose of this comparison was not only regulatory interpretation but also to provide a simple basis for communicating environmental priorities to community stakeholders.

3.7. Community-Service Interpretation

The community-service component was developed from the environmental assessment results. Parameters showing the greatest environmental concern were prioritized for communication and management recommendations. The analytical findings were translated into four community-service themes:

(i) environmental awareness regarding untreated abattoir wastewater;
(ii) explanation of major pollutant indicators;
(iii) introduction of practical wastewater-treatment options; and
(iv) promotion of routine monitoring and stakeholder participation.

3.8. Community-Service Framework

The community-service approach involved converting technical wastewater results into locally understandable environmental information. The intended stakeholders include abattoir workers, facility managers, nearby residents, local environmental officers, and relevant government institutions. **Table 6** summarizes the stages of the community-service framework.

3.9. Data Presentation and Analysis

The observed ranges and mean values were summarized in tabular form. The discussion focused on identifying the most important environmental differences among parameters and interpreting their implications for community awareness and wastewater management. The analytical values were retained without modification. Particular attention was given to turbidity and heavy metals because these parameters represented the principal concerns identified in the dataset.

Table 6. Stages of the community-service-based environmental assessment.

STAGE	MAIN ACTIVITY	EXPECTED OUTPUT
1	Wastewater sampling	Representative untreated wastewater samples
2	Physicochemical and heavy-metal analysis	Environmental dataset
3	Comparison with selected standards	Identification of priority pollutants
4	Interpretation for community awareness	Understandable environmental information
5	Introduction of treatment options	Practical wastewater-management knowledge
6	Stakeholder recommendations	Community and institutional action
7	Monitoring and follow-up	Continuous environmental improvement

4. RESULTS AND DISCUSSION

4.1. Physicochemical Characteristics of Abattoir Wastewater

The physicochemical characteristics of wastewater collected from the Dikumari abattoir are summarized in **Table 7**. The measured pH was slightly alkaline, while temperature, total dissolved solids (TDS), and electrical conductivity remained within the benchmark values applied in the assessment. In contrast, turbidity was substantially elevated, identifying suspended particulate matter as one of the principal environmental concerns associated with the untreated discharge. The relatively neutral pH and moderate conductivity indicate that not all measured parameters presented the same degree of concern. However, the very high turbidity indicates a large suspended-material load. Abattoir wastewater commonly contains blood residues, tissue fragments, manure, fats, and other suspended organic materials that can contribute to turbidity and environmental deterioration [1-4]. From a community-service perspective, turbidity is particularly useful as an educational parameter because its physical appearance can be readily understood by non-specialist stakeholders. Explaining the relationship between visibly turbid wastewater, suspended contaminants, and the need for pretreatment can help translate laboratory observations into practical environmental awareness.

Table 7. Physicochemical characteristics of Dikumari abattoir wastewater.

PARAMETER	OBSERVED RANGE	MEAN VALUE	BENCHMARK USED IN THE STUDY	INTERPRETATION
pH	7.70-7.94	7.82 ± 0.12	6.5-8.5	Within benchmark
Temperature (°C)	29.0-30.0	29.5 ± 0.50	<40.0	Within benchmark
Turbidity (NTU)	420.0-473.0	446.5 ± 26.50	5.0	Above benchmark
TDS (mg/L)	280.0-286.0	283.0 ± 3.00	500.0	Within benchmark
Electrical conductivity (µS/cm)	520.0-600.0	561.1 ± 38.90	1200.0	Within benchmark

4.2. Heavy Metals and Inorganic Ions

The concentrations of the analyzed heavy metals and inorganic ions are presented in **Table 8**. Cadmium, chromium, and lead exceeded the benchmark concentrations applied in the study, whereas nitrate and fluoride remained below the corresponding values used for comparison. This prioritization is useful for community service because it simplifies a complex analytical dataset into understandable environmental messages. Rather than communicating all parameters equally, outreach activities can emphasize the parameters requiring the greatest attention. The metal results represent an important concern because untreated wastewater is discharged onto unlined land. Continuous discharge can create pathways through which contaminants may enter soil or shallow groundwater. The study identified this local setting as particularly relevant because nearby communities use surrounding land and groundwater resources. The results should nevertheless be interpreted as evidence of wastewater contamination rather than direct evidence of human disease. Determining actual health risk would require additional information on environmental transport, exposure frequency, groundwater concentrations, food-chain transfer, and human intake.

Table 8. Heavy-metal and inorganic-ion concentrations in Dikumari abattoir wastewater.

PARAMETER	OBSERVED RANGE (mg/L)	MEAN VALUE (mg/L)	BENCHMARK USED IN THE STUDY (mg/L)	INTERPRETATION
Cadmium (Cd)	0.023-0.025	0.025	0.002	Above benchmark
Chromium (Cr)	0.060-0.100	0.073	0.023	Above benchmark
Lead (Pb)	0.017-0.018	0.018	0.001	Above benchmark
Nitrate (NO_3^-)	40.00-45.00	42.50 ± 2.50	50.00	Within benchmark
Fluoride (F^-)	60.00-69.00	64.50 ± 4.50	200.00	Within benchmark

4.3. Regulatory Benchmarking and Priority Pollutants

The measured parameters were compared with the regulatory benchmarks used in the assessment to identify environmental priorities. As summarized in **Table 9**, turbidity, cadmium, chromium, and lead were classified as the principal non-compliant parameters, while pH, temperature, TDS, conductivity, nitrate, and fluoride were reported as within the selected comparison values.

Table 9. Regulatory comparison and environmental-priority classification.

PARAMETER	MEASURED VALUE	BENCHMARK	STATUS IN THE ASSESSMENT	COMMUNITY-SERVICE PRIORITY
pH	7.82	6.5-8.5	Compliant	Routine monitoring
Temperature	29.5 °C	<40.0 °C	Compliant	Routine monitoring
TDS	283.0 mg/L	500.0 mg/L	Compliant	Routine monitoring
Conductivity	561.1 µS/cm	1200.0 µS/cm	Compliant	Routine monitoring
Turbidity	446.5 NTU	5.0 NTU	Non-compliant	High priority
Cd	0.025 mg/L	0.002 mg/L	Non-compliant	High priority
Cr	0.073 mg/L	0.023 mg/L	Non-compliant	High priority
Pb	0.018 mg/L	0.001 mg/L	Non-compliant	High priority
Nitrate	42.50 mg/L	50.00 mg/L	Compliant	Continued monitoring
Fluoride	64.50 mg/L	200.00 mg/L	Compliant	Continued monitoring

4.4. Translating Environmental Assessment into Community Service

The principal contribution of the present study is the transformation of technical wastewater data into a community-service framework. Environmental assessment alone identifies the problem, but community service extends this information toward awareness, education, stakeholder engagement, and practical management. The proposed sequence is illustrated in **Figure 2**. Wastewater sampling and physicochemical analysis provide the scientific evidence. Regulatory comparison then identifies priority pollutants, after which the findings can be translated into community education and treatment recommendations. Stakeholder participation and repeated monitoring complete the cycle. Community service should connect scientific evidence with local action. Abattoir workers can be informed about waste separation and wastewater-generation practices; facility managers can be introduced to treatment alternatives; nearby residents can receive information concerning environmental protection; and local environmental authorities can use monitoring data to support follow-up activities. Community-based environmental programs have similarly demonstrated the value of environmental education, waste reduction, and public participation in supporting sustainable practices [10, 11].

4.5. Treatment Education and Practical Wastewater Management

Because turbidity was one of the most prominent problems identified in the wastewater, physical pretreatment should be emphasized in community-service education. Screening can remove coarse slaughterhouse residues, while sedimentation can reduce settleable materials. Coagulation-flocculation and filtration can provide additional removal of smaller suspended particles. A simplified conventional treatment sequence is presented in **Figure 1**. The figure can be used as an educational tool to explain that wastewater treatment consists of several complementary stages rather than a single operation. Conventional filtration has previously been demonstrated as a practical approach for water treatment in community and rural contexts [8], while more advanced particle and catalyst technologies provide additional possibilities for pollutant removal [9]. For the Dikumari abattoir, the treatment concept should be interpreted as an educational framework rather than a final engineering design. Actual design would require additional measurements, including wastewater flow rate, biochemical oxygen demand, chemical oxygen demand, suspended solids, microbiological characteristics, and temporal variation.

4.6. Proposed Community-Service Activities

The environmental findings can be converted into specific community-service activities, as summarized in **Table 10**. Community-oriented environmental education is important because technical information must be understandable to the people responsible for daily waste generation and management. Water-quality education has similarly been used to improve awareness of water-related health and environmental issues [12]. Therefore, the laboratory dataset can serve as a practical educational resource rather than remaining only as scientific information.

Table 10. Proposed community-service activities for sustainable abattoir wastewater management.

ACTIVITY	TARGET STAKEHOLDER	MAIN MESSAGE OR ACTION	EXPECTED CONTRIBUTION
Environmental awareness session	Abattoir workers	Effects of untreated wastewater	Improved environmental understanding
Waste-separation demonstration	Workers and managers	Keep solid slaughter residues out of drains	Reduced particulate loading
Water-quality education	Workers and nearby residents	Meaning of turbidity and heavy metals	Improved risk awareness
Treatment demonstration	Facility managers and workers	Screening, sedimentation, filtration	Knowledge of practical treatment
Monitoring workshop	Environmental officers	Sampling and parameter interpretation	Improved monitoring capacity
Stakeholder meeting	Local authorities and facility management	Infrastructure and management priorities	Coordinated local action
Follow-up assessment	Researchers and regulators	Repeat wastewater measurements	Evaluation of improvement

4.7. Proposed Conventional Treatment Strategy for Dikumari Abattoir Wastewater

Based on the identified wastewater characteristics, particularly the high turbidity and elevated concentrations of selected heavy metals, a conventional treatment sequence is proposed for the Dikumari abattoir. The proposed system combines screening, coagulation-flocculation, sedimentation, filtration, optional disinfection, and sludge management to progressively reduce suspended solids and other pollutants before controlled discharge or reuse. The conceptual treatment design is illustrated in **Figure 4**. This figure presents a practical treatment concept that can be adapted to the operational conditions of the abattoir. Screening is proposed as the first stage to remove coarse residues such as tissue fragments, bones, plastics, and other solid materials. Coagulation-flocculation can then promote aggregation of fine suspended particles, followed by sedimentation to remove the formed flocs and reduce turbidity. Filtration provides further polishing by removing residual suspended matter, while disinfection may be applied when microbial control is required. The resulting screenings and sludge should be managed separately through appropriate collection, thickening, dewatering, and regulated disposal or beneficial reuse. This treatment concept also provides a useful basis for community-service activities because the process can be explained to abattoir workers, local authorities, and surrounding communities as a practical pathway from pollution assessment to environmental action. Where greater pollutant removal is required, more advanced treatment options may also be considered. Particle-based catalyst technologies have been reviewed as promising approaches for water-treatment applications and may provide future opportunities for improving treatment performance [9].

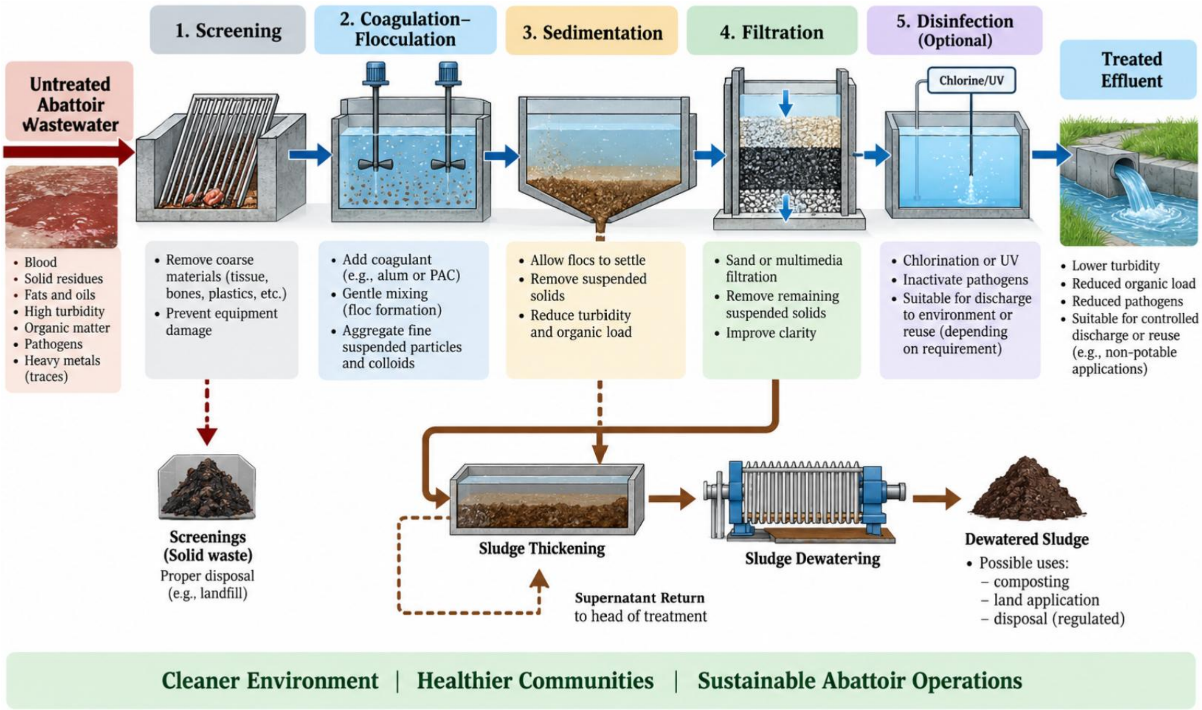

Figure 4. Proposed conventional treatment process for Dikumari abattoir wastewater, integrating screening, coagulation-flocculation, sedimentation, filtration, optional disinfection, and sludge management.

4.7. Sustainable Management Implications

The findings indicate that sustainable management of Dikumari abattoir wastewater should combine source control, basic treatment, environmental monitoring, and stakeholder participation. Solid residues should be separated before entering drainage systems, and appropriate primary treatment should be introduced to reduce suspended materials. Further treatment may then be selected according to wastewater characteristics and available resources [4-9]. The community-service approach also supports broader sustainable-development objectives. Community empowerment and environmental education can contribute to responsible production and waste management [10], while public environmental demonstrations can promote awareness and behavioral change [11]. Thus, environmental assessment and community service are complementary. Laboratory measurements identify what needs attention, while community engagement determines how the information can be translated into improved daily practices. Continuous monitoring can then provide feedback on whether management interventions are producing measurable environmental improvement.

5. CONCLUSION

This study demonstrates that environmental assessment can provide a practical basis for improving abattoir wastewater management through community service. The Dikumari wastewater showed serious concerns related particularly to turbidity and selected heavy metals, while several other measured parameters remained within the applied regulatory benchmarks. Based on these findings, a management approach integrating environmental awareness, routine monitoring, stakeholder participation, and conventional wastewater treatment was proposed. Screening, coagulation-flocculation, sedimentation, filtration, optional disinfection, and sludge management provide a practical treatment sequence for reducing wastewater pollution. The proposed framework connects laboratory evidence with community education and environmental action, supporting more sustainable management of abattoir wastewater in Damaturu.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper is free from plagiarism.

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