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ASSESSMENT OF ABATTOIR WASTE MANAGEMENT IN SABO ABATTOIR OF CHIKUN LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA

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Abstract

This study examines the environmental and health impacts of Sabo Abattoir's operations in Ungwan Pama, Kaduna State, Nigeria. The abattoir's proximity to water bodies and residential areas raises concerns about water pollution, air quality, and waste management. Despite regulations and enforcement agencies, inadequate waste disposal and lack of stakeholder involvement exacerbate the issues. This research investigates the appropriateness of water usage and release, stakeholder involvement, and waste management practices at Sabo Abattoir, aiming to ensure compliance with relevant regulations and mitigate environmental and health risks. Soil and water samples were collected from three different locations within and outside the abattoir, coupled with focus group discussion conducted with the abattoir union executives and members to gather information on waste management practices within the abattoir and to corroborate the findings from the laboratory results analyzed in NAFDAC laboratory. Parameters examined included appearance, odor, taste, pH, carbon dioxide, total alkalinity, total hardness, total dissolved solids, nitrite, chloride, conductivity, coliform, E. coli, P. aeruginosa, Salmonella spp., biological oxygen demand, and chemical oxygen demand. The study reveals contamination of water samples from the well, drainage, and stream, with elevated levels of organic pollutants, fecal coliform, E. coli, and other harmful bacteria. The findings highlight the need for improved waste management practices, enhanced hygiene protocols, and regular monitoring of water quality to protect public health and the environment. The study recommends education and training for abattoir operators on waste management practices, as well as the implementation of a circular economy approach to minimize waste generation.

Keywords: *Environmental, Health, Implications, Sabo Abattoir, Water and Waste, Management*.

Introduction

An increasing population leads to a higher demand for animal protein (Oruonye, 2015). These abattoirs employ a lot of people ranging from transporters, butchers, marketers and animal handlers thus significantly contributing positively to economic growth. However, siting and management of these abattoirs have a significant impact on the welfare and health of the people consuming these products and the environment especially when the management of the by-products (wastes) from the handling and slaughtering of these animals is unorganized.

According to Tolera and Alemu (2020) a portion of each cow, sheep or goat, pig, chicken and turkeys such as parts classified as inedible, bones, hides, and blood end up as becoming waste after processing. Overtime, the accumulation of waste becomes really significant and needs proper

management to safeguard the environment. Bandaw and Herago (2017) have classified wastes produced by abattoirs into liquid, solid and gaseous wastes. A lot of water (effluents) is used by the abattoir in flushing the blood of the slaughtered animals and in washing the slabs used in dressing the carcasses. Other liquid wastes produced by abattoirs include blood, urine, dissolved solids and gut contents (Fearon, Mensah and Boateng, 2014). The paunch content, occasional aborted fetuses, animal faeces, bones, dung and feed leftover constitute the solid waste (Fearon, *et al*,2014), and odour from production, smoke from burning of woods contribute to air pollution which could be potentially harmful to the operators of the abattoirs and the neighbourhood when they are exposed long term to this menace. According to Tolera and Alemu (2020) a portion of each cow, sheep or goat, pig, chicken, and turkeys end up as becoming waste after processing. Overtime, the accumulation of the waste becomes really significant and need proper management to safeguard the environment.

From field observations and also literature reviewed, it showed that abattoirs are often sited close to water bodies. This has a significant effect on the users of this water as oftentimes the effluents from production are released untreated into the streams, thus contribute significantly to water pollution, and make the water resource unavailable for other users. Also, during the dry season when the water level is low, there is a significant threat of serious odour disturbing the neighborhood constituting a potential source of conflict for the operators and host community. Smokes emanating from burning of animal carcasses also constitute an environmental hazard to human health especially with the abattoir sited within a residential and commercial neighborhood.

Finally, there are regulations such as The Animal Diseases (Control) Act (2022), National Environmental (Sanitation and Wastes Control) Regulation, (2009) and National Environmental (Air Quality Control) Regulations 2014 enforced by the National Environmental Standards and Regulation Enforcement Agency (NESREA) that are enacted to check environmental pollutions. Agencies such as NESREA domiciled in the federal ministry of environment, Kaduna Environmental Protection Agency, (KEPA), Veterinary Doctors and local government health inspectors are responsible for inspecting and certifying abattoir productions. As cited by Okereke, Uchua and Amodu (2019), the inability of the relevant authorities to involve waste generators in their disposal implementation strategies has compounded the ugly situation of abattoir waste management in Nigerian urban cities.

Against this background, this study intends to examine the appropriateness of water used and released in the environment by Sabo abattoir as a result of their activities, the level of involvedness of relevant stakeholders comprising of the abattoir union members, State and Local Government authorities involved in operating and managing the abattoir. Also, the type of waste generated and how they are managed to ensure compliance to relevant extant regulations guiding abattoir waste management.

Conceptual Framework

Abattoir

An abattoir is a facility designed and licensed for receiving, holding, slaughtering animals and animal meat products before they are released for public consumption (Alonge, 2005). Abattoir is derived from the French name which is commonly known as a slaughter house in the United States and much of English-speaking countries. A slaughter house is a place where animals are butchered for food (Bandaw and Herago, 2017).

An abattoir, or slaughterhouse, is a specialized facility approved and registered by regulatory authorities for the hygienic slaughtering, processing and effective preservation and storage of meat products for human consumption. It is designed to receive, hold, slaughter and inspect meat animals before the release of the meat to the public. This study adopts the definitions of abattoir provided by Okereke *et al*. (2019) and Mamhobu-Amadi, Kinigoma, Momoh, and Oji (2019), which describe an abattoir as an approved and registered facility for the hygienic slaughtering and inspection of animals, as well as the processing and preservation of meat products for public consumption.

Abattoir Waste

In the context of abattoirs, waste encompasses a variety of byproducts from animal slaughter and processing. This study adopts Mamhobu-Amadi's (2019) classification of abattoir waste, which includes solid, liquid, and gaseous pollutants. These wastes consist of blood, intestinal contents, waste tissue, bones, undigested ingest, aborted fetuses, urine, fat, animal trimmings, paunch content, and other byproducts from various stages of slaughterhouse operations such as stunning, bleeding, carcass processing, and by-product processing. The proper management of these wastes is crucial due to their potential adverse effects on the environment and public health if handled inappropriately (Chukwu, Adeoye and Chidiebere, 2011; Fearon *et al*., 2014).

3 R Waste Management Concepts

One of the key concepts introduced in waste management is the "hierarchy of waste management", also known as the 3Rs (Reduce, Reuse, and Recycle) (Malomo, Madugu and Bolu, 2018). This concept suggests a preferred order of waste management, prioritizing reduction, reuse, and recycling over disposal in landfills. The application of the 3Rs can contribute to meeting the pillars of sustainability and help achieve "zero waste" discharge. **Reduction** involves actions aimed at lessening the amount of waste production, leading to economic and environmental benefits (Aravinth and Prakash, 2015). **Reuse** involves using discarded items in their original state, either in the same manner or in a new manner, offering social, economic, and environmental benefits. **Recycling** involves recovering and processing materials to create new products, helping to conserve materials and energy, reduce landfill quantities, contribute to the economy, and generate jobs (Malomo *et al*., 2018). The 3R concept is highly relevant to the research on abattoir waste management, as it provides a framework for assessing and improving the sustainability of waste management practices in the abattoir context.

Circular Economy

Circular economy (CE) first introduced by Pearce and Turner (1990) in "Economics of Natural Resources and the Environment" is a sustainable development strategy aimed at tackling environmental degradation and resource scarcity. CE's 3R principles are to reduce, reuse, and recycle materials, creating a circular system where all materials are recycled, all energy is derived from renewables, and activities support and rebuild the ecosystem, supporting human health and a healthy society. Resources are used to generate value (Almas, 2015). This study adopt the circular economy concept to examine how waste such as blood and bones are recycled and reintegrated into the economy, aiming to phase out waste generated in the study area. This approach aligns with sustainable development goals and seeks to create a more efficient and environmentally friendly waste management system.

Various types of abattoir waste and their management strategies are been explored. Ezeoha and Ugwuishiwu (2011) highlight that animal blood, with its high oxygen demand; can significantly deplete dissolved oxygen in aquatic environments if discharged improperly. Paunch manure, as noted by Onunkwo (2009), contains undigested materials with high COD and BOD levels, potentially causing oxygen depletion and pathogen proliferation when mishandled. Animal faeces, according to Ezeoha and Ugwuishiwu (2011), comprise undigested food, proteins, and minerals, posing risks of oxygen depletion and nutrient over-enrichment in receiving environments. Abattoir effluent, as described by Onunkwo (2008), mainly consists of diluted blood, fat, and suspended solids, exerting oxygen demand and potentially causing malodor when decomposing. Improper disposal of animal horns and bones can lead to visual pollution and pest attraction (Ezeoha and Ugwuishiwu, 2011). Nwanta *et al*. (2008) point out that decomposing manure piles are persistent sources of pollution, attracting flies and breeding mosquitoes.

Regarding Waste Management, Roberts and De Jager (2008), proposed a model for red meat abattoirs, suggesting various uses for different waste types. For instance, blood can be used in food products, as animal feed, or fertilizer (Food Safety Authority of Ireland, 2013). They recommend composting stomach contents, treating wastewater for reuse, and processing condemned products into bone meal or pet food. Bridle (2011), notes ongoing research aimed at improving waste management practices in abattoirs, focusing on reducing disposal costs and exploring the potential for renewable energy production from waste products.

The Study Area

Sabo Abattoir is situated in Ungwan Pama, Chikun Local Government Area, Kaduna State, Nigeria, geographically located between Latitude 10°27'37.84" - 10°27'0.65"N and Longitude 7°27'11.97"-7°28'6.65"E, characterized by a tropical savanna climate with distinct wet and dry seasons, situated on hard rocky terrain, with well-drained tropical ferruginous soils, and a drainage system connected to River Kaduna via Rafin Firoro stream, supporting various socio-economic activities including a bustling market, commercial banks, transportation services, and agricultural practices (Kaduna state sub division 2024).

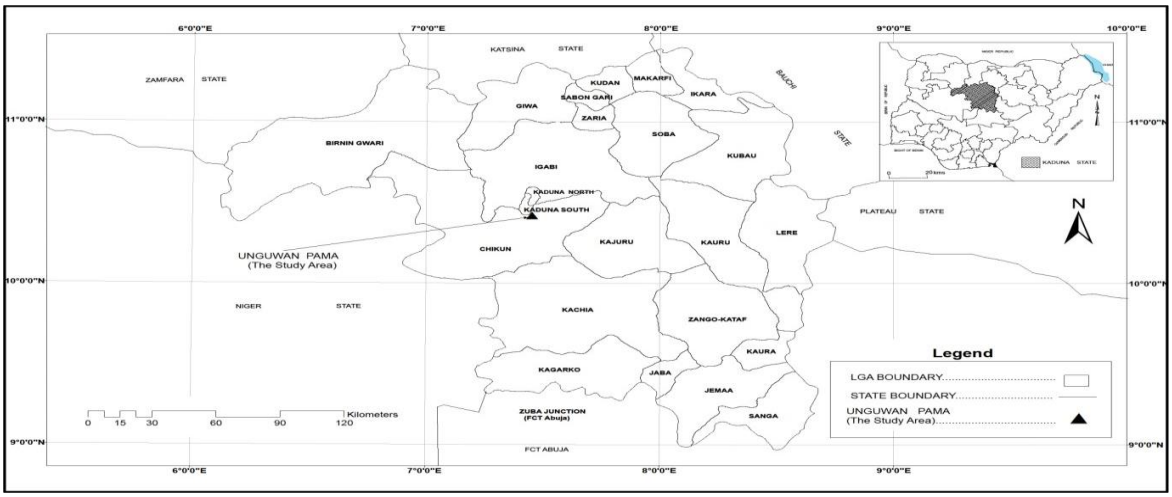

Figure 1: Ungwan Pama in Chikun Local Government Area of Kaduna State
Source: Department of Geography, Nigerian Defence Academy, Kaduna

Materials and Methods

A reconnaissance survey was conducted in August 2023 to gather preliminary information about the Sabo abattoir and to introduce the proposed research to the Sabo Butchers Union executives. During the survey, the researcher was given a guided tour of the facility and obtained insights into the origin of the abattoir, its operations, challenges, and the steps being taken to address them.

Primary and secondary data were used for this study. Primary data include water samples collected from three different locations within and outside the abattoir, namely well, the drainage system, and the stream that receives the discharged wastewater from the abattoir via surface runoffs and infiltrated well water. Abattoir site was used as control point and results derived from nearby well, drainage channel and nearby stream were all analyzed for comparing results. Additionally, a focus group discussion was conducted with the abattoir union executives to gather information on abattoir waste management practices within the abattoir and to corroborate the findings from the laboratory results.

The samples were collected in February 2024 and taken to NAFDAC laboratory for analysis. The parameters examined included appearance, odor, taste, pH, carbon dioxide, total alkalinity, total hardness, total dissolved solids, nitrite, chloride, conductivity, coliform, E. coli, P. aeruginosa, Salmonella spp., biological oxygen demand, and chemical oxygen demand.

The focus group discussion was conducted in March 2024 with key stakeholders from the Sabo Butchers Union, including the Chairman, Secretary, and five other members. The discussion aimed to gather in-depth insights into various aspects of waste management within the abattoir, including waste generation, waste management practices, challenges faced by the abattoir in managing waste, and actions being taken to address these challenges.

The data collected were analyzed and presented using descriptive statistics. The water samples results were presented in tabular form and compared to recommended guidelines in order to assess the quality and compliance of the water samples. The focus group discussions results were thoroughly described and analyzed to identify key themes, perspectives, and insights shared by the participants.

Results and Discussions

Analyses and Implication of Water Samples Result along the Sabo Abattoir Location

The comprehensive findings of water quality analysis conducted on the three water sources: Well

Water, Drainage Water, and Stream Water within and near Sabo Abattoir location, aimed at assessing their suitability for human consumption and identifying potential sources of contamination that may pose health risks to the community and the environment revealed that all the three water sources exhibit acidic pH levels with Well Water measuring at 5.65, Drainage Water at 5.91, and Stream Water at 5.84, indicating that these values fall below the recommended pH range for safe drinking water, which could adversely affect both human health and aquatic life.

Table 1: Results of Water Samples Collected from Well, Drainage Water and Stream Compared with NSDWQ and WHO

Parameters Determined	Unit	SAMPLED POINT			Nigerian standard for drinking water quality (NSDWQ)	WHO
		Well water	Drainage water	Stream water		
Appearance	TCU	Colourless	Amber liquid	Colourless	Colourless	Colourless
Odour	-	Colourless	objectionable	Odourless	Odourless	Colourless
Taste	-	-	objectionable	-	Tasteless	Tasteless
pH	-	5.65	5.91	5.84	6.50-8.50	-
Carbondioxide CO_2(mg/1)	-	82	68.0	58.0	50 Max	-
Total Alkaline (mg/1)	-	121	132	160	100 Max	-
Total Hardness	-	92.0	86.0	102	100 Max	-
Total Desolved solids (TDS)	mg/L	260	320	480.0	500 Max	1000mg/1
Nitrite (NO_2)	mg/L	0.64	0.81	1.62	0.2 Max	-
Chloride	mg/L	180.0	202.2	180.0	250 Max	250mg/1
Conductivity	uS/cm	520	642	860.0	1000 Max	500
Coliform	mpn/ml	42cfu/ml	68cfu/1	32cfu/ml	1 Max	00.5
E. Coli	cfu/ml	0 efu/ml	Present	Present	0	Ocfu/ml
P. aeruginosa	cfu/ml	Present	Present	Present	0	-
Salmonella Spp	cfu/ml	0 cfu/ml	Present	Present	0	-
Biological Oxygen demand (mg/1)	(mg/l)	50	280	250mg/1	< 5.0mg/1	30mg/1
Chemical Oxygen Demand (mg/1)	(mg/l)	350	650	800 mg/1	300-1000mg/1	100mg/1

Source: Researchers Laboratory Analysis NSDWQ (2015) ICS 13 060 20 WHO World Health Organization 2022 4th Edition

The Total Dissolved Solids (TDS): Concentrations were found to exceed the Nigerian Standard for Drinking Water Quality (NSDWQ) limits with Well Water at 260 mg/L, Drainage Water at 320 mg/L, and Stream Water at 480 mg/L. Such elevated levels can indicate a high degree of contamination and may impair the taste and safety of the water for human consumption and other domestic uses.

In terms of Nitrite Levels concentration: The three water sources presented elevated nitrite concentrations that surpass NSDWQ and World Health Organization (WHO) limits, with Well Water at 0.64 mg/L, Drainage Water at 0.81 mg/L, and Stream Water at 1.62 mg/L, which raises significant health concerns, particularly regarding methemoglobinemia or "blue baby syndrome" in infants.

Coliform and E. coli Presence: Detectable levels of Coliform bacteria and E. coli were found in both Drainage Water and Stream Water, strongly indicating fecal contamination that poses serious health risks and underscores the necessity for urgent remediation measures to protect public health.

Total Alkalinity Levels: The results indicated that Total Alkalinity levels exceeded the NSDWQ standard across all samples, with Well Water at 121 mg/L, Drainage Water at 132 mg/L, and Stream Water at 160 mg/L, which could affect the water's buffering capacity and lead to further ecological imbalances.

Carbon Dioxide (CO2) Levels: The CO2 levels in Well Water and Drainage Water were recorded at 82 mg/L and 68 mg/L, respectively, both exceeding the NSDWQ standard; elevated CO2 can

result from organic matter decomposition and contribute to lower pH levels, indicating ongoing pollution.

Total Hardness Levels: While Well Water and Drainage Water were found to be within the NSDWQ standard for total hardness, Stream Water slightly exceeded the permissible limit at 102 mg/L, which could impact the water's suitability for domestic use and increase scaling in plumbing systems.

Microbiological Contaminants: The presence of **Pseudomonas aeruginosa** was detected in all three water sources, while **Salmonella spp.** was found in both Drainage Water and Stream Water but absent in Well Water, highlighting critical contamination that poses severe health risks, especially in immune compromised individuals.

Biological Oxygen Demand (BOD): The BOD levels exceeded the maximum permitted limits in both Drainage and Stream Water, suggesting a high level of organic pollution and a significant impact on aquatic ecosystems by depleting oxygen levels necessary for aquatic life.

Chemical Oxygen Demand (COD): All three water sources also exhibited COD levels that surpassed the maximum permissible limits, reflecting the presence of a considerable amount of organic and inorganic pollutants that could degrade water quality and affect overall ecosystem health.

Odor: An assessment of odor revealed that Well and Stream Water were odorless, while Drainage Water presented an objectionable odor, which is often indicative of organic pollution and highlights the need for immediate investigation into the sources of this contamination.

Taste: Drainage Water was noted to have an objectionable taste, raising concerns about its palatability and safety, while the taste of Well and Stream Water was not evaluated; however, the perception of taste can significantly influence public acceptance of water quality.

Implications of Results along Abattoir in Sabo the Study Area

The objectionable odor from the drainage water is a clear indication of significant organic matter decomposition and potential presence of harmful bacteria, highlighting a serious issue of negligence to hygiene on the part of the abattoir operators.

Plate I: Drainage within Sabo Abattoir

This is further exacerbated by the challenge of accessing water during the dry season, as acknowledged by the abattoir chairman. Despite this, the chairman mentioned plans to construct a borehole, which could potentially address the water scarcity issue.

Plate II: Cow Dung Storage that Lead to High Nitrite and Fecal Coliform in Well Water

However, it is crucial to note that the construction of a borehole alone may not suffice to address the underlying issues of poor waste management and hygiene practices. The abattoir operators must also prioritize proper waste disposal, treatment, and sanitation measures to prevent contamination of water sources and ensure a safe environment for workers and the surrounding community.

Plate III: Dry Season Water Challenges Limiting Proper Sanitation at Sabo Abattoir

The Sabo Abattoir generates various types of waste, including blood, bones, cow dung, and wastewater. While the abattoir has some waste management practices in place, such as selling bone meal and blood meal to feed producers, and cow dung to crop farmers, the storage and management of these wastes are still rudimentary and unsatisfactory. By addressing these critical issues, the abattoir can reduce the risk of water pollution, protect public health, and ensure a safe and healthy environment for workers and the surrounding community.

The drainage system in Sabo Abattoir poses health risks to customers due to the objectionable odor and potential presence of harmful bacteria. This can reduce patronage and impact the quality of meat produced. To address this, regular cleaning and maintenance of the drainage system, as well as implementation of a strict hygiene protocol, are necessary.

The pH values of all water samples are found to be acidic, which is not desirable for human consumption and can have negative health effects. To remedy this, the water needs to be amended to make it more alkaline. A focus group discussion with the Sabo Butchers Union revealed various types of wastes generated in the abattoir, include blood collected, cooked, dried, and sold as blood meal to feed Producers.

Plate IV: Cooked and dried blood for Consumption

Sabo Butchers Union highlighted that the abattoir generates various types of waste, notably blood, which is collected immediately after slaughter, processed through cooking and drying to produce blood meal, a high-protein animal feed as shown in Plate IV. This process not only creates an additional revenue stream and promotes sustainability by reducing waste but also requires adherence to strict health regulations, while facing challenges such as market demand fluctuations and processing costs.

Bones and horns: During the focus group discussion with the Sabo Butchers Union, participants highlighted that bones and horns are collected after butchering, dried, burnt, and crushed to produce bone meal, which serves as a nutrient-rich supplement for poultry and fish feed as observed in Plate V. This process not only creates an additional income stream and promotes sustainability by recycling waste but also faces challenges such as processing costs, regulatory compliance, and market demand fluctuations.

Plate V: Bones Being Stored in the Open at Different Points in the Abattoir

Cow dung: participants noted that cow dung is collected from the abattoir, mixed with straw or leftover feed to enhance its nutrient content, and sold to crop farmers as an organic fertilizer; this practice not only creates an additional revenue stream and promotes sustainability by recycling waste but also improves soil health and supports environmentally friendly agricultural practices, while facing challenges related to storage, market demand, and quality control.

Waste water, straw, wood ash, and domestic wastes also generated, but no specific management practices mentioned. The abattoir has some waste management practices in place, such as selling bone meal and blood meal to feed producers, and cow dung to crop farmers. However, there is still a need for improved waste management practices to minimize environmental and health impacts.

Perception of People on the Sanitary Condition of the Abattoir in the Study Area

The focus group discussion revealed several challenges faced by the abattoir in managing waste which include:

- **i.** Water scarcity and high costs during the dry season, which hinders effective cleaning and waste disposal.
- **ii.** The use of firewood for animal processing, which is expensive and poses health risks due to smoke exposure.
- **iii.** Poor personal hygiene practices among some workers, which can compromise meat safety and pose health risks.
- **iv.** Complaints from neighboring residents about odors from the abattoir.
- **v.** Lack of government support and facilities for efficient waste management.

Conclusion and Recommendations

The analysis clearly indicates that Well Water, while meeting some quality standards, requires urgent attention regarding its pH, TDS, and nitrite levels to ensure it is safe for consumption. Drainage Water was found to be highly contaminated and is unequivocally unsuitable for human consumption due to the significant health risks posed by its microbial and chemical content. Additionally, Stream Water presents several concerning parameters, including pH, TDS, nitrite, and total hardness levels, which necessitate immediate intervention to safeguard both public health and environmental integrity. The study's findings align with similar research on abattoir waste management, emphasizing the urgent need for improved waste management strategies, alternative fuel sources, and government support to ensure environmental sustainability and compliance with regulations. To address the identified issues, the following recommendations are proposed**:**

1. **Regular Monitoring**: Establish a routine monitoring program for water quality across all sources to track changes and identify potential contamination trends promptly.
2. **Effective Treatment and Disinfection**: Implement robust water treatment and disinfection processes to ensure that water from all sources meets safety standards for human consumption.
3. **Contamination Source Identification**: Conduct thorough investigations to identify and address sources of contamination, particularly those related to agricultural runoff and improper waste disposal practices.
4. **Wastewater Management**: Ensure effective management of wastewater and organic waste to prevent further pollution of water sources, protect public health, and enhance the sustainability of local ecosystems.
5. **Access to Reliable Water Sources**: Provide access to reliable and sufficient water sources, such as boreholes located at a safe distance from abattoir operations, to reduce the risk of contamination.
6. **Education and Training**: Offer education and training for abattoir operators on proper hygiene and waste management practices to minimize environmental impact and improve compliance with regulations.

By implementing these recommendations, it is possible to significantly improve water quality and public health outcomes in the Sabo Abattoir area while promoting environmental sustainability.

References

Alonge, T. O. (2005). Abattoir Management and Environmental Pollution. *Journal of Environmental Science and Health, Part B*, 40(2), 247-254.

Almas, A. (2015). Circular Economy: A Sustainable Development Strategy. *Journal of Cleaner Production*, 106, 175-179.

Aravinth, V. & Prakash, M. (2015). Waste Reduction And Recycling Initiatives In The Meat Processing Industry. *Journal of Cleaner Production*, 96, 345-353.

Adejumobi, I. S. & Alonge, T. O. (2019). Water Quality Assessment of Well Water Sources in an Abattoir Environment. *Journal of Environmental Science and Health, Part B*, 54, 145-151.

Bandaw, F. A. & Herago, J. (2017). Abattoir Waste Management: *A Review. Journal of Environmental Management*, 188, 116-123.

Bridle, T. R. (2011). Waste Management in the Red Meat Industry. Meat Science, 89(3), 287-292. Centers for Disease Control and Prevention. (2020).

Chukwu, O., Adeoye, P. A. & Chidiebere, C. (2011). Environmental Impact Of Abattoir Waste in Nigeria. *Journal of Environmental Science and Health, Part B*, 46, 147-153.

Ezeoha, S. L. & Ugwuishiwu, B. O. (2011). Abattoir Waste Management in Nigeria: A Review. *Journal of Environmental Science and Health, Part B*, 46, 155-162.

Fearon, A. L., Mensah, G. A. & Boateng, E. (2014). Abattoir Waste Characterization and Management in Ghana. *Journal of Environmental Science and Health, Part B*, 49, 147- 155.

Food Safety Authority of Ireland. (2013). Guidelines for the Management of Abattoir Waste.

Malomo, O., Madugu, A. N. & Bolu, S. A. (2018). Waste Management Practices in the Meat Processing. Kaduna State Sub Division 2024 *www.citypopulation.de*. Retrieved 7 February 2024. industry: A Review. *Journal of Environmental Management*, 206, 123-129.

Mamhobu-Amadi, E., Kinigoma, B., Momoh, S. & Oji, C. (2019). Abattoir Waste Management in Nigeria: A Review. *Journal of Environmental Science and Health, Part B*, 54, 153-159. National Environmental (Air Quality Control) Regulations. (2014).

National Environmental (Sanitation and Wastes Control) Regulation. (2009). Nigerian Standard for Drinking Water Quality. (2015).

Nwanta, J. A., Ezemaduka, A. N. & Okoro, C. C. (2008). Environmental Impact of Abattoir Waste in Nigeria. *Journal of Environmental Science and Health, Part B*, 43, 147-153.

Okereke, C. C., Uchua, I. A. & Amodu, J. T. (2019). Abattoir Waste Management in Nigeria: A Review. *Journal of Environmental Management*, 231, 1111-1118.

Onunkwo, J. I. (2008). Abattoir Waste Management in Nigeria: A Review. *Journal of Environmental Science and Health*, Part B, 43, 155-161.

Oruonye, E. D. (2015). The Impact of Abattoir Waste on the Environment. *Journal of Environmental Science and Health, Part B*, 50, 143-149.

Pearce, D. W. & Turner, R. K. (1990). *Economics of Natural Resources and the Environment*. Johns Hopkins University Press.

Roberts, J. A. & De Jager, P. C. (2008). Waste Management in the Red Meat Industry. *Meat Science*, 80(1), 143-148.

The Animal Diseases (Control) Act. (2022).

Tolera, A. & Alemu, M. (2020). Abattoir Waste Management Practices in Ethiopia. *Journal of Environmental Science and Health, Part B*, 55, 123-129.

World Health Organization. (2017). *Guidelines for Drinking-Water Quality*.