Journal of Animal Science and Veterinary Medicine
Volume 9(6), pages 406-411, December 2024
Article Number: 041F9DB115
ISSN: 2536-7099
https://doi.org/10.31248/JASVM2024.514
https://integrityresjournals.org/journal/JASVM

Full Length Research

Evaluation of bacterial effluents from abattoirs and slaughter slabs in Zuru Emirate, Nigeria

Kaltume Mamman Mohammed[1]*, Asinamai Athliamai Bitrus[2], Musa Zakariah[3,4] and Musa Isiyaku Ahmed[5]

[1]Department of Veterinary Public Health and Preventive Medicine, College of Veterinary Medicine, Federal University of Agriculture, P. M. B. 28, Zuru, Kebbi State, Nigeria.
[2]Department of Veterinary Microbiology, Faculty of Veterinary Medicine, University of Jos, P. M. B. 2084 Jos, Plateau State, Nigeria.
[3]Department of Veterinary Anatomy, College of Veterinary Medicine, Federal University of Agriculture, P. M. B. 28, Zuru, Kebbi State, Nigeria.
[4]Department of Veterinary Anatomy, Faculty of Veterinary Medicine, University of Maiduguri, P.M.B. 1069 Maiduguri, Borno state, Nigeria.
[5]Department of Veterinary Parasitology and Entomology, College of Veterinary Medicine, Federal University of Agriculture, P. M. B. 28, Zuru, Kebbi State, Nigeria.

*Corresponding author. Email: kaltum.km@gmail.com

Received 20th November 2024; Accepted 14th December 2024

ABSTRACT: Effluents from abattoirs discharged into the environment and water bodies have serious health implications. This study aimed to investigate the bacterial load from abattoir and slaughter slab effluents in Zuru emirate. A total of 50 effluent samples from each of the abattoir and slaughter slabs were collected and used. The bacteria were isolated using standard bacteriological culture and identification. The bacterial colony counts (MPN/100mL) from abattoir and slaughter slab effluents in Zuru emirates ranges from 2.9×10^5 to 3.5×10^6 in Zuru LGA, 2.67×10^4 to 7×10^6 from Fakai LGA, 1.92×10^4 to 2.2×10^7 from Sakaba LGA, and 2.75×10^4 to 2.8×10^6 from Wasagu/Danko LGA. The bacteria discharged from effluents at the abattoir and slaughter slab from Zuru emirate was above the recommended limit for effluents released into the environment. Bacterial species isolated and identified were *Escherichia coli, Klebsiella spp., Salmonella spp., Shigella spp., Pseudomonas aeruginosa, Staphylococcus aureus*, and *S. epidermidis.* The findings of this study affirmed that abattoirs and slaughter slabs in Nigeria lacked basic effluent treatment facilities, thus, effluents discharged from the abattoirs have a high bacterial load.

Keywords: Abattoir, effluents, slaughter slab, Zuru.

INTRODUCTION

The Nigerian abattoir/slaughterhouse system is a key component of the Livestock value chain providing a non-stop domestic meat supply for the growing population and a unique source of employment prospects for the growing population (Okunmadewa, 1999). However, this aspect of the livestock value chain is not well developed and it is faced with a lot of challenges including unhealthy practices that do not promote the slaughter and supply of wholesome meat for human consumption (Nafarnda *et al*., 2012; Idu *et al*., 2023). Abattoir wastewater is a water used to clean up slaughtered cattle, sheep, goat, and pig carcasses, the floor of the slaughter hall, personnel, and slaughter equipment (Coker *et al*., 2001). One of the major impediments to the Nigerian abattoir system is the lack of basic facilities for the treatment of effluent waste (Istifanus and Bwala, 2017). The effluents from these abattoirs alongside a large host of microbial pathogens sips into the environment and the surrounding water bodies. Thus, poses a significant public health risk, especially to individuals and communities around the abattoirs who rely

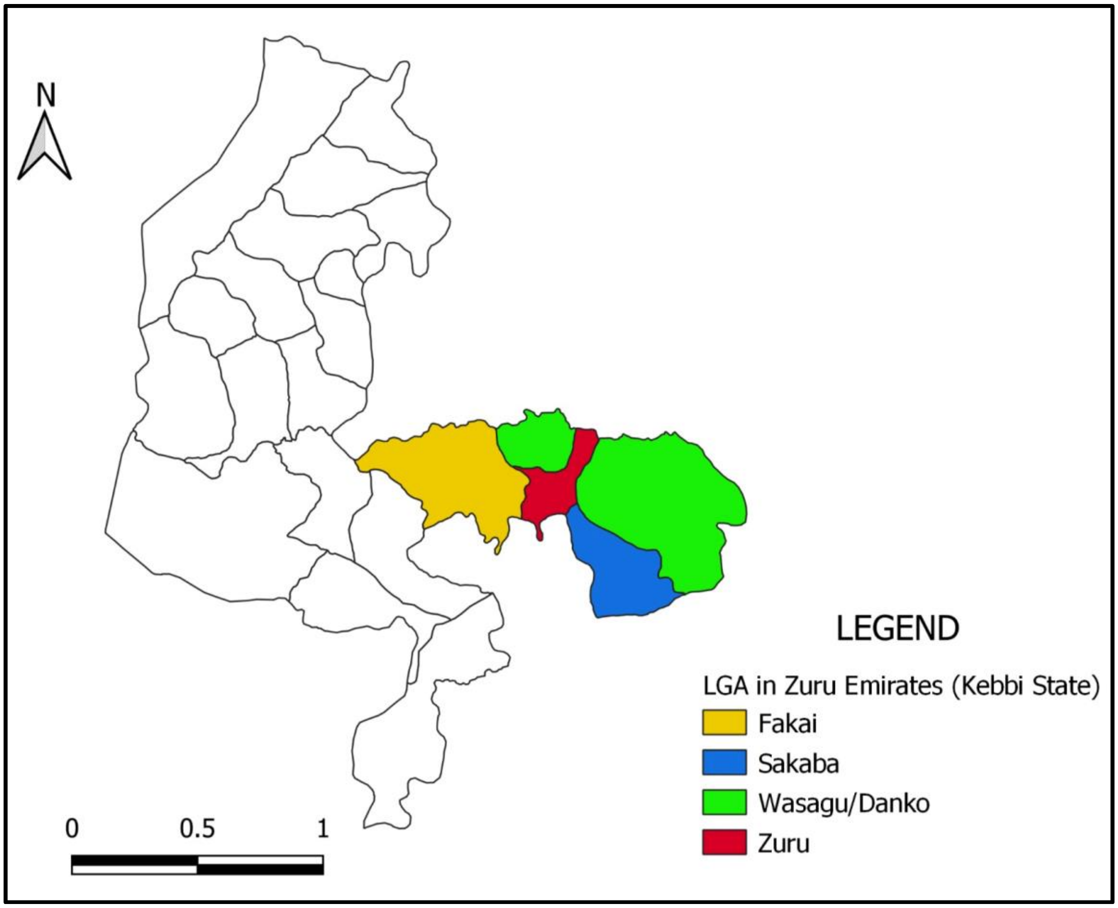

Figure 1. Map of Kebbi State, showing the four Local Government Areas under Zuru Emirate.

on rivers and other water bodies as their main sources of drinking water.

Additionally, abattoir and slaughter slab effluents could significantly intensify the amounts of nitrogen, phosphorus, and total solids in the receiving water body (Igbinosa and Uwidia, 2018). Wastewater from the abattoir is usually a concentrated source of oxygen-consuming waste (Mittal, 2006). With the growing incidences of waterborne diseases, antimicrobial-resistant pathogens, and increasing threat to human life, the decline in the quality of life, and the consequent reduction in working hours, it is necessary to examine the dangers associated with the consumption of abattoir-contaminated stream water (Foyle *et al*., 2023). The health of a population is a major consideration for an active workforce, and these are constantly being threatened by emerging and re-emerging pathogens.

Previous reports have shown that abattoir effluent impacts negatively on soil, well water, and groundwater (Ogbonna and Ideriah, 2014). Also, zoonotic diseases are yet to be eliminated or fully controlled in more than 80% of the public abattoirs in Nigeria, and many pathogenic species of bacteria were reported to be isolated from abattoir effluents (Nafarnda *et al*., 2012; Adebowale *et al*., 2016; Joseph *et al*., 2021). Thus, this study aimed to investigate the population health implication of abattoir effluents in Zuru Emirate, Kebbi state, Nigeria.

MATERIALS AND METHODS

Study area

This study was carried out in Zuru Emirate, Kebbi State, Nigeria. The Emirate is made of up four Local Government Areas including Zuru, Fakai, Sakaba and Wasagu/Danko (Figure 1). The Emirate is located at latitudes 11^{o} and 12^{o} N and longitudes 4^{o} and 5^{o} E of the equator. The climate is characterised by both wet and dry seasons of which the wet season dominates between April to October and the dry season between November and February. The average rainfall is between 1025 and 1050 mm per annum, and the mean temperature ranges between 31 and 38 °C. Animal husbandry is practiced side by side with crop production, on a limited scale. Hunting is an important economic activity after crop production and a supplement for meat production, hides and skin for shoes, warfare robes and local drums (Kamba *et al*., 2021).

Table 1. Bacterial load from abattoir and slaughter slab effluents in Zuru Local Government Area.

Samples	Colony count in MSA media (CFU/mL)	Colony count in SS media (CFU/mL)	Colony count in MCA media (CFU/mL
Zuru A1(10^{-2})	TNTC	$1.2×10^5$	$2.9×10^5$
Zuru A1(10^{-4})	$1.2×10^7$	$8.5×10^7$	$1.4×10^7$
Zuru A2(10^{-2})	$1.3×10^5$	$6.4×10^3$	$2.7×10^5$
Zuru A2(10^{-4})	$5.3×10^6$	TNTC	1.1×10
Zuru B1(10^{-2})	TNTC	$1.88×10^5$	$2.1×10^5$
Zuru B1(10^{-4})	TNTC	$9.3×10^6$	$9.2×10^6$
Zuru B2(10^{-2})	$2.16×10^5$	$1.05×10^5$	$1.8×10^5$
Zuru B2(10^{-4})	$1.21×10^7$	$3.5×10^6$	$8.7×10^6$
Zuru C1(10^{-2})	$1.42×10^5$	TNTC	$1.2 ×10^5$
Zuru C1(10^{-4})	$8.5×10^6$	$1.8×10^7$	$9.8×10^6$
Zuru C2(10^{-2})	$1.67×10^5$	$2.7×10^5$	$1.7×10^5$
Zuru C2(10^{-4})	$5.3×10^6$	$9.3×10^6$	$1.1×10^7$

Keys: TNTC = Too numinous to count, MSA = Mannitol Salt Agar, SS = Salmonella-Shigella agar, MCA = MacConkey Agar, TFTC= Too few to count, SKB = Sakaba, DWG = Wasagu/Danko.

Table 2. Bacterial load from abattoir and slaughter slab effluents in Fakai Local Government Area.

Samples	Colony count in MSA	Colony count in SSA	Colony count in MCA
Fakai A1(10^{-2})	$2.1×10^5$	$1.73×10^4$	$2.67×10^4$
Fakai A1(10^{-4})	$1.72×10^6$	$9×10^6$	$1.7×10^5$
Fakai A2(10^{-2})	TNTC	$9.3×10^3$	$1.27×10^4$
Fakai A2(10^{-4})	$1.13×10^6$	TNTC	$7×10^6$
Fakai B1(10^{-2})	$1.3×10^5$	$9.7×10^3$	$1.13×10^4$
Fakai B1(10^{-4})	$6.6×10^6$	$4.5×10^5$	$6×10^6$
Fakai B2(10^{-2})	TNTC	$9.1×10^3$	$1.3×10^5$
Fakai B2(10^{-4})	$2.11×10^6$	$4.0×10^6$	$5.8×10^5$

Keys: TNTC= Too numinous to count, MSA= Mannitol salt agar, SS = Salmonella-Shigella agar, MCA= MacConkey Agar, TFTC= Too few to count.

Sample collection and analysis

Samples (abattoir effluent waste) were collected from a total of eight abattoirs and slaughter slabs in Zuru Emirate (Zuru, Fakai, Sakaba and Wasagu/Danko), Kebbi state, Nigeria. The sample collection and processing were done as previously reported by Nafarnda *et al.* (2012). Effluent samples from abattoirs and slaughter slabs were collected every 4 to 5 days, with a total of 50 samples obtained from each site in each local government area. Sampling was conducted in the mornings, during peak activity between 8:00 and 9:00 AM, using the grab sampling method. Sterilized 500 mL Pyrex screw-cap glass bottles were used, leaving a 2.5 cm space at the top. Effluents were taken from a well-mixed point near the discharge outlet. Samples were stored on ice during transport and processed within 5 hours. Before analysis, samples were diluted in 0.1% peptone water by adding 10 mL of sample to 90 mL of diluent, creating a 10^{-1} dilution. Bacteria counts were determined using statistical most probable number (MPN) tables based on the number of positive findings. The mean value concentrations of *Salmonella spp.*, *Shigella*, *Staphylococcus*, and *E. coli* (MPN/100 mL) for abattoir and slaughter slabs in Zuru were analysed. The isolates were identified using standard bacteriologic culture using colony morphology, Gram-staining for cellular morphology and biochemical tests including catalase, coagulase, oxidase, indole and urease, and motility test as previously described by Cheesbrough (2006) and Nafarnda *et al*. (2012).

RESULTS

The bacterial colony counts from abattoir and slaughter slab effluents in Zuru Emirate are summarized as follows: In Zuru and Fakai Local Government Areas (LGAs), the colony counts ranged from $2.9 × 10^5$ to $3.5 × 10^6$ CFU/mL, and $2.67 × 10^4$ to $7 × 10^6$ CFU/mL respectively (Tables 1 and 2). While in Sakaba and Wasagu/Danko LGAs, the range was $1.92 × 10^4$ to $2.2 × 10^7$ CFU/mL and $2.75 × 10^4$ to $2.8 × 10^7$ CFU/mL (Tables 3 and 4) respectively. Major

Table 3. Bacterial load from abattoir and slaughter slab effluents in Sakaba Local Government Area.

Samples	Colony count in MSA	Colony count in SSA	Colony count in MCA
Sakaba A1(10^{-2})	TNTC	1.92×10^4	2.22×10^4
Sakaba A1(10^{-4})	2.33×10^6	7.6×10^5	1.8×10^7
Sakaba A2(10^{-2})	2.18×10^4	1.1×10^5	2.67×10^4
Sakaba A2(10^{-4})	1.12×10^6	6.0×10^6	1.1×10^7
Sakaba B1(10^{-2})	2.1×10^5	TNTC	2.6×10^5
Sakaba B1(10^{-4})	1.5×10^7	2.2×10^7	1.17×10^6
Sakaba B2(10^{-2})	TNTC	1.96×10^4	TNTC
Sakaba B2(10^{-4})	1.9×10^7	8.6×10^5	1.72×10^6

Keys: TNTC = Too numinous to count, MSA = Mannitol Salt Agar, SS = Salmonella-Shigella agar, MCA = MacConkey Agar, TFTC = Too few to count.

Table 4. Bacterial load from abattoir and slaughter slab effluents in Wasagu/Danko Local Government Area.

Samples	Colony count in MSA	Colony count in SSA	Colony count in MCA
Wasagu/Danko A1(10^{-2})	1.4×10^5	TNTC	TNTC
Wasagu/Danko A1(10^{-4})	6×10^6	2.2×10^7	2.8×10^7
Wasagu/Danko A2(10^{-2})	1.7×10^5	TNTC	TNTC
Wasagu/Danko A2(10^{-4})	5.5×10^5	1.73×10^7	2.3×10^7
Wasagu/Danko B1(10^{-2})	2.0×10^5	2.9×10^5	TNTC
Wasagu/Danko B1(10^{-4})	1.24×10^6	1.8×10^7	1.9×10^7
Wasagu/Danko B2(10^{-2})	2.8×10^5	2.75×10^4	TNTC
Wasagu/Danko B2(10^{-4})	1.3×10^7	1.1×10^7	1.7×10^7

Keys: TNTC = Too numinous to count, MSA = Mannitol Salt Agar, SS = Salmonella-Shigella agar, MCA= MacConkey Agar, TFTC = Too few to count.

Bacterial pathogens isolated were *Escherichia coli, Klebsiella spp., Salmonella spp., Shigella spp., Pseudomonas aeruginosa, Staphylococcus aureus*, and *Staphylococcus epidermidis.*

DISCUSSION

The findings of this study highlighted the potential health risks associated with contamination of meat, abattoir environment, water bodies, and all critical line stakeholders involved in meat processing at the abattoirs and slaughter slabs in the Zuru Emirate. The levels of bacterial contamination due to *Salmonella, Shigella, Pseudomonas aeruginosa, Bacillus cereus, Staphylococcus aureus, Escherichia coli*, and *Klebsiella* species isolated from effluents within the abattoir and slaughter slab facilities in Zuru Emirate indicated a significant public health problem. These organisms, apart from being major sources of antimicrobial resistance genes, are known to cause severe to life-threatening infections in both humans and animals. Also, because there is weak regulation with respect to the use of antimicrobials, and other veterinary medicinal products in livestock production, the chances of slaughtering animals under treatment are very high, and this may result in retention of these medicinal products in the tissues. The downside being the contamination of the environment, exposure of the microbial pathogens to sub-optimal doses of antibiotics, and dissemination of these pathogens to nearby streams and rivers, which are the sources of drinking water for some of these communities (Ndukwe *et al*., 2023). The microbiological concentrations (MPN/100 mL) of abattoir/slaughter slab effluents were found to vary between 2.9×10^5 to 3.5×10^6 for Zuru Local Government, 2.67 $\times10^4$ and 7 $\times10^6$ for Fakai Local Government, 1.92 $\times10^4$ and 2.2 $\times10^7$ for Sakaba Local Government, and 2.75 $\times10^4$ and 2.8 $\times10^7$ for Wasagu/Danko Local Government.

The bacterial load from the effluents discharged from the abattoirs/slaughters slab into the surrounding environment was beyond the normal recommended acceptable limits for effluents (FEPA, 1991; Wenibowei, 2018). This is more worrisome, because of the impending health hazards associated with abattoir effluents. Also, because of urbanization and population growth in Nigeria, most abattoirs and slaughter slabs are located within residential buildings and the risk of infection is very high. It is therefore pertinent, that abattoirs be upgraded with modern facilities that is fitted with modern gadgets for effluents treatments before discharging into the environment to reduce the risk of infection and public health hazards (Ogeleka *et al*., 2021).

The digestive tracts of warm-blooded animals typically harbour bacteria that are often used as surrogate indicators for gastro-intestinal pathogens (Carrero-Colón *et al*., 2010). Faecal coliform bacteria, such as *E. coli*, signal contamination by animal or human waste. *E. coli* is the most common faecal coliform, excreted in the faeces of animals that carry it (Fu *et al*., 2020). Its presence in water is considered a specific indicator of enteric pathogens and faecal contamination, as well as a general marker for faecal pollution (Khan and Gupta, 2020). Elevated levels of *E. coli* and total coliforms in receiving water bodies and abattoir wastewater suggest contamination with faeces and potentially harmful pathogens from untreated abattoir discharges, aligning with earlier studies (Chukwu, 2008). Wastewater from abattoirs has been found to contain bacterial pathogens, including *Salmonella spp., Staphylococci*, and *E. coli* (Barros *et al*., 2007, Musa *et al*., 2017), *Campylobacter*, and *Listeria monocytogenes* (Pepperell *et al*., 2003). The study's observations of microbial load from the abattoir and slaughter slab effluents can be of great consequence of risking people and animals in these areas.

In Nigeria, there is often minimal oversight and regulation regarding the placement and operations of abattoirs and slaughter slabs, commonly known as slaughterhouses (Elemile *et al*., 2019). Most of these facilities lack sufficient infrastructure and resources to manage wastewater and solid waste effectively (Lawan *et al*., 2013; Gali *et al*., 2020). Runoff from dairy farms, feedlots, grazed pastures, poultry waste, manure-treated grasslands, and abattoir effluents frequently contaminates water bodies, posing significant environmental and public health risks (Hooda *et al*., 2000; Nafarnda *et al*., 2012; Ekpunobi *et al*., 2024). Typical activities in abattoirs include butchering, hide removal, intestinal handling, rendering, trimming, processing, and cleaning (Nastasijevic *et al*., 2023; Ovuru *et al*., 2024). According to Akange *et al*. (2016), abattoir waste often consists of blood, oil, organic and mineral solids, salts, and chemicals used during processing. Consequently, the proper management of abattoir and slaughter slab waste is essential to ensure the safety of both humans and animals. The limitation of this study was that only abattoirs and slaughter slabs in the Zuru emirate were included in the study. Also, the bacterial pathogens isolated were phenotypically identified. Furthermore, antimicrobial resistance profiles of the isolates were not determined, as this would have added significant clinical value to the outcome of the study.

Conclusion

This investigation concluded that the effluents from the abattoir and slaughter slabs in Zuru emirate exceeded the permissible limits set by the Federal Environmental Protection Agency (FEPA) of Nigeria for discharge into water bodies. Additionally, the bacterial load in untreated abattoir wastewater from the Zuru emirate surpasses recommended thresholds for release into Nigerian waterways. It is recommended that the government upgrade abattoir facilities with modern technologies for effective wastewater treatment procedures for abattoirs.

CONFLICT OF INTEREST

The authors declare no conflict of interest with regards to the publication of this manuscript.

ACKNOWLEDGEMENT

The authors wish to acknowledge the Management of the Federal University of Agriculture Zuru (FUAZ) for recommending and supporting this research project. This research was funded by the TETFUND Institutional-Based Research (IBR) Grant. Grant number: TETF/DR&D/CE/UNI/ZURU/IBR/2024/VOL.1

REFERENCES

Adebowale, A., Oluwawemimo, O., Adedamola, J., Olanike, A., & Eniola, K. (2016). Potential bacterial zoonotic pathogens isolated from a major abattoir and its receiving surface water in Abeokuta, Nigeria. *Alexandria Journal of Veterinary Sciences*, *50*(1), 94-98.

Akange, E. T., Chaha, J. A., & Odo, J. I. (2016). Impact of Wurukum abattoir effluent on river Benue Nigeria, using macroinvertebrates as bioindicators. *International Journal of Aquaculture*, *6*(22), 1-11.

Barros, L. S. S., Amaral, L. A., Lorenzon, C. S., Junior, J. L., & Neto, J. M. (2007). Potential microbiological contamination of effluents in poultry and swine abattoirs. *Epidemiology & Infection*, *135*(3), 505-518.

Carrero-Colón, M., Wickham, G. S., & Turco, R. F. (2010). Taxonomy, phylogeny, and physiology of faecal indicator bacteria. In: *The Faecal Bacteria.* Willey. Pp. 23-38.

Cheesbrough, M. (2006). Distinct Laboratory Practice 2nd Ed. Biochemical test and identification of bacteria. Cambridge University Press United Kingdom. Pp. 146-157.

Chukwu, O. (2008). Analysis of groundwater pollution from abattoir waste in Minna, Nigeria. *Research Journal of Diary Science*, *2*(4), 74-77.

Coker, A. O., Olugasa, B. O., & Adeyemi, A. O. (2001). Abattoir wastewater quality in South Western Nigeria. 27th WEDC Conference: People and Systems for Water, Sanitation and Health. Retrieved from https://hdl.handle.net/2134/28798.

Ekpunobi, N. F., Adesanoye, S., Orababa, O., Adinnu, C., Okorie, C., & Akinsuyi, S. (2024). Public health perspective of public abattoirs in Nigeria, challenges and solutions. *GSC Biological and Pharmaceutical Sciences*, *26*(2), 115-127.

Elemile, O. O., Raphael, D. O., Omole, D. O., Oloruntoba, E. O., Ajayi, E. O., & Ohwavborua, N. A. (2019). Assessment of the impact of abattoir effluent on the quality of groundwater in a residential area of Omu-Aran, Nigeria. *Environmental Sciences Europe*, *31*, 1-10.

Federal Environmental Protection Agency (FEPA, 1991)

Guidelines and Standards for Environmental Pollution Control in Nigeria. Lagos, Nigeria: Ministry of Environment.

Foyle, L., Burnett, M., Creaser, A., Hens, R., Keough, J., Madin, L., Price, R., Smith, H., Stone, S., & Kinobe, R. T. (2023). Prevalence and distribution of antimicrobial resistance in effluent wastewater from animal slaughter facilities: A systematic review. *Environmental Pollution*, *318*, 120848.

Fu, S., Xia, W., Wang, Q., Rahman, M. M., Hao, J., Ye, S., Liu, Y., & Li, R. (2020). Genomic characterization and pathogenicity analysis of the probiotic *Vagococcus lutrae* strain VL-18 causing severe skin lesions in warm-blooded animals. *Aquaculture*, *523*, 735166.

Gali, A. U., Abdullahi, H. A., Umaru, G. A., Zailani, S. A., Adamu, S. G., Hamza, I. M., & Jibrin, M. S. (2020). Assessment of operational facilities and sanitary practices in Zangon Shanu abattoir, Sabon Gari Local Government Area, Kaduna State, Nigeria. *Journal of Veterinary Medicine and Animal Health*, *12*(2), 36-47.

Hooda, P. S., Edwards, A. C., Anderson, H. A., & Miller, A. (2000). A review of water quality concerns in livestock farming areas. *Science of the total environment*, *250*(1-3), 143-167.

Idu, E. G., Omidele, B. O., Nwaubani, D. A., Okwara, C. O. A., & Okpanachi, V. U. (2023). Bacteriological Survey of Abattoir Wastewater in Aba, Abia State, Nigeria. *Bioremediation Science and Technology Research*, *11*(1), 1-4.

Igbinosa, I. H., & Uwidia, I. E. (2018). Effect of abattoir effluents on the physicochemical properties of a receiving watershed in an urban community. *Ife Journal of Science*, *20*(2), 219-228.

Istifanus, V., & Bwala, H. B. (2017). Infrastructure challenges: The review of environmental and health implication of abattoir operation in a developing country. *Journal of Research in Humanities and Social Science*, *5*(6), 60-72.

Joseph, M. O., Ibrahim, B., Zaky, S. K., Abdulkadir, S., & Auta, I. K. (2021). Bacterial assessment of effluents from selected abattoirs into adjoining water bodies in Kaduna Metropolis. *Science World Journal*, *16*(1), 29-34.

Kamba, A. A., Ojomugbokenyode, E., Waziri, T. I., & Nabila, A. (2021). Socio-Economic Evaluation of Women Homestead Farmers in Zuru Emirate, Kebbi State, Nigeria. *International Journal of Applied Agricultural Science*, *7*, 84.

Khan, F. M., & Gupta, R. (2020). *Escherichia coli (E. coli)* as an Indicator of Faecal Contamination in Groundwater: A Review. *Sustainable Development of Water and Environment: Proceedings of the ICSDWE2020*. Pp. 225-235.

Lawan, M. K., Bello, M., Kwaga, J. K. P., & Raji, M. A. (2013). Evaluation of physical facilities and processing operations of major abattoirs in North-western states of Nigeria. *Sokoto Journal of Veterinary Sciences*, *11*(1), 56-61.

Mittal, G. S. (2006). Treatment of wastewater from abattoirs before land application—a review. *Bioresource Technology*, *97*(9), 1119-1135.

Musa, Z., Onyilokwu, S. A., Jauro, S., Yakubu, C., & Musa, J. A. (2017). Occurrence of Salmonella in ruminants and camel meat in Maiduguri, Nigeria and their antibiotic-resistant pattern. *Journal of Advanced Veterinary and Animal Research*, *4*(3), 227-233.

Nafarnda, W. D., Ajayi, I. E., Shawulu, J. C., Kawe, M. S., Omeiza, G. K., Sani, N. A., ... & Tags, S. Z. (2012). Bacteriological quality of abattoir effluents discharged into water bodies in Abuja, Nigeria. *International Scholarly Research Notices*, *2012*(1), 515689.

Nastasijevic, I., Boskovic, M., & Glisic, M. (2023). Abattoir hygiene. In *Present Knowledge in Food Safety* (pp. 412-438). Academic Press.

Ndukwe, M. K., Igara, C. E., Nkama, O. J., Ibe, C. O., Okoro, O. E., Nnnachi, E. O., & Atiaetuk, I. E. (2023). Effect of abattoir waste on surface water quality parameters of Iwofe River, Port-Harcourt, Rivers State, Nigeria. *Journal of Geography, Environment and Earth Science International*, *27*(9), 93-101.

Ogbonna, D. N., & Ideriah, T. J. K. (2014). Effect of abattoir waste water on physico-chemical characteristics of soil and sediment in Southern Nigeria. *Journal of Scientific Research and Reports*, *3*(12), 1612-1632.

Ogeleka, D. F., Emegha, M. C., & Okieimen, F. E. (2021). Ecotoxicological risk assessment of surface water receiving abattoir effluent. *Science Journal of Chemistry*, *9*(1), 14-22.

Okunmadewa, F. (1999). Livestock industry as a tool for poverty alleviation. *Nigerian Journal of Animal Science*, *2*(2), 21-30.

Ovuru, K. F., Izah, S. C., Ogidi, O. I., Imarhiagbe, O., & Ogwu, M. C. (2024). Slaughterhouse facilities in developing nations: Sanitation and hygiene practices, microbial contaminants and sustainable management system. *Food Science and Biotechnology*, *33*(3), 519-537.

Pepperell, R., Massanet-Nicolau, J., Allen, V. M., & Buncic, S. (2003). Potential for spread of some bacterial and protozoan pathogens via abattoir wastes applied on agricultural land. *Food Protection Trends*, 23(4), 315-325.

Wenibowei, K. (2018). An impact assessment of the national policy on guidelines and standards for environmental pollution control in Nigeria, 1991: A case study of the Niger Delta. *The International Journal of Social Sciences and Humanities Invention*, *5*(12), 5155-5162.