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Impact of Abattoir Waste on Water Quality and Public Health around Slaughterhouses in Jos Metropolis, Plateau State, Nigeria

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ABSTRACT
Water pollution occurs when harmful elements enter rivers, lakes, wells, streams, boreholes, or reserved freshwater sources in homes and industries. This study assesses the impact of abattoir waste on water quality in Jos metropolis, Nigeria. Two slaughterhouses were selected and data was collected through field surveys, interviews, and questionnaire administration to abattoir workers and residents living around the Abattoirs. Water samples were also collected from six wells near the abattoirs for physicochemical and bacteriological analysis. Simple descriptive statistics, the Chi-Square test and the Spearman Correlation Coefficient were applied to analyse the data collected. Results of water analysis from the laboratory show that all water samples collected do not fall within World Health Organization (WHO) permissible limits which is very critical to the wellbeing of the people living within the vicinity. Also, interviews and questionnaire results showed that abattoir wastes were discharged directly into the environment without proper treatment, thereby contaminating both surface and groundwater quality which residents depend on for domestic consumption. About 62% of the respondents depend on underground water source for their use. About 72% of respondents had observed changes in their water quality over the years, leading to diseases with typhoid at the fore. The Spearman correlation result reveals a strong and positive value of 0.664 at a p-value of 0.05 level of significance, which indicates a significant and positive relationship between abattoir waste and water quality. The X^2 value of 91.654[a] and Asymptotic significance (2-sided) was less than 0.05 (0.011) also giving reason to retain the alternative hypothesis and conclude that there is a significant relationship between abattoir waste and water quality in Jos Metropolis slaughterhouses. The research suggests addressing abattoir waste and water contamination in Jos metropolis through stricter environmental regulations, water treatment facilities, operator training, and sustainable waste management practices.

INTRODUCTION

Human activities, such as crop farming, piggery, poultry, aquaculture, deforestation and inappropriate disposal of human and animal wastes have, to a large extent, affect the ecosystem, including water quality (TWDGT, 2020). Water is one of the essential resources needed by every living organism for metabolic processes, which lead to growth and development. Inappropriate livestock rearing,

poor disposal of faeces and regular slaughtering of big animals like camels, cattle and donkeys just anywhere can, within a short period generate solid, liquid and gaseous wastes that adversely affect water quality and the biophysical environment. When there is an alteration in the water content, it will affect the aquatic life of the organisms and human beings that consume such untreated water (Fiset, 2018; Abdulsalam, Mohammed, & Kwajaffa, 2023).

An abattoir or slaughterhouse is a special facility designed and licensed for receiving, holding, inspecting and slaughtering animals and meat products before they are released to the public to ensure their safety and wholesomeness for human consumption. It is a building for butchering and houses facilities to slaughter animals: dress, cut and inspect meats; and refrigerate and preserve by-products (Alonge, 2015). The animals slaughtered result in the supply of meat and useful by-products like leather and skin. Orji, Neboh and Ilusanya (2013) explain that slaughterhouses are industries that are involved in the commercial slaughtering of animals such as cattle, goats, and sheep, among others and processing of the meat for human consumption. Abattoir operations generally use huge amounts of water for washing slaughtered meat and in the various cleaning processes in slaughterhouse areas; thus, abattoirs are usually located close to a waterways, because it facilitates the washing and processing of the meat.

Wastes are materials that are not usable economically or not (Ezejiofor, Enebaku, & Ogueke, 2014). Waste may be in the form of solid, liquid and gas. Abattoir produces waste from the remnant of the animals when they are slaughtered. The waste produced by these abattoirs could affect land and water. Abattoir activities are responsible for the pollution of surface and underground waters as well as air quality which indirectly affects the health of residents living within the vicinity of abattoirs (Dkinya & Mufwanzia, 2010). According to reports, abattoir waste piled up in the environment can cause pollution and as a result, emit methane gas, which enhances the greenhouse impact (Singh & Neelam, 2011). These wastes could also be washed away by surface runoff to contaminate ground and surface water including waterways in the streets. Waste that is dumped into waterways has the potential to contaminate surface water with excess nutrients and enteric pathogens. The wastes from abattoir operations which are often separated into solids, liquids and fats could be highly organic. The solid part of the wastes consists of condensed meat, undigested grass, bones, hairs, and aborted foetuses. The liquid aspect on the other hand consists of dissolved solids, blood, guts contents, urine, and water, while fat waste consists of fat and oil (Magaji & Chup, 2012).

Nigeria's livestock industry has grown over time, propelling the country to the forefront of African livestock production (Maina, 2017). The process of making meat production relevant has led the health ministry in Nigeria to check the health implications of these slaughterhouses. Abattoir waste, if not adequately disposed of or reutilized may lead to the transmission of foodborne diseases (Adebowale, 2019), and contaminate ground and surface waters with various pathogenic and non-pathogenic organisms (Elemile et al, 2019). Past studies have demonstrated the presence of zoonotic and antimicrobial-resistant pathogens which include Salmonella spp (Iroha et al., 2016), E. coli O157 (Adebowale et al., 2016), Campylobacter spp. (Sasakia et al., 2014), Cryptosporidium parvum and Giardia lamblia (O'Handley & Olson, 2006). Apart from microbes reported, the presence constitutes a public nuisance and denigrates the aesthetic value of the environment (Ogbonna et al., 2002). The effects worsen when abattoirs are located close to residents.

The United Nations Environment Programme (UNEP 2015) highlights the environmental effects of abattoir operations and waste disposal, which can generate large quantities of solid wastes and wastewater with a biochemical oxygen demand (BOD) and offensive odour. Abattoir wastes, such as blood, manure, hair, fat, bones, and undigested stomach content, pose a serious threat to the environment due to poor handling practices, resulting in adverse impacts on soil, air, and water.

In Nigeria, abattoir wastes pose a significant threat to the environment due to poor handling practices, leading to adverse impacts on soil, air, and water. Land pollution occurs when solid wastes like bones, pieces of flesh, and dung are left unattended in open spaces, leaving the land in a polluted state and part of it being washed into nearby streams. Wastewater from slaughterhouses increases the biochemical oxygen demand (BOD), chemical oxygen demand (COD), total solids (TS), pH, temperature, and turbidity of surface water bodies due to blood and paunch contents being washed off the slaughtered animals. Ezeoha (2016) reports that in both urban and rural areas of Nigeria, abattoir wastes are a menace, containing blood, fat, organic and inorganic solids, salts, and chemicals added during processing operations. Animal manure, consisting of undigested food, cellulose-fiber, undigested protein, excess nitrogen, residue from digested fluids, waste mineral matter, worn-out cells from intestinal linings, mucus, bacteria, and foreign matter, is also present in animal feces.

Developing countries lack an organized strategy for disposing of solid and liquid wastes generated in abattoirs, leading to public health risks and pollution control. Anaerobic digestion is one of the best options for slaughterhouse waste management, achieving high degrees of COD and BOD removal from slaughterhouse

effluent at a significantly lower cost than comparable aerobic systems.

The population explosion in Jos metropolis has led to a significant increase in livestock production, posing substantial environmental risks (Adzandeh, et al., 2015). Abattoirs, where meats are prepared, disembowel the animals, releasing blood and waste into the environment. Some abattoirs lack proper waste disposal systems, leading to waste contaminating surface and groundwater. The waste, including blood, fat, manure, urine, and meat tissue, is disposed of directly into rivers without treatment, affecting water quality and the health of the human population living near them. Waterborne diseases such as typhoid, cholera, amoebiasis, and bacillary dysentery are common in such environments (Rodarte, et al., 2023; Asati, et al., 2024).

It has been observed that Jos abattoirs lack proper facilities or health systems to manage waste peculiar to abattoirs, this leaves the operators with no choice but to dispose of waste into rivers or in heaps near the slaughterhouse. Water contamination among people living close to the abattoir system is inevitable, as they rely on nearby water sources. This study aims to focus on waste generated in abattoirs and its impact on underground water quality in the areas where they are located.

MATERIALS AND METHODS

Study Area

The two abattoir sites selected for the study are the Jos Abattoir located in Jos South LGA and the Yan-Shanu Abattoir Located in Jos North LGA, all within the Jos Metropolis. The Jos metropolitan area is located between latitudes 9°54'N and 10°10'N and longitudes 8°48'E and 9°30'E. The metropolis comprises Jos South, Jos East and Jos North local government areas with their headquarters at Bukuru, Angware and Jos respectively. The area is situated within the northern senatorial zone of Plateau State, and is bounded by Barkin-Ladi to the east, Riyom to the south and Bassa local government area to the west (Figure 1). Jos metropolis rises to an average of 1200m above sea level with a peak of about 1700m around Shere hills. It experiences A_W climate type and falls within the Koppen's Aw climatic sub-region. Generally, weather conditions are warmer during the rainy season (April-October) and much colder during the harmattan period (December-February) (Ariyo, 2000). The mean annual temperature of the city ranges between 20^0C and 26^0C while that of precipitation ranges from 700mm to 1000mm during the peak period with both wet and dry seasons. According to United Nations (2024) population projections, the population of Jos metropolis is put at 1,001,000 People.

Methods

The data for this research were obtained from both primary and secondary sources. The primary data were gathered through well-structured questionnaires and face-to-face interviews with slaughterhouse operators. Water samples were collected from wells (with three wells sampled in close proximity to each slaughterhouse) (Table 1). Clean and sterilized 250 ml glass bottles collected from the laboratory were used to harvest the water samples from the different privately owned wells for analysis of a variety of physicochemical and microbiological parameters according to the Nigeria Standard for Drinking Water Quality (NSDWQ, 2007). Standard Methods for the examination of water and wastewater. Specifically, Plateau State Water Board, Jos and the Department of Geology, University of Jos Laboratories were used in carrying out the various tests. The secondary data on the other hand are information from relevant maps, e-books, textbooks, newspapers, journals, web materials as well as published and unpublished project/dissertations in relevant departments to the research work. Information such as the demographic and socio-economic characteristics of the respondents, types of waste generated, awareness of abattoir waste, methods of waste disposal etc. gathered through the questionnaires were subjected to descriptive statistics: tables, frequencies, charts (bar and charts). Spearman's rank correlation analysis was used to find the relationship between abattoir waste and water contamination in the study area. The results of the water sample analyzed were compared with the World Health Organization (WHO) and Standard for Drinking Water Quality (NSDWQ) to see if they conform to relevant standards.

RESULTS AND DISCUSSION

This section discusses the results of water samples collected from the two slaughter houses (Abattoir and Yan Shanu) in Jos Metropolis. Additionally, the information collected through questionnaires was also presented and discussed descriptively and inferentially as it applies to different responses.

Analysis of Physio-Chemical and Bacteriological Characteristics of the Water Sample Collected Around the Slaughterhouses

A total of 6 parameters were tested for each water sample (Table 1). These parameters cut across the physical-chemical and microbial/biological properties of water. The parameters include Temperature, PH Total Dissolved Solids (PPM), Electrical Conductivity (µS/cm), Dissolved Oxygen (Mg/l), and Total Coliform Count. The results revealed that temperatures of the well waters under investigation are greater than 15^OC which when compared to the WHO standard is acceptable and healthy. Temperature is an important parameter because it affects

the amount of dissolved oxygen which further influences the survival of microorganisms; higher temperatures enhance the growth of opportunistic pathogens like Pseudomonas aeruginosa. According to van der Wielen, Dignum, Donocik, & Prest, (2023) an increase of 1°C can result in an increase of 0.22 and 0.052 log units of P. aeruginosa and M. kansasii, respectively. The pH level of the samples when compared with the WHO standard showed that all the samples of water both in A and B (as indicated in Table 1) are lower than the acceptable standard. A low pH can be acidic soft and corrosive water which can corrode pipes and fixtures, it can leach metals like copper, iron, lead, manganese and zinc from pipes and fixtures, causing damage and aesthetic problems such as metallic taste, laundry staining or blue-green stains. With regards to Health risk, pH values less than 6.5 are considered too acidic for human consumption and can cause different health complications such as acidosis. Water containing elevated levels of toxic metals could also show a low pH level (Musa, Otuaro, Musa, Dada, & Musa, (2020).

Electrical conductivity and Total dissolved solids are within the limits in wells A1 and A2 and very high and higher than the acceptable limit at wells B1 and B2 respectively when compared to WHO and NSDWQ standard water quality. Electrical conductivity is a measure of dissolved ionic components and total dissolved substitution in water. The consumption of water which has values above the permissible limit over a period of time has harmful effects on the health of man as it can defect the endocrine functions and cause total brain damage (Yogendra & Puttiah, 2008).

Total Dissolved Oxygen is also another important parameter in determining the quality of water. From Table 1, except for well A1, all other wells under investigation are quite higher than the permissible limit of water quality. Meanwhile implication of a high value of Total Dissolved Solids is that the water becomes undrinkable and it can corrode containers used to store water (Elemile et al, 2019).

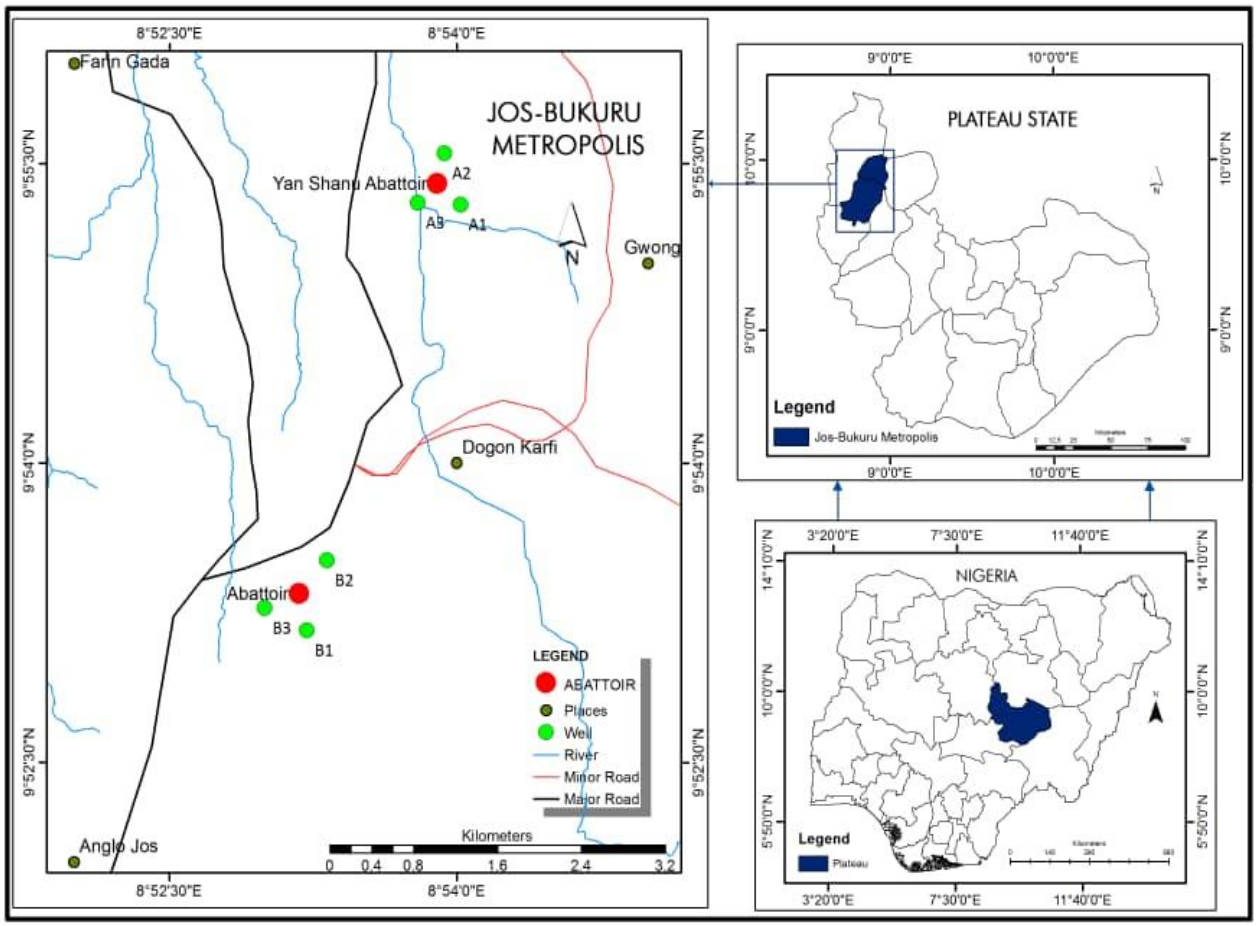

Figure 1: Study Area Jos Metropolis

Table 1: Water Sample Analysis of Two Major Slaughterhouses in Jos Metropolis

S/No	Parameters	WHO /NSDWQ Permissible Limits	Abattoir (A1)	Abattoir (A2)	Abattoir (A3)	Yan Shanu (B1)	Yan Shanu (B2)	Yan Shanu (B3)
1	Temperature(°C)	>15°C	23.7	23.8	23.5	23.7	23.8	24.0
2	P^H Value	6.5-8.5	6.48	6.17	6.13	6.45	6.23	6.19
3	Total Dissolved Solids(PPM)	≤500	468	436	428	657	1804	1622
4	Electrical Conductivity(µS/cm)	≤1000	678	660	664	931	1773	1758
5	Dissolved Oxygen(Mg/l)	2 – 6	5.80	6.43	6.36	6.96	6.83	6.88
6	Total Coliform Count	10/100ml	100/100ml	55/100ml	52/100 ml	85/100 ml	94/100 ml	91/100 ml

Note: A = ABATTOIR, B = YAN SHANU (B1), WN = WHO /NSDWQ Permissible Limits

Results of Total Coliform Count reveal that samples collected from the wells shows a high level of microorganism growth (bacterial contaminants), hence failed the microbial test carried out in the laboratory. This not only makes the water unsafe for human consumption but it also makes it unfit for abattoir facility processes. The presence of coliforms indicates growth and possible biofilm contamination and is in agreement with Oyewale, Odetoyin, Oluduro, & Adeniyi (2024). This occurs in both sewage and natural wastes from human and animal faeces (Yogendra & Puttiah, 2008).

Respondents' Knowledge of Abattoir Waste and Water Contamination in Slaughterhouses within the Study Area

Table 2: Respondents' awareness of the presence of Abattoir Waste around the slaughter houses

Gender	Frequency	Percentage (%)
YES	57	57
NO	43	43
TOTAL	100	100

From Table 2, the analysis identifies that 57% of the respondents are aware or witnessed the disposal of abattoir waste while 43% of the respondents have not witnessed the disposal of abattoir wastes around the slaughter houses. The type of waste disposed from the slaughterhouses shows that blood accounts for 32% of the waste generated, faeces account for 13%, paunch manure constitutes 6%, bones and horns account for 6% also while decomposing manure pile accounts for 43% which is the largest share of the total waste generated in the slaughterhouses as shown in Fig 2. This is in line with the findings of Magaji and Chup, 2012.

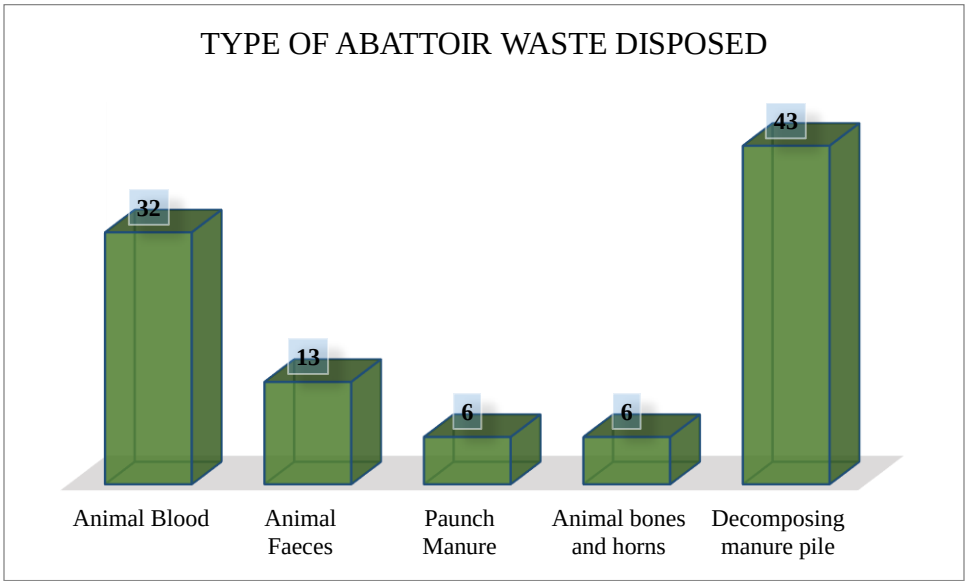

Figure 2: Types of Abattoir waste disposed majorly at the slaughter Houses

Table 3: Response to Methods of Abattoir Waste Disposal in the Slaughterhouses

Disposal method	Frequency	Percentage (%)
Burial	71	71
Composting/Composition	13	13
Incineration	2	2
Rendering	2	2
Solar Drying	5	5
Land spreading	7	7
TOTAL	100	100

Findings from Table 3 reveal that different methods of abattoir waste disposal exist. The most popular method of abattoir waste disposal employed by the respondents in the study area is burial (71%), followed by composting/composition (13%), others methods include incineration rendering solar drying and land spreading.

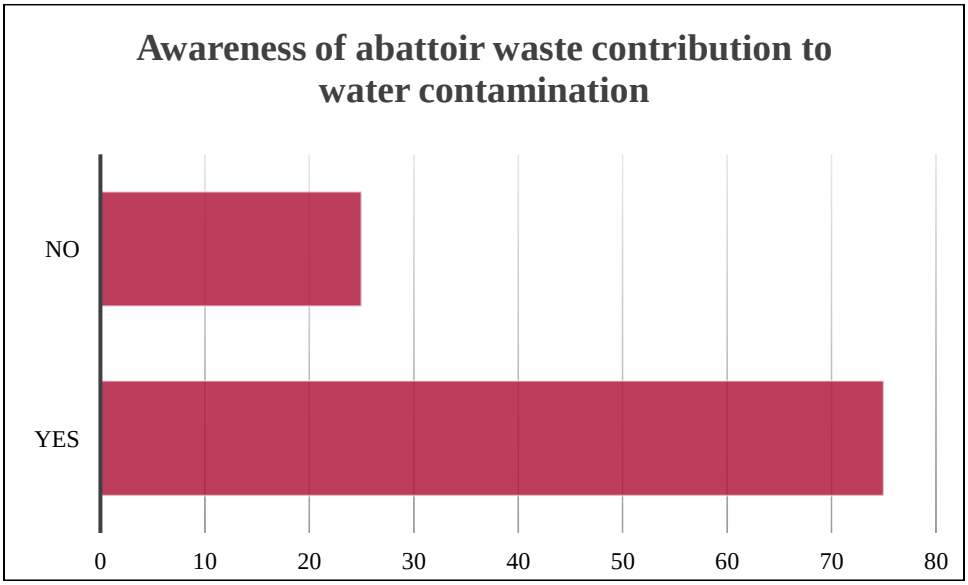

Figure 3: Awareness of Abattoir Waste Contributing to Water Contamination

Figure 3 reveals that the majority (75%) of the respondents are aware of the contribution of abattoir waste to water contamination in the study area, whereas the remaining 25% are not aware of the contribution of abattoir waste to water contamination. Results shown in Table 4 indicates that there are potential risks from water contaminated by abattoir waste. The risks according to the respondents are disease transmission (34%), surface water pollution (27%), others include groundwater contamination and Air/Environmental contamination which is in conformity with studies by Dkinya and Mufwanzia, (2010); Singh and Neelam, (2011).

Table 4: Potential Risks of Water Contamination from Abattoir Waste

Variables	Frequency	Percent	Cumulative
Disease transmission	34	34.0	34.0
Surface water pollution	27	27.0	61.0
Groundwater pollution/contamination	21	21.0	82.0
Air/Environmental contamination	18	18.0	100.0

Figure 4 show that typhoid (52%) is the most common water-related health issues experienced in the areas where these major slaughterhouses in Jos metropolis are located. This is followed by Diarrhea and dysentery with 21% and 20% respectively.

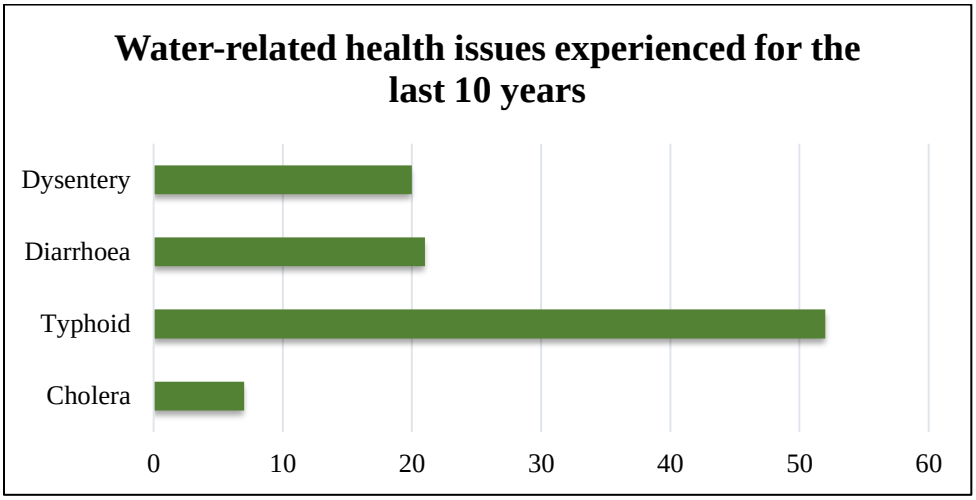

Figure 4: Water-related health issues experienced for the last 10 years

Relationship between Abattoir Waste and Water Contamination

Table 6: Correlation between Abattoirs Waste and Water Contamination in the Major Slaughter Houses in Jos metropolis

Correlations				
			Abattoir Waste	Water Contamination
Spearman's rho	Abattoir Waste	Correlation Coefficient	1.000	.661
		Sig. (2-tailed)	.	.475
		N	100	100
	Water Contamination	Correlation Coefficient	.661	1.000
		Sig. (2-tailed)	.475	.
		N	100	100

The correlation analysis between water contamination and abattoir waste in the study area as presented on table 6 reveals that there is strong and positive correlation with correlation coefficient of 0.661 which of course is statistically significant at 0.0475. This result is a testimony to a lot of water borne diseases ranging from typhoid, diarrhea, cholera and etc which is common in the study area. Other factors also contribute to water-borne diseases in the study area and they include indiscriminate disposal of solid waste, unhygienic environment and inappropriate sewage disposal amongst others.

Table 7: Chi-Square Analysis of Abattoir Waste and Water Contamination in the Major Slaughter Houses in Jos metropolis

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	91.654[a]	63	.011
Likelihood Ratio	51.901	63	.840
Linear-by-Linear Association	.117	1	.733
N of Valid Cases	100		

a. 80 cells (100.0%) have expected count less than 5. The minimum expected count is .02.

Also to test for significant level of the relationship and the effect size between abattoir waste and the water quality in the study area. From the X^2 table presented on Table 7 shows a value of 91.654[a] and Asymptotic significant (2-sided) of 0.011 which of course also known as the p-value, which is statistically significant. This establishes that there is a significant relationship between abattoir waste and water contamination in metropolis.

CONCLUSION

The unprocessed waste from slaughterhouses is one of the main causes of pollution in surface and groundwater, which can lead to health risks and fatalities. A lack of wastewater treatment infrastructure, ineffective environmental legislation, low knowledge, and limited resources all contribute to this problem. Environmental damage is caused by the ongoing production of untreated abattoir wastes, even when some outcomes are marginally in compliance with WHO criteria. Continuous effluent creation can exacerbate toxic amounts of hazardous elements, indicating a health risk to humans. The research revealed that the operations and administration of abattoirs have an impact on the built environment and the well-being of locals, especially in regions with insufficient waste disposal infrastructure. Abattoir locations' restricted outdoor recreation opportunities and inhabitants' poor health.

To avoid groundwater contamination, abattoir waste should be stored separately and taken away from residential areas with waste treatment equipment installed for proper waste disposal. Public awareness campaigns should be undertaken, and operators should get environmental management and sanitation training. Finally, abattoirs should be designated as industrial or agricultural land use, with laws governing animal movement, slaughter, service provision, and waste treatment.

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