The Impacts of Abattoir Waste on Soil and Water Quality: A Review

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ABSTRACT

Abattoirs are vital for providing well-processed meat, but they also contribute to environmental pollution through the large amounts of waste produced, often disposed of untreated into surrounding water and soils. Waste contains high organic matter and toxins, resulting in significant alteration of the physicochemical properties of receiving soil and water and increasing the microbial load of these environmental systems, degrading their quality. Numerous researches have therefore been done to call to attention the impact of these wastes. Highlighting the impact of abattoir activities, most studies focus on its influence on physicochemical and microbial levels in water and soil. Determining these levels provides useful insights into the extent of pollution caused by abattoirs to the surrounding environmental system. This review, therefore, using various studies on abattoir influence on soil or water properties shows the effect of abattoir waste on the quality of affected soil and water. The study further explores management practices that can help reduce the impact of abattoir waste to receiving ecosystem.

Keywords: Abattoirs, Soil, Water, Effluents, Waste, physicochemical properties

INTRODUCTION

In the past few decades, there has been a growing emphasis on maintaining good quality of water and soil due to their critical roles in disease prevention and normal ecosystem functioning (Ogbuene et al., 2020). Despite this, numerous studies have highlighted the decline in the quality of soil and water due to pollution arising from industrial and municipal waste (Idu et al., 2013; Istifanus & Bwala, 2017). Abattoirs, in particular, have been identified as significant sources of such waste.

Abattoirs, also known as slaughterhouses, are facilities designated for the slaughtering of animals for meat consumption (Nwanta et al., 2008). They play a vital role in human livelihood by providing processed meat products. In Nigeria, abattoirs are a crucial component of the domestic meat supply chain. However, their utility is overshadowed by the global recognition of their contribution to environmental pollution (Istifanus & Bwala, 2017).

The operations within an abattoir typically generate substantial waste. Maduka (2005) noted that a single slaughtered cow can produce up to 67.8 kg of waste, with dozens of animals processed daily. Whittle and Insam (2013) define this waste as the animal parts excluded from food production, including blood, internal organs, fat, faeces, undigested feed, hair, and both organic and inorganic solids such as urine, dung, bones, horns, and hooves. The release of these wastes into the environment leads to significant pollution.

It has been documented that abattoir waste is often disposed of in nearby water bodies and soil, creating considerable environmental challenges (Wizor & Nwakoala, 2019, Adesemoye et al., 2006). The improper disposal of this waste contributes to the accumulation of toxins and pathogens, depletion of oxygen levels, and an increase in nutrient availability, all of which detrimentally affects soil and water quality. The resultant pollution renders the affected water and soil unsuitable and unsafe for human use and disrupts the normal functioning of living organisms. For instance, in soil, such discharges can increase acidity, clog soil pores, and diminish microbial activity, ultimately leading to reduced fertility and agricultural yield (Ebong et al., 2020). In aquatic environments, waste can lead to oxygen depletion, eutrophication, and elevated ionic content, thereby endangering aquatic life. The consumption of contaminated water is associated with various illnesses and diseases, including cholera, pneumonia, asthma, dysentery, and typhoid (Ire et al., 2017) .

To study the extent of pollution which has resulted from abattoirs and its likelihood in causing environmental and health concerns to receiving soil and water, research has focused on determining their physicochemical parameters and microbial count in these ecosystems. This review therefore discusses the general trend observed by studies on the influence of abattoir on the physicochemical parameters of receiving water or soil. The study also provides sustainable management properties that will the reduce the impact from abattoir to the environment.

PHYSICOCHEMICAL PARAMETERS

Physicochemical parameters are important tools which provide insight to the quality of a given water or soil resource. These parameters encompass pH, electrical conductivity, temperature, total suspended solids (TSS), total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), organic carbon content, heavy metals, and nutrients. Determining these parameters gives us information on how useful an environmental resource is and also the degree to which pollution has affected a given water or soil environment. In the specific case of abattoir effluents, analyzing these parameters is instrumental in determining the impact of waste on environmental health. The information gained from such analyses are vital for devising effective waste treatment and disposal strategies to mitigate further contamination.

pH

The pH level indicates the acidity or alkalinity of water or soil, which is an important environmental factor influencing the metabolic processes of organisms in these habitats (Ocheje et al., 2021). Extreme pH can increase the bioavailability or mobility of nutrients and heavy metals, which can harm organisms through excessive uptake.

Abattoir waste or effluents can reduce the pH of the soil, water, and groundwater, leading to acidification. Abubakar and Tukor (2014), revealed that the pH of soils recorded in the new and old abattoir discharge sites in their study were lower than that of the control site. Similarly, Haruna et al., (2023) observed pH of water samples impacted by abattoir effluents were lower than the control samples. Likewise, studies on groundwater have revealed that the pH levels of wells within the range of abattoir effluents were lower than those outside this range. These findings suggest that abattoir effluents emit acidic compounds.

However, abattoir activities can also increase pH levels in both water and soil. Research by Ebong et al., (2020) showed that the pH of abattoir-affected soil varied from 5.74 to 6.69, with a mean value of 6.25, exceeding the control site's mean pH of 4.77. Similarly, in analyzing the impact of abattoir waste on the Ikpoba River in Benin City, Ogbuene et al. (2020) observed a higher pH at the discharge sampling point than at other sampling points. This increase in pH is attributed to the presence of alkaline substances in the abattoir effluents.

Total Suspended solids (TSS)

Total Suspended Solids (TSS) is a measure of the relative amount of materials suspended in water, which can include both organic and inorganic substances such as silt, plankton, and industrial waste (Adeyemo et al., 2019). By measuring TSS, we can assess the level of water pollution or contamination in a particular water source.

Abattoir waste is known to contain a substantial amount of suspended solids. Consequently, several studies have recorded high TSS values that exceed permissible limits. Omole and Longe (2018) assessed the impact of abattoir effluents on River Illo in Ota, Nigeria. Their study found that the TSS at the point of discharge

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recorded a high value of 1026 mg/L, significantly higher than the values obtained downstream, which ranged from 384 to 692 mg/L. Furthermore, this value exceeded the WHO standard of 500 mg/L. A similar study by Asibor (2019) also showed that TSS at the discharge point is higher compared to other stations downstream and upstream.

Measuring high TSS values in water indicates severe pollution, which adversely affects water quality and aquatic organisms. High TSS levels obstruct sunlight from reaching underwater vegetation, consequently impeding photosynthetic activity (Dauda et al., 2016). This reduction in photosynthesis lowers the release of dissolved oxygen from underwater plants. In cases of total blockage of sunlight, plant death occurs, leading to decreased availability of dissolved oxygen due to its use by bacteria during decomposition of dead plants. Reduced dissolved oxygen levels can result in fish deaths. Additionally, high TSS contributes to an increase in surface water temperature due to the absorption of heat from sunlight by the suspended particles, further lowering dissolved oxygen levels and adversely impacting aquatic life (Adeyemo et al., 2019).

Turbidity

Turbidity is a key parameter used to measure the clarity of water bodies (Isoken & Ita, 2018). It plays an essential role in assessing water quality. Turbidity refers to the cloudiness or haziness of a water body caused by the presence of suspended particles. The higher the number of suspended particles, the more turbid the water becomes.

One significant source of increased turbidity in water bodies is the presence of suspended particles from abattoir effluents, which include blood and animal urine. When these effluents enter water resources, they introduce a large number of particles, significantly increasing turbidity levels (Mulu & Ayenew, 2015).

Contaminated water bodies with high turbidity have several environmental consequences. Wizor and Nwakoala (2019) recorded high turbidity values (Table 1) and deemed it can cause suspended particles to accumulate in downstream sediments. This sediment buildup can obstruct natural drainage pathways, potentially leading to flooding. Furthermore, if such turbid water is used for irrigation, the suspended particles can clog soil pores, preventing proper drainage, increasing surface runoff, and potentially causing soil erosion and flooding.

Similar to the findings of Wizor and Nwakoala, other studies have reported elevated turbidity levels in areas affected by abattoir waste, often surpassing the permissible limits set by the World Health Organization (WHO). For example, in the Nassarawa River, turbidity measurements at various locations ranged from 227 to 647 NTU, significantly higher than the WHO's maximum acceptable limit of 25 NTU (Alabi et al., 2020).

Dissolved Oxygen (DO)

The measurement of dissolved oxygen provides information into the extent of pollution caused by organic materials (Mulu & Ayenew, 2015). Dissolved oxygen is defined as the amount of oxygen in water. For aquatic life to thrive, a minimum DO level of 5 mg/L is required. When DO levels fall below this standard, it indicates adverse effects on aquatic organisms.

Abattoir effluent discharge into surrounding water bodies significantly lowers the dissolved oxygen levels. The point where the effluent mixes with the river typically shows the lowest DO levels. This reduction in DO is primarily due to the decomposition of concentrated organic materials in the effluents by bacteria, which consume oxygen in the process. As a result, less dissolved oxygen is available for aquatic life, endangering their survival.

Several parameters influence the level of dissolved oxygen in water, including total suspended solids, turbidity, biochemical oxygen demand (BOD), and chemical oxygen demand (COD). According to Atikpo and Akonofua (2021), BOD and COD are inversely related. In their study, the BOD of the effluents at upstream, effluent discharge, and downstream points were 2.2 mg/L, 180.4 mg/L, and 2.2 mg/L, respectively, while the DO levels were 8.10 mg/L, 0.9 mg/L, and 5.97 mg/L, respectively. This inverse relationship shows that high levels of BOD and COD can result in low DO levels, and vice versa (Ogbuene et al., 2020; Alabi et al., 2020).

Colour

Colour, as a physicochemical parameter measures the aesthetic value of water (Mulu et al., 2015). Colour appearance in water is a consequence of dissolved and suspended particles present in it.

Abattoir wastewater, as well as the receiving water bodies, typically have displeasing colours, often with very high numerical values. Adesina (2018) observed that at the point where abattoir effluent mixes with a river, the water had a detestable colour, with a numerical value of 2,684 Pt.Co.APHA, which is significantly higher than the standards set by the Lagos State Environmental Protection Agency (LASEPA). This high level of colour is primarily due to the presence of blood in abattoir effluents, a naturally coloured substance.

The presence of a pronounced colour in water is a clear indicator of poor water quality. Coloured water often suggests contamination and the presence of substances that could be harmful to both human health and aquatic ecosystems.

Temperature

The temperature of an ecosystem is an important factor that controls the activity patterns of an organism and the solubility of gases and salts in water (Joanne et al., 2011). As a physicochemical parameter, temperature refers to the level of hotness and coldness of an environmental system.

Temperature measurements in abattoir effluents and its contaminated water or soil typically range from 21.00 to 35.00°C, which aligns with the normal ambient temperatures and international standards. However, affected environments exhibit higher temperatures at discharge points compared to further downstream and control areas (Dan et al., 2018; Bakume et al., 2018).

High temperatures in an ecosystem affects its normal functioning. It results in the depletion of dissolved oxygen in water, which is required for the oxidation of biodegradable waste, due to reduced solubility (Wizor & Nwankoala, 2019). Furthermore, it can lead to increase of the viscosity of water, leading to quick subsiding of solid particles and proliferation of undesirable algal forms.

Electrical Conductivity

The electrical conductivity measures the ability of an environmental sample to conduct electricity (Isoken & Ita, 2018). It is also referred to as a measure of the dissolved ions in an environmental system. Thus, electrical conductivity and total dissolved solids are strongly positively correlated; hence, an increase in dissolved solids increases the electrical conductivity (Bakume et al., 2018).

Abattoir effluents significantly increase the electrical conductivity of soil and water. A study by Dan et al., (2018) revealed that electrical conductivity values for abattoir-affected soils ranged from 40 to 46 µs/cm, which is higher than the 19.56 to 20.86 µs/cm obtained for control soils. This increase is due to the presence of soluble salts in the effluents. The dissociation of ions in these salts accounts for the rise in electrical conductivity.

Another study by Samson et al., (2023) showed the impact of abattoir effluents to receiving water. It was demonstrated that EC decreases as distance from the point of mixing increased. In the study, water samples were collected and analysed from point-of-discharge, 30 m, 60 m and 90 m downstream. The point of discharge had an electrical conductivity of 675.0(µS/cm), which declined to 670(µS/cm) at 30 m, and further to 650(µS/cm) and 630(µS/cm) respectively at 60 and 90 m. The declining trend can be attributed to water self purification and self dilution mechanism which lessens the impact as distance increases from the point of contamination.

The World Health Organization recommends that the electrical conductivity of water should be no higher than 1000 µS/cm (WHO, 2011). The continued consumption of water with high conductivity can result in endocrine disorders and brain damage (Aniobi et al., 2020).

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Organic Carbon Content

Organic carbon content is a measure of carbon contained in a soil organic matter. It is an important soil characteristic that determines its fertility. The higher the level of organic carbon in a soil, the more fertile it is. Ediene et al., (2016) showed that abattoir wastes significantly increased the carbon content of soils. The control soils were very low in organic carbon which was also below the critical level of 1.5% needed for fertile soils as recommended by the Federal Department of Agriculture and Land Resources (1990). However, the abattoir effluent contaminated soil had higher organic carbon content. The increase in the organic carbon is attributed to the decomposition and composting of the animal waste contained in the effluent. Similarly, Abhanzioya and James (2013) assessing the effect of abattoir effluent on soil properties cultivated with flint maize, showed that soil before application of abattoir waste had an organic carbon (8.5) below the critical level of 1%. Upon application of abattoir effluent, the organic carbon of soil increased to the range of 10.2 - 12.4 using various amount of abattoir effluent. This increase impacted the growth of the flint maize as the yield was very good.

Cation Exchange Capacity (CEC)

Cation Exchange Capacity (CEC) measures the capacity of soil to retain positively charged ions (Dan et al., 2023). This physicochemical characteristic is essential for plant growth as it influences soil pH, soil structure stability, and the availability of nutrients. Some crops, such as vegetables, tend to perform poorly in soils with low CEC but thrive in soils with moderate to high CEC levels.

The effect of abattoir effluents on the CEC of soils generally results in higher CEC levels compared to uncontaminated soils. A study by Dan et al. (2018) showed that abattoir-affected soils in various locations had CEC values ranging from 25.11 to 28.63 Cmol/kg, which were higher than the CEC values of control soils, ranging from 20.84 to 21.67 Cmol/kg. This increase in CEC is beneficial as it enhances soil fertility, making it more conducive for plant growth.

Heavy metals

In addition to solid waste, abattoir effluents often contain heavy metal pollutants. The presence of heavy metals in these effluents can be attributed to several factors, including the use of detergents to wash animals, burning animal skin with car tires, elevated organic matter, and metals being part of animal feeds (Ogun et al., 2023). Commonly detected metals include Iron (Fe) Copper (Cu), Chromium (Cr), Nickel (Ni), Magnesium (Mg), Cadmium (Cd), and Cobalt (Co) with Fe having the highest concentration.

Heavy metals as with other physicochemical parameter exhibits higher concentration in the contaminated area. Table 3 shows the concentrations of metals in abattoir affected soil and water from point of discharge. The increase in the contaminated area is attributed to the presence of these metals in the wastewater which then bioaccumulates when introduced into the environment.

The toxicity of heavy metals heavily affects the ecosystem. Heavy metals in soil markedly reduce the number of microbial organisms, leading to loss of the soil fertility and subsequently causing lower agricultural yields (Ogun et al., 2023). In water, heavy metals bioaccumulate in the tissues of aquatic life, leading to impairment and death at high concentrations. Humans are also affected through the consumption of contaminated plants and the use of contaminated water for domestic purposes.

Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is a useful parameter for determining the level of organic materials in water and required oxygen of effluents and contaminated water. It is defined as the amount of oxygen required to decompose biodegradable organic materials under aerobic conditions. BOD is important in assessing water quality for human consumption and the health of aquatic ecosystems. High BOD levels indicate a presence of large amounts of organic matter, which, when decomposed by microorganisms, leads to a depletion of dissolved oxygen.

In abattoir effluents or affected water, BOD levels are usually very high. Adeyemo et al. (2019) revealed that BOD measurements in wells located within an abattoir were greater than those in wells outside the abattoir area. The significant amount of organic matter in waste contributes to these high values. The implication of high BOD values is that abattoir-affected water is largely unsafe and unsuitable for any beneficial purposes.

Chemical Oxygen Demand

Chemical Oxygen Demand (COD) is similar to BOD as it also measures the amount of oxygen required to degrade the organic pollutant load in water. Its difference from BOD is, it is inclusive of non-biodegradable organic matter as well as chemical oxidants. High COD levels show the presence of significant amount of chemical oxidants in the abattoir effluent while low COD levels show otherwise (Ogbuene et al., 2020). Chemical oxidants include organic, nitrite, sulphide, and ferrous salts.

The COD values for abattoir wastewater or receiving rivers are often high, attributed to the presence of organic matter and various salts. Adeyemi et al., (2019) reported high COD levels of 338.42 mg/L upstream and 382.09 mg/L downstream, both of which exceed the National Environmental Standards Regulation and Enforcement Agency (NESREA) standard value of 30 mg/L, indicating that the studied river is unsafe for human consumption and other purposes. Similarly, Joseph et al., (2020) revealed COD values ranging from 3007 to 5410 mg/L, surpassing the WHO permissible limit of 1000 mg/L.

Nutrients

Nutrients commonly refers to the amount of nitrogen and phosphorous compounds found in soil and water. These compounds include phosphate, nitrate and nitrite. They are required for growth and development of living organisms. A moderate amount leads to healthy growth of plants. However nutrient levels may lead to detrimental effects.

Abattoir waste generally increases the level of nutrients in water or soil (Omole & Longe, 2008). This may be due to feed of the animals and high composition of organic matter in abattoir effluents. Ediene et al., (2016), recorded the enrichment of nutrients into soils from all the abattior areas studied. The abattoir contaminated soils were observed to be much higher in phosphorus content with the values exceeding 20 mg kg-1. Obtaining such high phosphorus content would indicate less availability and uptake of essential elements such as Fe, Mn, Zn, Cu and Mo and cause early maturity in plants which is very disturbing as it leads to shorter life cycles of plants and smaller plants.

Furthermore, high amount of nutrients cause eutrophication in water bodies (Mulu & Ayenew, 2015). Availability of excess nutrients to large number of microorganisms, which in turn may lead to the depletion of dissolved oxygen in the water (Dauda et al., 2016). These microorganisms consume oxygen for survival and reproduction, leading to a decrease in oxygen levels available for other aquatic life.

Chloride

The determination of chloride ion concentration is crucial for identifying sewage contamination in groundwater. High concentrations of chloride ions in water can harm plants when used for irrigation and cause drinking water to have an unpleasant taste, making it unfit for human consumption (Elemile et al., 2019). Furthermore, consuming water with high chloride ion concentration can result in health effects such as stomach ulcers, abdominal pains, and skin lesions (Aniobi et al., 2020). In soil, high chloride levels can induce toxic effects in crops from accumulation, thereby reducing crop yield.

Chloride ions have been reported in abattoir effluents and receiving water or soil, may be due to the use of detergents in washing animal skins and the blood of animals (Osinbajo & Adie, 2007). Detergents and blood contain soluble salts such as KCl and NaCl, which are disposed of in the effluents (Adeyemi-Ale, 2014). The dissolution of these compounds releases chloride ions, thus increasing chloride levels in soil or water.

A study by Adeyemo et al., (2019) revealed that abattoir activities affect the chloride ion concentration of groundwater. The study compared the concentrations of wells within the abattoir and outside, showing that

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the well within the abattoir had a value of 748.8 mg/L, which was higher than the well outside the abattoir with a value of 665.0 mg/L. Moreover, these values are above the WHO standard value of 250 mg/L for chloride concentration. Aniobi et al., 2020) showed that the concentration of chloride ions in wells decreased with increasing distance from the abattoir. The chloride concentrations of sampling points 1, 2, 3, and a control point were 53.08, 50.45, 46.18, and 41.04 mg/L, respectively. Sampling point 1 (S1) recorded the highest chloride concentration compared to the others due to its proximity to the abattoir.

Table 1. Comparison of physicochemical characteristics of water obtained from abattoir affected water from different locations and WHO standard.

Location	pH	TSS (mg/L)	TDS (mg/L)	DO (mg/L)	Turb. (NTU)	Chloride (mg/L)	Calcium (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	BOD (mg/L)	COD (mg/L)	Temp (°C)	EC (µs/cm)	References
Kaduna Metropolis	7.56	1158	4341	11.2	57	7.94	77	456	-	73.5	5305	-	-	Joseph et al., (2019)
Woji River, Port Harcourt, Rivers State	8.8	915	990	-	58	-	86.56	9.68	0.86	-	-	30	180	Wizor & Nwankoala (2019)
Nassarawa River, Nassarawa state	7.83	460	665	6.71	567	-	-	3.5	-	-	-	28.5	993	Alabi et al., (2020)
Ogun River, Oguns state	5.5	1495.47	757.03	0	-	183.58	-	89.43	18.62	686.53	1374.91	32	3400	Adeogun et al., (2011)
Ikpoba River, Benin City	6.58	30.93	153	1.93	63.12	29.57	19.66	8.7	2.1	33.06	60.66	29.4	305.33	Isoken & Ita (2018)
Orogodo River, Delta State.	6.76	227.2	750	0.2	150	49.3		10.9	10.55	112.5	1045	33.3	841	Asibor (2019)
River Brass, Yenagoa, Bayelsa State	7.8	140	157	1.01	-	-	-	-	-	323	-	-	165	Idisi & Uguru (2020)
River Illo, Ota, Ogun state	6.8	1026	45.5	0.01	-	-	-	0.19	3.05	670	1675		196	Omole & Longe (2008)
Gbagi Stream, Ibadan	7	-	-	2.53	-	53.1	-	-	257.63	90.46	382.09	-	-	Adeyemi-Ale (2014)
WHO	6.5 - 8.5	-	500	25	5	250	100	10	-	10	100	29	1000	WHO (2011)

Table 2. Comparison of physicochemical characteristics of soil affected by abattoir waste from different study locations.

Location	pH	EC (µs/cm)	Organic Matter (%)	Organic Carbon (%)	CEC (Cmol/kg)	Phosphorus (mg/kg)	Nitrogen (mg/kg)	References
Uyo Village	6.69	70.38	12.41		34.36			Ebong et al., (2020)
Ikot Enobong, Calabar Metropolis	6.3			7.5	25.37	27.75	7.5	Ediene et al., 2016
Obiakpor, Port Harcourt Metropolis	7	78.33	-	-	-	160.67	39.3	Chukwu &Anuchi, 2016

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Yola Metropolis, Adamawa State	5.06		2.94	1.7	8.64	5.28	2.81	Abubakar & Tukor, 2014
Swali, Yenagoa Metropolis	4.61	148.3	-	-	-	1.35	2.84	Idisi &Uguru, 2020

Table 3. Heavy metal concentrations in Abattoir affected water and Soils from different study locations

Locations	Fe	Cu	Zn	Pb	Co	Cr	Ni	Cd	Mn	Hg	References
Ikpoba River, Benin City	0.83	0.47	0.56	-	-	-	-	-	-	-	Ogbuene et al., 2020
Uyo Village Soil, Akwaibom State	877.8	18.2	24.04	0.99	-	0.24	9.68	-	-	-	Ebong et al., (2020)
Ijebu-Igbo River	86.38	9.6	55.8	0.06	-	-	-	-	0.26	69.6	Neboh et al., 2013
Ikot-Ekpene Soil, Akwa Ibom State	643.45	16.82	19.23	0.73	-	0.32	9.73	0.35	-	-	Dan et al., 2018
Yola Soil, Adamawa State	260.65	6.87	19	-	6.87	-	-	-	-	-	Ja'afaru et al., 2021

MICROBIAL CONTAMINATION

Another issue associated with abattoir waste contamination is microbial contamination, which is a major public health concern (Kenneth et al., 2019). Microbes in soil and water indicates severe deterioration of its quality, leading to various illnesses in humans and mortality of plants and aquatic life (Adamu & Dahiru, 2020).

The occurrence of microbes, mainly bacteria, coliforms, and fungi species, in abattoir waste and effluents is attributed to its high organic matter content. Organic matter serves as nutrients for the growth and development of these microbes. For example, blood is rich in protein, making it an ideal breeding ground for pathogenic microbes (Idu et al., 2023).

Bacteria and Coliform Bacteria

Bacterial analysis of abattoir contamination shows the presence of different bacteria species which includes Bacillus sp., Vibrio sp., Staphylococcus sp., Klebsiella sp., Micrococcus sp., Pseudomonas sp, Escherichia sp., Salmonella spp., Shigella spp., and Enterobacter spp (Adesemoye et al., 2006; Ire et al., 2017). These bacterial species are considered as pathogens. Escherichia coli presence indicates faecal contamination, as this bacteria live inside the rumen and digestive tract of slaughtered animals, making them components of animal faeces (Idu et al., 2023). E. coli is associated with causing severe illnesses, such as diarrhoea. Vibrio cholerae is the bacterium responsible for the widely known waterborne disease, cholera. Staphylococcus aureus and Klebsiella pneumoniae are known to cause food poisoning, skin infections, and urinary tract infections.

Abattoir contamination commonly exhibits high heterotrophic and coliform bacteria count. In the bacteriological survey of abattoir waste in Aba, Abia state, Nigeria, it was reported that the wastewater exhibited high bacterial load which range from 1.2×10^7 to 7.1×10^6 CFU/mL, coliform count range from 5.8×10^6 to 1.2×10^6 CFU/mL and cellulolytic count ranged from 3.7×10^6 to 1.3×10^6 CFU/mL (Idu et al., 2023). The study concludes if wastewater is released into the surrounding water or soil may result in severe consequences to the environment and human health.

Ire et al., (2017), showed heterotrophic bacteria count ranging from $4.6 - 5.6 \times 10^6$ and $3.5 - 4.1 \times 10^6$ for effluent and receiving water respectively. Coliform count ranged from $2.6 - 3.7 \times 10^6$. These values are above the WHO standard therefore not proper for domestic usage.

Neboh et al., (2013) compared soils contaminated with abattoir and uncontaminated soils. The results showed that contaminated soil had a higher bacterial count of 2.45×10^4 CFU/g than uncontaminated soil with 1.8×10^4 CFU/g. This shows the negative effect of abattoir to the bacterial load of receiving soil.

Fungi

Fungi isolates in abattoir contamination includes Aspergillus sp., Penicillium sp., Candida spp., Saccharomyces spp., Fusarium sp., Mucor sp., and Rhizobium spp (Neboh et al., 2013; Abhanzioya & James, 2021). Aspergillus spp., the most commonly found in abattoir contamination, is known to cause various illnesses and diseases such as Aspergillosis which leads to severe respiratory infections. Penicillium spp. are commonly known for their use in the production of antibiotics however certain of these species can cause food spoilage, leading to economic losses in agriculture. Candida spp. are pathogens known to cause well known candidiasis disease.

Fungal count in abattoir contaminated water or soil is greater than the uncontaminated soil and above standards. Neboh et al., (2013) observed that uncontaminated soil (Suc) had a higher value of 1.22×10^4 CFU/g than the contaminated soil (Sc) 1.12×10^4 CFU/g. Emeh et al., (2020) recorded that the point of discharge had the highest point of fungal count of 1.1×10^6 CFU/mL. This observed high levels of fungal count indicates the unsuitability of disposal of abattoir waste to the surrounding water or soil.

ABATTOIR WASTE MANAGEMENT

Given the negative effects of abattoir wastes on soil and water quality, researchers have called for the implementation of proper waste management practices. Effective waste management is essential to protect public health and the environment, and if implemented, the level of pollution resulting from abattoirs will be significantly reduced. Waste management practices include policy making, proper site selection, and various treatment methods.

Policy

Policy making involves the establishment of regulations and guidelines to control the disposal and treatment of abattoir wastes. These policies can enforce standards for waste management, ensuring that abattoirs comply with environmental protection laws.

According to Idu et al.,2023, there is a need to implement stringent policies that will stop the disposal of untreated abattoir wastewater or effluents into water and soil. Anunobi et al., (2015) showed that abattoir areas were disposing off waste into the surrounding area, nearby gutter, nearby farmland, nearby stream and nearby gully. This environmental menace is being carried out because there is no enforcement of policies regarding the disposal of abattoir waste. In the preceding discussion, it has been highlighted that abattoir activities are observed to significantly deteriorate the quality of water and soil. Therefore, if policies are not implemented, there will be a continued decline of surrounding water and soil quality and this poses a significant threat to public health.

Proper Site Selection

Before setting up an abattoir it is important to consider the site and appropraite design for the abattoir to minimize pollution that poses health risks to the sorroundings. The factors to be considered before setting up an abattoir include (Anunobi et al., 2015):

1. Reasonable diluting distance from contamination sources.
2. Aquatic locations must have fast-flowing rivers and waterways.
3. Selected site must have a suitable slope for effective drainage.
4. The site should be adequately large.

Treatment Methods

Treating abattoir wastes before final disposal helps lessen their negative impact on the environment and human health. Various treatment methods have been utilized, including incineration, burial, rendering, composting, blood processing, and anaerobic digestion (Kenneth et al., 2019;] Ogun et al., 2023; Mulu & Ayenew, 2015; Adamu & Dahiru, 2020; Gutu et al., 2021).

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1. **Incineration:** Incineration involves the controlled burning of abattoir waste at high temperatures in an incinerator. This method helps convert the waste into ash, significantly reducing its quantity and destroying most pathogens. However, operational costs for incineration are high, and improper management can lead to air pollution, causing nuisance to surrounding communities.

2. **Burial:** Burial is the most commonly used and viable method for treating abattoir waste. The waste is collected and buried in a designated area of land. It is crucial to cover burial sites immediately to prevent disease-causing agents or vectors from accessing the waste.

3. **Rendering:** Rendering converts materials obtained from abattoir waste into usable forms. For example, muscle, fat, bones, and animal tissues are transformed into a protein substance resembling sand or soil, which can be stored for long periods. The products of rendering can be used as animal feed additives, in oil lamps and candles, and in the production of soap and biofuels. This method kills most pathogens and significantly reduces the amount of waste.

4. **Composting:** Composting offers a cost-effective disposal option for abattoir waste. It involves the controlled biodegradation of organic matter using aerobic microorganisms, resulting in humus or compost-like materials. Abattoir waste is placed on a layer of carbonaceous materials, such as wood chips, shavings, hay, or straw, and covered in a compost pile. The compost material is turned every six weeks, with the process usually completed within 6-12 weeks.

5. **Blood Processing:** This method involves removing the blood from the slaughtered animals and sending them to a treatment facility. These facilities process the blood into a range of goods that contains nutrients.

6. **Anaerobic digestion:** Anaerobic digestion degrades waste in the absence of oxygen, producing methane and carbon dioxide. This method is ideal for treating abattoir waste due to its high organic matter and nutrient content. Advantages of anaerobic digestion include good removal of organic matter, efficient BOD and COD removal, low energy consumption, fewer chemicals and nutrients, and low sludge production. However, there are limitations, such as long startup and running duration, sensitivity to elevated temperature levels, and an inability to efficiently remove nutrients like phosphates and nitrogen.

CONCLUSION AND FUTURE DIRECTIONS

Abattoirs are important for our domestic sustenance, but their operations and waste disposal mechanism results in increasing the physicochemical and microbial levels of water and soils, sometimes exceeding standard limits. This results in a considerable deterioration of soil and water quality. While the addition of abattoir effluents may increase the fertile characteristics of soil and lead to good plant yields, studies typically involve controlled addition of effluents, which might not reflect real-world scenarios.

Addressing the pollution resulting from abattoirs is an immediate concern. Effective measures include implementing appropriate policies, selecting proper sites for abattoir activities, and adequately treating waste before its final disposal. Adhering to these waste management practices will significantly reduce pollution levels, help maintain the quality of our ecosystems, and protect public health.

Future research should focus on developing and optimizing waste treatment technologies, assessing long-term environmental impacts, and creating sustainable practices for waste management in abattoirs. Collaborative efforts among policymakers, researchers, and industry stakeholders are essential to ensure a balanced approach that supports both environmental sustainability and public health.

Conflict of interest

The authors do not have any form of conflict of interest in this work.

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