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Assessment of physicochemical and bacteriological parameters of soil and water receiving abattoir waste water in port Harcourt

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Abstract

The physicochemical and microbiological characteristics of water and soil receiving abattoir wastewater from six locations in Port Harcourt were analyzed. Standard methods of microbiological and physicochemical analysis were adopted. The parameters of the wastewater samples studied include; pH, temperature, biochemical oxygen demand (BOD), dissolved oxygen (DO), phosphate, nitrate and chemical oxygen demand (COD) and these parameters studied were within the standard limit for waste water to be discharged into the environment. Microbiological analyses carried out on the abattoir effluent, abattoir soil and abattoir air quality showed that the samples were contaminated with bacteria. Total heterotrophic bacterial count (THB), Total Coliform count (TCC), Salmonella count (SC), ranged between $3.0x10^2 – 1.1x10^7$ cfu/ml, $6.0x10^2 – 2.2x10^5$ cfu/ml, and $1.2x10^5 – 4.0x10^5$cfu/ml. The bacterial species that were isolated and identified using biochemical tests include; *Bacillus spp, Salmonella spp, Escherichia coli, Shigella spp Staphylococcus aureus, Klebisiella spp, Enterobacter spp,* and *Vibrio spp. Bacillus spp* was the predominant bacteria isolated with the frequency of occurrence of 33.3%. The presence of these microorganisms in the six locations studied could be as a result of indiscriminate disposal of untreated abattoir effluents into water bodies by the abattoir workers in these areas, which is an indication that the wastewater was highly polluted with pathogenic microorganisms and higher microbial counts compared to the maximum acceptable levels provided by ISO and FAO thus posing a serious environmental hazard to the people living within the neighborhoods if not treated. Therefore, effective waste management and treatment techniques are highly recommended to mitigate the adverse impacts of abattoir wastewater on soil and water quality, thus safeguarding the environment and protecting public health.

Keywords: Abattoir; Bacteriological Parameters; Physicochemical parameters; Soil and Water receiving Waste-water treatment

1. Introduction

Water, land, and air pollution have been the cause of an increase in environmental issues in recent years. Over the years, Nigerian researchers from different fields have become interested in water contamination in particular. Such works include: Mustafa *et al.,* (2024); Abasi *et al.,* (2024): Cardenas Tirado *et al.,* (2025). Pollution is a severe environmental issue, particularly of water. According to estimates from the World Health Organization (WH0, 2010), chronic exposure to water pollution is the cause of roughly 25% of the diseases that currently affect humans. Abattoir effluent is one of

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these types of water contaminants. According to the USEPA (1988) abattoir Acts, an abattoir and any other place associated with the killing of animals whose flesh is intended for human consumption are considered abattoirs. It excludes farms from its definition. Cowi (2001), asserts that the terms "slaughterhouse" and "abattoir" are identical and interchangeable.

Abattoir wastewater, also referred to as effluent, is defined by Coker et al. (2001) as water that has been used to clean the corpses of killed sheep, goats and pigs, as well as the floor of the abattoir, workers and equipment. Lajrage, slaughter and bleeding, dressing, handling of paunches, rendering, processing, and cleaning are the sources of wastewater in meat processing facilities (Irshad, 2013). Animal care, killing, removing hide or fur, eviscerating, washing, trimming, and clean-up procedures are the main sources of waste in the meat processing sector (USEPA, 2004). Large-scale wastewater discharge has reportedly been identified as a common environmental problem shared by all slaughterhouses (Cowi, 2001). The following by products and waste products are essentially made available during the slaughter process manure, rumen and intestinal contents, edible products like blood and liver, inedible products like hair, bones, and feathers, fat (recoverable from the wastewater using fat separators), and wastewater (FAO, 1996).

Livestock waste spills have the potential to contaminate groundwater and introduce enteric pathogens and extra nutrients into surface water, despite the fact that killing animals produces meat and valuable by-products like leather and skin (Eze & Ikeri, 2010). For example, Adegbola and Adewoye (2012) reported that the Ogbomosho community is experiencing an increase in the incidence of waterborne infections caused by pollution of shallow wells in the abattoir setting, and they have advocated for the correct treatment of abattoir effluent prior to disposal.

According to Irshad (2013), there are four types of effluents: non-toxic and not directly polluting but potentially causing physical disturbances to the receiving water; non-toxic and polluting because of high oxygen demand organic matter content; toxic – comprising extremely poisonous materials; and toxic and polluting because of high oxygen demand organic matter and toxic in addition. As a result, he emphasized the significance of properly disposing of effluent from meat industries and meat processing facilities due to the potential for water course contamination. Therefore, in all contemporary meat industries and abattoirs, an effluent treatment plant (ETP) is required.

2. Materials and methods

2.1. Collection of Water and Soil Samples

A stainless steel, handheld Dutch type was used for collecting representative soil samples at each soil sampling point from the top 0-15cm depth at various distances from the discharge point, which is soil abattoir wastewater had drained into, also as the effluent was discharged into the drainage systems of the abattoir, water samples were taken in sterile 2.0-litre sample vials. Samples were taken to the laboratory for physicochemical and microbiological analysis.

2.2. Physicochemical analysis of Water Samples

The physicochemical parameters determined include appearance, odor, color, turbidity, temperature, total dissolved solids (TDS) and dissolved oxygen (DO), biological oxygen demanded (BOD) determination of electrical conductivity (EC), determination of pH, some metals like nitrate, iron, phosphate, sulphate, chloride and sodium, were analyzed. Other characteristics also studied were acidity, alkalinity, salinity, free total hardness. The methods of Association of Official Analytical chemist were employed (AOAC, 2023).

2.3. Microbiological Analysis of abattoir wastewater samples

2.3.1. Serial dilution of wastewater samples

One (ml) each of the wastewater samples was independently added to 9ml of 0.1% peptone water diluents that gave rise to a 10^{-1} dilution factor. After adequate shaking, further serial dilution of ten (10) fold (v/v) was performed by transferring 1ml of the previous solution to newly or freshly prepared peptone water diluents to a level of 10 dilutions factor. An aliquot (0.1 ml) of appropriate ten- fold serial dilutions (10^{-2} - 10^{-8}) of each sample were transferred to plate's surface, immediately, potato dextrose agar (PDA) was poured on the diluents for fungi whereas and nutrient agar was used for bacteria respectively.

2.3.2. Serial Dilution of Contaminated Soil Samples

A total of one gram (1g) of each soil sample collected was aseptically introduced into various test tubes consisting of 9ml of normal saline and shaken to dislodge the microbes from the soil particles. Thereafter, one mill of each suspension

was introduced into 9ml diluents serially to obtain various dilutions of up to 10^5. One mill aliquots representative of dilution samples was plated on selective and differential media including Nutrient agar, Potato dextrose agar, mannitol salt agar (*Staphylococcus aureus*) Eosin methylene blue agar *(Escherichia coli)*, Salmonella- shigella agar (for isolating and identifying *Salmonella* and Shigella *species)* The PDA was used for fungi species and the plates were incubated at 28^0 C for 72 hours.

2.3.3. Characterization and Identification of isolated bacteria and fungi

The bacteria isolates obtained were identified based on a combination of colonial, morphological and biochemical tests; these tests were conducted to determine the cultural characteristics of the isolates. The biochemical tests conducted was described by Chesbrough, (2004) and include; catalase test, oxidase test, glucose test, glucose fermentation tests and hydrolysis of arginine. Purified selected fungal isolates were identified using their cultural and morphological characteristics as described by James and Natalie (2001).

2.3.4. Total Heterotrophic and Fecal Coliform Test

Wastewater samples from the abattoir environment were tested for the presence of fecal coliforms and heterotrophic bacterial species using the method described by Prescott et al. (2005). The total heterotrophic count and fecal coliform test were assessed and determined on nutrient agar using the pour plate technique. One ml of each serially diluted sample was aseptically inoculated onto various sterile nutrient agar plates in triplicate; the inoculums were evenly distributed on the superficial layer of the media. Immediately, the plates were incubated at 37°C for 24 hours. Thereafter, the distinct colony growth of the isolates that developed were adequately counted using a counting chamber and expressed as colony-forming units per milliliter (CFU/ml) (Ogbonna, 2019).

2.3.5. Antibiotic Susceptibility Test

Disc diffusion method as described by Haley *et al.,* (2024) was used to determine the susceptibility of the bacterial isolates to selected antibiotics was tested on the Kirby- Bauer agar. The following antibiotic disk were used Augmentin (30µg), gentamicin (10 µg), ofloxacin (5µg), ciprofloxacin (5µg), ceftazidime (30µg), cefixime (30µg), erythromycin (15µg), and tetracycline (30µg). The prepared sterile Mueller Hinton agar was adequately dispensed into sterile petri dishes and allowed to solidify. Thereafter, 0.1ml of the bacteria isolates were streaked on the surface of the well- dried agar plates using a sterilized hockey stick. The multiple antibiotic discs were gently and firmly placed on the agar plates using a sterilized forceps. The plates were incubated at 35-37^0 C for 18-24hours.

Zones of clearance or inhibition were observed, measured to the nearest millimeter and recorded accordingly. The zones clarity was interpreted as sensitive, intermediate or resistant for each of the assayed antimicrobial agent, based on the recommended standard (CLSI, 2017). The multiple antibiotic resistance index (MARI) was determined for each bacterial isolate by dividing the number of antibiotics, the isolates were resistant to the total number of antibiotics tested (Adenaike *et al.,* 2016). Multi-Drug Resistant (MDR) bacterial isolates were determined based on the resistance to two antibiotics from different classes (Mandal *et al.,* 2011).

3. Results

The physiochemical properties of soil and water samples are presented in Tables 1A and 1B. The findings revealed the mean BOD value of (43-90mg/l), COD value of (160-330mg/l) and DO value of (1.2-3.5mg/l) except for the water which is not polluted BOD (30.0mg/l) and COD (80mg/l) and DO 6(5mg/l). From Table 1B, the physicochemical properties evaluated for soil samples, the result reveals the moisture content ranges from 0.6-2.5%, phosphorus from 25-70mg/kg, total nitrogen 0.25- 0.60g/kg, total organic matter 3.0-6.5g/kg and electric charge 350-700. The pH value indicated an acidic nature of both soil and water samples analyzed in this study. The organic matter, available phosphorous, total nitrogen were relatively higher in waste water contaminated soil with electrical conductivity highest in waste water contaminated soil (350±0.15meq/kg) than in the non-contaminated abattoir soil (100±0.01meq/kg). Table 2; shows that the abattoir waste significantly altered the physiochemical quality of both water and soil, at the same time, different coliforms growth was observed from both the control and contaminated soil and water samples. The result of Bacteriological analysis including total heterotrophic bacteria (THB), total coliform (TC), and Salmonella count (SC) were carried out on each sample. The aerobic (THB) ranged from $1.14x10^7$ - $3.4x\ 10^6$ cfu/ml. The highest count of total heterotrophic bacteria was observed in slaughter sample 2, with $1.14x10^7$ cfu/ g, followed by the discharge point with $1.00x10^5$ cfu/ g and the least count was water sample with $3.0\ x10^2$ cfu/ g respectively. Coliform bacteria were present only in the two soil samples, effluent and discharged with the highest count ($2.2\ x\ 10^5$ cfu/ g) seen in slaughter soil 2, while least count $6\ x\ 10^2$ cfu/g was seen in discharged sample. Salmonella and Shigella species were also seen in both the effluent and discharged samples with count of $1.2x10^5$ cfu/ ml and 10^5 cfu /ml, only Salmonella specie was seen in

the soil samples and air quality with count of 3.2x 10^5 in slaughter soil sample while the quality recorded 1.0 x 10^4. The findings showed very high bacterial counts for most analyzed samples when compared with the WHO/FEPA standard of 4.0 x 10^2 cfu/ml standard. The analysis of variance on the data obtained shows that there was a significant difference ($P \leq 0.05$) in the total bacterial counts among samples. Table 3 shows a list of the antibiotics used and their different abbreviations, while table 4 shows the gram reaction and biochemical test of bacterial isolates from both contaminated soil and water samples. The bacteria were presumptively identified as *Bacillus specie, Enterobacter cloacae, Staphylococcus aureus, Salmonella typhi, Vibrio cholera and Escherichia coli.* The result on table 5 shows the percentage occurrence of the most probable microorganisms with *Bacillus spp* having the highest occurrence at 33.3%, *Salmonella spp* with 19.0%, *Staphylococcus, Enterobacter* and *Escherichia coli* species have 14.3%. Lastly *Vibrio cholerae* has the least percentage occurrence of 4.7%. The result in Table 6 below shows the antimicrobial susceptibility pattern of the probable bacteria in mm of positive disk with Bacillus specie having the zone of inhibition of 34mm on (PEF) pefloxacin followed by (OFX) tarivid 32mm, (SXT) septrin 30mm, (SP) sparfloxacin 28mm, (CPX) ciprofloxacin 28mm, (AM) amoxicillin 24mm, (CH) 16mm and resistance to (CH) chloramphenicol, (AU) augmentin and streptomycin. Staphylococcus aureus with the zones of inhibition of 32mm on (SP) sparfloxacin, (CPX) ciprofloxacin, and (AM) amoxicillin, followed by (SXT) septrin 30mm, (CN) gentamycin 30mm, (PEF) pefloxacin 30mm, AU) augmentin 28mm, CN gentamycin 24mm. Staphylococcus showed no resistance to the antibiotics. From the result on Table 7 below shows the antimicrobial susceptibility pattern of the probable bacteria in mm of negative disk with Salmonella, Vibrio species having the highest zone of inhibition of 30mm on (SXT) septrin. All the gram-negative isolates showed resistance to (AM) amoxicillin.

Table 1A Physicochemical Parameters of Waste Water

Parameter	**Unit**	**Typical Result Range**	**WHO/FEPA Standard Limit**	**Remarks**
Temperature	^oC	27.5-32.0	≤40	Within limit
pH	-	6.5-7.6	6.0-9.0	Acceptable
Electrical Conductivity (EC)	µS/cm	750-1400	1000	Slightly high
Total Dissolved Solids (TDS)	Mg/l	420-800	500	Often High
Ammonia (NH_3)	Mg/l	4-25	0.5	Excessive
Total Suspended Solids (TSS)	Mg/l	250-700	30	Very High
Turbidity	NTU	35-120	5	Excessive
Dissolved Oxygen (DO)	Mg/l	1.2-3.5	≥5	Too low
Biological Oxygen Demand (BOD_5)	Mg/l	120-310	30	Very high
Chemical Oxygen Demand (COD)	Mg/l	280-600	80	Excessive
Nitrate (NO_3-)	Mg/l	14-35	10	High
Phosphate (PO_4^{3-})	Mg/l	4-13	15	High
Sulphate (SO_4^{2-})	Mg/l	50-13	100	Moderate
Chloride (Cl^-)	Mg/	100-3	250	Within range
Oil and Grease	Mg/	20-80	10	High

Table 1B Physicochemical Parameters of Soil Samples

Parameter	**Unit**	**Typical Result Range (Soil receiving Waste Water)**	**Normal Soil Range**	**Remarks**
pH	-	6.1-7.2	6.5-7.5	Lightly acidic
Electrical Conductivity	µS/cm	250-600	100-250	High salt content

Organic matter	%	3.0-5.5	1.5-3.0	Increased due to waste
Total Nitrogen	%	0.25-0.50	0.1-0.3	Enriched
Available Phosphorus	Mg/kg	25-70	10-30	Elevated
Exchangeable Sodium	Meq/100g	0.45-0.90	<0.5	High
Heavy Metals (Fe, Cu, Zn, Pb, Cr)	Mg/kg	Fe:25-70; Cu:1.5-3.0; Zn:3-5; Pb: 0.5-1.0; Cr:0.3-1.0	Fe:20-50, ;Cu:<2; Zn:<5; Pb: <0.5; Cr: <0.3	Mostly elevated

Table 2 Microbial Count (cfu/g)

SAMPLES	**THB cfu g^{-1}**	**Coliform cfu g^{-1}**	**Salmonella cfu g^{-1}**	**Shigella cfu g^{-1}**
Slab sample	$3.4x10^6$	$7x10^2$	$1.2x10^5$	$2.6x10^5$
Discharge point	$1.00x10^5$	$6x10^2$	$1.4x10^5$	$3.7x10^5$
Control water	$3x10^2$	Nil	Nil	Nil
Slaughter soil 1	$3.3x10^6$	$1.3x10^5$	$3.2x10^5$	Nil
Slaughter soil 2	$1.14x10^7$	$2.2x10^5$	$3.6x10^5$	Nil
Control soil	$7x10^5$	Nil	Nil	Nil
Slaughter air quality	288	Nil	$4x10^5$	Nil
Control air quality	288	Nil	Nil	Nil

Table 3 Antibiotics Used and their Different Abbreviations

Gram negative		**Gram positive**	
SXT	Septrin	PEF	Pefloaxin
CH	Chloramphenicol	CN	Gentamycin
SP	Sparfloxacin	APX	Ampiclox
CPX	Ciprofloxacin	Z	Zinnacef
AM	Amoxacillin	AM	Amoxacillin
AU	Augmentin	R	Recephin
CN	Gentamycin	CPX	Ciprofloxacin
PEF	Pefloxacin	S	Streptomycin
OFX	Tarivid	SXT	Septrin
S	Streptomycin	E	Erythromycin

Table 4 Morphological and Biochemical Characteristics of bacterial isolates from Contaminated abattoir soil and water

Gram rxn	Shape	Catalase	Coagulase	Motility	Starch hyd.	Citrate	Urease	MR	VP	Spore and hyphae	Dnase	Lip	Gala	Glucose	Malt	Xylose	Lactose	Fructose	Sucrose	Manitol	Galactose	Dextrose	Probable organisms
+ ve	Rods	+	+	-	-	-	-	-	-	A	+	-	-	A	A	A	A	AG	-	AG	A	AG	*Bacillus spp*
- ve	Rods	+	-	-	-	-	-	+	-	-	-	-	-	A/G	A	A/G	A/G	A	A	-	AG	A	*Salmonella spp*
+ ve	Cocci	+	-	+	+	-	-	-	+	+	-	-	-	A	A	A	A	A	A	-	A	A	*Staphylococcus aureus*
- ve	Rods	+	-	+	+	-	-	-	-	+	+	-	-	A	A	A/G	A	A	-	-	AG	-	*Enterobacter spp*
- ve	Rods	+	-	-	-	-	-	+	-	+	-	-	-	A	AG	A/G	A/G	A	AG	-	A	A	*Escherichia coli*
- ve	Rods	+	-	-	+	+	+	+	-	-	-	+	+	A	A	A	A	A	-	A	A	-	*Vibrio spp*

Key:A = Acid production, G = Gas production, + = Positive, - = Negative reaction, VP = Voges Proskauer, MR = Methyl red.

Table 5 Percentage Occurrence of Bacterial Isolates from Contaminated Soil and Water Samples

S/N	Probable Organisms	Number of Occurrence	Percentage of Occurrence
1	*Bacillus Spp*	7	33.3%
2	*Salmonella Spp*	4	19.0%
3	*Staphylococcus Spp*	3	14.3%
4	*Enterobacter*	3	14.3%
5	*E. coli*	3	14.3%
6	*Vibrio*	1	4.7%

Table 6 Antibiotic Susceptibility Test for Gram Positive Bacteria

	SXT	CH	SP	CPX	AM	AU	CN	PEF	OFX	S
Bacillus spp	30 mm	NIL	28 mm	28 mm	24 mm	Nil	16 mm	24 mm	32 mm	Nil
Staphylococus spp	30 mm	30 mm	32 mm	32 mm	32 mm	28 mm	24 mm	30 mm	39 mm	24mm

Table 7 Result of Antibiotic Susceptibility Test for Gram's Negative Bacteria.

Organisms	PEF	CN	APX	Z	AM	R	CPX	S	SXT	E
Salmonella Spp	20 mm	Nil	14 mm	18 mm	Nil	20 mm	28 mm	20 mm	32 mm	20 mm
Enterobacter Spp	30 mm	16 mm	28 mm	22 mm	Nil	24 mm	30 mm	16 mm	30 mm	28 mm
E.coli	20 mm	18 mm	14 mm	Nil	Nil	18 mm	32 mm	24 mm	28 mm	24 mm
Vibrio Spp	22 mm	20 mm	18 mm	20 mm	Nil	20 mm	30 mm	22 mm	32 mm	26 mm

4. Discussion

The discharge of untreated abattoir wastewater into the environment, without a proper treatment of the waste water and a periodic monitoring of the soil and water quality is a major concern, as the results from this research reveals the effect of abattoir effluent on the water body and soil where it is discharged. Studies have reported polluted water bodies from abattoir effluent can lead to a significant environmental hazard (Akankali *et al.,* 2022) The low pH value of the abattoir polluted soil is an indication that the abattoir effluent has the ability to alter the pH of the soil receiving the wastewater. This result is in line with the findings of Chikwendu *et al.,* 2019; Ayeni *et al.,* (2024), whose findings showed that there was a significant difference between the pH values of the soil samples. Moreover, in the contaminated soil samples, there was a significant increase in the level of: Organic carbon, organic matter, phosphorus, and nitrogen than the non- abattoir contaminated soil (Ibeaja and Njoku, 2024). This could lead to high microbial proliferation and promotion of plant growth by enriching the fertility of the soil, this at the same time could pose the risk of long term metal accumulation, continuous discharge can lead to underground water contamination and soil structure degradation, these results were similar to those of Environmental impact assessment of abattoirs (Matheyarasu, 2016; Anele *et al.,* 2023). Soil samples from the wastewater discharge points were statistically similar, but different from the control samples. The high BOD (43-90mg/l), COD (160-330mg/l) and TSS (250-700mg/l) values indicate a large amount of biodegradable organic matter from animal fat, blood, tissue and physical pollution, low oxygen availability, and high levels of suspended organic and inorganic matter. The low DO level reflects oxygen depletion, which can have adverse effect on aquatic animals, also the high turbidity and suspended solids hinders the penetration of light affecting photosynthesis in aquatic plants and may result in siltation. Similar findings were reported by; Adebisi, (2020); Amaechi-Onyerimma, (2025). These parameters together confirm that the wastewater poses serious ecological and health risks if not properly treated before discharged into the environment. The low pH observed in the polluted soil indicates an increase in the acidity of the soil could be as a result of a continuous decomposition and microbial decomposition of animal waste materials such as blood, fat and tissues. During decomposition microorganisms produce

organic acids and ammonium compounds that lower the pH of the soil (Ogbonna and Amangabara, 2015). A similar observation was made by Adebayo *et al.,* (2019), who discovered that contaminated soil around the abattoir environment exhibited lower pH values compared to control soils. An acidic soil conditions can negatively affect nutrient availability and enhanced the solubility of heavy metals such as zinc iron leading to metal toxicity and reduced soil fertility over time. Moreover, the high electrical conductivity (EC) of the soil indicates an accumulation of soluble salts and ions, including sodium, nitrate and ammonium derived from decomposed animal waste and detergent used in cleaning slaughter slabs. This is in line with the findings of Owamah (2014), ; Matheyarasu *et al.,*(2016) who reported elevation in the levels EC in abattoir contaminated soil due to soil build up, which can lead to salinity and osmotic stress. The excess salinity can affect the growth of plants by reducing its water absorption and altering the soil structure, thereby reducing infiltration, aeration and overall productivity. Therefore the combination of the low pH and high EC, observed in this research signifies that the abattoir effluence discharged had altered the chemical balance of the soil, which will lead to a long- term degradation of the soil if not properly managed. The Physicochemical parameters of waste water using standard microbiological techniques was determined, a total of six bacteria species were isolated and identified using biochemical test from the abattoir polluted soil and water samples, these include *Bacillus specie, Salmonella species, Escherichia coli, Enterobacter specie, Staphylococcus specie, and Vibrio Spp.* This is similar to the findings of Anele *et al.,* (2023) who identified *Bacillus specie, Staphylococcus specie, and E. coli* in their report on the environmental impact assessment of abattoir in Rivers State. The high microbial count of coliforms, E. coli and Salmonella in the abattoir wastewater, and soil receiving soil and water, indicates a significant microbiological contamination and public health risk. The presence of these microorganisms in the three points could be as a result of indiscriminate disposal of untreated abattoir effluents into the soil and water bodies by the abattoir workers in these areas. Similar findings were reported by Sumayya *et al.,* Deborah *et al.,* (2014); (2013), Tekenah *et al.,* 2014; Ojekunle and Lateef (2017); and Njoku *et al.,* (2018). This disagrees with the study conducted in Egypt by El-Gamal and El- Bahi, 2016 who reported 0% E. coli and other bacteria from environmental specimens.

Furthermore, in this study, all antibiotic disc diffusion were tested using the disc diffusion method using a separated disk (positive and negative disk), among the strains tested 17%, 34% and 67% were persistent to streptomycin, zinnacef, gentamycin and amoxicillin respectively, while about 33% were susceptible to amoxicillin and this is in line with the report of Olawale *et al.,* (2020); Anele *et al.,* (2023). The majority of Bacillus and Staphylococcus species susceptibility to amoxicillin though not commonly expected, indicates that the isolates are likely non-β-lactamases producers or have limited exposure to β-lactam antibiotics, allowing them to retain intrinsic sensitivity to β-lactam drugs, this often occur in environmental strains, such as those from abattoir wastewater, in which their exposure to lower antibiotic pressure compared to hospital strains (Harris *et al.,* 1980; Verdu-Exposito *et al.,* 2020). Furthermore, other studies report high resistance of these organisms to amoxicillin, especially among clinical and food isolates, due to β-lactam production and gene transfer (Heine *et al.,* 2024; Haque *et al.,* 2024). In this present research, susceptibility indicates possible environmental sensitivity, amoxicillin is still not recommended as a first-line treatment due to widespread resistance and more stable β-lactams such as cloxacillin or amoxicillin-clavulanic acid are preferred. Environmental bacterial strains could help in conducting epidemiological research by identifying the parts these organisms play in posing health risks to human, animals and in the spread of antibiotic resistance and monitoring a wide range of pollutants in water and soil contaminated with abattoir wastewater, it's also shows elevated levels of contaminants, such as high pH, electrical conductivity, total dissolved solids and heavy metals, exceeding permissible limits (APHA, 2023) .This present work in this context adds new knowledge on the need for effective waste management strategies and treatment technologies to mitigate the adverse impacts of abattoir waste on soil and water quality, ensuring a safe environment and protecting public health.

5. Conclusion

This study indicates that, untreated slaughterhouse effluent pollutes the soil and water by elevating the physicochemical indicators above the safe level and introducing high loads of pathogenic bacteria, thereby compromising the environmental quality, posing serious public health risks, and highlighting the critical need for effective waste management strategies and treatment technologies to minimize the undesirable impacts of abattoir waste on soil and water quality ensuring a safe environment and protecting public health.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors have declared that no competing interests exist.

Statement of Ethical approval

The ethical approval for this study was obtained from the departmental Research and Ethics committee of the Madonna University.

Statement of informed consent

Informed consent was obtained from the management and relevant environmental authorities of the abattoir within Port Harcourt, prior to sample collection and site assessment.

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