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Environmental impact assessment of abattoirs in Rivers State, Nigeria

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Abstract

Abattoir waste discharged randomly into a recipient ecosystem can have a serious ecological impact. This study aimed to assess the environmental impact of abattoir operations, looking at the physicochemical and microbiological quality of air, soil and wastewater within the vicinity of operations. Physicochemical parameters of air, soil and water were found to differ across locations, though not significant ($p>0.05$). BOD and COD exceeded the tolerable limits of 30-100 mg/l and 250 mg/l respectively, for all samples. Only the pH (10.62) of wastewater from the Mbodo-Aluu abattoir exceeded the tolerable limit of 5.5-9.0. All heavy metals were within tolerable limits, except Zn, which exceeded 0.2 mg/l. Microbiological parameters of air, soil and water were also found to differ across locations, though not significant ($p>0.05$). Abattoir operations impact the physicochemical characteristics of wastewater, soil, and air in the abattoir environment. Microbes associated with wastewater, soil impacted by abattoir wastewater, and air from the abattoir environment were found to include pathogenic species of bacteria and fungi. Proper waste management should be encouraged among abattoir operators and should include treatment of wastewater.

Keywords: Abattoir; Physicochemical characteristics; Microbiological quality; Environmental impact; Assessment

1. Introduction

Environmental problems brought on by air, water, and land pollution have become more prevalent recently. Wastes are commonly generated by different facilities and industries, which in turn affect the environment where these activities are carried out. Hence, abattoirs are also regarded as one of the contributors to the production of environmental waste, leading to environmental pollution if not managed adequately.

Inadequate sanitary practices emanating from operators of abattoirs are primarily to blame for the severe pollution of the aquatic, soil, and atmospheric environments near slaughterhouses. Airborne and waterborne diseases, in particular typhoid, diarrhoea, dysentery, tuberculosis, the common cold, and pertussis, can be concurrently or quickly spread alongside noxious gasses emanating from this environment [1-3].

Clean unpolluted air is very essential and peculiar for human existence, but due to inadequate environmental sanitation planning and monitoring practices in abattoirs, such as the indiscriminate disposal of faecal waste materials and carcasses that ooze offensive smell within the vicinity, and the singeing of animal skin with plastics and tyre, all would make the surrounding ecological habitat perturbed, thus increasing the chances of respiratory diseases, particularly among the young and elderly in such an environment [1,4]. If abattoir waste is spilt into the environment, enteric

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pathogens, excessive nutrients, and heavy metals that could reduce soil fertility could be exposed to surface waters, groundwater, and soil [5].

In Nigeria, the majority of abattoirs lack facilities for managing animals and disposing of waste properly. All reports and visits revealed imprecise methods and operations across the entire process that a typical abattoir should have, from arrival to packaging. The killing of animals causes suffering, the processing of the meat is subpar, and the trash produced is not properly disposed of [6, 7]. Regulatory authorities seem not to be bothered by the environmental health threat of abattoir operations in Nigeria. In the Niger Delta where there is the bigger problem of oil pollution, much attention has not been paid to a key contributor to water pollution, abattoir operation.

Abattoirs in Nigeria frequently struggle to properly dispose of, handle, and process these wastes in a way that does not harm the environment, and those in Rivers State are no exception. This study aimed to assess the environmental impact of abattoir operation on air, soil and water within abattoirs in Rivers State.

2. Materials and Methods

2.1. Study Area

Port Harcourt is the administrative capital of Rivers State, Nigeria- a megacity with a population of over 10 million persons. It is the oil and gas hub of the country, with vast oil and gas infrastructure. The city is within the tropical rainforest belt, having a very long wet season (8-10 months) and a short dry season (2-4 months). The population of the city is mixed with traders, technical experts, administrators, local and multinational business persons, civil servants, and a whole lot of other professionals, among the indigenous people that engage in fishing, farming and trading. Several abattoirs located in the city, including those at Rumuokoro, Chokocho Etche, Mbodo Aluu, and Trans-Amadi provide meat processing services.

2.2. Sampling

Abattoirs located at Rumuokoro, Chokocho Etche, Mbodo Aluu, and Trans-Amadi were conveniently chosen for the assessment of environmental quality. Air quality was determined using a handheld air quality analyser. Analysis of air was done once in the morning between 7 a.m. and 10 a.m. during peak operation and once in the evening between 4 p.m. and 5 p.m. when all activities would have been concluded.

Soil samples were collected within the abattoir environment in sterile plastic bags. Wastewater samples were collected from trenches within the abattoir in sterile 2.0-litre sample vials. Samples were to the laboratory and subjected to microbiological and physicochemical analyses.

2.3. Physicochemical Analysis

The pH, temperature, conductivity and turbidity were determined using a pH meter and handheld multiparametric meter (Hana) respectively. Biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), total suspended solids (TSS), total dissolved solids (TDS) and chloride concentrations were determined by the method described by APHA [8]. Heavy metal concentrations were determined using Atomic Absorption Spectrophotometer (ASS).

2.4. Microbiological Analysis

Enumeration of microorganisms in the air was done by settling plate method, using nutrient agar for bacteria and potato dextrose agar (PDA) for fungi. Enumeration of microorganisms in soil and water samples was conducted using the pour plate method, in nutrient agar plates, for total heterotrophic bacterial count (THBC) and PDA plates, for total fungal count (TFC), as described by Aneja [9]. The method described by Prescott et al. [10] was used for the determination of total coliform count TCC.

Pure isolates were obtained by repeated sub-culturing in nutrient agar and characterized following schemes described by Cheesbrough [11]. Identification of fungal isolates followed the taxonomic keys provided by Harrigan and McCance [12].

2.5. Statistical analysis

Descriptive and inferential statistics were used for results representation and interpretation. ANOVA test was conducted for the various physicochemical and microbiological parameters of wastewater samples.

3. Results

3.1. Physicochemical Parameters

Table 1 shows the mean, standard deviation, and confidence interval for the air quality at abattoirs based on their locations. The mean values are Air Temp. 139.93^oC; Relative Humidity, 249.205 %; SO_2, 0.995 ppm; NO_2, 0.21 ppm; VOC, 1372.77 ppm; CH_4, 84 ppm; CO, 73.2 ppm, CO_2, 6200 ppm; NH_4, 2.14 ppm; H_2S, 1.17 ppm; $PM_{2.5}$, 331.575 ppm, PM_{10}, 700.925 ppm and TSP, 790.275 ppm. There is no significant difference in the mean samples of air quality at abattoirs based on the different locations ($F[3,104] = 0.234$, $P > 0.05$) at a 5% level of significance.

Table 1 Air quality at the abattoir

Parameters	Rumuokoro	Chokocho	Trans-Amadi	Mbodo-Aluu	Avg.
Air Temp. ^0C	34.98	35.875	34.325	34.75	139.93
Relative Humidity (%)	64.48	58.9	65.15	60.675	249.205
SO_2, ppm	0.02	0.3	0.275	0.4	0.995
NO_2, ppm	0.0245	0.045	0.0885	0.052	0.21
VOC, ppm	211	414.75	261.9	485.12	1372.77
CH4, ppm	4.55	27.5	35.75	16.2	84
CO, ppm	22.875	14.25	15.75	20.325	73.2
CO_2, ppm	1775	1351.5	1595.75	1477.75	6200
NH_4, ppm	0.53	0.625	0.475	0.51	2.14
H_2S, ppm	0.275	0.275	0.2	0.42	1.17
Suspended $PM_{2.5}$, ppm	59	138.85	65.225	68.5	331.575
PM_{10}, ppm	162.75	254.8	114.25	169.125	700.925
TSP, ppm	192.85	263.15	159.675	174.6	790.275

Table 2 shows the physicochemical parameters of abattoir soil samples. The mean values are pH, 5.24-5.81; E.C., 390.03-500.10 µs.cm-1; Temp., 34.22-36.10 °C; Alkalinity, 38.00-86.00 mg/Kg; Total Moisture Content, 13.70-20.04 %; Chloride, 20.32 - 92.22 mg/Kg; Total Nitrogen, 1.79 - 3.12 %, Nitrate (NO_3^-), 0.52 - 0.84 %; Phosphorus, 0.85 -1.06 %; Total Organic Carbon, 14.25 - 19.60, %, Total Organic Matter, 22.15 - 26.26 mg/Kg, and Oil/Grease, 319.46 - 700.86 mg/Kg. There is a significant difference in the average physicochemical parameters of abattoir soil. ($F[11,46] = 46.147$, $P < 0.05$) at 5% level of significance.

Table 2 Physicochemical parameters of abattoir soil samples

Parameters	Rumuokoro	Chokocho	Trans-Amadi	Mbodo-Aluu
pH	5.24	5.81	5.37	5.26
E.C. ($\mu s.cm^{-1}$)	500.10	421.29	390.03	480.34
Temp. (OC)	36.10	34.22	35.20	35.05
Alkalinity (mg/Kg)	38.00	76.00	86.00	54.12
Total Moisture Content (%)	20.04	13.70	18.32	16.55

Chloride (mg/Kg)	20.32	45.02	92.22	38.43
Total Nitrogen (%)	2.24	2.10	3.12	1.79
Nitrate (NO^{3-}) (%)	0.52	0.84	0.79	0.59
Phosphorus (%)	1.06	0.85	0.90	2.1
Total Organic Carbon (%)	19.60	14.25	16.40	15.24
Total Organic Matter (mg/Kg)	23.20	22.15	26.26	24.33
Oil and Grease (mg/Kg)	420.25	319.46	700.86	462.98

Table 3 shows the heavy metal contents of abattoir soil samples. The mean values are, Mn, 0.01-0.02 mg/kg; Ni, 0.01 mg/kg; Zn, 6.99-12.00 mg/kg; Cu, 0.01-0.06 mg/kg; Pb, 0.03; Cr, 0.02 0.05 mg/kg, and Cd 0.01-0.02 mg/kg. There is a significant difference in the average heavy metal contents of abattoir soil, ($F_{[6,27]} = 28.805$, $P < 0.05$) at a 5% level of significance.

Table 3 Heavy metals contents of abattoir soil samples

Parameters	**Rumuokoro**	**Chokocho**	**Trans-Amadi**	**Mbodo-Aluu**
Manganese (mg/kg)	0.02	0.01	ND	0.01
Nickel (mg/kg)	0.01	ND	0.01	ND
Zinc (mg/kg)	12.00	10.23	8.42	6.99
Copper (mg/kg)	0.04	0.06	0.01	0.02
Lead (mg/kg)	0.03	ND	ND	ND
Chromium (mg/kg)	0.02	0.05	0.02	ND
Cadmium (mg/kg)	ND	0.01	0.01	0.02

Table 4 shows the physicochemical parameters of wastewater samples. The mean values are in the ranges provided: pH, 6.91-10.62; E.C., 830.17 - 1570.11 μs.cm^{-1}); Turbidity, 48.00 - 367.38 NTU; BOD, 288 – 389 mg/l; COD, 864 - 1200 mg/l; TDS, 150 – 2000 mg/l, and TSS, 100 - 500 mg/l.

Table 4 Physicochemical parameters of the abattoir wastewater samples

Parameters	**Rumuokoro**	**Chokocho**	**Trans-Amadi**	**Mbodo-Aluu**	**FMeV**
pH	6.91	7.52	8.41	10.62	5.5–9.0
E.C. (μs.cm^{-1})	1570.11	1170.50	1340.15	830.17	-
Turbidity (NTU)	300	47.02	48.00	367.38	-
BOD (mg/l)	288	388	389	384	30–100
COD (mg/l)	790	864	1200	1152	250
TDS mg/l	200	150	700	800	2000
TSS mg/l	250	150	450	500	100

Table 5 shows the heavy metal contents of abattoir wastewater samples. The heavy metals were in the ranges, Zn, 5.05-8.26 mg/l; Pb, 0.01-0.03 mg/l; Cr, 0.02 mg/l, and Cd, 0.01 mg/l.

Table 5 Heavy metals contents of abattoir wastewater samples

Parameters	Rumuokoro	Chokocho	Trans-Amadi	Mbodo-Aluu	NESREA
Zinc (mg/l)	7.05	8.26	11	5.05	0.2
Lead (mg/l)	0.03	0.01	0.01	ND	0.1
Chromium (mg/l)	0.02	ND	0.02	ND	0.5
Cadmium (mg/l)	0.01	0.01	0.01	ND	0.01

3.2. Microbiological Parameters

Figure 1 shows the microbial population in abattoir air. The mean THBC in air within the sampled abattoir ranged from 2.7 x 10^4 CFU/ m^3 – 2.3 x 10^5 CFU/m^3, while TFC ranged from 1.7 x 10^3 CFU/ m^3 – 5.3 x 10^3 CFU/ m^3.

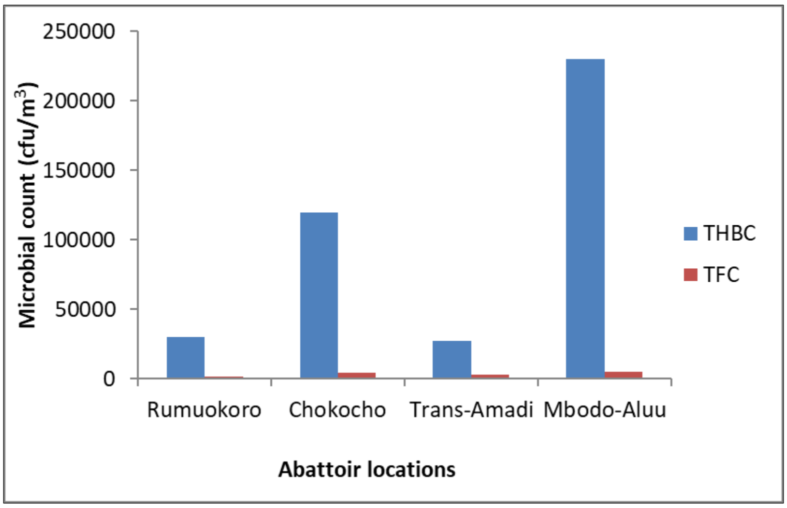

Figure 1 Microbial population in abattoir air

Figure 2 shows the microbial population in abattoir soil. THBC in soil samples ranged from 3.3 x 10^5 – 5.0 x 10^6 CFU/g, while TFC ranged from 9.0 x 10^4 CFU/g – 3.5 x 10^5 CFU/g.

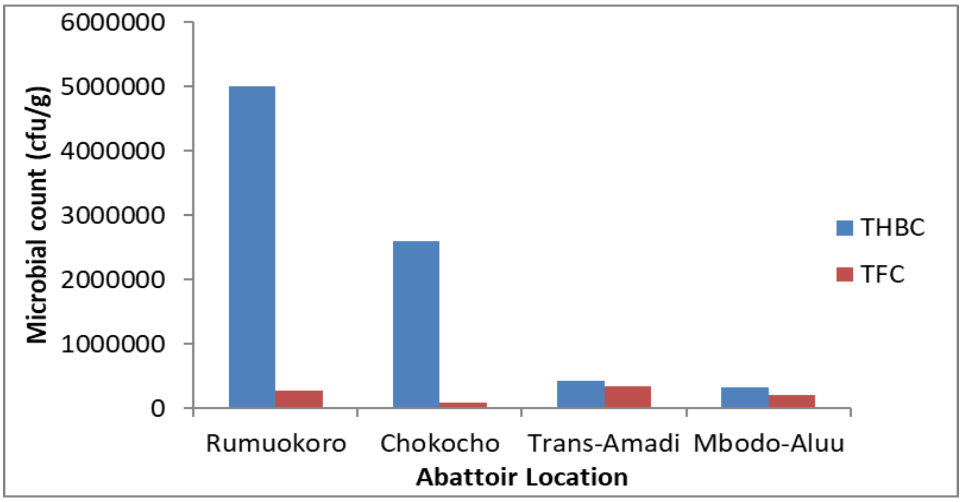

Figure 2 Microbial population in abattoir soil

Table 6 shows the microbial population in abattoir wastewater. THBC of wastewater obtained from the abattoirs ranged from 3.7 x 10^5 CFU/ml - 5.6 × 10^7 CFU/ml, while TFC ranged from 2.7 × 10^4 CFU/ml – 1.1 × 10^5 CFU/ml. Total coliform count (TCC) ranged from 460 MPN/100ml - ≥2,400 MPN/100ml.

Table 6 Microbial counts of wastewater obtained from abattoirs in Rivers State

Locations	THBC (cfu/ml)	Total coliform count (MPN/100ml)	TFC (cfu/ml)
Rumuokoro	5.6 × 10^7	≥2,400	2.7 × 10^4
Chokocho	2.2 × 10^7	≥2,400	0.4 × 10^5
Trans-Amadi	4.8 × 10^6	1,100	1.1 × 10^5
Mbodo-Aluu	3.7 x 10^5	460	3.1 × 10^4

Table 7 shows bacteria and fungi isolated from the abattoir environment. The dominant species are *Micrococcus* sp., *Bacillus* sp., *Staphylococcus* sp., *Streptococcus* sp., *Corynebacteria* sp., *Salmonella* sp., *Shigella* sp., *Klebsiella* sp. and *E. coli*, among the bacteria while the fungal species are *Aspergillus* sp., *Trichophyton* sp., *Mucor* sp. *Rhizopus* sp. and *Penicillium* sp.

Table 7 Bacteria and fungi isolated from the abattoir environment

	Bacteria	Fungi
Abattoir air	*Micrococcus* sp., *Bacillus* sp., *Staphylococcus* sp., *Streptococcus* sp., *E. coli*	*Aspergillus* sp., *Trichophyton* sp., *Mucor* sp., *Penicillium* sp.
Abattoir soil	*Acinetobacter* sp., *Bacillus* sp., *Corynebacteria* sp., *Staphylococcus* sp., *Streptococcus* sp. *E. coli*	*Mucor* sp., *Aspergillus* sp., *Rhizopus* sp., *Penicillium* sp.
Abattoir wastewater	*Acinetobacter* sp., *Bacillus* sp., *Corynebacteria* sp., *Salmonella* sp., *Shigella* sp., *Klebsiella* sp., *Staphylococcus* sp., *Micrococcus* sp., *Streptococcus* sp. *E. coli*,	*Mucor* sp., *Aspergillus* sp., *Rhizopus* sp., *Penicillium* sp.

4. Discussion

4.1. Physicochemical Parameters

The present study assessed the environmental risk of abattoir operations. Assessment of the air quality around four abattoirs in the study area showed that physicochemical parameters varied across locations, although not significant ($p>0.05$). This implies that the locations of abattoirs had no significant impact on the air quality. This is not unexpected because the sampled abattoirs operate under similar conditions. The mean concentrations of VOC, CH_4, CO, CO_2, NH_4, H_2S, $PM_{2.5}$, PM_{10}, and TSP, which were 1372.77 ppm, 84 ppm, 73.2 ppm, 6200 ppm, 2.14 ppm, 1.17 ppm, 331.575 ppm, 700.925 ppm and 790.275 ppm respectively, were very high. The detected gases and particulate matter are known pollutants of public health concern. NRC [13] examined emissions from various animal production facilities, including abattoirs, and demonstrated that the release of hazardous air pollutants such as volatile organic compounds, ammonia, and particulate matter, can contribute to air pollution. The health and well-being of an individual within his environment are strongly dependent on the healthy quality of the air, which can be translated as oxygen inhaled into the body system, which is expected to a large extent to be devoid of all forms of pollutants [14,15].

Abattoirs can have an impact on soil quality due to the disposal of animal waste and by-products generated during slaughtering and processing activities. Analysis of the soil physicochemical parameters revealed the mean ranges as follows: pH, 5.24-5.81; E.C., 390.03-500.10 µs.cm-1; Temp., 34.22-36.10 °C; Alkalinity, 38.00-86.00 mg/Kg; Total Moisture Content, 13.70-20.04 %; Chloride, 20.32 - 92.22 mg/Kg; Total Nitrogen, 1.79 - 3.12 %, Nitrate (NO_3^-), 0.52 - 0.84 %; Phosphorus, 0.85 -1.06 %; Total Organic Carbon, 14.25 - 19.60, %, Total Organic Matter, 22.15 - 26.26 mg/Kg, and Oil/Grease, 319.46 - 700.86 mg/Kg. ANOVA result for the physicochemical parameter revealed that there is no significant difference in the average physicochemical parameters across locations ($p>0.05$). There is the potential for these pollutants to accumulate in the soil and impact its quality and fertility.

The heavy metals contents of an abattoir in the soil were in the ranges, Mn, 0.01-0.02 mg/kg; Ni, 0.01 mg/kg; Zn, 6.99-12.00 mg/kg; Cu, 0.01-0.06 mg/kg; Pb, 0.03; Cr, 0.02 0.05 mg/kg, and Cd 0.01-0.02 mg/kg. Heavy metals are known to be toxic even at low concentrations. ANOVA result for the physicochemical parameter revealed that there is no significant difference ($p>0.05$) in the average physicochemical parameters across locations. Although heavy metals exist naturally in soil, their concentrations can be increased by anthropogenic activities such as operations in slaughter.

The application of slaughterhouses to soil amendment can increase nutrient levels, particularly nitrogen and phosphorous, and at the same lead to higher levels of heavy metals in the soil. Azuonwu et al. [16] in their study revealed that abattoir wastewater led to an increase in the concentrations of heavy metals, such as lead and cadmium. Sanda et al. [17] in their study of heavy metals in soil and water linked to the operations of abattoirs in Kano detected the presence of manganese, nickel, chromium, arsenic, copper and zinc, which they found to be higher in concentrations in soil than in water, as a result of the retention action in soil over time.

The physicochemical parameters of abattoir wastewater samples were in the ranges pH, 6.91-10.62; E.C., 830.17 - 1570.11 $\mu s.cm^{-1}$); Turbidity, 48.00 - 367.38 NTU; BOD, 288 – 389 mg/l; COD, 864 - 1200 mg/l; TDS, mg/l 150 – 2000, and TSS, 100 - 500 mg/l. The value reported for pH and turbidity in this study is within the range reported in other previous studies in Nigeria [18, 19].

ANOVA result for physicochemical contents of abattoir wastewater shows there is no significant difference in the average physicochemical contents of abattoir wastewater based on their location. This implies that the treatment of the abattoir wastewater had no significant impact on the physicochemical contents based on their location.

The BOD exceeded the FMeV limit of 30-100 mg/l; COD exceeded the 250 mg/l limit, TSS limit of 100 mg/l, and the pH of the wastewater at Mbodo-Aluu abattoir exceeded the pH limit of 9. Unlike the present study, Amaoma [20] reported lower BOD values ranging from 6.98-34.01 mg/l, COD ranging from 340.69-968.42 mg/l, and 1.52-28.62 mg/l in their study of wastewater from abattoirs in Port Harcourt. However, Ogunnusi and Dahunsi [21] reported higher values of BOD 2765 mg/l, COD 5185 mg/l and TSS 3528 mg/l in abattoir effluents from Oyo, Oyo State, than in the present student.

The heavy metals were in the ranges Zn, 5.05-8.26 mg/l; Pb, 0.01-0.03 mg/l; Cr, 0.02 mg/l, and Cd, 0.01 mg/l. ANOVA result for heavy metal contents of abattoir wastewater shows there is no significant difference in the average heavy metal contents of abattoir wastewater based on their location. ($P > 0.05$). This implies that the treatment of the abattoir wastewater had no significant impact on the Heavy metal contents based on their location. Vershima et. al. [22] reported that heavy metal content from effluents from abattoir contributed to upsetting the physicochemical balance of the River Katsina–ala in Benue State, Nigeria.

4.2. Microbiological Parameters

The mean THBC in air within the sampled abattoir in Rivers State ranged from 2.7×10^4 CFU/ m^3 – 2.3×10^5 CFU/m^3, while TFC ranged from 1.7×10^3 CFU/ m^3 – 5.3×10^3 CFU/ m^3. The bacteria in the air were identified as *Micrococcus* sp., *Bacillus* sp., *Staphylococcus* sp., *Streptococcus* sp. and *E. coli*, while the fungal isolates were identified as *Aspergillus* sp., *Trichophyton* sp., *Mucor* sp. and *Penicillium* sp. isolates such as *Bacillus* sp., *Staphylococcus* sp., *Streptococcus* sp., *E. coli* and *Aspergillus* sp. have pathogenic strains that could be carriers of antibiotic resistance and virulence genes in the environment. Dada et al. [23] investigated the microbial and toxicological air quality of a rural abattoir, and highlighted the presence of potentially harmful microorganisms and their association with the slaughtering process, indicating the potential risks for workers and nearby residents. According to Magaji & Hassians [4], some infectious agents are normally suspended on atmospheric media which makes the abattoir environment a potential route for the transmission of infectious diseases either through direct or indirect contact by humans.

THBC in soil samples ranged from 3.3×10^5 – 5.0×10^6 CFU/g, while TFC ranged from 9.0×10^4 CFU/g – 3.5×10^5 CFU/g. The bacteria isolated were identified as *Acinetobacter* sp., *Bacillus* sp., *Corynebacteria* sp., *Staphylococcus* sp., *Streptococcus* sp. and *E. coli*, while the fungi were identified as *Mucor* sp., *Aspergillus* sp., *Rhizopus* sp. and *Penicillium* sp. These isolates are common soil bacteria and fungi and their population lies within normal ranges in soil [24]. Their role principally is in contributing to the level of soil organic matter in the soil [25]. Williams and Dimbu [26] in their study in Rivers State also isolated *Escherichia* sp., *Staphylococcus* sp. and *Aspergillus* sp., among other isolates.

THBC of wastewater obtained from the abattoirs ranged from 3.7 x 10^5 CFU/ml - 5.6 × 10^7 CFU/ml, while TFC ranged from 2.7 × 10^4 CFU/ml – 1.1 × 10^5 CFU/ml. Total coliform count (TCC) ranged from 460 MPN/100ml - ≥2,400 MPN/100ml. Nnamdi (2022) reported THBC of 4.53-8.14 Log CFU/ml, TFC of 0-3.7 Log CFU/ml lower and TCC of 300 - >1600/100 ml, which are close in range as in the pfrese4nt study. There was no statistically significant difference (P>0.05) in microbial counts with the point of sampling.

The bacteria isolated were identified as *Acinetobacter* sp., *Bacillus* sp., *Corynebacteria* sp., *Salmonella* sp., *Shigella* sp., *Klebsiella* sp., *Staphylococcus* sp., *Micrococcus* sp., *Streptococcus* sp. and *E. coli*, while the fungal isolates were *Mucor* sp., *Aspergillus* sp., *Rhizopus* sp. and *Penicillium* sp. Nnamdi [17] also identified similar bacterial isolates in wastewater samples in abattoirs within Port Harcourt. Microorganisms isolated by Ogunnusi and Dahunsi [21] also included what we reported in our study. Williams and Dimbu [26] argued that some of the isolates from the abattoir environment being part of the normal flora of the skin and stomach of the animals being slaughtered, find their way into wastewater and any receptacle for the wastewater.

Several studies conducted in Nigeria on the microbiological quality of slaughter wastewater have consistently reported the presence of pathogenic bacteria and fungi including *Escherichia coli* (including *E coli* O157:H7 strains), *Salmonella* sp., *Shigella* sp. and several members of *Enterobacteriaceae* and other opportunistic pathogens [21, 27-36]. *Staphylococcus aureus, E. coli*, *Shigella* and *Salmonella* are known to cause food-borne infections, skin infections, enteric fever and urinary tract infections amongst other health conditions [29, 30].

5. Conclusion

Abattoir operations impact the physicochemical characteristics of wastewater, soil, and air in the abattoir environment. Microbes associated with wastewater, soil impacted by abattoir wastewater, and air from the abattoir environment were found to include pathogenic species of bacteria and fungi. Proper waste management should be encouraged among abattoir operators and should include treatment of wastewater.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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