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MICROBIOLOGICAL AND PHYSICOCHEMICAL CHARACTERIZATION OF ABATTOIR WASTEWATER IN OBIO/AKPOR LOCAL GOVERNMENT AREA OF RIVERS STATE, NIGERIA

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INTRODUCTION. The spread of pathogenic bacteria from food production processes has become a problem worldwide. Abattoir effluents are potential carriers of resistant pathogenic bacteria and could contribute to these strains' global spread in the environments. This study extensively analyzed abattoir wastewater in Obio/Akpor (Nigeria), focusing on its microbiological and physicochemical aspects.

MATERIALS AND METHODS. 250 ml of abattoir wastewater samples were aseptically collected from each of four different abattoirs within Obio/Akpor using standard methods. The study was conducted from September 2023 to November 2023. Frequency of occurrence, percentage occurrence, charts, mean count and standard deviation of microbiological parameters were generated. Physicochemical parameters were identified using American Public Health Association (APHA) gold standard.

RESULTS. Microbiological assessments showed that the total heterotrophic bacteria count obtained ranged from $2.6 \pm 0.14 \times 10^7$ to $6.5 \pm 0.28 \times 10^8$ CFU/ml. *E. coli* count obtained ranged from $2.3 \pm 0.07 \times 10^6$ to $2.6 \pm 0.14 \times 10^6$ CFU/ml. The total coliform counts ranged from $2.5 \pm 0.07 \times 10^3$ CFU/ml to $4.3 \pm 0.07 \times 10^8$ CFU/ml. *Vibrio* count of $4.5 \pm 0.70 \times 10^3$ CFU/ml was only recorded from Choba while fungal count was only recorded from Rumuokoro ($1.1 \pm 0.70 \times 10^4$ CFU/ml) and Rumuodara ($2.8 \pm 0.70 \times 10^5$ CFU/ml). For the physicochemical parameters, pH ranged from 5.58 to 7.05, Total Dissolved Solids (TDS) ranged from 4.26 to 7.21 mg/l, Total Suspended Solids (TSS) ranged from 2.01 to 4.86 mg/l, Phosphate ranged from 1.13 to 2.42 mg/l, Nitrate ranged from 4.97 to 10.27 mg/l, Dissolved Oxygen (DO) ranged from 13.93 to 26.25 mg/l, Biochemical Oxygen Demand (BOD) ranged from 7.06 to 15.43 mg/l and Chemical Oxygen Demand (COD) ranged from 165.42 to 256.38 mg/l.

CONCLUSION. The study emphasizes the diverse microbial composition and physicochemical characteristics of abattoir wastewater, highlighting environmental and public health concerns. Effective wastewater treatment pre-discharge into water bodies is vital to mitigate adverse impacts.

KEYWORDS: abattoir, wastewater, pathogenic, physicochemical parameters.

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МИКРОБИОЛОГИЧЕСКАЯ И ФИЗИКО-ХИМИЧЕСКАЯ ХАРАКТЕРИСТИКА СТОЧНЫХ ВОД СКОТОБОЕН В РАЙОНЕ МЕСТНОГО САМОУПРАВЛЕНИЯ ОБИО/АКПОР ШТАТА РИВЕРС, НИГЕРИЯ

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ВВЕДЕНИЕ. В данном исследовании был проведен анализ сточных вод со скотобоен в районе Обио/Акпор (Нигерия) с оценкой их микробиологических характеристик и физико-химических свойств.

МАТЕРИАЛЫ И МЕТОДЫ. Образцы сточных вод (250 мл) были собраны с 4 скотобоен в районе Обио/Акпор в сентябре-ноябре 2023 г. Оценивались частота выявления и количество различных микроорганизмов, а также физико-химические параметры.

РЕЗУЛЬТАТЫ. Общее количество гетеротрофных бактерий составило от $2,6 \pm 0,14 \times 10^7$ до $6,5 \pm 0,28 \times 10^8$ КОЕ/мл. Количество *E. coli* варьировало от $2,3 \pm 0,07 \times 10^6$ до $2,6 \pm 0,14 \times 10^6$ КОЕ/мл. Общее количество колиформных бактерий составило от $2,5 \pm 0,07 \times 10^3$ КОЕ/мл до $4,3 \pm 0,07 \times 10^8$ КОЕ/мл. Представители рода *Vibrio* были выявлены только в районе Чоба ($4,5 \pm 0,70 \times 10^3$ КОЕ/мл), а грибковая флора была обнаружена только в г. Румуокоро ($1,1 \pm 0,70 \times 10^4$ КОЕ/мл) и г. Румуодара ($2,8 \pm 0,70 \times 10^5$ КОЕ/мл). Значения pH варьировали от 5,58 до 7,05, общее количество растворенных твердых веществ — от 4,26 до 7,21 мг/л, взвешенных твердых веществ — от 2,01 до 4,86 мг/л, концентрация фосфатов — от 1,13 до 2,42 мг/л, нитратов — от 4,97 до 10,27 мг/л, растворенного кислорода — от 13,93 до 26,25 мг/л. Биохимическое потребление кислорода составило от 7,06 до 15,43 мг/л, химическое потребление кислорода — от 165,42 до 256,38 мг/л.

ЗАКЛЮЧЕНИЕ. Результаты исследования свидетельствуют о разнообразии микробного состава и различных физико-химических свойствах сточных вод отдельных скотобоен. Эффективная очистка сточных вод важна для предотвращения неблагоприятного влияния на состояние окружающей среды и общественное здоровье.

КЛЮЧЕВЫЕ СЛОВА: скотобойня, сточные воды, патогенные микроорганизмы, физико-химические показатели.

ДЛЯ ЦИТИРОВАНИЯ: Алеручи О., Окундейе О.Г., Эксонсон В., Исаак А.Х., Харольд И. Микробиологическая и физико-химическая характеристика сточных вод скотобоен в районе местного самоуправления Обио/Акпор штата Риверс, Нигерия // Juvenis scientia. 2024. Том 10. № 3. С. 26-37. DOI: 10.32415/jscientia_2024_10_3_26-37. EDN: QRRDAP.

INTRODUCTION

Abattoirs are industrial sites dedicated to processing animals for meat production [1]. Most meat processing businesses begin in abattoirs, particularly in areas where livestock is directly supplied to the food chain from farms or the market [2]. Abattoirs are known to produce enormous amounts of waste from several operations, including the processing of meat and byproducts and the killing of animals or cattle [1]. Depending on the quantity, kinds, and processing method of the stock being processed, slaughterhouse effluent has different daily qualities [3–4]. Water is used in the slaughterhouse process for animal transportation, sanitation, and equipment washing [4]. Thus, throughout this process, large volumes of wastewater are produced that contain a range of contaminants, including suspended particles, pathogens, blood, fats, oils, and grease (FOG) [5]. In these facilities, fresh meat is processed for both customers and traders [6]. Meat is an essential part of the livestock business, which is a significant source of jobs and meat supply in Nigeria [2]. Large amounts of wastewater are produced during the processing of meat and animal slaughter. Untreated abattoir wastewater improperly released into the environment contaminates it and changes the unique microbial ecosystems [7]. In Nigeria, the effects of these activities on public health are extremely concerning in both urban and rural areas [1]. This change may have some negative environmental effects, such as an increase in the production of methane by anaerobic methanogens, which would increase greenhouse gas emissions and global warming [7]. Abattoirs typically discharge wastewater into ecosystems without following proper treatment procedures, which puts public health, surface water quality, and overall environmental safety in grave danger [1]. The primary cause of the significant pollution of the soil, water, and air near slaughterhouses is the operators of abattoirs' inadequate sanitary measures [8]. These pollutants pose serious risks to human and animal health if they are not well managed [4]. They can seep into surface and groundwater reserves [1]. Following the death of such animals, these metals naturally sink into the soil and then seep into neighboring streams or other bodies of water [9–10]. Abattoir wastewater comes from a variety of sources, including cleaning and washing operations, processing areas, and slaughterhouses [11]. When organic matter builds up faster than the water's microorganisms can decompose and recycle it, it promotes algal blooms that cause eutrophication [10–12]. Depending on the type of animal, how it was killed, and how it was cleaned and washed, this wastewater has different qualities [13]. However, when these slaughterhouse operations are not managed properly, they might pose a direct or indirect risk to public health [1–2]. The effluents from these abattoirs have the potential to seriously harm the environment and human health if they are not properly treated, contaminating the soil and river bodies [2]. Additionally, if wastewater seeps into the soil, denitrifying bacteria may decrease nitrate to nitrogen, which could have negative impacts on the atmosphere when it reaches the atmosphere [7]. The release of untreated wastewater into the environment is a serious public health concern in Nigeria, as it is in many other developing nations [5, 14]. The lotic water system has been significantly impacted by inadequate hygienic conditions in animal abattoirs and compromised water quality [14]. For instance, wastewater from processing beef has higher levels of suspended particles and organic matter than effluent from processing poultry [3–7]. Handling effluent from slaughterhouses is difficult for several reasons [15]. First of all, the wastewater's high organic content and suspended particles make treatment challenging [12–15]. Second, to ensure a safe release into the environment, the presence of viruses and heavy metals requires the use of sophisticated treatment methods [15]. If the raw meat and waste material are contaminated, the risk of transmitting zoonotic pathogens through waste becomes high [6–7]. The difficulty of abattoir wastewater management is further increased by poor infrastructure for wastewater treatment and limited financial resources in developing countries [15]. Because of the natural drainage patterns and sequencing, abattoir wastewater can pose a threat to both humans and the environment when it reaches natural water bodies [3, 7]. Most abattoirs in Nigeria lack the necessary infrastructure to properly manage animals and dispose of waste [10–14]. Every report and visit revealed erroneous procedures and practices in every area of the process that a normal abattoir ought to have, from arrival to packaging [8, 10]. Because of the inappropriate channeling of wastewater from the dressing of the killed animals and washings at the lairage, the surrounding area is frequently swampy [14]. Whether they enter a body of water from a point source or a nonpoint source, abattoir effluents lower the oxygen content of the water, endangering aquatic life and sometimes having fatal consequences [2–6]. The addition of organic nutrients to groundwater leads to an overabundance of microbial growth, which gives the water from this source a disagreeable taste and odor [9]. These issues are further made worse by the local community's and slaughterhouse employees' ignorance of the importance of wastewater treatment. For environmental protection and sustainable growth, abattoir wastewater must be managed well [16]. To overcome the challenges related to its management, it is necessary to put in place source control mechanisms, modern treatment technologies, infrastructure for wastewater treatment, and excellent hygiene standards [16]. Effective management of abattoir effluent necessitates close cooperation between government agencies, local communities, and workers in the slaughterhouse [16]. Wastewater from slaughterhouses can be a useful resource for agricultural and energy generation if managed properly [17]. To successfully manage wastewater from abattoirs, several techniques can be implemented [4–7]. First off, implementing proper hygiene procedures in slaughterhouses can lower the wastewater's organic load and suspended particle content [13]. Secondly, wastewater may be efficiently treated and biogas produced for energy generation by using anaerobic digestion and aerobic treatment technologies [17]. Thirdly, the pollutant load in wastewater can be decreased by implementing source control methods, such as isolating the streams of wastewater from various processes [16]. Lastly, the establishment of public-private partnerships and the building of appropriate wastewater treatment infrastructure can supply the monetary and technical assistance required for the management of effluent from slaughterhouses [18–19].

Wastewater from slaughterhouses frequently contains a large number of microorganisms, with bacteria being the most prevalent [20–21]. Bacteria can flourish in a variety of conditions, including those associated with slaughterhouses where effluent is dumped [21]. Specifically, chemicals and disinfectants used in animal processing can inhibit the growth of bacteria, and these substances end up in the wastewater [22]. Furthermore, certain nutrients found in polluted soil that originate from abattoir effluent can affect the proliferation of bacteria [2,21]. Not every type of bacteria will be able to grow in these conditions, which could inhibit some bacterial strains and reduce the overall number and diversity of bacteria [3–6]. Wastewater from slaughterhouses usually has high nutrient concentrations, which promote the growth of other species like algae and fungus [2]. The growth of these organisms could lead to predatory behavior in the diversified environment, which would then impact the bacterial pollution in effluent from abattoirs [7–9].

This study extensively analyzed abattoir wastewater in Obio/Akpor, focusing on its microbiological and physicochemical aspects.

MATERIALS AND METHODS

Study area

Table 1 shows the study areas and their coordinates. Obio/Akpor is one of the biggest Local Government Areas in Rivers State. The study areas are places where animals are slaughtered and sold commercially, people come from different communities to buy and sell. There are streams around the abattoir close to where the animals are slaughtered, water was collected for the washing of meat and equipment, used in the abattoir. The wastewaters generated are also discharged into the stream.

Table 1

GPS coordinates of the study area

Study area	Coordinate
Choba	Latitude: 4.888938 Longitude; 6.901184
Egbelu	Latitude; 4.835720 Longitude; 6.949747
Rumuokoro	Latitude; 4.869029 Longtiude; 6.998611
Rumuodara	Latitude; 4.860022 Longitude; 7.024802

Collection of samples

250 ml of abattoir wastewater samples were collected, each from 4 different abattoir locations. Some of these samples were gotten from buckets used to wash animal bodies and blood water washed from bodies of animals. These samples were aseptically placed in sterile bottles and put into an ice pack cooler, then transported to the microbiology laboratory at Rivers State University for microbiological and physicochemical analysis.

Microbiological analysis

Sample preparation

A ten-fold serial dilution was carried out. In this method, 1 ml of the water sample was measured and transferred aseptically into test tubes containing sterile 9 ml diluents (normal saline), resulting in an initial dilution of 1:10. Subsequent dilutions were carried out by transferring 1 ml from the previous dilution to another test tube containing 9 ml sterile diluents, resulting in a ten-fold increase in dilution (1:100, 1:1000, etc.). This process was repeated until a dilution of $1{:}10^6$ was reached.

Enumeration of total heterotrophic bacteria

Water samples' total heterotrophic bacterial counts were determined using the standard plate count method on nutrient agar. A serial ten-fold dilution was prepared using 1 ml of water and 9 ml of diluent. 0.1 ml or 1 ml of the appropriate dilution was inoculated and plated in duplicates on nutrient agar. Plates were properly labeled and incubated at 35 °C ± 2 °C for 24–48 hours.

Characterization and identification of bacterial isolates

The bacterial isolates were characterized by observing them microscopically and subjecting them to a series of biochemical tests such as Gram stain, catalase, citrate, oxidase, coagulase, Methyl Red, Motility, indole, starch hydrolysis, Voges Proskauer and sugar fermentation tests. Further confirmation was done by comparing their characteristics with those of known taxa as outlined in Bergey's Manual of Systematic Bacteriology [23].

Enumeration and isolation of fungi

Aliquot (0.1 ml) of 10 and 10 dilutions were transferred on prepared Sabouraud Dextrose agar (SDA) plates which have been fortified with tetracycline antibiotics for the inhibition of bacterial growth. The plates were later spread evenly using a sterile bent glass rod. Inoculation was done in duplicates and after inoculation, plates were incubated at room temperature (22–25 °C) for 4 days. Enumeration of fungal counts was carried out after incubation, while distinct fungal colonies were morphologically characterized and sub-cultured on fresh SDA plates for further identification.

Identification of fungal isolates

Isolates were identified using their morphological features such as colony color, shape, texture, and size of the colony followed by microscopic examination (conidial shape, arrangement of hyphae, and type of spore) of their wet mounts prepared with lactophenol cotton blue and reference made to fungal identification manual [24].

Determination of physicochemical parameters

The pH was determined using a pH meter. Biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), total suspended solids (TSS), total dissolved solids (TDS), phosphate, and nitrate were determined by the method described by the American Public Health Association [25].

Statistical analysis

Data were entered into the computer and analyzed using SPSS version 26. Errors were checked for and corrected. Frequency of occurrence, percentage occurrence, charts, mean counts and standard deviation of microbiological parameters were generated. Physicochemical parameters were identified using American Public Health Association (APHA) gold standard and tabulated.

RESULTS

Microbial population of sample

Table 2 shows the microbial count obtained from the various locations. The total heterotrophic bacteria count obtained ranged from $2.6 \pm 0.14 \times 10^7$ to $6.5 \pm 0.28 \times 10^8$ CFU/ml. The least count was obtained from Egbelu while the highest count was shown in Rumuokoro and was significantly different. E. coli count obtained ranged from $2.3 \pm 0.07 \times 10^6$ to $2.6 \pm 0.14 \times 10^6$ CFU/ml. The least count was obtained from Choba while Rumuokoro and Rumuodara recorded the highest count. The total coliform counts recorded the least

Table 2

Microbial counts from various abattoir wastewater samples

Sample	Total heterotrophic bacteria count (CFU/ml)	*E. coli* count (CFU/ml)	Total coliform count (CFU/ml)	Vibro count (CFU/ml)	Fungal (CFU/ml)
Egbelu	$2.6 \pm 0.14 \times 10^7$	$2.4 \pm 0.07 \times 10^6$	$4.5 \pm 0.07 \times 10^6$	No count	No count
Choba	$7.1 \pm 0.14 \times 10^7$	$2.3 \pm 0.07 \times 10^6$	$4.3 \pm 0.07 \times 10^8$	$4.5 \pm 0.70 \times 10^3$	No count
Rumuokoro	$6.5 \pm 0.28 \times 10^8$	$2.6 \pm 0.07 \times 10^6$	$2.5 \pm 0.07 \times 10^3$	No count	$1.1 \pm 0.70 \times 10^4$
Rumuodara	$5.6 \pm 0.001 \times 10^6$	$2.6 \pm 0.14 \times 10^6$	$1.1 \pm 0.14 \times 10^7$	No count	$2.8 \pm 0.70 \times 10^5$

Table 3

Physicochemical parameters of the water samples

Parameter	Egbelu	Choba	Rumuokoro	Rumuodara
pH	6.28	7.05	6.57	5.58
TDS (mg/l)	5.29	7.21	4.26	6.34
TSS (mg/l)	3.75	4.86	2.01	3.12
Phosphate (mg/l)	1.81	2.42	1.13	1.86
Nitrate (mg/l)	10.27	8.32	6.25	4.97
DO (mg/l)	24.62	26.25	24.61	13.93
BOD (mg/l)	11.21	15.43	10.38	7.06
COD (mg/l)	189.45	256.38	179.56	165.42

count of $2.5 \times 10^3 \pm 0.07$ CFU/ml from Rumuokoro while the highest count of $4.3 \pm 0.07 \times 10^8$ CFU/ml was recorded from Choba. *Vibrio* count of $4.5 \pm 0.70 \times 10^3$ CFU/ml was only recorded from Choba while fungal count was only recorded from Rumuokoro ($1.1 \pm 0.70 \times 10^4$ CFU/ml) and Rumuodara ($2.8 \pm 0.70 \times 10^5$ CFU/ml).

Identification and characterization of bacteria

Figure 1 shows the results of the phenotypic characterization of the bacterial isolates. Bacterial isolates and their percentage occurrence were: *Staphylococcus aureus* (9.6%), *Staphylococcus epidermidis* (4.1%), *Staphylococcus saprophyticus* (10.1%), *Cronobacter spp.* (8.1%), *Micrococcus spp.* (5.2%), *Serratia spp.* (7.3%), *Enterococcus faecalis* (3.5%), *Streptococcus pyogenes* (12.8%), *Leuconostoc mesenteroides* (2.6%), *Pseudomonas aeruginosa* (7.6%), *Cedecea spp.* (8.4%), *Proteus spp.* (6.1%), *Escherichia coli* (11.6%), *Vibrio cholerae* (2.9%). More so, *Streptococcus pyogenes* was the most occurring bacterial isolate followed by *Escherichia coli* while *Leuconostoc mesenteroides* was the least occurring bacterial isolate.

Identification and characterization of fungi

Figure 2 shows the results of the fungal isolates and their frequency of occurrence as *Rhizopus spp.*, (11.9%), *Aspergillus spp.* (34.5%), *Mucor spp.* (16.7%), *Candida spp.* (22.6%), *Fusarium spp.* (14.3%).

Physicochemical parameters

Table 3 shows the results of the physicochemical properties of the water samples. The values of pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Phosphate, Nitrate, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) are presented. pH ranged from 5.58 to 7.05 and was more acidic in Rumuodara and neutral in Choba, TDS ranged from 4.26 to 7.21 mg/l, TSS ranged from 2.01 to 4.86 mg/l, Phosphate ranged from 1.13 to 2.42 mg/l, Nitrate ranged from 4.97 to 10.27 mg/l, DO ranged from 13.93 to 26.25 mg/l, BOD

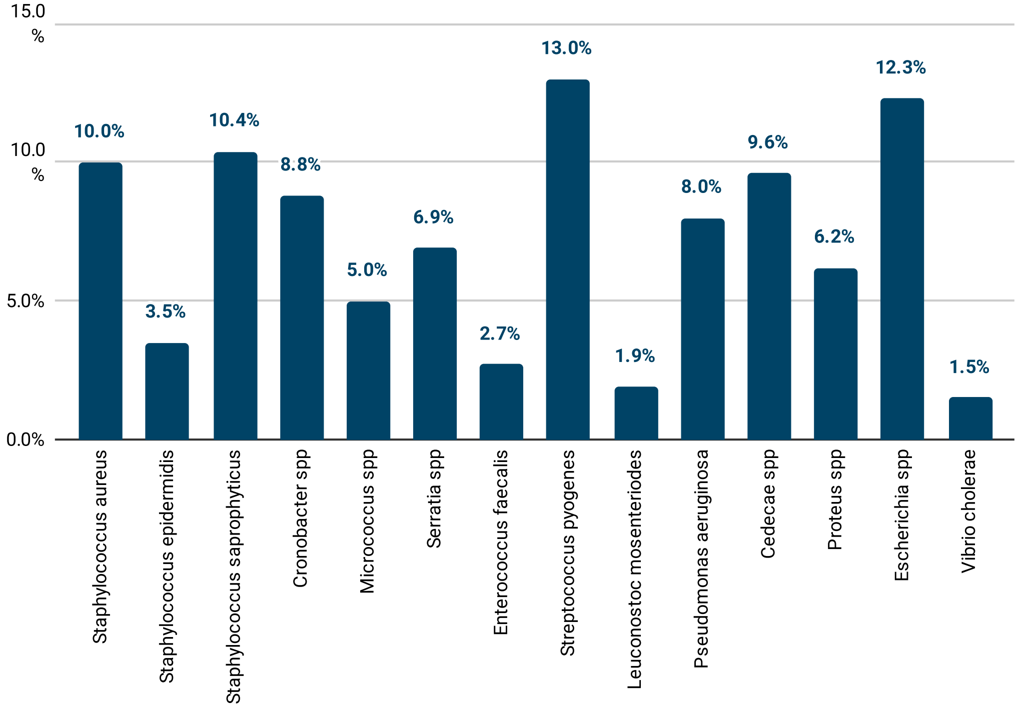

Figure 1. Distribution of bacterial isolates

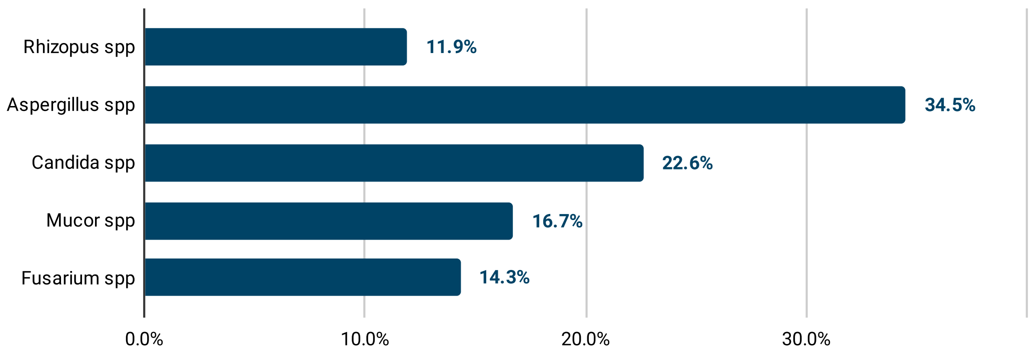

Figure 2. Distribution of fungal isolates

ranged from 7.06 to 15.43 mg/l and COD ranged from 165.42 to 256.38 mg/l.

DISCUSSION

The total heterotrophic bacterial counts range significantly, from 5.6×10^6 CFU/ml to 6.5×10^8 CFU/ml across samples. This variance indicates substantial differences in microbial load among wastewater samples from different abattoirs. With relatively consistent counts (ranging from 2.3×10^6 to 2.6×10^6 CFU/ml) across most samples, except for a notably lower count in one instance (2.5×10^3 CFU/ml), there's a consistent presence of fecal indicator bacteria. A wider range, from 4.5×10^6 to 4.3×10^8 CFU/ml, indicates varied levels of coliform bacteria, suggesting potential fecal contamination in these wastewater samples. The presence and absence of *Vibrio* and fungal counts across samples signify inconsistencies in the occurrence of these microorganisms in the studied wastewater. *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Staphylococcus saprophyticus* collectively account for significant percentages (24%) among the identified isolates. These are common skin commensals but can pose health risks under certain conditions [26–27]. Notably, pathogenic bacteria like *Streptococcus pyogenes*, *Escherichia coli*, and *Pseudomonas aeruginosa* are prevalent, collectively representing nearly 33% of the isolates. These pathogens are associated with various infections and can be of significant concern in both healthcare and environmental settings [28]. *Cronobacter spp.*, *Micrococcus spp.*, *Serratia spp.*, *Enterococcus faecalis*, *Leuconostoc mesenteroides*, *Cedecea spp.*, *Proteus spp.*, and *Vibrio cholerae* contribute to the remaining identified isolates, each with varying occurrence percentages. *Streptococcus pyogenes* emerges as the most prevalent bacterium, followed closely by *Escherichia coli*. This suggests a potential high risk associated with these organisms and their implications for public health. *Leuconostoc mesenteroides* were the least occurring but remain a notable part of the bacterial composition, its presence could have specific implications, especially in understanding environmental dynamics or in certain niche roles. The presence of pathogenic bacteria such as *Streptococcus pyogenes*, *Escherichia coli*, and *Pseudomonas aeruginosa* raises concerns regarding potential health hazards, especially if these organisms persist in clinical or community settings. Similar pathogenic microorganisms were isolated from abattoir wastewater in different parts of Nigeria by Adesemoye et al. and Chinakwe et al. [29–30]. Understanding the distribution of these microbes, including less common isolates like *Leuconostoc mesenteroides*, could offer insights into environmental niches or processes within the studied ecosystem.

Identification of these bacterial species and their relative prevalence emphasizes the importance of stringent hygiene practices, appropriate antimicrobial strategies, and surveillance in clinical and environmental settings. The distribution and prevalence of these bacterial isolates, particularly the presence of pathogenic species, highlight the importance of comprehensive surveillance, understanding microbial ecology, and implementing effective control measures to mitigate potential health risks associated with these organisms.

With the highest frequency of occurrence at 34.5%, Aspergillus species are common environmental molds. Some species within this genus can produce toxins and allergens, posing potential health risks, especially for workers exposed to these fungi. *Candida species*, representing 22.6%, are often found to be part of the normal human microbiota. However, in certain conditions, they can cause infections, especially in immunocompromised individuals. The presence of *Mucor spp.* (16.7%) is noteworthy. Some *Mucor spp.* can cause mucormycosis, a severe fungal infection, particularly in individuals with weakened immune systems. These fungi, at 11.9% and 14.3% respectively, also have various species within their genera that can cause infections or produce mycotoxins under specific conditions. Fungal presence in abattoir settings could pose health risks to workers if not adequately managed [31]. Exposure to certain fungal species, especially in dusty or poorly ventilated areas, may lead to respiratory issues or infections. Some fungi are known for producing mycotoxins that can contaminate food if proper hygiene measures are not maintained. Contamination of meat or surfaces within the abattoir could compromise food safety. Strict sanitation measures and regular cleaning protocols can help minimize fungal growth and dissemination within the abattoir. Proper ventilation and controlling humidity levels can mitigate fungal proliferation in the environment. Providing workers with appropriate personal protective equipment, such as masks or respirators, can reduce their exposure to airborne fungal spores. The presence of diverse fungal species within abattoir environments, including some known for their pathogenic potential or toxin production, emphasizes the importance of implementing robust hygiene measures and environmental controls to mitigate health and food safety risks for workers and consumers alike. The abattoir wastewater is discharged into open drainage, potentially carrying enteric pathogens into nearby rivers, acting as carriers for gastrointestinal infections. The presence of these microorganisms suggests potential contamination of the receiving water bodies. Such organisms have the potential to induce illnesses like diarrhea, aspergillosis, and various other health issues [32–34].

P[H] values range from acidic to slightly alkaline across the locations (ranging from 5.58 to 7.05). Egbelu and Rumuodara samples exhibit relatively lower pH values, indicating slightly acidic conditions, which might impact the water's suitability for certain aquatic life forms [25]. Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) vary among the locations. Higher TDS and TSS levels, as observed in Choba and Rumuodara, may indicate higher levels of dissolved and suspended particles, potentially affecting water clarity and indicating pollutant presence. Phosphate and nitrate levels differ across locations. Elevated phosphate and nitrate levels in Egbelu suggest potential organic pollution from agricultural runoff or wastewater, which could lead to eutrophication if discharged into water bodies. Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) vary among samples. Higher DO levels (Choba, Rumuokoro) suggest better oxygen availability for aquatic life. Elevated BOD and COD in Choba and Rumuokoro samples indicate higher organic content, potentially stressing aquatic ecosystems if discharged untreated. Variations in parameters indicate differences in water quality among locations, possibly due to varying sources of contamination (industrial, domestic, agricultural). Higher nutrient levels (phosphate, nitrate) and organic content (BOD, COD) suggest potential environmental stress if untreated wastewater is discharged into receiving water bodies [35]. Elevated pollutant levels in some locations emphasize the importance of effective wastewater treatment before discharge to minimize adverse environmental impacts. Continuous monitoring and regulatory measures are essential to manage and maintain water quality, especially in areas prone to pollution. The analysis of these physicochemical parameters highlights variations in water quality among different locations, underscoring the need for effective management and treatment strategies to mitigate potential environmental impacts and safeguard water resources.

LIMITATIONS OF THE STUDY

This study was limited to using small sample size. It also lacks adequate temporal and geographical coverage. However, this does not render the results of this study irrelevant, since the results shows amounts of harmful parameters contained in abattoir wastewaters regularly disposed in human environment. Thus, further research that will involve the use of larger sample size to achieve more precision is encouraged.

CONCLUSION

The comprehensive analysis of Obio/Akpor abattoir wastewater indicates a significant presence of pathogenic microorganisms and elevated levels of various physicochemical parameters. The observed microbial and chemical content poses substantial environmental and public health threats, necessitating immediate remedial action. Implementing stringent regulatory measures, employing advanced treatment technologies, and continual monitoring are imperative for mitigating these contaminants' adverse effects. Future research should focus on developing innovative, sustainable treatment strategies to address these challenges effectively. Resolving these issues is critical not only for environmental preservation but also for safeguarding public health within the Obio/Akpor community.

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