ENVIRONMENTAL SCIENCE ARCHIVES
ISSN: 2583-5092
Volume II Issue 2, 2023
www.envsciarch.com

RESEARCH PAPER OPEN ACCESS

Isolation and Characterization of Bacterial Species from Selected Swimming Pools of Makurdi, Nigeria

Joel Inya Odo[1], Ebah Esther Eneyi[2] and Odion Blessing[2]
[1]Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University, Makurdi, Nigeria
[2]Departments of Microbiology, Joseph Sarwuan Tarka University, Makurdi, Nigeria
Correspondence and requests for materials should be addressed to SR (email: odojoel@gmail.com)

Received: 2023/07/10
Accepted: 2023/08/16
Published: 2023/08/22

Abstract
Swimming pools are used for recreational activities, rehabilitative treatment or sport. Swimming pool water should meet portable water standards by being transparent, odourless and tasteless and should be devoid of harmful organisms. The study was carried out to determine the bacteria associated with selected swimming pools in Makurdi. A total of 6 water samples were collected from six different swimming pools (both used and unused) in Makurdi metropolis. The swimming pools were City Bay, Reuphina A, Reuphina B, Smile View Hotel, Hallidays and M J Resort. Standard microbiological and biochemical tests were carried out to identify the organisms. A total of 51 isolates were obtained from the 6 water samples and the organisms identified were *Bacillus* species, *Escherichia coli, Klebsiella* species, *Proteus* species and *Pseudomonas* species. The percentage prevalence of bacterial isolates shows that *Staphylococcus* species and *Klebsiella* species were the most prevalent (23.53%). Statistically, data analysis using ANOVA shows that there was no significant difference ($P>0.05$) in the Total Colony Counts of bacteria in the unused swimming pools. The highest bacterial count among the unused pool was found in Smile View ($5.75x10^2 \pm 7.70x10^1$ CFU/ml) while the lowest was in Reuphina B ($9.50x10^1 \pm 9.90$ CFU/ml). In the used swimming pools, there was a significant difference ($P<0.05$) in the bacterial total colony counts. Hallydays swimming pool had the highest total colony count of bacteria ($7.00x10^3 \pm 2.83x10^2$ CFU/ml) while City Bay had the lowest counts ($1.38x10^3 \pm 3.68 x10^2$ CFU/ml). Majority of the bacterial populations in the swimming pools are contaminations or release from bathers. This implies that the microbial load has a direct proportional relation to the number of users as well as the sanitation condition of users.

Keywords: Isolation; Bacteria; Characterization; Swimming pool; Physicochemical analysis; Total Colony Counts

Introduction
Water is the liquid that descends from the clouds as rain, form streams, lakes, and seas, and is the major constituent of all living matter and when pure, and odourless, tasteless, very slightly compressible liquid oxide of hydrogen H_2O which appears bluish in thick layers freezes at 0°C and boils at 100°C, has a maximum density at 4°C and a high specific heat feebly ionizes to hydrogen and hydroxyl ions and is a poor conductor of electricity and a good solvent. Water occupies about 70% of the earth surface and is considered the largest natural resources around us (Odo, 2019). Water plays an indispensable role in sustaining life and it is a key pillar of health determinant, since 80% disease in developing countries are due to lack of good quality water. Although water is a basic requirement for human existence, it can serve as a medium for the transmission of pathogenic microorganisms (Favero, 2004). The importance of water includes drinking, washing, cooking, swimming, and also cooling the ecosystem. Therefore, its importance to humans cannot be neglected. But in spite of the awareness to safeguard our waters the resource is still contaminated by pathogenic microbes.

People go swimming in the pools for different reasons, such as recreational activities, sports or for rehabilitative treatment. Others go swimming for cooling down heat. However, previous epidemiological studies have indicated that bathing or swimming in contaminated water can be a potential health risk (Cabral, 2012). There are also reports that swimming pools can be a vehicle for the transmission of infectious diseases throughout the world (Sule et al., 2010). This means that with the excitements, the average Nigerian attaches to swimming pools if care and additional precautions are not taken, they could be exposed to harmful microorganisms. It is known that unsafe water, inadequate sanitation and insufficient hygienic condition account for the global burden of diseases and of all deaths which includes drinking water and recreational waters (Favero, 2004). Therefore, the importance of microbiological analysis of swimming pool water in the city of Makurdi metropolis cannot be over emphasized. It has been reported that pools could also be as a result of direct animal's contamination for example, from birds and rodents (13). The release of faeces by swimmers may be unwitting in the case of diarrheic stool. Bacteria such as *Enterococcus faecalis, Clostridium perfringens, Bacillus cereus, Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, Staphylococcus epidermidis, and Proteus vulgaris* may be present (Favero, 2004).

The presence of high level of coliforms and faecal coliform bacteria, *Escherichia coli* shows that the swimming pools have not met the world health organization (WHO) standard for recreational waters. Swimming pools that did not meet WHO standard for recreational water constitute a serious public health threat; hence, there is need for urgent and effective intervention (WHO, 2006). Quarters of the population in Makurdi are still very poor despite being in the state's capital. Waste management, sanitary and sewage conditions are very poor in most areas and residents are sometimes amenable to use inhabited lands or buckets for the discharge of faeces and human waste. Sometimes the content of the buckets are discharged into the open drainage systems. And during heavy rain falls, since most of these communities get flooded, these polluted water overflows and run-off and sometimes contaminate open pools with poor boundaries. It is usually impossible to test for all the diverse pathogenic microbes known to be associated with swimming pool contaminations; hence, microbes known to be associated with swimming pool contamination; hence, microbiological indicators have been designed primarily to monitor water safety and quality. These indicators have been statistically associated with water contaminated disease (Wade et al., 2006). Other diseases associated with untreated pools and poorly maintained pools are; cryptosporidiosis, otitis externa, commonly called swimmers ear, skin infections and respiratory infections (Sohrabi et al., 2016).

These organisms can either occur naturally or a result of contaminations from human or animal waste. The traditional role entrusted to indicators is to show the presence or absence of faucal contamination in water supplies. Gastro intestinal indicators include *Escherichia coli, faecal streptococci and staphylococcus* species are now usually monitored during water quality assessment. Therefore, as long as contamination of our water bodies remains a threat, more people are at risk of exposure to water borne microbial pathogens as increasing numbers of people visit the swimming pools. The health effects of exposure to disease causing pathogens in swimming pool water vary. Most commonly, manifestation of water borne illness is gastrointestinal upset including nausea, vomiting and diarrhea. Recreational use of water can deliver important benefits to the health and well-being of humans. Yet, there may also be adverse health effects associated with it if the water is polluted or unsafe (Sohrabi et al., 2016). Microbiologically, safe swimming pool water is obtained by adding an instantly effective disinfectant, such as chlorine, to the water. To maintain good water quality, the pool water is continuously treated and treatment processes such as filtration, coagulation, flocculation, pH and temperature adjustment and disinfection should be carefully balanced. The aim of this study is to evaluate the bacteriological quality of swimming pool water.

Material and methods

Materials

Nutrient Agar (NA), Salmonella Shigella Agar (SSA), Mannitol Salt Agar (MSA), Eosin Methylene Blue Agar (EMBA), Cystine Lactose Electrolyte Deficient Agar (CLED), Petri dishes, wire loop,

measuring cylinder, conical flasks, test tubes, test tube racks and spatula. The following equipments were used during the course of the laboratory analysis of the samples; microscope, autoclave, refrigerator, incubator and weighing balance. The study also used Gram Reagents, Oxidase reagents, Urease reagents, Citrate and Coagulase reagents, Catalase reagents, Kovac's reagent, Oil immersion and distilled water.

Study Area

The study area is Makurdi the capital of Benue State, Nigeria. It is a metropolitan city located in latitude $7^{o}39^{1}$ and $7^{o}45$N & longitude $8^{o}33$ and $8^{o}35$E with over 365,000 people as of 2016. The population of people in the city has increased as well as the social life of the residents. The building of hotels with recreational centers such as swimming pools had been on increase. In fact, most of the hotels and club house in Makurdi have swimming pools for recreational purposes.

Description of Swimming Pools

The numbers of swimming pools used for this study were six (5); the five swimming pools were all located in hotel premises and would subsequently be referred to by their names.
Six (6) swimming pools selected were located in Makurdi metropolis and permission was obtained from the authorities to conduct this study. The swimming pools were of varying shapes (e.g rectangular, circular etc.) and sizes ranging from 50-150om. Their flow through were from 2.2-22.85m deep and the swimming pools were made of glazed tiles.

Collection of Samples

The actual sample collection for the study covered five (5) swimming pools, representing swimming pools in the Makurdi metropolis which made themselves available for the study. A total of 5 different samples were collected in sterile containers from the selected pools for the study. Each water sample was collected into a sterile sample bottle. The samples were taken to microbiology laboratory, department of microbiology, Federal University of Agriculture Makurdi, Nigeria, for immediate bacteriological analysis.

Sample Preparation (Serial Dilution)

Methods as described by APHA (2005) were adapted. Nine milliliter of sterile normal saline was dispensed into sterile test tube and one gram of each sample was suspended in the 9mls of sterile normal saline. After mixing properly, 1ml of dilution was aliquot from the first test tube and dispensed into second test tube in that order in a ten-fold serial dilution up to 10^{5} (fifth test tube) one milliliter aliquot from 10^{-3} and 10^{-5} were dispersed in sterile petri dish. Sterile media (Nutrient and MacConkeyagear) approximately 15mls were dispensed into each of the petri dish and swirled clockwise and anti-clockwise to ensure even mixture of the medium and the inoculum. The plates were allowed to gel for about 30minutes after which were wrapped together in aluminum foil and incubated at 37°C for 24hours.

After incubation, the plasters were viewed and discrete colonies were counted and colony forming unit was calculated using

$$\text{Colony Forming Unit (CFU/ml)} = \frac{No\ of\ colonies}{Volume\ of\ inocolum} \text{ x Dilution factor}$$

Where number of colonies on plates = Counted colonies on plates.
Volume of inoculums =1ml
Dilution factor= 10^{-3} and 10^{-5}

After colony counts, representative colonies were sub-cultured on sterile Nutrient agar plates and incubated for 18-24hours at 37°C from where pure culture were saved in sterile agar slants at 4°C for characterization.

Preparation of Culture Media

Nutrient Agar

This was done according to manufacturer's instruction. 28g of powdered agar was weighed using a digital meter balance poured into a 1 liter capacity conical flask. 500mls of distilled water was added and stirred very well to suspend the agar in the water. It was later made up to one 1litre

with distilled water, after which it was corked and heated on a laboratory hot plate to dissolve the agar and finally sterilized in an autoclave at 121°C, for 15minutes. The medium was allowed to cool to 40-42°C before it was dispensed (15-20mls) into sterile petri dishes.

MacConkey Agar

This was prepared by suspending 51.55g in 1000mls of water in a conical flask. The flask was corked with cotton wool wrapped in aluminum foil and heated on a laboratory hot plate to boil in other to dissolve the medium completely. It was finally sterilized by autoclaving at 15lb pressure, 121°C for 15minutes.

Eosin Methylene Blue Agar

36g of the agar was suspended in 1000mls of distilled water 1litre capacity conical flask. The flask was corked with cotton wool wrapped in aluminum foil and heated on a laboratory hot plate to boil in order to dissolve the medium completely. It was finally sterilized by autoclaving at 15lb pressure, 121°c for 15 minutes.

Bacteriological Analysis

The total bacterial count was determined using standard plate count (SPC) as described by APHA (2005). The total faecal coliform counts were determined using MacConkey agar and Muller-Hinton agar respectively; using pour plate technique. The bacteriological analysis of the sample was carried within 2hour from the time of sample collection and inoculated plates were incubated at 37°C for 24-48hours.

Isolation of Bacteria

The colonies were pocked with a sterile wire loop and were streaked on already solidified medium to obtain a pure culture. Each pure culture was then sub-cultured into agar slants in bijou bottle and kept as stock culture (Ebah *et al*., 2022)

Characterization of Isolates

Gram staining of the isolates

The gram staining divides bacteria into two groups which are gram positive (purple or bluish colour) and gram negative (pink or reddish in colour) bacteria. The gram staining was conducted as follows:

A smear of culture was prepared on clean slide by emulsifying a colony of the growth organism on a drop of distilled water. The smear was allowed to air dry and was heat fixed. Crystal violet was then added as a primary stain for 30 seconds and then washed off with distilled water, Lugol's iodine was added and allowed to react for 30 seconds and immediately washed off with distilled water. Acetone alcohol was also added as decolorize and immediately washed off with distilled water. The smear was counter stained with safranin for 10 seconds and washed with distilled water. The smear was allowed to dry. A drop of oil immersion was placed on the stained smear and viewed with x100 objective lens.

Biochemical Tests for Identification of Bacteria

Methods described by Awua et al. (2022) was adapted for bacteria identification

Catalase Test

The test demonstrates the presence of catalase which is an enzyme that catalyzes the release of oxygen from hydrogen peroxide (H_2O_2). A colony of 24h old culture was picked using a sterile wireloop and then emulsified in a few drops of 3% hydrogen peroxide on a clean slide. Presence of effervescence indicated catalase positive reaction whereas negative reaction showed no effervescence.

Motility Test

This test carried out to determine the presence or absence of flagella as organelle of movement in the bacteria isolates. A colony of the test organism was sub-cultured in a people/nutrient broth and incubated for 18-24hours. A drop of this broth culture is put onto an engraved microscopic

slide. Circle it with Plaster bin and covered with cover ship and observe with x 40 objective. Motile organisms were seen swimming around indicating a positive reaction organism.

Tripple Iron Sugar (TSI) Test

The test was carried out by stabbing the butt and streaking the slant of the triple sugar iron Agar with the test organism using a flame sterilized wire loop. This was then incubated at 37°C for 24 hours. Glucose is fermented only when butt appear yellow and slant is red in colour. Also glucose, lactose and sucrose are fermented when both butt and slant appear red or pink in colour. Hydrogen sulphide production was indicated by the presence of black precipitate.

Indole Test

Some organisms have tryptophanese enzyme which helps them to hydrolyze the amino acid tryptophan. The sterile wire loop was used to inoculate organism in a test tube containing 5*ml* of prepared peptone water (medium) and incubated for 48hours at 37° c. after incubation, 0.5ml of kovac's reagent was added into the tube and allowed to stand for 15 minutes. A rose spank color indicated positive reaction.

Methyl Red Test

In carrying out this test, a test organism was incubated in a test tube containing 5*ml* of prepared peptone water and was incubated for 18-24 hours at 37° c, after incubation, 0.5ml of methyl red was added into the test tubes and allowed to stand for 15 minutes. Red ring color formation indicated positive result.

Citrate Utilization Test

A colony of 18-24hours was inoculated onto a Simmon citrate agar slant and lightly on the slant by touching the tip and incubated for 24hours at 37°C. Then development of blue colour was observed, which indicate a positive Simmon citrate test.

Urease Test

Urea is diamines of carbonic acid. It is hydrolyzed with the release of ammonia and carbon dioxide. Many organisms especially those that infect the urinary tract, have a urease enzyme which is able to split urea in the presence of water to release ammonia and carbon dioxide. The ammonia combines with carbon dioxides and water to form ammonium carbonate which turns the medium alkaline, turning the indicator phenol red from its original orange yellow color to bright pink.

Procedure

- Urease agar slant was prepared according to manufacturer's instruction.
- Colony of a pure insolate of the test organism was inoculated onto it and incubated for 18-24hours.
- A colour change from Amber to Pinkish indicates positive urease.

Oxidase Test

An oxidase reagent strip was moistened with sterile distilled water. A glass rod was used to pick a colony of test organism and rubbed on the moistened strip. A red-purple colour within 10 seconds indicate positive oxidase test.

Coagulase Test

A drop of distilled water was placed on one end of a glass slide. A colony of the test organism was picked using sterile wire loop to make a thick suspension. A loopful of blood plasma was added and mixed gently. Clumping within 10 seconds is coagulase positive. No clumping within 10 seconds is coagulase negative.

Determination of Physicochemical Parameters

A number of physicochemical parameters of the stream water samples were determined. They included temperature, Dissolved oxygen (DO), pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC) and others were nitrate, Ammonia, and Biochemical Oxygen Demand (BOD). The pH, temperature, Total Dissolved Solids (TDS) and Electrical Conductivity (EC) were

measured in-situ using Hanna multi parameter water checker (Model HI 98129). The Dissolved Oxygen was also measured in-situ using Hach DO meter (Model DO175). Nitrate was determined using Lovibond tintometer model MD600 while Biochemical Oxygen Demand was determined using Walklers method (Hassan, 2023; Pandiarajan et al., 2023)

Statistical Analysis

The results obtained from the experiments were entered into a database and analyzed statistically using the statistical package for social science (SPSS) version 20 statistical software for Microsoft windows and a summary was presented using the descriptive statistics such as means and percentages.

Results

Table 1 present the total viable count of samples collected from the pools. The results are express in colony forming unit per mililitre of water (CFU/ml). The results shows that the highest bacteria count among the unused pool was found in SV ($5.75x10^2 \pm 7.70x10^1$ CFU/ml) while the lowest was in RB ($9.50x10^1 \pm 9.90$ CFU/ml). There is no significant difference across the unused pool in their total viable count. The used pool, the total viable count ranges from $1.38x10^3 \pm 3.68 x10^2$ CFU/ml to $7.00x10^3 \pm 2.83 x 10^2$ CFU/ml for CB and HAD respectively. There is significant difference across the used pool in the bacteria population.

Table II shows the cultural, morphological and biochemical characteristic of bacteria isolates. In all, six genera of bacteria were isolated in this study (*Staphylococcus* species, *Bacillus*, *Escherichia coli*, *Klebsiella* species, *proteus* species and *Pseudomonas* species). Whereas *Staphylococcus* is a gram positive cocci others are gram negative rod except *Bacillus* species which is gram positive rod. Table III on the other hand present the physicochemical analysis of the pool water. Eight physicochemical parameters were checked. Table IV present the percentage prevalence of bacteria isolate across the pools. The table shows that among the bacteria isolates *Staphylococcus* species and *Klebsiella* species are the most prevalent (23.53%) while *Pseudomonas* species account for the least prevalence (9.80%). Across the pool, City bay pool account for the highest percentage of bacteria (21.57%) while MJ (11.76%) have the least percentage prevalence of bacteria.

Table 1. Total Viable Count of Samples from the various Swimming Pools.

Sample Sites	Total Colony Count CFU/ml)	
	Unused water	**Used water**
CB	$4.62x10^{2ab} \pm 3.14x 10^2$	$1.38 x10^{3bc} \pm 3.68 x 10^2$
RB	$9.50x10^{1a} \pm 9.90x$	$1.78x10^{3c} \pm 7.35x10^2$
RA	$2.04x10^{2a} \pm 2.26 x10^1$	$2.48x10^{3c} \pm 1.018x10^3$
SV	$5.75x10^{2ab} \pm 7.70x10^1$	$1.72x10^{3c} \pm 8.41x10^2$
MJ	$1.60x10^{2a} \pm 5.7x10^1$	$4.65x10^{3d} \pm 3.54x10^2$
HAD	$4.95x10^{2ab} \pm 1.09x10^2$	$7.00x10^{3e} \pm 2.83x10^2$

Mean with different superscript differ significantly.
DF = 1 P = 0.05

CB - City bay
RB: - Reuphina second pool
RA: - Reuphina first pool
SV: - Smile View
MJ: - MJ Resort
HAD - Hallydays

Discussion

The microbiological qualities of water in swimming pool have become a major subject of public health concern as there is an upsurge in the use of swimming pool both by adults and infants for recreational purposes and also for sports. In this study the total viable count of bacteria among the treated pools which have not been put to use are mostly within world health organization recommended limit of not more than 200 Cfu/ML of pool water but all the pools that have been put to use all fall short of this standard (WHO, 2006).

Table 2: Cultural, Morphological & Biochemical Characteristic of Bacteria Isolates

Colony Colour	Colony Shape	Morphology	Gram's rxn	Cat	Cit	Ve	MR	Idole	Mot	H_2S	Oxi	Coa	Suspected Organism
Cream	Circular	Cocci	+	+	+	-	-	-	-	-	-	+	*Staphylococcus aureus*
White	Irregular	Rod	+	+	+	+	-	-	-	-	-	NA	*Bacillus* species
Pink	Circular	Rod	-	+	-	-	+	+	+	-	-	NA	*Escherichia coli*
Mucoid Pink	Circular	Rod	-	+	+	+	+	-	-	-	-	NA	*Klebsiella* species
Pale	Circular	Rod	-	+	+	+	+	-	-	+	-	NA	*Proteus* species
Greenish	Circular	Rod	-	+	+	-	+	-	+	-	+	NA	*Pseudomonas* species

Cat – Catalase; MR-Methyl/Red; H_2S–Hydrogen Sulphide; Cit – Citrate; Mot – Motility; Oxi – Oxidase; Coa-Coagulase

Table 3. The physiochemical characteristics of the water samples

Parameter	Hallydays	Reuphina A	Reuphina B	Smile view	City bay	MJ resort
pH	8.82	9.37	8.96	9.14	6.58	9.19
TDS (mg/L)	360	241	272	476	402	223
EC (µs/cm)	720	485	557	954	804	448
Temperature (°C)	30.4	30.6	29.8	30.6	31.2	31.3
DO (mg/L)	7.6	6.7	5.7	6.8	7.1	7.0
Ammonia (mg/L)	0	0	0	0	0	0
Nitrate (mg/L)	–	–	–	–	–	–
BOD (mg/L)	0	0.1	0.0	0.1	0.0	0.1

Table 4: Percentage prevalence of bacteria isolates across pools

Pools	*Staphlococus* Spp (%)	*Escherichia coli* (%)	*Bacillus* spp (%)	*Klebsiella* spp (%)	*Proteus* spp (%)	*Pseudomonas* spp (%)	Total (%)
CB	3(25.00)	2(33.33)	1(11.11)	3(25.00)	1(16.67)	1(16.67)	**11(21.57)**
RB	2(16.67)	1(16.67)	2(22.22)	3(25.00)	0(0.00)	0(0.00)	**8(15.69)**
RA	3(25.00)	0(0.00)	1(11.11)	2(16.67)	1(16.67)	2(33.33)	**9(17.64)**
SV	1(8.33)	2(33.33)	3(33.33)	1(8.33)	1(16.67)	2(33.33)	**10(19.61)**
MJ	2(16.67)	1(16.67)	0(0.00)	2(16.67)	1(16.67)	0(0.00)	**6(11.76)**
HAD	1(8.33)	0(0.00)	2(22.22)	1(8.33)	2(33.33)	1(16.67)	**7(13.73)**
Total	**12(100)**	**6(100)**	**9(100)**	**12(100)**	**6(100)**	**6(100)**	**51(100)**

CB - City bay
RB: - Reuphina second pool
RA: - Reuphina first pool
SV: - Smile View
MJ: - MJ Resort
HAD - Hallydays

The result of this investigation divulged that all six (George et al., 2014) swimming pools in Makurdi used for this experiment had bacteria isolate. Previous reports from other studies have indicated that various bacteria have been isolated. In Port Harcourt, Smart isolated *Staphylococcus epidermidis, Bacillus cereus, Micrococcus and Staphylococcus aureus* (Smart, and Constancy, 2010). In Accra Ghana, (WHO.2006) isolates *Escherichia coli, Enterobacter faecalis, Staphylococcus aureus, Klebsiella pneumonae and Staphylococcus epidermidis.* Also, a related study on swimming pools in Lagos, Nigeria, the bacteria isolated were *Clostridium pefringes, Escherichia coli, Proteus vulgaris, Staphylococcus epidermidis, Enterococcus faecalis, Pseudomonas aeruginosa and Bacillus cereus* (Bello et al., 2019). A similar study of swimming pools in Illorin, Nigeria, isolated; *Aeromonas, Klebsiella, Micrococcus, Pseudomonas, Lactobacillus, Bacillus, Escherichia coli, Citrobacter and Staphylococcus aureus* (Bello et al., 2019). The bacterial isolates in this study

consisted of *Staphylococcus* species, *Bacillus*, *Escherichia coli, Klebsiella, Proteus and Pseudomonas* which agrees with the work of (Odo, 2019). The presence of *Staphylococcus* and *Bacillus* species may not be unconnected with releases from skin and nostrils of bathers while *Klebsiella, Proteus and E. coli* are likely faced contamination of the pool water. These isolates in this study agrees with the works of (Bello et al., 2019), The presence of *Pseudomonas* in some of these pools may also be as a result of releases from the ears of some users who may be suffering from otitis media. Faecal Coliform presence in this recreational water is of great health concern as the potent serious health risk for users of the facility. These are water borne pathogen which can result in disease outbreak and even death as have been reported in other studies round the world. The use of these pools that have enteric bacteria by infants, the elderly and immuno compromised individual may result in infection if by accident they ingest the water.

There is also the problem of possible skin infection because of the presence of *Staphylococcus* species, *Bacillus* species and *Pseudomonas* species. *Klebsiella* species which is an air-borne pathogen also constitute the majority of bacteria isolated in this study can cause disease of the air way such as pneumonia. On the physicochemical analysis of the pools, the result shows that as the pool is put to use, the physicochemical parameters degenerates resulting in increased total dissolved solid and temperature. This increase in total dissolved solid can be attributed to the tiny dirt particles on the skin of swimmers while the rise in temperature may be from both environmental influences as well as the fact that user's temperature before use is usually higher than after they have used it. Because swimming is a form of exercise, it results in higher metabolic activities in the body thereby resulting in increased temperature.

Finally, this high prevalence may be due to the metropolitan nature of these two bacteria genera. It is also in line with earlier studies (Mustapha, 2020). In all it can be said that most of these pools fall short of international standard as they have become reservoirs of some pathogenic bacteria and hence its consequent health implications. It is worthy of note that isolation of enteric pathogens in recreational water is not just peculiar with developing nations but even the well industrialized nations of the world like the United States of America have well documented disease outbreaks that have been epidemiologically and clinically linked to recreational water where dangerous strain of coli were implicated like the *E. coli* 0157 (enterohaemorrhagic *Escherichia coli*) (Brewster, 2018). The significant difference in the total viable count between the unused and used pool goes further to buttress the assumption that majority of the bacteria population are contaminations or release from bathers. This implies that the microbial load has a direct relation or proportional to the number of users as well as the sanitation condition of users.

Conclusion

The following conclusions can be drawn based on the results of this study. Most swimming pools within Makurdi Metropolis have high bacterial populations above WHO recommended standards. There are indicator bacteria of faecal contamination among the bacterial isolates. It's also worthy of note that pathogenic bacterial genera were implicated as being contaminates of these swimming pools. There are chances of disease outbreaks from these pools, if proper measures are not taken.

References

APHA (2005) Standard methods for the examination of waste and waste water. 21st ed. American Public Health Association, Washington, D.C

Awua Y, Tsekaa ET, Atu BO, et al. (2022) Isolation and Identification of Bacteria on Automated Teller Machines (ATMs) in Makurdi Metropolis. Frontiers in Environmental Microbiology. 8(1):1-5. doi: 10.11648/j.fem.20220801.11

Bello OO, Mabekoje OS, Egberngbe HO and Bello TK (2019) Microbial qualities of swimming pools in Lagos, Nigeria. International Journal of Applied Science and Technology, 2, 89-96.

Brewster DH, Brown MI, Robertson D, et al. (2018) An outbreak of Esherichia coli 0157 associated with a children's paddling pool. Epidemiology and Infection, 112:441-447.

Cabral JPS (2012) Water microbiology. Bacterial pathogens in water. International Journal of Environmental public Health, 7:3657-3703.

Ebah EE, Odo JI, Aniebonam S (2022) Comparative Study of Indicator Organisms in Different Water Sources in North Bank Area of Makurdi. Journal of Environmental Issues and Climate Change 1(1): 59-64

Favero MS (2004) Use of Staphylococci as indicators of swimming pool pollution. Journal of Public Health, 79:61-70.

George O, Simon KS, Emmanuel L and Emmanuel T (2014) Bacteriological Quality Assessment of swimming, Journal of Water health 5 (4):15-18.

Hassan NE (2023) A Comparative Investigation of Rain Water Quality Parameters Between Natural and Industrial Areas in Duhok Governorate, Kurdistan Region-Iraq. Environmental Science Archives 2(2):131-140.

Mustapha DS (2020) Outbreak of Pseudomonas aeruginosa folliculitis associated with a swimming pool inflatable. Journal of Epidemiology of Infectious Diseases, 130:187-192.

Odo JI (2019) Effect of Concentrations of Vestaline® (Pendimethalin) Herbicide on Growth Performance of Clarias gariepinus Juveniles.Frontiers in Environmental Microbiology 5(6):106-110. doi: 10.11648/j.fem.20190506.11

Pandiarajan A, Shanmugaselvan R and Dheenadayalan MS (2023) Environmental Monitoring of Bore Water Quality at Selected Locations in Kottapatti Village. Environmental Science Archives 2(1):59-64.

Smart W and Constancy P (2010) Long-term shedding and clonal turnover of enterohemorrhagic Escherichia coli 0157 in diarrheal diseases. Journal of Clinical Microbiology. 7(8): 1602-1605

Sohrabi MS, Kalso L, Jokpii, D, et al. (2016) Microbiological quality in finish public swimming pools and whirlpools wearers. Journal of Ophthalmology, 79:178-181.

Sule IO, Agbabiaka TO, Saliu BK and Oyerinde EO (2010) Physicochemical and Bacteriological Assessment of some swimming pools within Ilorin metropolis, Kwara, Nigeria. Journal infectious disease, 7:108-12.

Wade TJ, Calderon E, Beach K, et al. (2006) Rapidly measured indicators of recreational water qualities are predictive of swimming-associated gastrointestinal illness. Environmental Health Prospective, 114(1): 24-28.

WHO (2006) Guidelines for Recreational Water Environments. Swimming pools and similar Environments. 3rd ed. WHO press.

Author Contributions
JIO, EEE and OB conceived the concept, wrote and approved the manuscript.

Acknowledgements
Not applicable.

Funding
There is no funding source for the present study.

Availability of data and materials
Not applicable.

Competing interest
The authors declare no competing interests.

Ethics approval
Not applicable.

Citation: Odo JI, Eneyi EE and Blessing O (2023) Isolation and Characterization of Bacterial Species from Selected Swimming Pools of Makurdi, Nigeria. Environ Sci Arch 2(2): 185-194.