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Original Research Paper

Water Quality Assessment of Outdoor Public Swimming Pools in Ovia North East, Edo State, Nigeria

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Abstract

Poor water quality management practices of public swimming pools have raised concerns about the health safety of these recreational facilities. This study evaluated the physicochemical properties and bacteriological quality of four (4) outdoor swimming pools in Ovia North East, Local Council of Edo State, Nigeria. Results of physicochemical analysis showed that water temperature (25.75 - 26.38°C), pH (3.78 - 6.1), electrical conductivity (37.5 - 72.5 mg/L), total dissolved solids (14.58 - 38.43mg/L), turbidity (0.75 - 4NTU), dissolve oxygen (6.03 - 7.43mg/L), residual chlorine (0.03 - 0.13mg/L), alkalinity(7 - 26.5mg/L), hardness (6 - 36mg/L), were within the World Health Organisation and Environmental Protection Agency stipulated maximum permissible limit for recreational waters except for pH and residual chlorine levels. The presence of pathogenic microorganisms in all the studied pools – total bacteria count (1 – 3 cfu/100mL), total coliform count (1 – 5 cfu/100 mL) and E. coli count (1 – 2 cfu/100 mL) predisposes the users of these facilities to microbial infection. The findings demonstrated that the swimming pools did not meet the required standards, particularly in terms of pH levels, residual chlorine, and microbial parameters. There is a need for ongoing monitoring of swimming pool water quality, improving bathers' hygienic practices, raising awareness about the associated risks, and providing training for governmental inspectors

Keywords: Pool water quality, Physicochemical analysis, Bacteriological contamination, Recreational water safety, Heavy metals detection, Public health standards

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1. Introduction

Water is essential to life and serves multiple functions, including recreation, food production processes, transportation, and cooling of irrigation systems (Saberianpour et al., 2015; Egun and Oboh, 2023). Water is undeniably crucial for human needs, including recreation and food. A pool is a contained body of water primarily designed for aquatic and swimming activities. Thus, it is a limited-sized water body held within a structure, which could be large artificial basins, large paved holes, or concrete tanks (Saberianpour et al., 2015; Onifade et al., 2019).

The global use of public swimming pools for recreation, rehabilitation, and sports is increasing (Al-Khatib and Salah, 2003). To maintain cleanliness, swimming service providers use various chlorine-based disinfectants, such as sodium hypochlorite, dichlor, or trichlor (Sule and Oyeyiola, 2010). It is crucial to maintain the pool's pH between 7.2 and 7.6 when using these chemicals (Sule and Oyeyiola, 2010). Physicochemical factors like pH significantly impact disinfection efficacy, prevent damage to pool infrastructure, and ensure user comfort (Sule and Oyeyiola, 2010). For instance, an alkaline pH reduces the effectiveness of chlorine as a disinfectant.

Additionally, high pool temperatures can promote fungal contamination (Al-Khatib and Salah, 2003; Onifade et al., 2019). Residents of Edo State usually visit popular recreational facilities such as hotel swimming pools for leisure and relaxation (Saberianpour et al., 2015; Onifade et al., 2019). However, pools are generally susceptible to contamination through various means: the discharge of pathogenic microorganisms from infected swimmers through skin secretions, urine, vomit, nasal discharge, saliva and mucus; accidental release of faeces; airborne contaminants; water from unclean origins; and bird droppings (Sule and Oyeyiola, 2010). These contaminants can introduce viruses, parasites, fungi, and bacteria, into the water, some of which may be pathogenic (CDC, 2009; Sohrabi et al., 2016; Onifade et al., 2019).

Swimming pools have been linked to outbreaks of waterborne infections (Dufour et al., 2006; Schets et al., 2011; Onifade et al., 2019). Pathogens in the water can cause digestive system infections, eye and ear infections, upper respiratory tract infections, systemic infections, and skin diseases in swimmers, particularly in those with compromised immune systems (Papadopoulou et al., 2008). Often, the danger of illness or infection is associated with faecal contamination from excreta discharged by swimmers and birds (Papadopoulou et al., 2008; Onifade et al., 2019). To protect public health World Health Organisation, regions such as United State of America, Europe, Australia, Asia and several countries including, Europe, Malaysia, Iran, Jordan, Palestine, South Africa, Kenya and Egypt have developed swimming pool water quality guidelines. However, it is interesting to note that Nigeria does not have water quality guideline for public swimming pool. Numerous authors have investigated the water quality of swimming pools in various cities across Nigeria (Opafola et al., 2022; Verla et al., 2021; Onifade et al., 2019; Esinulo and Ogbuagu, 2016; Indabawa et al., 2015) and in regions around the globe, including Egypt (Abd El-Salam 2012), Ethiopia (Yedeme et al., 2017; Natnael et al., 2024), Ghana (Saba and Tekpor, 2015), Iran (Hoseinzadeh et al., 2013), Portugal (Felgueiras et al., 2020; Gabriel et al., 2019), France (Tsamba et al., 2020). Various sanitation methods have been implemented to ensure the cleanliness of pools. These include filtration to remove pollutants, disinfection to eliminate infectious microorganisms, promoting cleanliness among swimmers to minimize the introduction of contaminants, and regular water analysis to monitor chlorine and pH levels (Bello et al., 2012; Onifade et al., 2019). Despite the health and well-being benefits provided by recreational water use, adverse health effects can occur if the water is polluted or unsafe. For many swimming pools in Ovia Local Government, Benin City, there is limited data on the quality of public pools in hotels and government facilities. The present study aims to evaluate the physicochemical and bacteriological quality of outdoor public swimming pools in designated public hotels and sport complex in Ovia North East Local Council, Benin City, Nigeria.

2. Materials and Methods

2.1 Description of study site

This study was conducted at the outdoor swimming in Ovia-North East Local Government Area, Benin City, (Figure 1). It is one of the eighteen local government areas that make up Edo State. Ovia-North East Local Government is part of Ovia Federal Constituency. The local government which is situated in the South-South region of the country is geographically located at 6°20′00″ N latitude and 5°37′ 20″ E longitude, with an estimated area of 1,204 km2 and a total population of approximately 1,782,000 as of 2021 (Egware et al., 2021). The local council has several swimming pools, however four swimming pool comprising three hotel swimming pool and one sport swimming pool was selected for this study. Swimming Pool: 1 It is a private swimming pool located in a hotel around Akure-Owo Road. The swimming pool is rectangular in shape with a length of 7.0m and width of 4.5m. It lies between latitude 6.30061 N and longitude 5.63420 E. The swimming pool is mostly used by customers who patronize the hotels. The bather load of the swimming pool per day is between 12 – 20. The swimming pool water undergoes treatment once every week. Swimming Pool 2: It is a private swimming pool located in a hotel around Oluku community, Akure-Owo Road. It is a rectangle shaped swimming pool with a length of 10.m and with of 6.9m. It lies between latitude 6.45615 N and longitude 5.57986 E. The bather load per day of the swimming pool is between 15 – 25. The water in the swimming pool is treated once every week. Swimming Pool 3: It is a public swimming pool located in the University of Benin Sports Complex, Ugbowo Campus. It is a square shaped pool with the length of 14.1m and with of 11.5m. It lies between latitude 6.39829 N and longitude 5.61004 E. The bather load per day of the swimming pool is between 55 – 100. Swimming Pool 4: It is a private swimming pool located in a hotel in Nineteen Street, Off Ugbowo Benin City. This is a rectangle

shaped pool with the length of 9.0m and with of 8.0m. It lies between latitude 6.39829 N and longitude 5.61004 E. The bather load per day of the swimming pool is between 15 – 20.

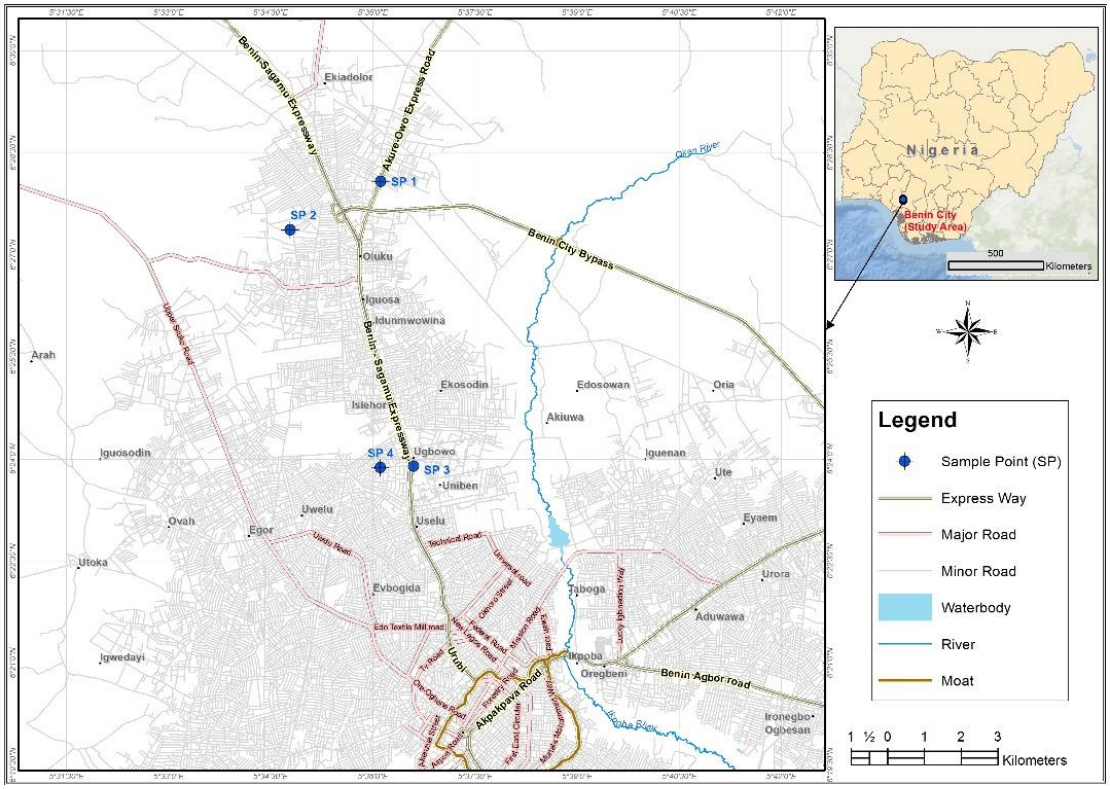

Figure 1. Map Showing Study Area and Swimming Pool location

2.2 Sample Collection

A total of 16 water samples were purposively collected four times from four public swimming pools in the local government in the dry season months of January and February, 2024. Samples were gathered from four locations in each pool using sterile 250mL bottles and then combined. This was done each morning after high-traffic days (typically weekends) from a water depth of approximately 1 foot. The samples were subsequently transported to the laboratory in an ice box. On-site measurements were taken for temperature, pH, electrical conductivity and total dissolved solids.

2.3 In-situ measurements

On-site measurements were taken for temperature, pH, electrical conductivity and total dissolved solids.

2.3.1 Temperature

The temperature was determined using a mercury-in-glass thermometer. To take the temperature reading, the thermometer was inserted in the swimming pool water sample for five minutes to allow for a stable value to be obtained.

2.3.2 Hydrogen Ion Concentration (pH)

The pH was measured using a Hanna pocket-size pH meter (HANNA instruments HI9107). This was done by calibrating the pH meter and then take off the protective cap and switch on the pH meter. Submerge it in the swimming pool water sample up to the maximum immersion depth. Stir gently and wait for the display to stabilize. The reading is then recorded in the field note.

2.3.3 Electrical Conductivity (EC)/ Total dissolved Solids (TDS) mg/L

For the determination of EC and TDS the HANNA device (HI96301) was switched on and immersed in the water sample up to the maximum immersion level without touch the bottom of the beaker. Stir gently and wait until the display stabilizes. Then the value on the display is read and recorded. This value multiply by 10 to give you the EC, this can be converted into TDS by calculation.
EC can be converted to TDS using the equation:
TDS = (0.548 x EC) + (2.2 x 10-6 x EC2)
where TDS = Total Dissolved Solids (mg/L) EC = Electrical conductivity (µS/cm)

2.4 Ex-situ measurements

2.4.1 Dissolve Oxygen (DO) mg/L

The brown precipitate was dissolved using 2ml of H_2SO_4, with a measuring cylinder, 100ml of the sample was measured, poured into a conical flask. Then 1ml of starch solution indicator was added which changed the sample colour to dark blue. The burette was filled with sodium thiosulphate ($Na_2S_2O_3$), the initial titre value was noted then the sample was titrated until a colourless endpoint is achieved. The final titre value was recorded.

2.4.2 Turbidity (NTU)

Switch on the meter and rinse the cells with distilled H_2O. Measure 10ml of De-ionized water and pour into a cell. Measure 10ml of sample and pour into the other cell. Program the meter to an SOP of 95, then press enter. Uncover the meter to expose the cell holder, clean the cells using a wiper to erase finger prints and dry off spills. Insert the cell containing 10ml de-ionized water into the cell holder and cover before pressing zero for blanking. Do same to the 10ml sample in the other cell, but this time press read. Record the readings displayed. Rinse the cells before reusing.
The device was switched on and the cells were rinsed properly with distilled H_2O. With a measuring cylinder, 10ml of de-ionized H_2O was measured and poured into a cell. Then 10ml of the sample was measured and poured into another cell. The device was programmed to SOP 95 and then the enter button was pressed. The meter was then uncovered to expose the cell holder and the cells were wiped using a wiper to erase finger prints and dry off any spills. The cell containing 10ml deionized H_2O was inserted and covered, then the zero button was pressed for blanking. The display screen read zero and this was repeated for the 10ml sample, but this time the read button was pressed and the reading displayed was recorded.

2.4.3 Free Residual Chlorine (mg/L)

A measuring cylinder was used to measure 50ml of the sample and was poured into a conical flask. One millilitre (1ml) of K_2CrO_7 indicator was added. The burette was filled with silver nitrate, and the initial titre value was noted before titrating to an orange endpoint. The final titre reading was recorded.

2.4.4 Heavy Metals (mg/L)

The heavy metals analyzed for were chromium, cadmium, copper, Iron, lead and zinc. The water sample was filtered through a Whatman No. 42 filter paper and was then made up to 50ml using distilled water. The digestion of the water sample was done using aluminium block digester 110. 100ml of the sample was measured and 4ml perchloric acid, 20ml concentrated nitric acid and 2ml concentrated tetraoxosulphate VI acid was added. The solution was digested and was heated until white fumes evolved and a clear solution was obtained. The sample was then allowed to cool before it was transferred to 100ml volumetric before flask and made up to point by adding distilled water. The sample was thoroughly mixed before it was allowed to stand overnight (in place of centrifuge) to separate insoluble materials. It was then filtered through 0.45µ millipore type filter (Bashir et al., 2023).
The metals of interest were read using the Atomic Absorption Spectrophotometer (ASS) Solar 969 Unicam Series Model. Each metal has a hollow cathode lamp for its determination. The instrument was set to the wavelength

specific to each metal to be analyzed. Distilled de-ionized water aspiration between each reading was conducted. The reading of the absorbance was obtained by observing the steady galvanometer reading for like 1-2minutes. The concentration of the metals was calculated using the standard calibration plot (Beauchemin and berman, 1989).

2.5 Bacteriological Qualities in Swimming Pool Water

2.5.1 Determination of Total Heterotrophic Bacterial Count

The enumeration of total heterotrophic bacterial count followed the method described by Oluwatoyin and Adebayo (2014) and was performed using both the serial dilution and pour plate techniques. Serial 10-fold dilutions were made in sterile water, and 1 mL of each dilution was aseptically placed in sterile petri dishes in triplicate. Twenty milliliters of molten plate count agar (Oxoid), cooled to 45°C, were then added to each plate and thoroughly mixed. After solidification, the plates were incubated at 22°C and 37°C for 24-72 hours. The bacterial colonies were counted and reported as colony-forming units per milliliter.

2.5.2 Determination of Total Coliform Count

This was measured using the Most Probable Number (MPN) method as outlined by APHA (1998). Ten millilitres (10 mL) of MacConkey broth were dispensed into each of 15 bottles using a sterile syringe. Inverted Durham tubes were placed in each bottle, which were then sealed and autoclaved at 121°C for 15 minutes. After autoclaving, the bottles were transferred to a sterile environment. Ten millilitres of the water sample were inoculated into the first five bottles, 1 mL into the second five bottles, and 0.1 mL into the last five bottles. The bottles were incubated and observed after 48 hours. The number of positive bottles, indicated by color change and gas production, was recorded, and the bacterial load was determined using the Most Probable Number (MPN) table.

2.5.3 Determination of Faecal Coliform Count

The Most Probable Number (MPN) technique was also employed to identify faecal coliforms in the samples as reported by APHA (1998). Serial dilutions ranging from 10-1 to 10-2 were prepared by adding 1 mL of the sample to 9 mL of sterile distilled water. One millilitre aliquot from each dilution were then inoculated into 5 mL of MacConkey Broth and incubated at 44°C for 18-24 hours. Tubes that exhibited a colour change from purple to yellow and gas accumulation in the Durham tubes after 24 hours were identified as positive for faecal coliforms. Counts per 100 mL were determined using MPN tables.

2.6 Data Analysis

Data were analyzed using Microsoft Excel© 2019 software. Variation plots illustrated the mean levels of the water quality parameters for the sampled pools. One-Way ANOVA assessed the homogeneity of mean variance of the parameters across different sampling locations, with post-hoc mean separation performed using the Duncan Multiple Range Test (DMRT) at $P<0.05$. The Pearson correlation coefficient (r) was employed to examine potential relationships between the parameters.

3. Results

3.1 Physicochemical Analysis of Swimming Pools

The results in **Table 1** present the physicochemical analysis of various parameters conducted on outdoor swimming pool water samples gathered from the selected hotels and Sport Complex in Benin City. The water samples from the pool were transparent and devoid of colour. The various variables analyzed for each hotel exhibited different levels of values. On average, it was observed that the pH values exceeded the guidelines set by WHO and EPA. The distribution of various physicochemical parameters studied on the swimming pool water

samples are presented in **Figures 2**(A–I). The distributions allow for easy comparison of the results obtained from the different pools in Ovia North East Local Government, Benin City.

The mean temperature recorded for the investigated four swimming pools ranged between 25.75°C and 26.38°C. The highest mean temperature (26.38°C) was recorded in Sp 4 and the lowest (25.75°C) in Sp 2. There was no significant difference in the variation of temperature across the swimming pools. The mean temperature values recorded in this study were within the stipulated Standard limit by World Health Organisation (WHO) 2006. The pH levels varied significantly across all the swimming pools examined, where none of swimming pools evaluated had the recommended WHO standard pH values. Swimming pool (Sp) 1 recorded the highest mean pH value of 6.1, while the least pH value of 3.1 was recorded in Sp 2.

Table 1. Physicochemical characterization of the swimming pool water samples

Parameters	Sp 1	Sp 2	Sp 3	Sp 4	P value	F value	Standard
Temperature (°C)	26.13± 0.85	25.75±0.29	25.88± 0.75	26.38± 0.48	0.53	3.49	22-26*
	(25-27)	(25.5-26)	(25.5-27)	(26-27)			
pH	**6.1±1.23**	**3.78±0.26**	**5.53±0.38**	**4.58±1.84**	**0.02**	**3.49**	**7-7.8***
	(6- 6.2)	(3.4-4)	(5-5.9)	(3.1-6.9)			
EC (mg/L)	72.5±61.31	27.5±9.57	52.5±29.86	35±5.77	0.31	3.49	1000*
	(0.1-4.5)	(20-40)	(10-80)	(30-40)			
TDS (mg/L)	38.43±1.49	14.58±5.07	27.83±15.83	18.55±3.06	0.31	3.49	500*
	(5.3-79.5)	(10.6-21.2)	(5.3-42.4)	(15.9-21.2)			
Turb. (NTU)	**0.75±1.5**	**1±1.41**	**4±4.69**	**1.25±1.5**	**0.32**	**3.49**	**5***
	(0-0.3)	(0-3)	(0-9)	(0-3)			
DO (mg/L)	**7.05±0.71**	**6.73±0.57**	**7.43±1.36**	**6.03±1.11**	**0.28**	**3.49**	**9 - 10***
	(6-7.5)	(5.9-7.1)	(5.4-8.3)	(4.6-7.3)			
Residual Chlorine (mg/L)	**0.03± 0.05**	**BDL**	**BDL**	**0.13±0.19**	**0.27**	**3.49**	**1-3***
	(0-0.1)			(0-0.4)			
Alkalinity (mg/L)	26.5±20.35	7±2	21.±12.80	15±10.39	0.24	3.49	150*
	(6-44)	(4-8)	(12-40	(6-30)			
Hardness (mg/L)	35±29.28	6±0	36±29.39	25.5±39	0.45	3.49	150*
	(4-60)	(6-6	(20-80)	(6-84)			
Cd (mg/L)	BDL	BDL	BDL	BDL			0.003+
Cr (mg/L)	0.037±0.014	0.032±0.007	0.04±0.013	0.048±0.013	0.36	3.49	
	(0.024-0.059)	(0.027-0.042)	(0.032-0.064)	(0.032-0.064)			
Cu (mg/L)	0.055±0.006	0.062±0.02	0.048±0.008	0.063±0.009	0.22	3.49	0.3+
	(0.047-0.59)	(0.036-0.073)	(0.043-0.059	(0.052-0.074)			
Fe (mg/L)	0.17±0.05	0.022±0.05	0.186±0.048	0.19±0.032	0.46	3.49	0.3+
	(0.13-0.24)	(0.18-0.28)	(0.15-0.25)	(0.167-0.228)			
Pb (mg/L)	BDL	BDL	BDL	BDL			
Zn (mg/L)	0.21±0.10	0.28±0.09	0.099±0.077	0.25±0.096	0.71	3.49	<0.1+
	(0.28-0.36)	(0.22-0.42)	(0.17-0.36)	(0.18-0.39)			

+WHO (2006), * WHO and EPA Guideline for swimming pool reported by Indabawa et. al., (2015)

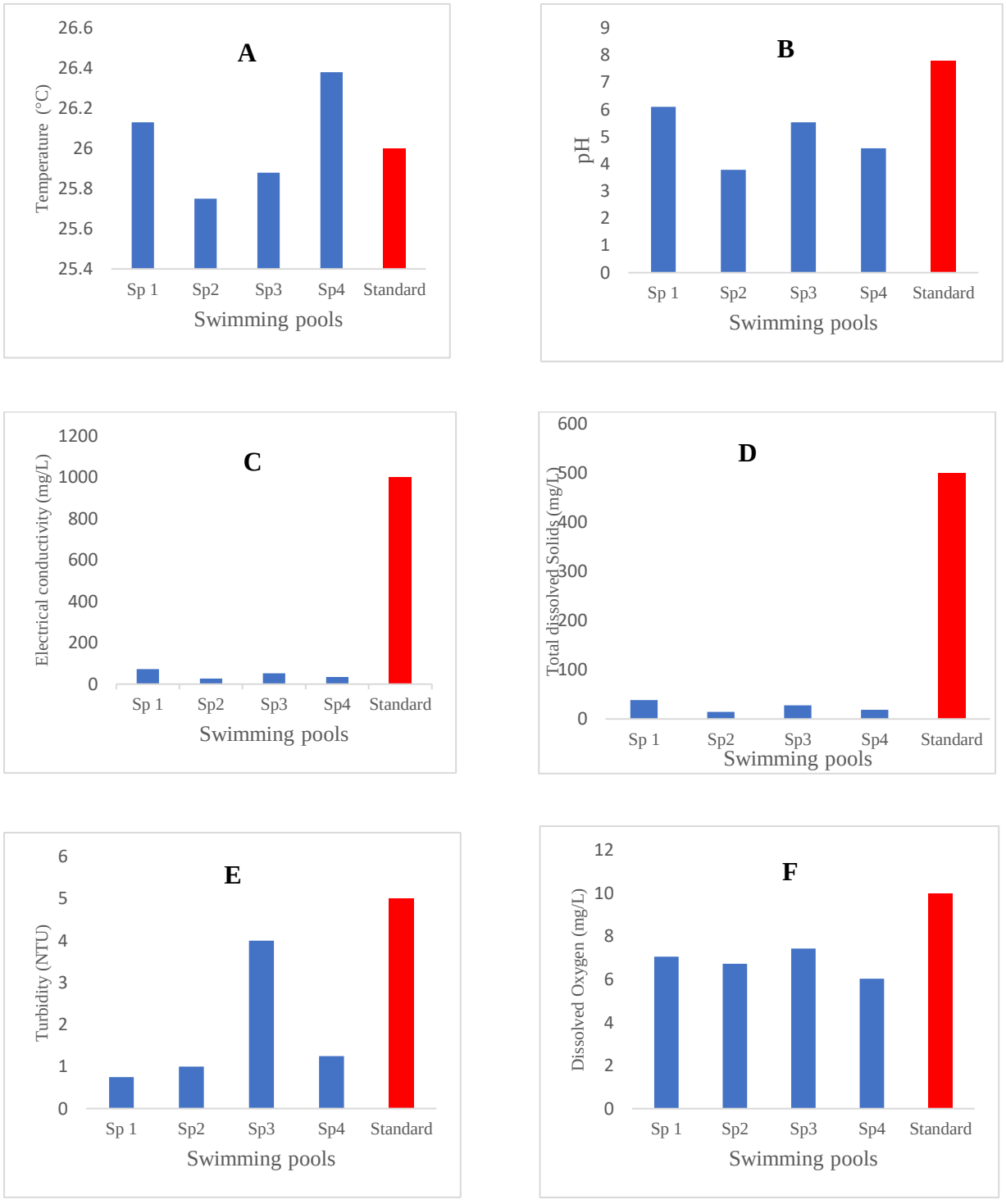

Figure 2. (A-F). Distribution of physicochemical parameters across the swimming pools. The highest mean turbidity was recorded in sp 3 (4NTU) while the least mean turbidity value was recorded in sp1. The highest turbidity value was recorded in sp 3 (9NTU) and the least was 0NTU recorded in all swimming pools. The least mean residual chlorine was 0.03mg/L in sp 1 and the highest mean residual chlorine was 0.13mg/L in sp 4.

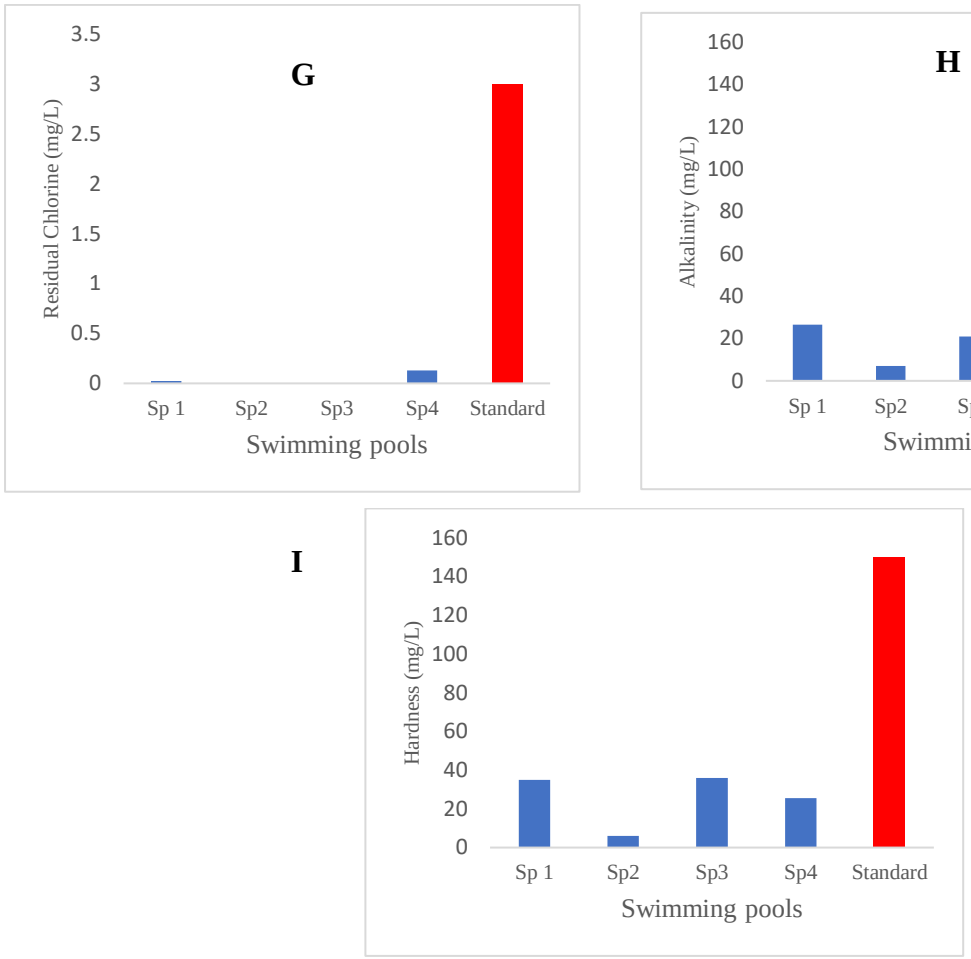

Figure 2. (Cont'd.) (G-I). Distribution of physicochemical parameters across the swimming pools. The highest mean turbidity was recorded in sp 3 (4NTU) while the least mean turbidity value was recorded in sp1. The highest turbidity value was recorded in sp 3 (9NTU) and the least was 0NTU recorded in all swimming pools. The least mean residual chlorine was 0.03mg/L in sp 1 and the highest mean residual chlorine was 0.13mg/L in sp 4.

3.2 Bacteriological Analysis of Swimming Pools

Table 2 presents the results of the bacteriological analysis of swimming pools in Ovia North East Local Government, Benin City. The bacteriological evaluation of outdoor swimming pool water samples from three different hotels and the University of Benin sports complex in Benin City, Nigeria, was conducted after swimming, as shown in **Table 2**. The Total Bacteria Count (TBC), Total Coliform Count (TCC), and Escherichia coli Count were measured. Among all the swimming pools (sp), Sp 3 had the highest Total Bacteria Count (TBC) of 3 x 10^2 CFU/100mL, followed by Sp 2 and Sp 4, each recording a TBC of 2 x 10^2. Sp 1 had the lowest TBC of 1 x 10^2. Total Coliform Count (TCC) was recorded across all four swimming pools, with Sp 3 having the highest count at 5 CFU/100mL, and Sp 1, Sp 2, and Sp 3 each recording 3 CFU/100mL. Although Faecal Coliform Count (FCC) was detected in all swimming pools, it was most prevalent in Sp 3, followed by Sp 2, then Sp 1 and Sp 4, respectively.

4. Discussion

It is crucial to ensure that recreational water meets the same standards as drinkable water, as there is a considerable likelihood that swimmers might accidentally swallow the water. Additionally, it was noted that some outdoor swimming pools are overseen by staff without proper training, who are merely hired to oversee the facility's operations with little regard for hygiene or the health of swimmers, thereby neglecting measures to protect public health. There are varying opinions on how to assess swimming pool water quality. Some researchers suggest focusing on microbes that indicate good hygiene, such as heterotrophic bacteria and total coliforms, while others argue that monitoring for faecal pollution is more important, as infection risk is often

linked to microbes associated with the mouth, skin, and upper respiratory tract of swimmers rather than fecal contamination (Mossel, 2006; Mood, 2007; Onifade et al., 2019). In the present study, both physicochemical and bacteriological analyses were evaluated. A key factor in assessing bathing water quality is the density of bathers. High swimmer density—such as the 1,100 bathers per day observed in the fifth studied pool—can increase the risk of pathogen contact and disease transmission. The personal hygiene of recreational water users can also significantly impact water quality (WHO, 2005; Abd El-Salam, 2012).

Table 2. Microbial assessment swimming pool water sample in Benin City, Nigeria

Water Samples	Total Bacteria Count (CFU/100mL)	Total Coliform Count (CFU/100mL)	E. *coli* Count (CFU/100mL)
WHO Limits	<1	<1	<1
1st visit in swimming pool 1 (Sp 1a)	1×10^1	0×10^1	0×10^1
2nd visit in swimming pool 1 (Sp 1b)	0×10^1	1×10^1	0×10^1
3rd visit in swimming pool 1 (Sp 1c)	1×10^1	3×10^1	2×10^1
4th visit in swimming pool 1 (Sp 1d)	1×10^1	1×10^1	1×10^1
1st visit in swimming pool 2 (Sp 2a)	1×10^1	1×10^1	1×10^1
2nd visit in swimming pool 2 (Sp 2b)	1×10^1	0×10^1	2×10^1
3rd visit in swimming pool 2 (Sp 2c)	2×10^1	3×10^1	1×10^1
4th visit in swimming pool 2 (Sp 2d)	1×10^1	1×10^1	1×10^1
1st visit in swimming pool 3 (Sp 3a)	3×10^1	5×10^1	2×10^1
2nd visit in swimming pool 3 (Sp 3b)	2×10^1	2×10^1	2×10^1
3rd visit in swimming pool 3 (Sp 3c)	1×10^1	2×10^1	1×10^1
4th visit in swimming pool 3 (Sp 3d)	2×10^1	2×10^1	1×10^1
1st visit in swimming pool 4 (Sp 4a)	1×10^1	3×10^1	1×10^1
2nd visit in swimming pool 4 (Sp 4b)	1×10^1	3×10^1	0×10^1
3rd visit in swimming pool 4 (Sp 4c)	2×10^1	0×10^1	1×10^1
4th visit in swimming pool 4 (Sp 4d)	1×10^1	1×10^1	1×10^1

The study found that some of the swimming pools met WHO and EPA standards for water quality. The recorded temperature range of 25.75°C to 26.38°C falls within the WHO's recommended limit from 2006. According to Attah et al. (2007), swimming pools with temperatures above 27°C are more likely to be contaminated compared to those maintained between 22-27°C, as higher temperatures can promote bacterial growth (Leoni et al., 2001). The significant temperature variations (25.2–33.1°C) observed in the four surveyed swimming pools may be due to water heating in some pools and others being shaded from the sun during peak hours. The pH levels in most pools tended to rise after use, which is a key indicator of microorganism presence (EPA, 2011). Adrian et al. (1984) reported that 37% of swimming pools in South Australia had pH levels outside the recommended range, similar to the findings in this study where pH levels exceeded the standard limit, possibly due to untrained staff managing the pools and excessive use of chlorine as a disinfectant.

Swimming pools Sp 3 and Sp 4 had the lowest chloride content both before and after use, which could result from ineffective treatment or poor management. These pools also attracted more visitors due to lower charges. According to the EPA (2007), the presence of chloride in water indicates the effectiveness of chlorine as a disinfectant. Other parameters, such as electrical conductivity, total dissolved solids, turbidity, dissolved oxygen, alkalinity, and hardness, varied across the pools but remained within the standard limits. However, residual chlorine, a crucial parameter, was lacking in all pools, particularly in Sp 2 and Sp 3, consistent with previous studies linking inadequate sanitation in public swimming pools to decreasing sanitizer levels (Sule and Oyeyiola, 2010; Agbagwa and Harry, 2012; Esinulo and Ogbuagu, 2016).

The average total bacterial counts (TBC) for all the outdoor swimming pool waters were generally high and exceeded the guideline set by the EPA and WHO for water. This high bacterial count suggests the presence of

significant amounts of organic matter and dissolved salts in the water. The main origins of these bacteria are typically human and animal wastes. Other sources of bacterial contamination include surface runoff, pasture areas, and other lands where animal waste is deposited, as well as discharges from sewage treatment facilities, seepage, or, septic tanks and bacteria from unprocessed soils or plants (Howe et al., 2002; Onifade et al., 2019).

While the bacteriological guidelines for outdoor swimming pools vary by region and nation, they are often stricter than those for drinking water, which are established through international agreements among stakeholders. For example, in the United Kingdom, it is advised that outdoor swimming pool water should not contain any coliform bacteria in 100ml of water (Craun et al., 2005; Indabawa et al., 2015). The average values of TBC, total coliform count (TCC), and faecal coliform count (FCC) were relatively high across the four swimming pools, particularly in Sp 3, and exceeded the WHO's (2011) recommended value of zero for drinking water. This result is consistent with the findings of Onifade et al. (2019), who assessed the physicochemical and bacteriological quality of public swimming pools in designated hotels in Ado-Ekiti, Nigeria.

5. Conclusion

These outcomes indicate that none of the investigated outdoor public swimming pools fully complied with the WHO guidelines for recreational water. Given the correlation between low chlorine concentrations and the presence of bacteriological contamination detected in the present study, the Ministry of Health should implement stricter inspection procedures, focusing on regular cleaning of filtration systems to remove biofilm and enhance disinfection. To create a more secure environment in these outdoor swimming pools, it is also essential to raise users' awareness and understanding of the hazard to promote proper manners around pools.

Declarations

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