Quality Assessment of Selected Public Recreational Waters in Sango-Ota Metropolis, Nigeria

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ORIGINAL RESEARCH

Abstract- The evaluation of selected public swimming pools within Sango-Ota metropolis was done to determine whether the pools adapt to the recommended WHO standard for swimming pool water. Six pools were selected based on the average population per use and user ratings. A total of 12 water samples were analysed physicochemical and microbial qualities using standard methods. The physicochemical characterization results are as follows; pH, 5.00 - 5.73 with mean value of 5.3; Total Dissolved Solids (TDS), 44.00 - 48.50 mg/L with mean 46.0 mg/L; Alkalinity, 24.00 - 28.50 mg/L with mean 26.0 mg/L; total hardness, 0.80 - 1.23 mg/L with mean 1.0 mg/L; iron, 0.05 – 0.69 mg/L with mean 0.3 mg/L; residual chlorine, 1.06 – 3.25 mg/L with mean 1.9 mg/L. The microbial characterization results are as follows; Zero count for *Salmonella-shigella*; Total Aerobic Plate Count (TAPC),1360 - 7270 cfu/mL; *Escherichia coli* count, 0 - 7 cfu/mL; coliform count, 2 – 25 cfu/mL. The isolated microorganisms from the pools were *Escherichia coli*, *Proteus Vulgaris*, *Yersinia Enterocolitica*, *Proteus Mirabilis*, *Citrobacter Freundi* and *Vibro Chlorea* occurred in 8.33%, respectively while *Klebsiella Pneumonia*, *Entrobacter Aerogenes*, *Pseudonomas sp.* occurred 16.67%. The pH of the analysed pools didn't comply with the WHO standards while other physicochemical parameters conform to the standard except for pools C and F which had a higher concentration of iron. However, the existence of pathogenic microorganisms in the pools classified them as unsafe for swimming activities. This study recommends routine testing and comprehensive treatments with respect to regulatory standards. Pool managers should strictly adhere to the bathing load limit and ensure the pool users take shower before using the swimming pools to forestall the outbreak of waterborne diseases

Keywords- Isolation, microbial, physicochemical, Sango-Ota, swimming pool

1 INTRODUCTION

Swimming pools are structures aesthetically designed and constructed to safely retain a large volume of treated water for swimming among other leisure activities. It could be indoor or outdoor swimming pools and are mostly constructed from different materials such as concrete, fiberglass and plastic among other. The swimming pool has become a popular sport activity around the world (Hang *et al*., 2016). Waterborne infections are transmitted in numerous ways, including but not limited to inhalation, ingestion of algal toxins, long-term chemical exposures and airborne or contact with contaminated water by a variety of infectious agents (Eze *et al*., 2015; Wei *et al*., 2018). Disinfection is important to demobilize pathogenic microorganisms and prevent the spread of water-borne diseases. Emerging organic contaminants from numerous indoor and outdoor swimming pools have been traced to Disinfection By-Products DBPs.

Several researchers have studied the water qualities of swimming pools in different metropolis of Nigeria (Verla *et al*., 2021; Indabawa *et al*., 2015; Esinulo & Ogbuagu, 2016) and some areas around the world such as Ghana (Courage and Saviour, 2015), China (Wei *et al*., 2018; Zhou *et al*., 2019; Lau *et al*., 2021), Ethiopia (Yademe *et al*., 2017), Portugal (Felgueiras *et al*., 2020; Gabriel *et al*., 2019), France (Tsamba *et al*., 2020). It is known that recreational waters get contaminated due to exposure to pathogens owing to the input of human fluids, animal faeces and rain surface runoffs, leading to the alterations in both physicochemical and bacteriological properties of the water. It is vital to assess the quality of recreational waters with dense users and highlight the possible health effects that users are not aware. Against this background, it is noteworthy that only very few studies have been undertaken to characterize the microbial and physicochemical properties of swimming pool within Sango-ota metropolis. Hence, it is essential to evaluate the physicochemical and microbial qualities of the pools within Sango-ota metropolis and to determine whether or not they conform to the suggested WHO standards for recreational water.

2 METHODOLOGY

2.1 STUDY AREA

The study area is situated within Sango-ota Metropolis in Ogun state, having the coordinate of 6° 42' 0" N, 3° 14' 0" E as presented in Figure 1. The recreational waters receive a dense population of users, tentatively used mostly at weekends for relaxation and sporting purposes.

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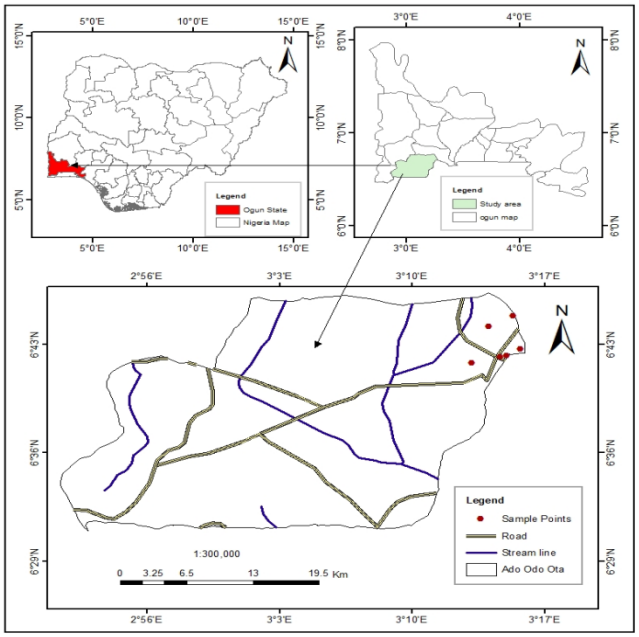

Fig. 1: Map of Sango-Ota metropolis

2.2 Field Survey and Sampling Exercise

The samplings were carried out after pool treatment (January, 2021) to assess whether the pools adapt to the recommended standards for swimming pool water. The selected sampling stations are private hotels, with the dense population of users in Sango-Ota Metropolis. The selection of sampling sites was based on the average population per use; it was carefully determined using user ratings. Twelve (12) water samples were purposively taken for physicochemical and bacteriological analysis, from the six selected sample sites listed notably as A, B, C, D, E, and F as shown in Table 1. The samples were collected from five (5) separate points and composited in sterile 250 mL plastic containers in the morning after pool treatment on high visit weekdays from 1 m depth of the pool. The samples are labelled accordingly with the corresponding date and time of collection. The description with reference to shape, length, width, average depth, area and volume of water are represented in Table 1. Water samples meant for the physicochemical analysis were obtained in 750 mL plastic bottles and placed in a vacuum storage maintained at 4°C, while the pool water samples meant for bacteriological determination were collected in 450 mL plastic bottles (USEPA, 2016). All the samples were analysed at SMO laboratory situated within Ibadan, Oyo state in accordance with the recommended standards (APHA, 2012) in a baggage containing ice blocks as preservatives for analysis of each sample within 48 hours of sample collection.

2.3 Characterization of Physicochemical Properties

The Temperature, pH and Total Dissolved Solids (TDS) were analysed using portable handheld multi-parameter device. Turbidity was analysed using HACH turbidimeter (HACH Company, model 2100P). Alkalinity, calcium, magnesium, iron and residual chlorine were assessed using the procedures described in (APHA 2012; Opafola *et al.*, 2020; Zhou *et al.*, 2019).

2.4 Characterization of Microbial Properties

The microbial parameters were assessed by multiple tube fermentation technique as described in APHA (2012). External contamination was prevented by adequate sterilization of laboratory containers and apparatus. The analytical grade reagents utilised for the microbial analysis were Nutrient agar (MERCK, Darmstadt, Germany) and MacConkey agar, salmonella shigella agar and eosin methylene blue agar.

3 Results and Discussion

3.1 Physicochemical Characterization

The temperature of the swimming pool water samples ranged from 30.1 to 31.7 °C. Pool E had the lower pH value of 5.00 while the highest pH value of 5.73 was accredited to pool C. The pH values analysed were slightly acidic and below the WHO guidelines for recreational water which states that pH value should be between 6.5 and 8.5. Slightly acidic water due to low pH can reduce the efficiency of chlorine, irritability of the skin and eyes of the swimmers and corrosion metallic utilities used in the swimming pool (Opafola *et al.*, 2020; Hoseinzadeh *et al.*, 2013).

The Total Dissolved Solids (TDS) values obtained were within 44 to 48.5 mg/L. All the TDS values analysed were within the WHO standard value of 50 mg/L. The finding is in tandem with Verla *et al.* (2021) who reported moderate turbidity in the pools examined in Owerri municipal, Nigeria. Turbidity for all pool water samples was below detection level. Alkalinity values ranged from 24.0 to 28.5 mg/L with pool E with the lowest value of 24.0 mg/L while pool B had the highest alkalinity value of 28.5 mg/L. The total hardness values acquired from the analysis ranged from 0.80 - 1.23 mg/L across the selected sampling sites, with the highest total hardness level of 1.23 mg/L found in the swimming pool site F and the lowest hardness value of 0.80 mg/L at the swimming pool Site A.

The obtained hardness values conform to the research outcome of Eze *et al.*, (2015). Low calcium hardness could damage the pool's metal and plastering, while a higher hardness in water might be an avenue for the growth of foliage and foggy water. The lowest (0.05 mg/L) and highest (0.69 mg/L) concentrations of iron were recorded for sampling sites B and C respectively. Swimming pool sampling sites A, C and F failed to comply with the WHO guideline iron value of 0.3 mg/L. High concentration of iron might be traced to the low pH, alkalinity or calcium hardness of the water. The analysis revealed that residual chlorine values range from 1.06 to 3.25 mg/L while sampling sites C and B had the lowest and highest values respectively. All the values obtained exceed the WHO threshold limit of residual chorine value > 1 mg/L. According to WHO (2006), poorly maintained and inadequately chlorinated swimming pools might lead to an outbreak of waterborne diseases. The results of the physicochemical characterization are summarized in Table 2.

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Table 1. Sample points description

Sample pools	Shape	Length (m)	Width (m)	Area (m^2)	Volume (m^3)	GPS
A	Rectangular	10.0	5.6	4.7	291.5	6.71°N, 3.26°E
B	Rectangular	8.9	4.9	44	213.2	6.73°N, 3.23°E
C	Irregular	4.4	44.0	10.0	341.0	6.74°N, 3.25°E
D	Irregular	10.4	5.1	52.9	285.9	6.72°N, 3.24°E
E	Square	7.0	7.0	49	312.6	6.70°N, 3.21°E
F	Rectangular	13.4	6.9	91.9	689.9	6.70°N, 3.25°E

Table 2. Physicochemical characterization of the swimming sites

Sample ID	Temp ^{0}C	pH	TDS (mg/L)	Turbidity (mg/l)	Alkalinity (mg/L)	Total Hardness (mg/L)	Iron (mg/L)	Residual Chlorine (mg/L)
A	30.3	5.10	47.80	Nil	27.80	0.86	0.32	1.28
B	30.7	5.50	48.50	Nil	28.50	1.02	0.05	3.25
C	31.6	5.73	44.70	Nil	24.70	0.80	0.69	1.06
D	30.5	5.30	44.80	Nil	24.80	1.08	0.25	1.62
E	30.5	5.00	44.00	Nil	24.00	1.03	0.09	2.48
F	30.1	5.10	46.00	Nil	26.00	1.23	0.66	1.95
*WHO		6.5 - 8.5	50	5		50	0.3	> 1

*WHO = World Health Organisation Standard (2006)

Table 3. Characterization of microbial parameters

Sampling Sites	TAPC (cfu/mL) x 10^3	Salmonella-shigella (cfu/mL)	Escherichia coli (cfu/mL)	Coliform count (cfu/mL)
A	1.64	0	4	9
B	1.45	0	0	2
C	1.73	0	7	25
D	1.81	0	2	5
E	7.27	0	5	7
F	1.36	0	2	8

TAPC = Total aerobic plate count

3.2 Microbial Characterization

The results of microbial characterization are presented in Table 3. The total aerobic plate count analysed in the swimming pools water samples range from 1360 to 7270 cfu/mL. All the pools were free from *Salmonella-shigella* bacterium. This result is in tandem with that of Wei *et al.*, (2018) which reported zero *Salmonella-shigella* count in the public swimming pools assessed in Guangzhou, China. *Escherichia coli* count ranged from 0 to 7 cfu/mL. Pool C had highest E coli value of 7 cfu/mL while pool B had 0 cfu/mL. The entire water samples except pool B failed to conform to WHO recommended standard of zero cfu/mL for *Escherichia coli* in swimming pool water. The result is similar to that of Fadaei and Amiri (2014) which reported an average of 19.41 *Escherichia coli* count per 100 mL in the pools analysed in Shahrekord, Iran. The lowest (2 cfu/mL) and highest (25 cfu/mL) coliform count values were recorded for pools B and C, respectively. All the pool water samples did not toe the line of WHO guideline for zero total coliforms per 100 mL in recreational water. The surge in *Escherichia coli* and coliform counts in the swimming pools could be attributed to the introduction of pathogenic organisms from the swimmers bodies, accidental discharge of faeces from flying birds and inadequate residual chlorine (Lempart et al., 2020; Verla et al., 2021).The biochemical analysis revealed isolated bacteria such as *Escherichia coli, Proteus vulgaris, Yersinia enterocolitica, Proteus mirabilis, Citrobacter freundi and Vibro chlorea occurring* in 8.33%, respectively while *Klebsiella pneumonia, Entrobacter aerogenes, Pseudonomas sp. occurred* 16.67%, respectively in the analysed swimming pool water.

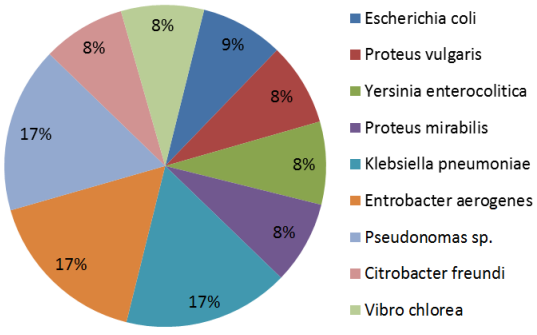

Fig. 2: Percentage occurrence of isolated bacteria

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Pathogenic micro-organisms are introduced to pools through defective pool filters, swimmers and flying birds. Poorly treated water and biofilms are often its breeding ground (Eze et al., 2015; Yang et al., 2018; Verla et al., 2021). Exposure of these bacteria to the eyes, skin, ear, nostrils, lungs and urinary tracks could lead to life treating infections (Villanueva et al., 2015; Lempart et al., 2020). Figure 2 shows the percentage occurrence of isolated bacteria in the sampled swimming pools.

4 CONCLUSION

The physicochemical investigation of the selected swimming pools revealed that all physicochemical parameters conform to the WHO standard except for pH and iron for pools C and F that failed to comply with the WHO standards. Consequently, the microbial safety indicators such as total aerobic plate counts, *escherichia coli*, coliform counts were higher than the WHO recommended standards. These results suggest that the analysed pools are unfit for recreational activities. There is urgent need to shield the pool users and forestall the spread of pathogenic microorganisms through routine testing and comprehensive treatments with respect to regulatory standards. The contamination could be mitigated by adhering strictly to the bathing load limit and enforcement of pool users to shower before using the swimming pools.

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