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PHYSICOCHEMICAL AND BACTERIOLOGICAL ASSESSMENT OF SOME SWIMMING POOLS WITHIN ILORIN METROPOLIS, KWARA, NIGERIA

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ABSTRACT

Six swimming pools within Ilorin metropolis were analysed after treatment prior to use and after use by bathers in order to determine their physicochemical and bacteriological parameters. These swimming pools were Kwara hotel swimming pools (I and II), Bekandims, Stella, Kingstone and Successxs swimming pools. The pH ranged from 4.8 to 6.9 and 4.9 to 7.6 before and after use by bathers respectively. Residual chlorine ranged from 8.95 to 11.08 ppm and 7.17 to 10.08 ppm before and after use by bathers respectively. The temperature of the pools water ranged from 25.5 – 27.5°C and 26.0 – 28.5°C before and after use by bathers respectively. The bacterial count ranged from 2.0×10^0 to 2.8×10^3 cfu/ml and 1.4×10^2 cfu/ml to 3.0×10^3 cfu/ml before and after use respectively. Faecal coliform counts ranged from zero to 4 cfu/ml and zero to 6 cfu/ml before and after use by bathers while the corresponding values of total coliforms were 0.00 to 2.0×10^2 cfu/ml and 4×10^0 cfu/ml to 3.0×10^2 cfu/ml respectively. T-test statistical analyses showed that there were significant differences ($p < 0.05$) in the bacterial count and the free residual chlorine contents of the pools water prior to use and after use by the bathers. The bacterial species isolated were: *Enterobacter aerogenes*, *Staphylococcus aureus*, *Pseudomonas* sp., *Bacillus* sp., *Streptococcus* sp., *Micrococcus luteus*, *Aeromonas aerogenes*, *Aerococcus* sp., *Lactobacillus* sp., *Klebsiella* sp., *Citrobacter freundii*, *Corynebacterium* sp. and *E. coli*. The possible sources of contaminations were identified and mitigation measures highlighted.

Keywords: Bacteriological, physicochemical, Swimming pools, Ilorin

INTRODUCTION

A swimming pool is an artificially enclosed body of water intended for swimming or water based recreation. Bathing and swimming for pleasure has been practiced by many land animals for unrecorded ages, and human record of the pleasure of immersion in water go back several thousand years ago (Perkins, 1988).

The depth of a swimming pool depends on the purpose of the pool, and whether it is open to the public or strictly for private use. Many countries now have strict pool fencing laws for private pools which require pool areas to be isolated so that unauthorized children younger than six years can't enter (EPA, 2007). Public pools are often found as part of a larger leisure center or recreational complex. Public pools may belong to a hotel or holiday resort as an amenity for the recreation of their guests (Kate and Dominick, 2008).

The water supply to a pool is usually taken from the mains of a public supply. Swimming pool sanitation refers to both visual clarity and levels of microflora such as bacteria, protozoans and viruses in swimming pools (Totkova *et al.*, 1994). The goal of sanitation is to prevent the spread of diseases and pathogens between users.

Swimming pool water may become contaminated by micro-organisms from infected swimmers, incoming water from an unsanitary source,

airborne contamination and droppings from birds is possible (Podewils *et al.*, 2007). Contaminated water can lead to a variety of disease including diarrhoea, skin, ear and upper respiratory infections particularly if the swimmer's head is submerged or water swallowed.

Some potential protozoan diseases in poorly maintained public swimming pools include cryptosporidiosis (caused by *Cryptosporium*) and giardiasis (caused by *Giardia* sp.) and amoebic meningoencephalitis (caused by *Naegleria fowleri*) (CDC, 2006).

E. coli and *Shigella* spp. are relatively sensitive to chlorine or bromine so most outbreaks have occurred in locations where no disinfectants are added. Non faecal human shedding (from mucus, saliva, skin) in the swimming pool is a potential source of non-enteric pathogenic organisms. Other non-enteric pathogens that can be found in swimming pools are *Legionella* spp., *Pseudomonas aeruginosa*, *Mycobacterium* spp., *Staphylococcus aureus*, *Leptospira interrogans*, *Molluscipoxvirus*, *Human papilloma virus*, *Acanthamoeba* spp., *Trichophyton* spp., and *Epidemophyton floccosum*, that usually produce dermic or respiratory infections (Eric and Ronel, 1982; WHO, 2008).

Strong oxidizing agents are often used to disinfect pools water especially chlorine compounds such as sodium hypochlorite, dichlor or trichlor.



When any of these chemicals are used, it is very important to keep the pH of the pool in the range of 7.2 to 7.6 (CDC, 2006). Ozone can be used as a booster in order to reduce the requirement for chlorine to be used in home swimming pools. Ozone is short lived, generally completely depleted within five minutes of introduction into pool, but highly effective in killing unwanted pathogens in the water.

This study was undertaken in order to evaluate some of the physicochemical and bacteriological quality of some pools water within Ilorin Metropolis with a view to determining their suitability or otherwise. Recommendations would also be proffered that can bring about improvements of the pools water quality.

MATERIALS AND METHODS

Collection of water samples

Water samples were collected from the following pools: Kwara hotel pools (I and II), Bekandims, Stella Obasanjo multipurpose complex, Kingstone hotel, and Successxs hotel. The water sample was collected into different sterile sampling bottles using methods as described by APHA (1985) and Fawole and Oso (1988). Two replicates of the samples were collected between the month of November and December, 2008. The bottles were properly tightened and immediately taken to the laboratory for analysis.

Physicochemical analysis of the water samples:

Residual Chlorine was determined as described by British pharmacopoeia (1993). Ten millilitre of the pool water sample was added to 90ml of distilled water. Then, 2ml of 5% Potassium chromate was added as an indicator. The resulting solution was titrated using 0.1N silver nitrate solution until the colour of the solution turned from yellow to faint pink. Each ml of 0.1N AgNO₃ is equivalent to 0.3546 mg/l of chloride ion.

pH was determined according to standard methods (ASTM, 1985). The pH meter was standardized before used and its electrode was dipped into the sample and reading was taken when the deflection stabilized.

Temperature of the pools water was determined by dipping the thermometer into the sample and the reading taken when the mercury thread stabilized (Pelczar *et al.*, 2005).

Bacteriological analysis of the water samples :

The viable bacterial count was determined using standard plate count (SPC) as described by APHA (1985). One millilitre of the sample was introduced into sterile plate. Then, sterile molten nutrient agar was introduced. The plate was gently swirled and allowed to solidify. The plates were inverted and incubated at 37 °C for 24 – 48 hours. The number of colonies that developed in the two plates for each location were counted and the average recorded.

The total coliform was determined by introducing 1ml of the sample on to the surface of

sterile set plate of MacConkey agar and spread by means of sterile spreader. The plate was incubated inverted at 37°C for 24- 48 hours. Typical coliform gave pink to red colour on MacConkey agar.

In a similar manner, Eosin methylene blue agar was used to isolate faecal coliform. Colonies with greenish metallic sheen were taken as *E. coli* and this was further confirmed by the ability of the isolate to ferment lactose with the production of acid and gas at 44.5°C for 24 – 48hours (Salle,1973).

Characterization and identification of the bacterial isolates:

Bacterial isolates were characterized on the basis of their colonial morphology, cellular morphology and biochemical characteristics. The colonial morphology observed for each isolate included the colour, shape, elevation, colony surface and optical characteristics. Cellular morphology of the isolate was also noted: Gram's reaction/behaviour, shape of cell, arrangement and spore staining. The biochemical tests done included methyl red, Voges-Proskauer, Indole, Coagulase, Oxidase, Citrate utilization, Haemolysis, Catalase, Starch hydrolysis. In order to arrive at the probable name of each isolate, reference was made to standard texts such as Joklit *et al.* (1992) as well as Buchanan and Gibbon (1974).

Statistical analysis of the results: T- test was used to determine if there is significant differences between the results obtained for each parameter before and after use by the bathers (Bello and Ajayi, 2000).

RESULTS

The pH of the swimming pools water prior to use after disinfection and after use ranged from 4.8–6.9 and 6.4–7.6 respectively. Similarly, the residual chlorine level ranged from 8.95–11.08mg/l and 7.17–10.08mg/l before and after use respectively (Table 1). The temperature of the pools water ranged from 25.5 – 27.5 °C and 26.0 – 28.5°C before and after use by bathers respectively. The highest pool's water temperature was obtained at Stella Obasanjo multipurpose complex (Table 1).

The viable bacterial count of the pools water prior to use and after use ranged from 2.0×10^0 – 2.8×10^3 cfu/ml and 1.4×10^2 to 3.0×10^3 cfu/ml respectively (Table 2).

The total coliform count ranged from 0.00 to 2.0×10^2 cfu/ml and 4.0×10^0 – 3.0×10^2 cfu/ml before and after use while the corresponding values of faecal coliform were 0.00 to 4.0×10^0 cfu/ml and 0.00 to 6.0×10^0 cfu/ml (Table 3). The growth characteristics of the isolates as presented in Table 4 were observed on the nutrient agar plates for viable bacterial counts determination as well as from the subcultures made on nutrient agar from selective or differential media plates or broth tubes. The distribution of the various bacterial species isolated were as depicted in Table 5.



The results of the T-test statistical analyses showed that there were no significant differences between the results obtained from the pools water prior to use by bathers and after use ($p > 0.05$) for the following: pH, temperature, faecal coliforms and total coliforms

(Tables 1 and 3). However, there were significant differences in the bacterial counts and the free residual chlorine levels before and after use by the bathers (Tables 1–2).

Table 1: Physicochemical qualities of water samples from the Swimming pools

Swimming Pools	pH*		Residual chlorine*(ppm)		Temperature* (°C)	
	BU	AU	BU	AU	BU	AU
Kwara hotel I	6.6 ^a	7.0 ^a	9.80 ^b	9.44 ^c	25.5 ^d	26.0 ^d
Kwara hotel II	6.5 ^a	7.0 ^a	9.73 ^b	9.30 ^c	25.5 ^d	26.5 ^d
Bekandims hotel	6.9 ^a	6.4 ^a	9.94 ^b	8.66 ^c	26.0 ^d	27.0 ^d
Stella	6.5 ^a	6.9 ^a	9.23 ^b	7.31 ^c	27.5 ^d	28.5 ^d
Kingstone hotel	5.9 ^a	7.6 ^a	11.08 ^b	10.08 ^c	25.5 ^d	26.0 ^d
Successxs hotel	4.8 ^a	4.9 ^a	8.95 ^b	7.17 ^c	26.0 ^d	26.5 ^d

* Values are means of two replicates. Values of the same parameter followed by the same letters show no significant difference before and after use by the swimmers at $\alpha = 0.05\%$

Table 2: Bacterial counts of the swimming pool water samples

Swimming Pools	Viable bacterial count* (cfu/ml) $\times 10^2$	
	Before use	After use
Kwara hotel I	0.02 ^d	1.4 ^e
Kwara hotel II	0.3 ^d	6.9 ^e
Bekandims	0.33 ^d	8.0 ^e
Stella	28.0 ^d	30.0 ^e
Kingstone	0.23 ^d	1.7 ^e
Successxs	0.36 ^d	2.3 ^e

* Values are means of two replicates. There is significant difference if the columns are followed by different letters at $\alpha = 0.05\%$

Table 3: Total coliform and faecal coliform counts of water samples

Swimming Pools	Total Coliform count* (cfu/ml) $\times 10^1$		Faecal Coliform count* (cfu/ml) $\times 10^1$	
	Before use	After use	Before use	After use
Kwara hotel I	0.0 ^a	0.6 ^a	0.0 ^b	0.0 ^b
Kwara hotel II	0.0 ^a	2.6 ^a	0.0 ^b	0.0 ^b
Bekandims	0.0 ^a	0.4 ^a	0.0 ^b	0.0 ^b
Stella	20.0 ^a	30.0 ^a	0.0 ^b	0.0 ^b
Kingstone	1.8 ^a	4.0 ^a	0.0 ^b	0.2 ^b
Successxs	0.6 ^a	2.0 ^a	0.4 ^b	0.6 ^b

* Values are means of two replicates. Values of the same parameter followed by the same letters are not significantly different before and after use by the swimmers at $\alpha = 0.05\%$

DISCUSSION

It is obvious from the results that none of the swimming pools fully complied with the WHO Standards in terms of residual chlorine not exceeding 5 mg/l in public swimming pools; absence of coliform, *E. coli*, *Pseudomonas* sp., *Legionella* spp. and *S. aureus* (WHO, 2008). This is similar to the observation of Attah *et al.* (2007) who found that none of the surveyed public swimming pool was in full compliance with the Jordanian standards for swimming pools water. Only one of the water sample from the swimming pools (17%) had pH within the range of pH 7.2 – 7.8 as recommended by WHO (2008). The pH range of 4.8 – 6.9 of the pools water before used by the bathers is far outside the recommended level and this possibly indicates excessive use of chlorination. The pH of most of the

pools tend to increase after used by the bathers. Adrian *et al.* (1984) found that 37% of the swimming pools in South Australian had pH outside the recommended level. Furthermore, the residual chlorine level of the pools are well above the standard of 5 ppm recommended by WHO (2008). The residual chlorine contents of all the pools diminished after used by the bathers. The residual chlorine of the pools which ranged from 9.23 – 11.08 ppm is far above the recommended dose of 5 ppm although this is less than the recommended shock dose of up to 20 ppm allowed by WHO (2008) as a preventive measure to correct specific problems. The excessive chlorine level observed could come from superchlorination in order to cover for bad management or ineffective mixing of the pool water.

**Table 4: Colonial, cellular and biochemical characteristics of bacterial isolates**

Isolates	Colour *	Shape *	Optical characteristics *	Elevation *	Colony surface *	Gram's reaction			Spore staining	Oxidase	Starch hydrolysis	Citrate	Coagulase	Catalase	Methyl red	Voges - Proskauer	Indole	Haemolysis	Probable identity
						Gram's reaction	Shape	Arrangement											
1	C	Ci	TI	F	S	-ve	Rod	Chain	-	-	-	-	+	-	-	-	-	-	<i>Enterobacter aerogenes</i>
2	Y	Ci	TI	Co	S	+ve	Cocci	Cluster	-	-	+	-	+	+	-	-	-	-	<i>Staphylococcus aureus</i>
3	G	Ir	Op	F	S	-ve	Rod	Chain	-	+	+	+	-	+	-	-	-	-	<i>Pseudomonas</i> sp.
4	C	Ci	TI	Ra	S	+ve	Rod	Single	+	-	+	-	-	+	+	-	-	-	<i>Bacillus</i> sp.
5	W	Ci	TI	Ra	S	+ve	Cocci	Chain	-	-	+	-	-	-	-	-	Y	-	<i>Streptococcus</i> sp.
6	Y	Ci	TI	Ra	S	+ve	Cocci	Single	-	-	+	-	-	+	-	-	-	-	<i>Micrococcus luteus</i>
7	C	Ir	TI	F	S	-ve	Rod	Single	-	+	+	+	-	+	-	-	-	-	<i>Aeromonas aerogenes</i>
8	C	Ir	Op	Ra	S	+ve	Cocci	Single	-	-	-	-	-	-	-	-	Y	-	<i>Aerococcus</i> sp.
9	W	Ci	TI	Ra	S	+ve	Rod	Single	-	-	-	+	-	-	-	-	-	-	<i>Lactobacillus</i> sp.
10	C	Ci	TI	F	S	-ve	Rod	Single	-	-	+	+	-	-	+	-	+	-	<i>Klebsiella</i> sp.
11	W	Ir	TI	F	S	-ve	Rod	Single	-	-	+	+	-	-	+	-	+	-	<i>Citrobacter freundii</i>
12	W	R	TI	F	S	+ve	Rod	Single	-	-	+	-	-	+	-	-	-	-	<i>Corynebacterium</i> sp.
13	C	R	TI	Ra	S	-ve	Rod	Single	-	-	+	-	-	+	+	-	+	-	<i>E. coli</i>

Keys: C, cream; Y, yellow; G, green; W, white; Ci, circular; Ir, irregular; R, round; TI, translucent; Op, opaque; F, flat; Co, convex; Ra, raised; S, smooth; -ve, Gram negative; +ve, Gram positive; -, negative reaction; +, positive reaction; *, growth observed on nutrient agar.

Table 5: Distribution of bacterial isolates in the swimming pools water.

Isolates	K I	K II	B	S	K	SU
<i>Enterobacter aerogenes</i>	-	-	+	+	-	+
<i>Staphylococcus aureus</i>	+	+	+	+	+	+
<i>Pseudomonas</i> sp.	-	-	-	+	-	+
<i>Bacillus</i> sp.	+	+	+	+	-	+
<i>Micrococcus luteus</i>	+	+	-	-	+	-
<i>Aeromonas aerogenes</i>	-	+	+	+	-	+
<i>Aerococcus</i> sp.	+	-	-	-	-	-
<i>Lactobacillus</i> sp.	-	-	+	+	+	+
<i>Klebsiella</i> sp.	-	+	-	+	-	+
<i>Citrobacter freundii</i>	+	+	+	-	-	-
<i>Corynebacterium</i> sp.	-	-	+	+	+	+
<i>E. coli</i>	-	-	-	-	+	+
<i>Streptococcus</i> sp.	-	+	+	+	-	+

Keys: +, isolated; -, not isolated; K I, Kwara hotel pool I; K II, hotel pool II; B, Bekandim; S, Stella; K, Kingstone; SU, Successxs.

The temperature of the pools water after use by bathers ranged from 26.0 – 28.5°C with highest temperature obtained at Stella Obasanjo multipurpose complex pool which also had the highest bacterial count (Tables 1 - 2). This same pool had the highest temperature of 27.5°C before use by bathers. According to Attah *et al.* (2007), pools with a temperature of more than 27°C are more likely to be contaminated than pools with a temperature between 22 – 27°C. Increase in temperature encourages the growth of bacteria (Leoni *et al.*, 2001).

Five (83.3%) out of the six swimming pools met up with WHO (2008) standards in terms of bacterial

count of less than 100 cfu/ml before use by bathers after disinfection. The high bacterial count at Stella's pool water prior to use by bathers could probably come from contaminated water source or ineffective treatment (Table 2). Socioeconomic level of the users and the location of the pool could affect its quality. Stella's pool is located within the heart of Ilorin township where the population is denser while the rest are located in government reserve area and are mostly patronized by the elites who are well informed about safety swimming habits.



The immediate environment of all the pools sampled were cleaned and tiled. Le-Chevallier *et al.* (1988) has reported the occurrence of coliforms in the presence of disinfectant residual. All the pools had increment in bacterial load after use by bathers. This is in conformity with the work of other workers who reported that bathers tend to shed bacteria from faecal and non-faecal sources (Craun *et al.*, 2005). Another perspective to increase bacterial count after use could be due to stirring up of sediments harbouring micro-organisms which chlorine did not act upon.

Fifty percent of the swimming pools had zero coliform count while only one (16.7%) had faecal coliform count of 4.0×10^0 cfu/ml prior to use (Table 3). All the pools had varying number of total coliforms after use by the bathers while 33.3% had faecal coliforms count. The total coliforms count tend to increase in all the pools while the level of faecal coliforms remained constant in 66.7% of the pools sampled. This increase in total and faecal coliform may be attributed to the users. Presence of pathogenic micro-organisms such as *S. aureus*, *Pseudomonas* sp., *E. coli* etc is not desirable in pool water.

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