Original Research Article

Assessment of the Physicochemical and Bacteriological Quality of Swimming Pool Water in Some Hotels in Ado-Ekiti, Nigeria

ABSTRACT

The physicochemical and bacteriological assessment of some hotel swimming pools in Ado-Ekiti, Nigeria was investigated to determine possible risks of infections to swimmers. Five swimming pools were studied with samples collected before and after swimming from two different sections in each of the pool. The average pH of the pool water ranged from 6.76 - 7.13. Pool water temperatures varied over a narrow range of 23.0 to 27.50 °c. With regards to microbial contamination, coliform counts were generally high in the pool waters after swimming, relative to their respective levels before swimming. *Escherichia coli* and *Enterococcus faecalis* were detected in all the five swimming pools while *pseudomonas aeruginosa* was detected in only two of the swimming pools. Some of these isolated bacteria showed resistance to selected antibiotics. The results revealed that the swimming pools have not met the World Health Organization (WHO) standard for recreational waters. The swimming pools may pose a serious public health hazard, hence, the need for an effective and urgent intervention while there is need for constant monitoring of recreational facility to safeguard the health of the pool users.

Keywords: Physicochemical, assessment, bacteriological, Quality, swimming pool

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1. INTRODUCTION

Swimming pool is a confined body of water that is mainly for swimming and aquatic recreation. It is a body of water of limited size contained in a holding structure, could be concrete tanks, large paved holes or large artificial basins containing water for swimming. Hotel swimming pool is one of the recreational facilities being visited by residents of Ado-Ekiti for pleasure or leisure. Public swimming pools are increasingly used worldwide for the purpose of recreation, sport and rehabilitative treatment (4).

Comment [H1]: It should be "(1)"

However, there are diverse kinds of microorganisms that can be found in swimming pools, they may be introduced into the pool water in so many ways, through the pollution by pathogenic micro-organisms from infected swimmers, via skin secretion, mouth sources such as (saliva, mucus, vomit), urine, and nose. Also, through accidental release of faeces, or by contaminated objects and clothes, airborne contamination, incoming water from unhygienic source, and bird droppings (11). These pathogenic organisms found in swimming pools and other recreational water bodies includes bacteria, virus, fungi, and parasites (12, 14). Swimming pools have been known to be associated with the outbreaks of waterborne infections (21, 5). The pathogens found in the pool can cause digestive system infection, eyes and ear infection, infections of the upper respiratory tract, systemic infection and skin diseases in swimmers, especially for immunocompromised persons. Many times, the risk of illness or infection is associated to faecal contamination of the water as a result of the excreta released by swimmers, direct animal contamination can also make outdoor pools unsafe. Pathogenic organisms are being introduced into the swimming pool through non-faecal human source including vomit, saliva, mucus or skin (8).

Comment [H2]: It should be "(2)".

Comment [H3]: It should be revised.

Comment [H4]: It should be revised.

Comment [H5]: It should be revised.

Although, the sanitary condition in swimming pool is scanty and some of the pools have inadequate water quality monitoring units. Sanitation methods including filtration in order to remove pollutants, disinfection to kill infectious microorganisms, promotion of hygiene by swimmers to reduce the risk of introducing contaminants into the swimming pool water, as well as regular analysis of pool water, checking for chlorine and pH levels is essential (8).

Ordinarily, the water for swimming is supposed to meet the same standard as portable water by being transparent, odourless, and tasteless having a freezing and boiling point of 0° and 100° respectively. It must also be free from pathogenic contaminants. With the use of disinfectants and regular change of the water, the portability of the swimming pool water can be improved (22). Chemicals are globally used by most hotels to sanitize the pool water. Liquid form of chlorine, sodium hypochlorite or calcium hypochlorite solution are used by some hotels. Though, some of these Swimming pool operators prefers iodine to chlorine since it is a disinfectant whose action is less hindered by organic matter and having lesser risk of eye and skin irritation than chlorine. There is also the recommendation of bromine (22).

Comment [H6]: °C

Viable microorganisms should be absent in a properly managed and disinfected pool water. A re-circulating system in which water is effectively filtered and disinfected is now present in modern swimming pools. Although, researches have shown that hi-tech systems or disinfectant cannot hinder the colonization of the pool water with hazardous pathogens (10, 2).

Therefore, this study aimed at assessing the physicochemical and microbiological quality of swimming pools in selected hotel swimming pool in Ado-Ekiti metropolis, Nigeria. Also, to check for the antimicrobial susceptibility of the isolated bacteria from the pools and relate the findings to hygiene, pool maintenance and possible implication on public health.

2. MATERIAL AND METHODS

2.1 Sources and collection of samples

Water samples were aseptically collected from 5 different hotel swimming pools in Ado-Ekiti Metropolis, Nigeria using the techniques of Cruickshank et al., (15) and Okafor (19). All swimming pools are constructed with glazed tile and are of varying shapes (irregular, square, circular, rectangular and oval) while their sizes ranged from 50 to 1500 m^2. The sampling periods were in the morning before swimming takes place, and evening after swimming.

2.2 Physicochemical Assessment

The physico-chemical properties examined included pH, temperature, total dissolved solid (TDS), Total hardness, nitrate, chlorides, turbidity, conductivity, calcium hardness, magnesium hardness, and total dissolved solid. The conductivity, pH and temperature were determined in situ using portable digital conductivity, pH meter (Beckman, Model 50) and thermometer respectively. The turbidity of the water samples was determined by the turbidimetric method using a colorimeter (JENWAY, Model 6051). Ultra-violet spectrometer was used for the determination of nitrate concentrations.

2.3 Microbiological Analyses

Esherichia coli count, Total Coliform Count (TCC) and Total Bacterial Count (TBC), were carried out using Eosin methylene blue Agar (EMB), MacConkey agar and Nutrient agar (NA) respectively. However, pour plate method was used, by pouring agar to sterile Petri-dishes containing 0.1 ml serially diluted swimming pool water samples of 10^3 and 10^4 and the plates were incubated in inverted position aerobically at 28^0C for 48 hours. The number of colonies between 40-300 were counted were counted after incubation.

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2.4 Identification of Bacterial Isolates

The bacterial isolates were identified by morphological characteristics, Gram's reaction, motility test, catalase test, oxidase test, citrate, methyl red test, sugar fermentation and indole test.

2.5 Antibiotic Sensitivity Test of Bacterial Isolates

Susceptibility of the bacterial isolates to antibiotics was carried out with the use of Kirby Bauer disk diffusion method on Mueller-Hinton medium. The results were read and interpreted according to the guidelines of Clinical and Laboratory Standards Institute Guidelines (CLSI, 2012). The antibiotics tested were Tarivid, Ciproflox, Reflacine, Augmentin, Gentamycin, Streptomycin, Ceporex, Nalidix A-C, Septrin, Ampicillin, pefloxacin, Gentamycin, Ampiclox, Zinnacef, Amoxicillin, Rocephine, Ciprofloxacin, Streptomycin, Erythromycin

Comment [H7]: Concentration of antibiotics ???

3. RESULTS AND DISCUSSION

3.1 RESULTS

The bacteriological assessment of swimming pool water samples obtained from five (5) different hotels in Ado-Ekiti, Nigeria was carried out before and after swimming. The Total Bacteria Count (TBC), Total Coliform Counts (TCC) and *Escherichia coli* Count was enumerated. Also, the physicochemical analysis of the swimming pool water samples was obtained. The bacteria isolates were further evaluated for antibiotic susceptibility.

Table 1. Physicochemical Analysis of Swimming Pool Water

Parameters	Pool A		Pool B		Pool C		Pool D		Pool E		Average		WHO and EPA Permissible Limit
											BU	AU	
	BU	AU	BU	AU	BU	BU	AU	AU	BU	AU			
Transparency	Clear		Clear		Clear		Clear		Clear				
Colour	Colourless		Colourless		Colourless		Colourless		Colourless				
Turbidity (NTU)	4.5	5.5	5.5	6.5	4.5	5	5.5	6.5	4.5	5.5	4.9	5.6	5 NTU
Temperature (^{0}C)	23.5	25	25.5	27.5	23.5	26	25.5	26.5	23	25.5	24.2	26.1	26^{0}C
Ph	6.99	7.03	6.56	7.08	6.95	7.2	6.57	7.23	6.71	7.12	6.76	7.13	8.50
Chlorine (mg/L)	1	0.8	1.8	1	0.9	0.7	1.6	0.9	0.9	0.7	1.24	0.82	3 (mg/L)
Nitrate (mg/L)	2.4	3.2	3.5	4.8	3.1	3.5	3.5	4.5	3.6	4.2	3.22	4.04	5 (mg/L)
Conductivity (µs/cm)	40	44	43	56	80	88	266	298	130	146	111.8	126.4	250.00 (µs/cm)
Total Hardness (mg/L)	52	74	78	98	80	93	89	100	95	112	78.8	95.4	150 (mg/L)
Calcium Har-dness (mg/L)	32	43	45	46	42	56	52	75	58	68	45.8	57.6	150 (mg/L)

Comment [H8]: pH

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Magnesium Hardness (mg/L)	20	31	33	54	38	43	37	25	37	54	33	42.2	150 (mg/L)
Total Dissolved Solids (mg/L)	**340**	**394**	**562**	**764**	**452**	**553**	**798**	**896**	**435**	**654**	**517.4**	**655.2**	**500 (mg/L)**

Key: BU = Before use AU = After use Pool A- Delight hotel, Pool B- Prosperous hotel, Pool C- Pathfinder hotel, Pool D- Midas Hotel Pool E- KSSD Hotel

Table 2. Total Bacteria Count (TBC)

Sample Site	**Before use**		**After use (cfu/ml)**	
	10^3	10^4	10^3	10^4
Pool A	90	85	155	112
Pool B	0	0	82	50
Pool C	74	71	128	122
Pool D	76	62	92	85
Pool E	95	52	157	102
Mean	67.0	54.0	122.8	94.2

Key: Pool A- Pathfinder Hotel Pool B- Prosperous Hotel Pool C- Midas Hotel Pool D- KSSD Hotel Pool E- Delight Hotel

Table 3. Total Coliform Count (TCC)

Sample Site	**Before use**		**After use (cfu/ml)**	
	10^3	10^4	10^3	10^4
Pathfinder Hotel	112	100	170	129
Prosperous Hotel	0	0	129	104
Midas Hotel	66	59	96	75
KSSD Hotel	94	70	99	94
Delight Hotel	68	72	68	104
Mean	68.0	60.2	112.4	101.2

Key: Pool A- Pathfinder Hotel Pool B- Prosperous Hotel Pool C- Midas Hotel Pool D- KSSD Hotel Pool E- Delight Hotel

Table 4. *Escherichia Coli* Count

Sample Site	**Before use**		**After use**	**(cfu/ml)**
	10^3	10^4	10^3	10^4
Pool A	93	63	104	59
Pool B	0	0	63	81
Pool C	73	61	80	62
Pool D	90	57	103	93
Pool E	40	41	81	58
Mean	59.2	44.4	86.2	70.6

Key: Pool A- Pathfinder Hotel Pool B- Prosperous Hotel Pool C- Midas Hotel Pool D- KSSD Hotel Pool E- Delight Hotel

Table 5. Antibiotic Sensitivity of Gram-Positive Bacteria

Sample	Bacteria isolated	Antibiotics									
		P*efloxacin	**Gentamycin**	**Ampiclox**	**Zinnacef**	**Amoxacin**	**Recephine**	**Ciprofloxacin**	**Streptomycin**	**Septrin**	**Erythromycin**
MS BU 1	*E. faecalis*	R	I	I	I	I	I	I	R	R	I
PAT AU 1	*E. faecalis*	S	I	S	S	I	S	R	S	I	I
PRO AU 3	*E. faecalis*	I	I	I	I	I	R	I	R	I	R
DEL BU 2	*E. faecalis*	1	S	I	I	S	I	S	I	S	S
KSD AU 1	*E. faecalis*	R	R	R	R	R	I	R	R	I	R

Key: S- susceptible; R- Resistant; I- Intermediate; MS- Midas; BU- Before Use; PAT- Pathfinder; AU- After Use; PRO - Prosperous; DEL- Delight; KSD- KSSD

Table 6. Antibiotic Sensitivity Reaction of Gram-Negative Bacteria

Sample	Bacteria isolated	Antibiotics									
		Tarivid	**Reflacine**	**Ciproflox**	**Augmetin**	**Gentamycin**	**Streptomycin**	**Ceporex**	**Nalidix A.C**	**Septrin**	**Ampicilin**
MS BU 2	*Escherichia coli*	I	I	R	R	S	I	I	I	I	I
MS AU 1	*Escherichia coli*	S	R	R	I	I	I	I	R	R	I
MS AU 2	*Escherichia coli*	I	R	I	I	I	S	I	I	I	I
MS AU 3	*Escherichia coli*	I	I	R	I	I	I	I	I	I	I
PAT BU 1	*Escherichia coli*	S	I	R	R	I	I	I	R	I	I
PAT BU 2	*Escherichia coli*	R	S	I	I	I	I	I	I	I	I
PAT AU 1	*P. aeruginosa*	I	I	I	I	I	I	I	R	I	R
PAT AU 3	*Escherichia coli*	I	I	I	I	I	S	I	I	I	S
PRO BU 1	*Escherichia coli*	I	I	I	I	I	I	I	I	I	S
PRO BU 2	*Escherichia coli*	I	I	I	S	I	S	S	I	I	I
PRO AU 1	*P. aeruginosa*	R	I	I	I	I	R	I	I	I	I
DEL BU 1	*Escherichia coli*	R	R	I	I	R	R	I	I	I	I
DEL AU 1	*Escherichia coli*	I	I	I	R	I	I	I	I	I	I
KSD BU 1	*Escherichia coli*	I	I	S	I	I	I	I	S	S	I
KSD BU 2	*Escherichia coli*	I	I	I	I	I	S	I	I	I	I

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KSD AU 2	*Escherichia coli*	R	I	I	I	I	R	R	I	I	I

S- susceptible; R- Resistant; I- Intermediate; MS- Midas; BU- Before Use; PAT- Pathfinder; AU- After Use; PRO - Prosperous; DEL- Delight; KSD- KSSD

3.2. DISCUSSION

There are a lot of contrary opinion as to how the quality of swimming pool water can be assessed. Some researchers opined that microbes which are indicators of good hygiene such as heterotrophic bacteria and total coliform should be looked out for, while others consider those of faecal pollution to be the best, since infection risk is more related to microbes associated with the mouth, skin, and upper respiratory tract of swimmers other than faecal contamination(18). However, there is no much assurance that microbes can give a reliable prediction regarding the risks of swimming to public health (32, 16, 18, 17, 20).

The average pH values recorded in all the five swimming pools ranging from 6.56-7.23 before and after use were all within WHO and EPA permissible limit. The pH of water is an essential parameter in swimming pools since it necessary for the effective disinfection and coagulation, it also prevents pool fabric from destruction in order to safeguard the users (30).

The chlorine level detected in all the studied swimming pool was between 0.7-1.24 and within the WHO (9) permissible limit. The low residual chlorine level in the pool could be due to high presence of bacteria or inadequate chlorination. chloride detection in water implies its effectiveness as a disinfecting agent and an indication that the swimming pool water is properly sanitized (3). All the analysed swimming pool water were colourless. Although, human activities, peat, plankton, vegetation and natural metallic ions are responsible for change in the colour of water.

The values of total dissolved solids (TDS) recorded before and after swimming were within the acceptable range of 500 mg/l recommended by WHO for drinking water. However, before swimming, the value was generally lower than after swimming, this may be due to the presence of inorganic salts and other dissolved materials in the pool (3). The values obtained is similar to that reported by Aremu *et al.,* (27). The turbidity values observed before swimming were lower than after swimming except Prosperous and Midas Hotel which recorded values of 5.5 respectively, above the WHO (31) guideline of 5 NTU for drinking water. This may be as a result of the discharged colloidal and organic matter from bathers during swimming, it is not impossible that most of the swimmers do not shower before swimming.

John Girvan deduced that nitrate in the pool can cause the presence of algae and other contaminants that may not respond to normal treatment. However, some other pool techs opined that nitrates in pool lock up chlorines and could drastically increase the consumption of sanitizer (3).

The temperature values obtained before swimming were within the recommended limit of WHO (31) which is 22^{0}C - 26^{0}C. This is similar to the results of Edimeh et al. (25), Clarke et al. (24). While the values reported after swimming were generally high with Prosperous Hotel recording the highest value of 27.5^{0}C which was slightly above the WHO (31) guidelines of 22^{0}C - 26^{0}C. The values of temperature obtained in this research is dissimilar to that of Onifade et al., (1) who recorded temperature greater than 26^{0}C. The high values of temperature observed could be attributed to the various body temperature of the swimmer. The weather also affects the temperature considering the different sampling times of the pools (28). The increase in temperature of the swimming pool aids the growth of bacteria (7).

The bacteriological analysis of the analysed swimming pools water showed the extent to which the water was contaminated by various microorganisms, since *Esherichia coli, Enterococcus faecalis and*

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Pseudomonas aeruginosa were isolated*.* The isolation of significant numbers of bacteria from swimming pools is an evident indication that it is either the source of raw water doesn't have enough protection or deficiency in the treatment of the pool water (35). Although, the bacteriological limits for swimming pools varies per country compared to that of drinking waters which are according to international agreement by stakeholders. For instance, it is recommended in the United Kingdom that pool water should not have any coliform microbe in 100ml of water (6).

The mean total bacterial counts (TBC) for all the pool water before and after swimming were generally high and exceeded the EPA and WHO permissible limit for water. The high total bacteria count indicates that organic and dissolved salts may be highly present in the water. Mostly, animal and human wastes are the primary sources of these bacteria in water. Other sources of bacterial contamination are surface runoff, pasture, and other land areas where animal wastes are deposited. Discharge from septic tanks, seepage or sewage treatment facilities and natural soil or plant bacteria can also contaminate water (36).

Some of the pools considered in the study recorded high levels of *Escherichia coli* and this do not conform with the recommended standard of WHO for swimming pools. According to Edberg *et al.,* (26), water sample from swimming pools should be devoid of any organism, not even coliforms in a 100 ml of water because most swimmers get to swallow some of the pool water when swimming. *E. coli* being present in swimming pool is as a result of poor pool management, lack of compliance to safeguarding measures of the source of water and insufficient disinfection of the pool (34). The result of this research is similar to that of Bello *et al.,* (22) who also isolated *Escherichia coli, Pseudomonas aeruginosa, Enteroccocus faecalis* from swimming pool.

The mean values of TBC and TCC before and after swimming were relatively high in four of the swimming pools and above the recommended value of zero for WHO (31) guideline for drinking water. Indabawa *et al.,* (33) similarly isolated coliforms in their research, Onifade et al (1) also isolated *Escherichia coli* from water samples in Ado-Ekiti. The capabilities of Pathogenic microbes have been reported in large number of bacteria species including *Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumonia* and *Staphylococcus aureus* (29).

The antimicrobial susceptibility test revealed that majority of the isolates have intermediate and high resistant to most of the antibiotics that could be used in treating resulting infection. The implies that it will be difficult to treat any infection gotten as a result of swimming in the contaminated pools. (13). Opportunistic pathogen can also intensify the situation and therefore increase the health risks associated with swimming on these contaminated pools (23). This study shows the need to do more investigation on the prevalence of antibiotic susceptibility genes in the swimming pool water, as well as the distribution of susceptible genes among the pathogenic bacteria.

4. CONCLUSION

The isolation of pathogenic bacteria from this study implies that there is poor sanitary maintenance of the pool and improper hygienic practices by swimmers. Hence, the need to effectively monitor recreational outfits such as hotel swimming pools by sensitizing everyone associated with the facility, improving pool circulation and ensure the construction is done in such a way to prevent external contamination. By such doing, there will be lesser risk posed on swimmers and bring about improvement in public health.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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