

# Original Research Article

## Assessment of the Physicochemical and Bacteriological Quality of Swimming Pool Water in private/public pools Hotels in Ado-Ekiti, Nigeria

### ABSTRACT

The physicochemical and bacteriological assessment of some hotel swimming pool water in Ado-Ekiti, Nigeria was investigated. Water samples were collected from five (5) selected before and after swimming in two different sections of 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 bacterial 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*

### 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 (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 (2). 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).

Although, the sanitary condition in the swimming pool is scanty and some of the pools have inadequate water quality monitoring units. Sanitation methods including filtration to remove pollutants, disinfection to

33 kill infectious microorganisms, promotion of hygiene by swimmers to reduce the risk of introducing  
34 contaminants into the swimming pool water, as well as regular analysis of pool water, checking for  
35 chlorine and pH levels is essential (8).

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

45  
46 Viable microorganisms should be absent in a properly managed and disinfected pool water. A re-  
47 circulating system in which water is effectively filtered and disinfected is now present in modern swimming  
48 pools. Although, researches have shown that hi-tech systems or disinfectant cannot hinder the  
49 colonization of the pool water with hazardous pathogens (10, 2).

50  
51 Therefore, this study aimed at assessing the physicochemical and bacteriological quality of swimming  
52 pools in a selected hotel swimming pool in Ado-Ekiti metropolis, Nigeria. Also, to check for the antibiotics  
53 susceptibility of the isolated bacteria from the pools and relate the findings to hygiene, pool maintenance  
54 and possible implication on public health.

## 55 56 **2. MATERIAL AND METHODS**

### 57 58 **2.1 Sources and collection of samples**

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

### 64 65 **2.2 Physicochemical Assessment**

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

### 72 73 74 **2.3 Microbiological Analyses**

75 *Escherichia coli* count, Total Coliform Count (TCC) and Total Bacterial Count (TBC), were carried out  
76 using Eosin methylene blue Agar (EMB), MacConkey agar and Nutrient agar (NA) respectively. However,  
77 pour plate method was used, by pouring agar to sterile Petri-dishes containing 0.1 ml serially diluted  
78 swimming pool water samples of 10<sup>3</sup> and 10<sup>4</sup> and the plates were incubated in inverted position  
79 aerobically at 28°C for 48 hours. The numbers of colonies ranging from 40-300 were counted after  
80 incubation.

81 **2.4 Identification of Bacterial Isolates**

82 The bacterial isolates were identified by morphological characteristics, Gram’s reaction, motility test,  
83 catalase test, oxidase test, citrate, methyl red test, sugar fermentation and indole test.  
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85 **2.5 Antibiotic Sensitivity Test of Bacterial Isolates**

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

94 **3.1 RESULTS**

95 The bacteriological assessment of swimming pool water samples obtained from five (5) different hotels in  
96 Ado-Ekiti, Nigeria was carried out before and after swimming. The Total Bacteria Count (TBC), Total  
97 Coliform Counts (TCC) and *Escherichia coli* Count were enumerated. Also, the physicochemical analysis  
98 of the swimming pool water samples was obtained. The bacteria isolates were further evaluated for  
99 antibiotic susceptibility.  
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**Table 1. Physicochemical Analysis of Swimming Pool Water in Ado-Ekiti, Nigeria**

Parameters	Pool A		Pool B		Pool C		Pool D		Pool E		Average		WHO and EPA Permissible Limit
	BU	AU	BU	AU	BU	AU	BU	AU	BU	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 (°C)	23.5	25	25.5	27.5	23.5	26	25.5	26.5	23	25.5	24.2	26.1	26°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 Hardness (mg/L)	32	43	45	46	42	56	52	75	58	68	45.8	57.6	150 (mg/L)

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

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

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118 **Table 2. Total Bacteria Count (TBC) from swimming pool Water in Ado-Ekiti, Nigeria**

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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

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111 **Legend:** Pool A- Pathfinder Hotel Pool B- Prosperous Hotel Pool C- Midas Hotel Pool D- KSSD Hotel  
 112 Pool E- Delight Hotel

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114 **Table 3. Total Coliform Count (TCC) from swimming pool Water in Ado-Ekiti, Nigeria**

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Sample Site	Before use		After use (cfu/ml)	
	$10^3$	$10^4$	$10^3$	$10^4$
Pool A	112	100	170	129
Pool B	0	0	129	104
Pool C	66	59	96	75
Pool D	94	70	99	94
Pool E	68	72	68	104
Mean	68.0	60.2	112.4	101.2

116 **Legend:** Pool A- Pathfinder Hotel Pool B- Prosperous Hotel Pool C- Midas Hotel Pool D- KSSD Hotel  
 117 Pool E- Delight Hotel

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119 **Table 4. Escherichia Coli Count from swimming pool Water in Ado-Ekiti, Nigeria**

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

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123 **Table 5. Antibiotic Sensitivity of Gram-Positive Bacteria**

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

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

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130 **Table 6. Antibiotic Sensitivity Reaction of Gram-Negative Bacteria**

Sample	Bacteria isolated	Antibiotics										
		Tarivid	Reflacine	Ciprofloxx	Augmetin	Gentamycin	Streptomycin	Ceporex	Nalidix A.C	Seprtrin	Ampicilin	
MS BU 2	<i>Escherichia coli</i>	I	I	R	R	S	I	I	I	I	I	I
MS AU 1	<i>Escherichia coli</i>	S	R	R	I	I	I	I	R	R	I	I
MS AU 2	<i>Escherichia coli</i>	I	R	I	I	I	S	I	I	I	I	I
MS AU 3	<i>Escherichia coli</i>	I	I	R	I	I	I	I	I	I	I	I
PAT BU 1	<i>Escherichia coli</i>	S	I	R	R	I	I	I	R	I	I	I
PAT BU 2	<i>Escherichia coli</i>	R	S	I	I	I	I	I	I	I	I	I
PAT AU 1	<i>P. aeruginosa</i>	I	I	I	I	I	I	I	R	I	R	I
PAT AU 3	<i>Escherichia coli</i>	I	I	I	I	I	S	I	I	I	S	I
PRO BU 1	<i>Escherichia coli</i>	I	I	I	I	I	I	I	I	I	S	I
PRO BU 2	<i>Escherichia coli</i>	I	I	I	S	I	S	S	I	I	I	I
PRO AU 1	<i>P. aeruginosa</i>	R	I	I	I	I	R	I	I	I	I	I
DEL BU 1	<i>Escherichia coli</i>	R	R	I	I	R	R	I	I	I	I	I
DEL AU 1	<i>Escherichia coli</i>	I	I	I	R	I	I	I	I	I	I	I
KSD BU 1	<i>Escherichia coli</i>	I	I	S	I	I	I	I	S	S	I	I

KSD BU 2	<i>Escherichia coli</i>	I	I	I	I	I	S	I	I	I	I
KSD AU 2	<i>Escherichia coli</i>	R	I	I	I	I	R	R	I	I	I

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

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134 **3.2. DISCUSSION**

135 There are different opinions as to how the quality of swimming pool water can be assessed. Some  
 136 researchers opined that microbes which are indicators of good hygiene such as heterotrophic bacteria  
 137 and total coliform should be looked out for, while others consider those of faecal pollution to be the best,  
 138 since infection risk is more related to microbes associated with the mouth, skin, and upper respiratory  
 139 tract of swimmers other than faecal contamination(18). However, there is no much assurance that  
 140 microbes can give a reliable prediction regarding the risks of swimming to public health (32, 16, 18, 17,  
 141 20).

142

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

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

154

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

163

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

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168 The temperature values obtained before swimming were within the recommended limit of WHO (31)  
 169 which is 22°C - 26°C. This is similar to the results of Edimeh *et al.* (25), Clarke *et al.* (24). While the  
 170 values reported after swimming were generally high with Prosperous Hotel recording the highest value of  
 171 27.5°C which was slightly above the WHO (31) guidelines of 22°C - 26°C. The values of temperature  
 172 obtained in this research is dissimilar to that of Onifade *et al.*, (1) who recorded temperature greater than  
 173 26°C. The high values of temperature observed could be attributed to the various body temperature of the  
 174 swimmer. The weather also affects the temperature considering the different sampling times of the pools  
 175 (28). The increase in temperature of the swimming pool aids the growth of bacteria (7).

176

177 The bacteriological analysis of the analysed swimming pools water showed the extent to which the water  
178 was contaminated by various microorganisms, since *Escherichia coli*, *Enterococcus faecalis* and  
179 *Pseudomonas aeruginosa* were isolated. The isolation of significant numbers of bacteria from swimming  
180 pools is an evident indication that it is either the source of raw water doesn't have enough protection or  
181 deficiency in the treatment of the pool water (35). Although, the bacteriological limits for swimming pools  
182 vary per country compared to that of drinking waters which are according to international agreement by  
183 stakeholders. For instance, it is recommended in the United Kingdom that pool water should not have any  
184 coliform microbe in 100ml of water (6).

185  
186 The mean total bacterial counts (TBC) for all the pool water before and after swimming were generally  
187 high and exceeded the EPA and WHO permissible limit for water. The high total bacteria count indicates  
188 that organic and dissolved salts may be highly present in the water. Mostly, animal and human wastes  
189 are the primary sources of these bacteria in water. Other sources of bacterial contamination are surface  
190 runoff, pasture, and other land areas where animal wastes are deposited. Discharge from septic tanks,  
191 seepage or sewage treatment facilities and natural soil or plant-bacteria can also contaminate water (36).

192  
193 Some of the pools considered in the study recorded high levels of *Escherichia coli* and this do not  
194 conform with the recommended standard of WHO for swimming pools. According to Edberg *et al.*, (26),  
195 water sample from swimming pools should be devoid of any organism, not even coliforms in a 100 ml of  
196 water because most swimmers get to swallow some of the pool water when swimming. *E. coli* being  
197 present in swimming pool is as a result of poor pool management, lack of compliance to safeguarding  
198 measures of the source of water and insufficient disinfection of the pool (34). The result of this research is  
199 similar to that of Bello *et al.*, (22) who also isolated *Escherichia coli*, *Pseudomonas aeruginosa*,  
200 *Enterococcus faecalis* from swimming pool.

201  
202 The mean values of TBC and TCC before and after swimming were relatively high in four of the swimming  
203 pools and above the recommended value of zero for WHO (31) guideline for drinking water. Indabawa *et*  
204 *al.*, (33) similarly isolated coliforms in their research, Onifade *et al* (1) also isolated *Escherichia coli* from  
205 water samples in Ado-Ekiti. The capabilities of Pathogenic microbes have been reported in large number  
206 of bacteria species including *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia* and  
207 *Staphylococcus aureus* (29).

208  
209 The antimicrobial susceptibility test revealed that the majority of the isolates have intermediate and high  
210 resistant to most of the antibiotics that could be used in treating the resulting infection. This implies that it  
211 will be difficult to treat any infection gotten as a result of swimming in the contaminated pools. (13). The  
212 opportunistic pathogen can also intensify the situation and therefore increase the health risks associated  
213 with swimming in these contaminated pools (23). This study shows the need to do more investigation on  
214 the prevalence of antibiotic susceptibility genes in the swimming pool water, as well as the distribution of  
215 susceptible genes among the pathogenic bacteria.

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#### 218 **4. CONCLUSION**

219  
220 The isolation of pathogenic bacteria from this study implies that there is poor sanitary maintenance of the  
221 pool and improper hygienic practices by swimmers. Hence, the need to effectively monitor recreational  
222 outfits such as hotel swimming pools by sensitizing everyone associated with the facility, improving pool  
223 circulation and ensure the construction is done in such a way to prevent external contamination. By such  
224 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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