



## **Assessment of the Physicochemical and Bacteriological Quality of Public Swimming Pool in Selected Hotels in Ado-Ekiti, Nigeria**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author OOE designed the study, wrote the protocol and the first draft of the manuscript. Authors OOE and OBM managed the analyses of the study. Authors OOE, OBM and OJ managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The physicochemical and bacteriological assessment of pool water samples from selected hotels in Ado-Ekiti, Nigeria was investigated. A total of 10 pool water samples were collected from five pools before and after use following standard procedures. Physicochemical and bacteriological analyses were performed using standard methods. Antibiotic sensitivity testing was carried out according to CLSI procedures. Physicochemical analyses showed that the pool water samples were clear and colourless. The different parameters examined for each of the hotel showed varying degree of values. On the average, it was observed that values for turbidity, temperature and total dissolved solids were above the WHO and EPA permissible limit after use. The total bacterial, coliform and Escherichia coli counts of the pool water samples were higher after use than before use. A total of 21 isolates were recovered and presumptively identified as *Enterococcus faecalis*, *Escherichia coli* and *Pseudomonas aeruginosa*. From among the 21 isolates, 14 (66.7%) were

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*Escherichia coli*, 5 (23.8%) were *Enterococcus faecalis* while only 2 (9.5%) were *Pseudomonas aeruginosa*. All the isolates tested for antibiotic sensitivity showed considerable resistance to some of the antibiotics used. Findings from this study showed that some of the pools sampled did not meet up to WHO and EPA standards. Hence, the need for an effective and urgent intervention in constant monitoring of recreational facility to safeguard the health of the pool users.

**Keywords:** Physicochemical; assessment; bacteriological; quality; swimming pool.

## 1. INTRODUCTION

Water is very basic to life and also functions among others, in, transportation, recreation, cooling of irrigation systems, and food production processes [1]. Water, is undoubtedly, a vital need of man for food and recreation. A pool is a confined body of water that is mainly meant for swimming and aquatic recreation. It is therefore, a body of water of limited size contained in a holding structure, which could be concrete tanks, large paved holes or large artificial basin. Hotel swimming pool is one of the recreational facilities being visited by residents of Ado-Ekiti for pleasure or relaxation [1]. However, pools generally are prone to contamination via many ways: Release of pathogenic micro-organisms from infected swimmers, via skin secretion, saliva, mucus, vomit, urine, and nose. Also, through accidental release of faeces, airborne contamination, incoming water from unhygienic source, and bird droppings [2]. The organisms released as a result of this contamination may include bacteria, viruses, fungi, and parasites and some of which could be pathogenic [3,4].

Swimming pools have been known to be associated with outbreaks of waterborne infections [5,6]. Also, 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 [7]. Many a times, the risk of illness or infection is usually associated with faecal contamination of the water as a result of the excreta released by swimmers and flying birds [7]. Several sanitation methods have put in place to ensure sanitary of pools. Among these include filtration 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 [7,8,9,10].

In spite of benefits to health and well-being being delivered by the recreational use of water, there may also be adverse health effects associated with recreational use, if the water is polluted or unsafe. For most swimming pools in Ado-Ekiti, there is little data, if any, on the quality of public pools found in hotels. In view of this, the study aimed to assess the implications of physicochemical and bacteriological quality of public swimming pools in some selected hotels in Ado-Ekiti metropolis, Nigeria.

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

## 2. MATERIALS AND METHODS

### 2.1 Sources and Collection of Samples

Following the standard procedures of Cruickshank et al. [11] and Okafor [12] the samples were collected at two different times of the day (Monday and Tuesday). The first batch (before swimming) was collected from 9 am to 12 pm and the second batch (after swimming) was collected from 5 pm to 6:30 pm. All the swimming pools were constructed with glazed tile and are of varying shapes (irregular, square, circular, rectangular and oval) while their sizes ranged from 50 to 1500 m<sup>2</sup>. For each of the five selected swimming pools, two (2) separate 1.5 L water samples were collected from two different sections of each specific pool of which samples collected from each section were in duplicates. For the two samples collected, one was used for physiochemical analysis and the other for microbial analysis. The water samples were collected into sterile sampling bottles with little amount of sodium thiosulphate which served as inhibitor of chlorine action, properly corked, placed on ice and transported to the laboratory within twenty-four [13] hours for analysis. The

sampling was done within two months September 2018 to October 2018. A total of 10 samples were collected from the entire sampling sites during the study.

## 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 Bacteriological Analyses

*Escherichia 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. Standard pour plate method was used by inoculating 0.1ml of sample of dilution  $10^3$  and  $10^4$  each. and the plates were incubated in inverted position aerobically at  $28^{\circ}\text{C}$  for 48 hours. The number of colonies between 40-300 were counted were counted after incubation.

## 2.4 Identification of Bacterial Isolates

The bacterial isolates were identified using morphological characteristics, Gram's reaction and biochemical tests: motility, catalase, oxidase, citrate, methyl red, sugar fermentation and indole test. The identification procedures for the microorganisms were carried out using methods of Holt et al., [14].

## 2.5 Antibiotic Sensitivity Test of Bacterial Isolates

Antibiotic susceptibility testing of the bacterial isolates 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 [15]. The antibiotics tested were Pefloxacin (10  $\mu\text{g/ml}$ ), Ofloxacin (30  $\mu\text{g}$ ), Cephalexin (25  $\mu\text{g}$ ), Nalidixic acid (50  $\mu\text{g}$ ), Cotrimoxazole (25  $\mu\text{g}$ ), Ciprofloxacin (10  $\mu\text{g/ml}$ ), Augmentin (30  $\mu\text{g}$ ), Amoxicillin (30  $\mu\text{g/ml}$ ), Gentamycin (10  $\mu\text{g/ml}$ ),

Streptomycin (30  $\mu\text{g/ml}$ ), Septrin (30  $\mu\text{g/ml}$ ), Ampiclox (30  $\mu\text{g/ml}$ ), Zinnacef (20  $\mu\text{g/ml}$ ), Amoxicillin (30  $\mu\text{g}$ ), Recephine (25  $\mu\text{g/ml}$ ), Ciprofloxacin (10  $\mu\text{g/ml}$ ), Streptomycin (30  $\mu\text{g/ml}$ ), Erythromycin (40  $\mu\text{g/ml}$ ), Reflacine (25  $\mu\text{g/ml}$ ), Ampicillin (25  $\mu\text{g}$ ).

## 2.6 Statistical Analysis

The data generated from this study were compiled and analyzed descriptively using MS Excel (Microsoft Corp., USA) and descriptive statistics were used to summarize the results of the water samples.

## 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 were enumerated. Also, the physicochemical analysis of the swimming pool water samples was obtained. The bacteria isolates were further evaluated for antibiotic susceptibility.

The results in Table 1 shows the physico-chemical analyses of different parameters carried out on the swimming pool water samples collected from different hotels in Ado-Ekiti. The pool water samples were clear and colourless. The different parameters examined for each of the hotel showed varying degree of values. On the average, it was observed that values for turbidity, temperature and total dissolved solids were above the WHO and EPA permissible limit after use. The total bacterial count (TBC) of the selected swimming pool water samples was higher after use than before use (Table 2). The table also revealed that pool B had no bacterial count before use while other pools had varying counts of bacterial load before use (Table 2). Likewise, Table 2 also shows an increase in total coliform and *E. coli* count after use. Pool B again showed no coliform count before use.

From all the samples collected before use and after use of the pool, a total of 21 isolates were recovered and presumptively identified as *Enterococcus faecalis*, *Escherichia coli* and *Pseudomonas aeruginosa*. From among the 21 isolates, 14 (66.7%) were *Escherichia coli*, 5 (23.8%) were *Enterococcus faecalis* while only 2 (9.5%) were *Pseudomonas aeruginosa*.

**Table 1. Physicochemical analyses of pool water samples from selected hotels in Ado-Ekiti**

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	CR	CR	CR	CR	CR	CR	CR	CR	CR	CR	CR	CR	CR
Colour	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS
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
Temperature (°C)	23.5	25	25.5	27.5	23.5	26	25.5	26.5	23	25.5	24.2	26.1	26
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
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
Conductivity(µS/cm)	40	44	43	56	80	88	266	298	130	146	111.8	126.4	250
Total Hardness (mg/L)	52	74	78	98	80	93	89	100	95	112	78.8	95.4	150
Calcium (mg/L)	32	43	45	46	42	56	52	75	58	68	45.8	57.6	150
Magnesium (mg/L)	20	31	33	54	38	43	37	25	37	54	33	42.2	150
Total Dissolved Solids (mg/L)	340	394	562	764	452	553	798	896	435	654	517.4	655.2	500

Key: BU = Before use; AU = After use; CR = Clear; CS= Colourless

**Table 2. Total bacteria count (TBC), total coliform counts and *E. coli* counts of pool water samples from selected hotels in Ado- Ekiti**

Sample Sites	Total Bacterial Count (cfu/ml)				Total coliform counts (cfu/ml)				<i>E. coli</i> counts(cfu/ml)			
	Before use		After use		Before use		After use		Before use		After use	
	10 <sup>3</sup>	10 <sup>4</sup>	10 <sup>3</sup>	10 <sup>4</sup>	10 <sup>3</sup>	10 <sup>4</sup>	10 <sup>3</sup>	10 <sup>4</sup>	10 <sup>3</sup>	10 <sup>4</sup>	10 <sup>3</sup>	10 <sup>4</sup>
Pool A	95	52	157	102	68	72	68	104	40	41	81	58
Pool B	0	0	82	50	0	0	129	104	0	0	63	81
Pool C	90	85	155	112	112	100	170	129	93	63	104	59
Pool D	74	71	128	122	66	59	96	75	73	61	80	62
Pool E	76	62	92	85	94	70	99	94	90	57	103	93
Mean	67.0	54.0	122.8	94.2	68.0	60.2	112.4	101.2	59.2	44.4	86.2	70.6

The percentage resistance of *E. faecalis* recovered from the samples is depicted in Fig. 1. And it was observed that the resistance of the organisms to streptomycin was high with 60% while a considerable resistance to all other antibiotics was also observed. Fig. 2 also shows considerable resistance to the antibiotics used. Resistance was high in *E. coli* compared to *P. aeruginosa*

### 3.2 Discussion

It is important to ensure that recreational water meets the necessary standard as potable water, because there is a high probability that swimmers may swallow the water while swimming. Also, it was observed that some of these swimming pools are managed by untrained personnel who are just hired to monitor the

running of the facility, with little or no focus on hygiene nor adequate consideration for the health of swimmers, in order to put measures in place to safeguard public health.

There are different opinions 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 considered 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 [16,17,18,19,20]. In this study, both physicochemical and bacteriological analyses were considered.

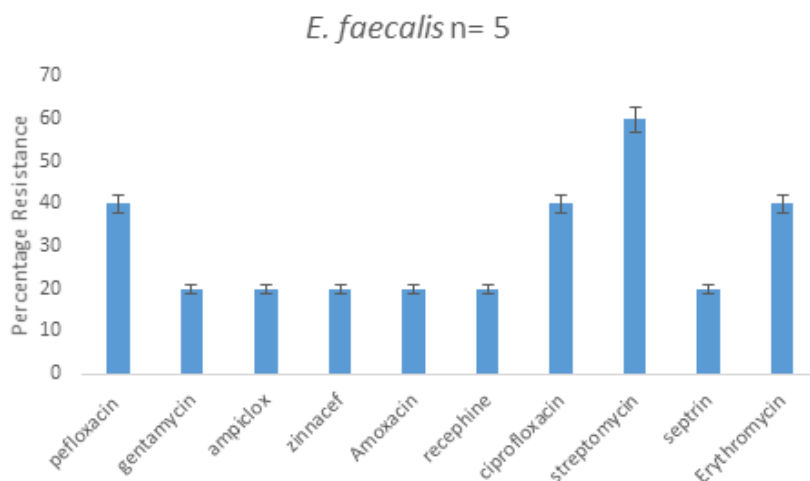


Fig. 1. Percentage resistance of *E. faecalis* recovered from pool water samples to antibiotics

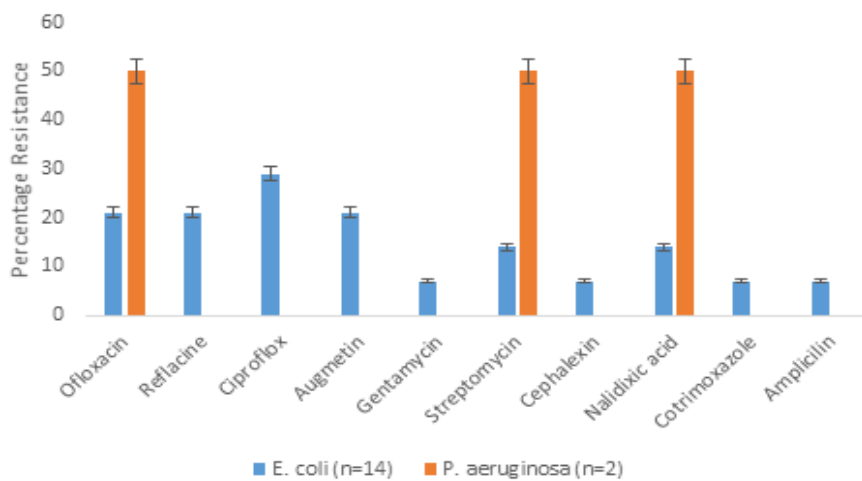


Fig. 2. Percentage resistance of isolates recovered from pool water samples to antibiotics

The average pH values recorded in all the five swimming pools 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 [21]. The chlorine level detected in all the pool samples were also within the WHO [22] permissible limit. The low residual chlorine level noticed in the pool could be due to inadequate chlorination. chlorine detection in water implies its effectiveness as a disinfecting agent and an indication that the swimming pool water is properly sanitized [23]. All the analysed swimming pool water were clear and colourless. Although, human activities, peat, plankton, vegetation and natural metallic ions are responsible for change in the colour of water.

The residual chlorine of swimming pools water was in the range of 0.7 to 1.24 mg/l before and after swimming. It was observed that some of the pool managers use chlorine for the treatment of the swimming pool water. This finding is similar to the result of Yedema et al., [24] who had an average value of 1.16 mg/Lin their study.

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 [23]. The values obtained is similar to that reported by Aremu et al. [25]. The turbidity values observed before swimming were lower than after swimming. 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.

Nitrate level in all the samples were within the permissible limit. Although, John Girvan deduced that nitrate in pool can cause the presence of algae and other contaminants that may not respond to normal treatment [23]. However, some other pool techs opined that nitrates in pool lock up chlorines and could drastically increase the consumption of sanitizer [23].

The temperature values obtained before swimming were within the recommended limit of WHO [26] which is 22°C - 26°C. This is similar to the results of Edimeh et al. [13], Clarke et al.

[27]. While the values reported after swimming were generally high with pool B recording the highest value of 27.5°C which was slightly above the WHO [26] guidelines of 22°C - 26°C. The values of temperature obtained in this research is dissimilar to that of Onifade et al. [28] who recorded temperature greater than 26°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 [29]. The increase in temperature of the swimming pool aids the growth of bacteria [30].

The bacteriological analyses of the pool water samples showed the extent to which the water was contaminated by various microorganisms, since *Escherichia coli*, *Enterococcus faecalis* and *Pseudomonas aeruginosa* were isolated. The isolation of significant numbers of these bacteria from swimming pools is an indication that it is either the source of raw water doesn't have enough protection or a deficiency in the treatment of the pool water [31]. 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 [32]. George et al. [33] also isolated *E. coli*, *Staphylococcus aureus*, *Enterobacter faecalis*, *Klebsiella pneumoniae*, and *Staphylococcus epidermidis* from swimming pools in Accra Ghana.

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 [34].

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. Saberianpour et al. [1] also isolated *Escherichia coli*, *Pseudomonas*

*aeruginosa*, *Enterococcus faecalis* from swimming pool. According to Edberg et al. [35], 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 [36]. The result of this research is similar to that of Bello et al. [8] who also isolated *Escherichia coli*, *Pseudomonas aeruginosa*, *Enterococcus faecalis* from swimming pool. The presence of Enterococcus in recreational water indicates poor quality. They are residents of the human intestine and warm-blooded animals, so being present in the water signifies faecal contamination [24].

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 [26] guideline for drinking water. Indabawa et al. [37] similarly isolated coliforms in their research, Onifade et al. [28] also isolated *Escherichia coli* from water sources 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* [38]. In contrary to this study, Amala and Aleru [39] didn't isolate coliform or faecal coliform in their research, this implies that some of the swimming pools in Port Harcourt Nigeria may have complied to the standard for recreational waters.

The antimicrobial susceptibility testing revealed that few of the isolates were resistant to most of the antibiotics that could be used in treating resulting infection. There is high resistance of *Enterococcus faecalis* to Streptomycin, Perfloxacin, and Erythromycin. *Pseudomonas aeruginosa* had high resistance to Ofloxacin, Streptomycin and Nalidixic acid. While *Escherichia coli* had intermediate resistant to most of the antibiotic tested. This implies that difficulty may arise in treating infection that arises from swimming in these contaminated pools.

#### 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 hence safeguarding the health of the public.

#### ETHICAL APPROVAL

An ethical clearance was obtained from departmental research of the Department of Science Laboratory Technology, Ekiti State University, Ado-Ekiti. Purpose of the research was then clearly explained by the principal investigator to selected hotels with swimming pools in Ado-Ekiti. Finally, informed consent was obtained from the respective hotels and data collection was started after then.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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