

Water Quality Index assessment of some selected swimming pools around Ladoke Akintola University of Technology Ogbomoso

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Abstract

The usage of swimming pools in guest houses and hotels has been considered as a hazard zone for public health and an en route to transmission of some skin diseases or endemic waterborne diseases. The study hereby focuses on assessing swimming pool water quality in a growing environment mainly occupied by youths. The investigation employs a stratified random sampling technique involving random selection of five hotels with swimming pools in the growing environment of LAUTECH Ogbomoso. Parameters such as temperature, Total dissolved solids (TDS), acidity, alkalinity, salinity, pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), free chlorine, and E. coli were investigated in the laboratory using standard procedures. The results of the analyses were compared with World Health Organisation (WHO) and the Centers for Disease Control and Prevention (CDC). Water quality index (WQI) was computed to evaluate the quality of water in each of the five sampled swimming pools. The physicochemical results reveal that the temperature, TDS, Turbidity, Acidity, Alkalinity, salinity, pH, COD, BOD, free chlorine and E. coli ranges from 28.5-30.7°C, 55-862 mg/l, 0.0-0.4 NTU, 155-385 mg/l, 15-45 mg/l, 0.6×10^{-4} - 0.97×10^{-3} mg/l, 6.8-7.2, 110-180 mg/l, 100-160 mg/l, 3-5 mg/l, and (2 – 8) cfu /100 mL. Comparing results with permissible standards reveals that the pools did not meet the standards in acidity, free chlorine, and E. coli count having higher values, and pH with lower values. The WQI from a five-point scale (excellent, good, poor, very poor and unsuitable) indicate those that falls into the different categories. The study recommends routine and periodic surveillance of swimming pools to guarantee optimum health and wellbeing of users.

Keyword: Swimming pool, Health, Environment, Routine, Water Quality Index

Introduction

Water is not only used for drinking, cooking, laundry, toileting and agricultural purposes but very important for re-creation. Swimming pool can be constructed either above or in the ground using concrete material. Pools designated for public use are called public pools while private pools are those used exclusively for few people or in homes. Swimming pool as a feature in hotels are more common in tourist area or near convention centres (Ibanga *et al.*, 2020). Educational facilities such as high schools and universities sometimes have pools for physical education classes, recreational activities, leisure, and competitive athletics such as swimming teams. A swimming pool is considered as not merely a static body of water but a dynamic biological and chemical reactor where the constant introduction of organic matter from swimmers interacts with disinfection protocols and environmental variables. In the usage of swimming pools, users may be exposed to contamination by accidental ingestion of water, and absorption through skin (Wyczarka-Koket *et al.*, 2020). Other contaminants in swimming pools includes contaminants through sweat, saliva, cosmetics, urine, source of water used by pool and the use of disinfectants. It is essential to evaluate the risks associated with pools which includes physiological responses to infection, poisoning, toxicity, and other conditions that may arise from the inhalation and ingestion of pool water.

The assessment of swimming pools in Nigeria, and specifically Ogbomoso, presents unique challenges rooted in the local climate, geology, and regulatory landscape. The chemical stability of pool water is governed by a suite of parameters that collectively dictate the efficacy of the sanitation system and the structural integrity of the facility, these parameters are physical, chemical and biological indicators that are most commonly used in assessing the quality of water in swimming pools (CDC, 2003). Several authors

have investigated the water quality of swimming pools in various cities across Nigeria (Indabawa et al., 2015; Esinulo and Ogbuagu, 2016; Onifade et al., 2019; Verla et al., 2021; Opafola et al., 2022) and have come to the conclusion that Nigeria does not currently have a dedicated national guideline for swimming pool water, often relying on the Nigerian Standard for Drinking Water Quality (NIS 554, 2015) for benchmark values. For many swimming pools in Ogbomosho there is limited data on the quality of public pools in hotels. Hence the introduction of water quality index (WQI) as a concept used in water quality monitoring and assessment. This gap highlights the need for tailored regulations that account for recreational water use, microbial risk, and environmental factors unique to regions like Ogbomosho.

The index (WQI) gives the overall water quality status in a single term that is helpful for the selection of right management approach to meet concerned issue (Ibanga *et al.*, 2020). A Water Quality Index combines various water quality parameters into a single score to indicate suitability for human consumption, aquatic life, or recreation. There are a number of physical, chemical, and biological indicators that are most commonly used in assessing the quality of water in swimming pools. The physical indicators include temperature, total suspended solids (TSS), total dissolved solids (TDS), electrical conductivity, and turbidity. Chemical indicators include pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), chlorine and total hardness (TH). The biological indicators are total coliform count (TCC), faecal coliform count (FCC) and other pathogenic bacteria and algae. Water Quality index is not to be assumed as water quality standards (Ibanga *et al.*, 2020), water quality standards are governance frameworks covering specific uses and water quality criteria to save users from unnecessary harm, and depicts the scientifically established targets approved by regulatory agencies for different water uses (United States Environmental Protection Agency - USEPA, 2016). However several water quality indices have been postulated by a number of national and international organizations and documented in contemporary literature. Most popular ones include the Weighted Arithmetic Water Quality Index (WAWQI), National Sanitation Foundation Water Quality Index (NSFWQI), Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI), and Oregon Water Quality Index (OWQI) among others (Anastasopoulos and Akratos, 2025). Moreover, water quality indices have been used for various water quality assessments in Ogbomosho, none has been developed for the swimming pool of the growing environment of LAUTECH, hence the importance of this study.

Material and methods

The study Area: Ladoke Akintola University of Technology (LAUTECH) is situated in Ogbomosho Oyo State, Southwest Nigeria. Ogbomosho is the second largest city in Oyo State and also among the most populated town in Nigeria. Although the principal inhabitants of the city are the Yoruba people, there are people from other parts of Nigeria and other West African countries who are residents of the city. The town is located between the longitudes 08° 03' to 08° 12' N and latitudes 04° 11' to 04° 19' E (Ogunmola and Ojoawo, 2024; Onawumi and Adewuyi, 2025).

Sample Collection

The investigation employs a stratified random sampling technique involving rationally selecting 5 hotels with swimming pools. The samples were taken from 5 Hotels, and a total of 10 water samples were collected (two from each pool) using sterilized sampling bottles, air-tight and filled to the brim, well-capped and taken to Civil Engineering Laboratory and university central laboratory for tests. Parameters such as temperature, total dissolved solids (TDS), turbidity, acidity, alkalinity, salinity, pH, chlorine, chemical oxygen demand (COD), biochemical oxygen demand (BOD), and *E.coli*. were investigated in the laboratory in accordance with standard procedures. The mean values of test results of parameters measured from the swimming pools water samples were recorded and the results were compared with World Health Organization (WHO, 2021) and the Centers for Disease Control and Prevention (CDC, 2003).

Water Quality Index:

The water quality index adopted was based on physico-chemical indices, these indices are based on the values of various physico-chemical information of the water sample. These was achieved by using mathematical approach of weighted Arithmetic Water Quality Index (WAWQI) (Chandra *et al.*, 2017Adelagun *et al.*, 2021).

Calculating WQI Using WAWQI Method

Step 1: Data of various physico- chemical water quality parameters was collected

Step 2: Proportionality constant " K " value was calculated using equation 1.

$$K = 1 \div \sum_i^n (1/s_i) \quad (1)$$

where "s_i" is standard permissible for nth parameter.

Step 3: quality rating for nth parameter (q_n). This was calculated using formula in equation 2

$$q_n = 100 \left\{ \frac{v_n - v_{io}}{s_n - v_{io}} \right\} \quad (2)$$

Where v_n = Estimated value of the nth parameter of the given sampling station.

V_{io} = Ideal value of nth parameter in pure water. Vio = 0 (except pH =7.0 and DO = 14.6 mg/l).

s_n = Standard permissible value of the nth parameter.

Step 4: Calculate unit weight for the nth parameters using equation 3

$$W_n = \left(\frac{k}{S_n} \right) \quad (3)$$

Step 5: Calculate Water Quality Index (WQI) using equation 4

$$WQI = \left(\frac{\sum W_n \cdot q_n}{\sum W_n} \right) \quad (4)$$

The WQI and description of water quality status is as shown in Table 1.

Table 1: Water Quality Index (WQI) and status of water quality

Water Quality Index Level	Water Quality Status
0-25	Excellent Water Quality
26-50	Good Water Quality
51-75	Poor Water Quality
76-100	Very poor Water Quality
>100	Unsuitable for Drinking

Source: Chandra *et al.*, (2017)

Results and Discussions

The test results of the swimming pools water samples showed the physico-chemical parameters of the swimming pools ranged from Temperature, TDS, Turbidity, Acidity, Alkalinity, salinity, pH, COD, BOD, and free Chlorine ranges from 28.5-30.7°C, 55-862 mg/l, 0.0-0.4 NTU, 155-385 mg/l, 15-45 mg/l, 0.6×10⁻⁴-0.97×10⁻³ mg/l, 6.0-7.2, 110-180 mg/l, 100-160mg/l, and 4-5mg/l respectfully, and *E. coli* 2-8 (cfu/100 ml). Figures (1-7) shows clearly the variations of the laboratory measurements with the standards. The Ogbomoso's tropical climate with an average temperature of 30°C, though it meets the stipulated standards value but places a significant oxidant demand on swimming pools. The high water temperatures not only speed up the metabolic rates of algae and bacteria but also accelerate the breakdown of chlorine residuals. Research indicates that for every 10°F increase in temperature above 80°F, the chlorine requirement effectively doubles (Casas-Monroy *et al.*, 2018). Furthermore, the intense urban heat island effect in Ogbomoso aggravates the rate of evaporation, concentrating total dissolved solids (TDS) and minerals. This necessitates a daily replenishment of 5% to 10% of the total water volume with fresh water to prevent the water from becoming "chemically saturated" and resistant to treatment. Ikhuoriah and Ikegu, 2024

reported a significant temperature variations (25.2–33.1°C) values of temperature similar to this study, while Ajadi *et al.*, 2016 and Onifade *et al.*, 2019 recorded lesser values. Comparing results with WHO and CDC standards, temperature measurements of all the five hotels fall within the stipulated standards.

Turbidity and TDS are within the standards and is in agreement with the findings of Angaye *et al.*, 2023 and Ikhuorah and Ikegu, 2024, although the result does not agree with the findings of Ajadi *et al.*, 2016. The pH value, representing the activity of hydrogen ions, is the most critical variable in the aquatic chemical matrix. The recommended range of 7.2 to 7.8 is predicated on three primary objectives i.e. swimmer comfort, protection of infrastructure, and the optimization of chlorine efficacy. A lower pH makes the water more acidic hence swimmer may experience burning eyes, itchy skin and low effectiveness of the chlorine used in water. The pH values of hotels 1 and 4 is relatively low compared to the standards while the remaining are within the acceptable standards. Some authors have reported values of pH range similar to this current study; 6.0-7.2 , 6.20 - 7.10 (Nnaji, 2011); others were slightly higher but within limits of WHO including; 7.20 – 7.80 (Esinulo and Ogbuagu, 2016) 7.20 – 7.80 (Yedeme, 2017); also lower pH values have been reported by Ajadi *et al.*, 2016 (4.58 – 6.69), ; Nnabugwu, & Uchenna, 2019 (5.60 - 6.90), and Angaye *et al.*, 2023 (6.33-6.88).

Results of free chlorine showed values that ranged from 3-5mg/l. The detection of chlorine in swimming pool water indicates the efficacy of treatment provided its threshold concentration does not exceed 3.00 mg/l (WHO, 2021). Values of free chlorine in this study agreed with earlier Studies of Onifade *et al.*, 2019, it does not agree with Opafola *et al*, 2022. Although the free chlorine is adequate in pool 1 and pool 4, but the pH is acidic, the presence of active *E. coli* indicates a severe contamination or filtration failure, meaning the water is unsafe for swimming and require immediate balancing and sanitization. For pool 2,3 and 5, indicating adequate chlorine and pH, the *E. coli* results were not desirable because its putting swimmers at risk of diarrhea and ear or skin infections. The pools pH should still be adjusted slightly to 7.5 to make the chlorine more effective as recommended by Model Aquatic Health Code (MAHC, 2024).

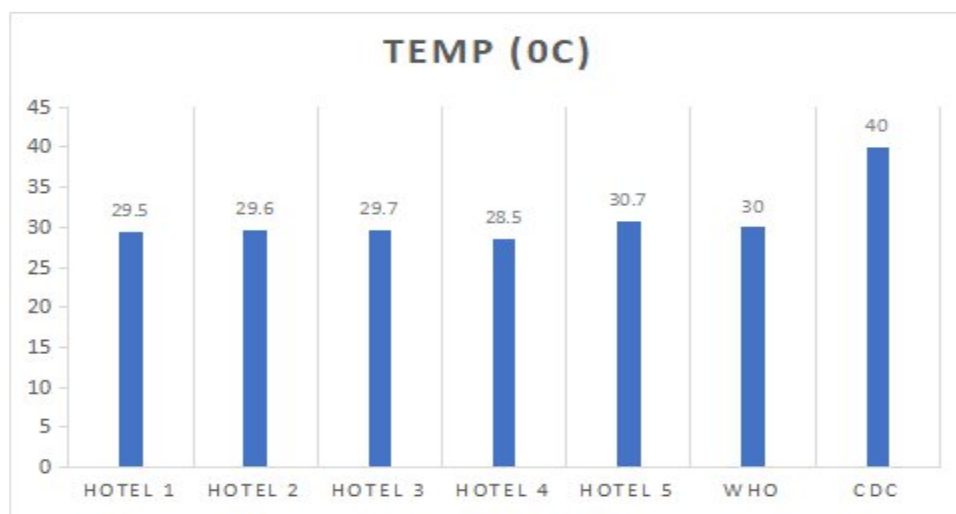


Figure 1: Graph of Temperature compared with standards

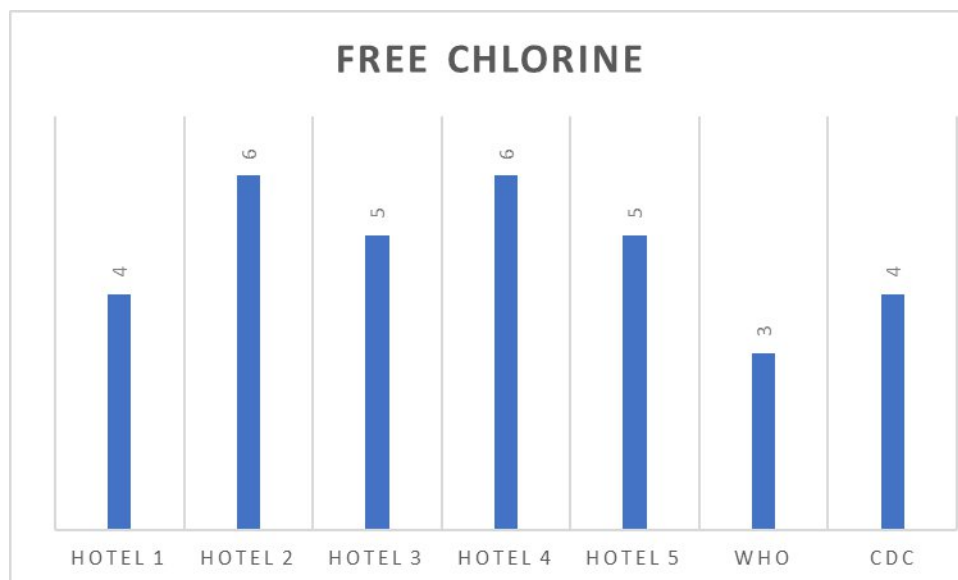


Figure 2: Graph of Free chlorine compared with standards

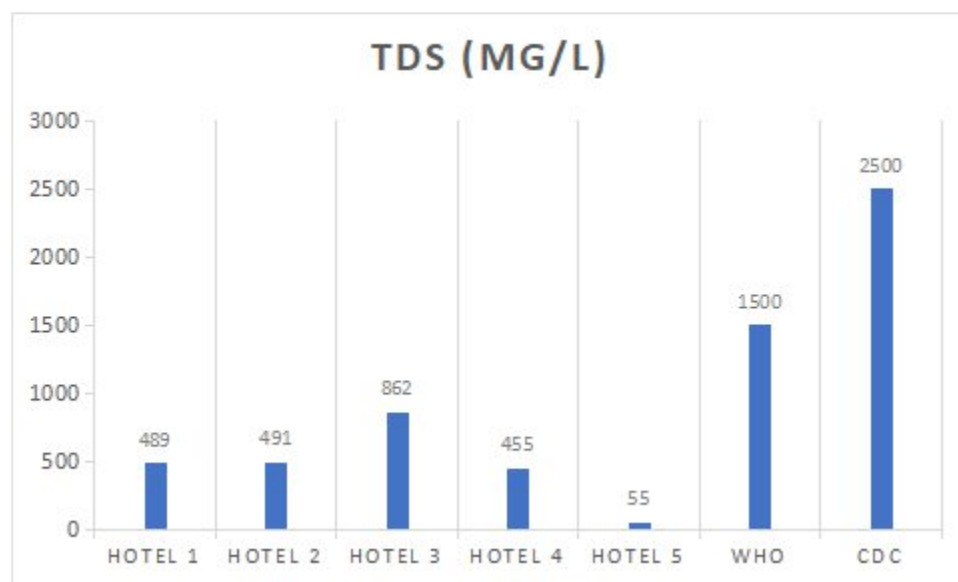


Figure 3 : Graph of TDS compared with standards

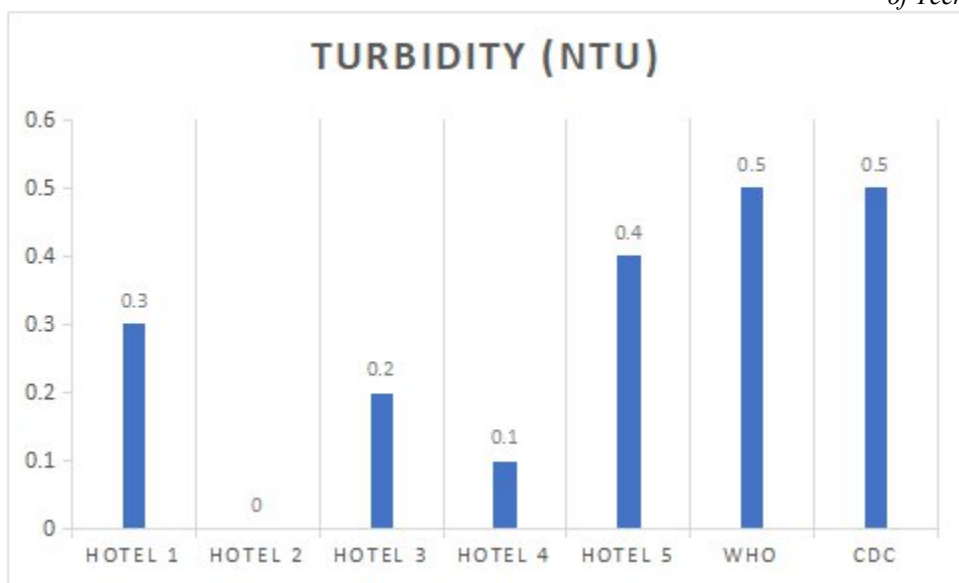


Figure 4: Graph of Turbidity compared with standards

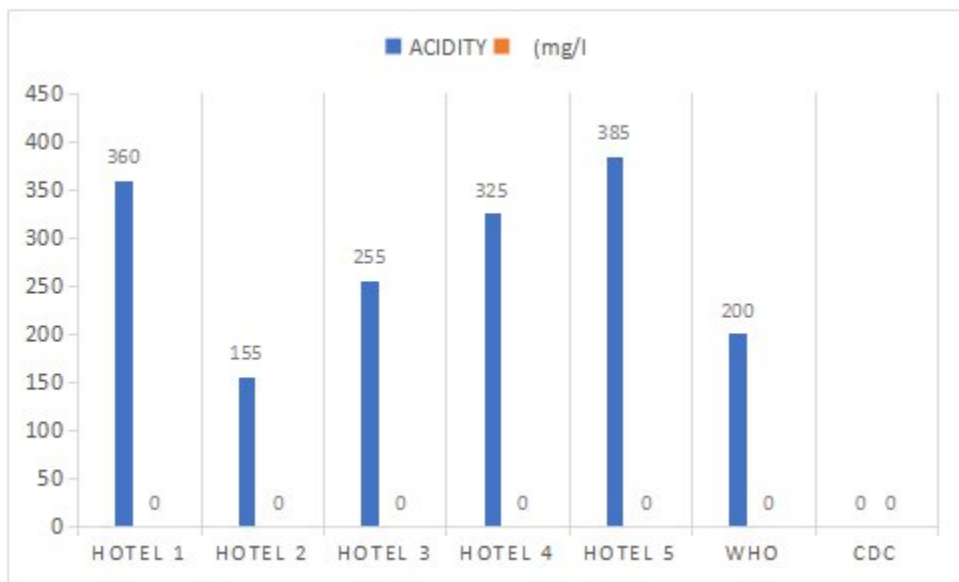


Figure 5: Graph of Acidity compared with standards

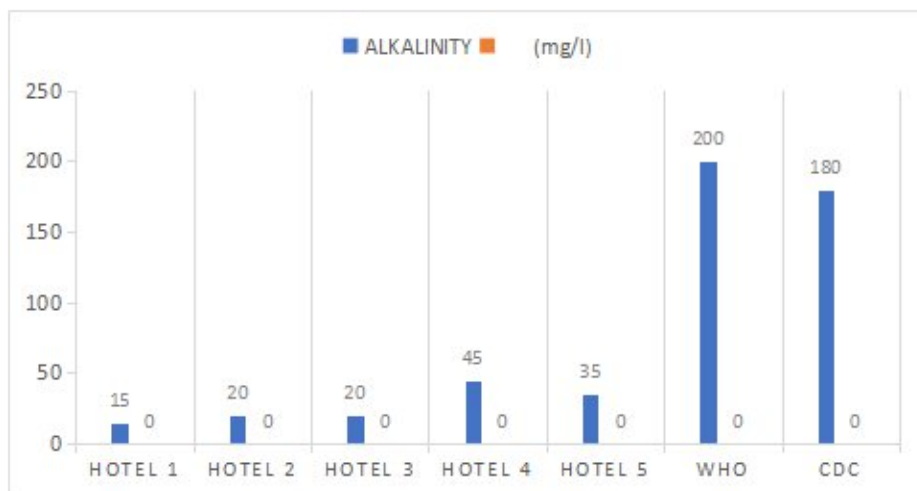


Figure 6: Graph of Alkalinity compared with standards

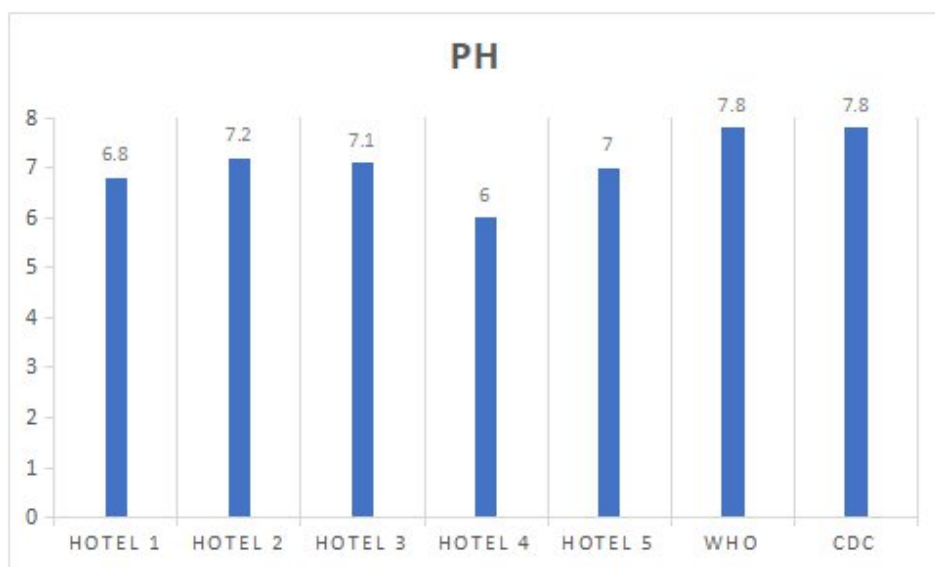


Figure 7: Graph of pH compared with standards

Computation of Water Quality Index (WQI) of Swimming Pools

With the aid of Equations (1-4) earlier stated the laboratory results of water quality indicators per swimming pool were used as input in water quality index computation. The following parameters are used for the computation i.e. temperature, total dissolved solids, acidity, alkalinity, pH and turbidity as shown in Table 2, Q1 to Q5 is the estimate of quality rating of hotel 1 to hotel 5.

Table 2: Computation of water quality index (WQI)

Parameters	K	Vio	Wi	Q1	Q2	Q3	Q4	Q5
Temperature	30.30	0	1	98.33	98.67	99	95	102.33
TDS	1515.15	0	1	32.6	32.73	57.47	30.33	3.67
Acidity	200	0	1	180	77.5	127.5	162.5	192.5
Alkalinity	200	0	1	7.5	10	10	22.5	17.5
pH	7.81	7.0	1	-25	25	12.5	-125	0

Turbidity	0.5	0	1	60	0	40	20	80
$\sum QiWi$	—	—	—	353.43	243.9	346.47	205.33	396
$\sum Wn$	—	—	6	—	—	—	—	—
WQI	—	—	—	58.91	40.65	57.75	34.22	66

The overall water quality index of the five sampled swimming pool is as summarized in Table 3. From the results, none of the hotel swimming pool water samples can be consider as excellent but samples 2 and 4 has good water quality status while all others are classified as poor water quality.

Table 3: Summary of water quality index

S/NO	Sampled hotel	WQI	Standard value	Classification
1	Hotel 1	58.9	51-75	Poor Water Quality
2	Hotel 2	40.7	26-50	Good Water Quality
3	Hotel 3	57.8	51-75	Poor Water Quality
4	Hotel 4	34.2	26-50	Good Water Quality
5	Hotel 5	66	51-75	Poor Water Quality

Conclusion

The results of this study revealed that the physiochemical measurements of the sampled swimming pools Temperature (28.5-30.7°C), Turbidity (0.0-0.4 NTU), and Alkalinity (15-45 mg/l) of the five hotels fall within the stipulated standards, all the pH (6.8-7.2), except for Hotel 2 were lower compared with standards, free chlorine ranges (3-5 mg/), all the sampled has high *E. coli* compared with standards which is not desirable. The results of the water quality index of the five sampled swimming pool indicate that none of the hotel swimming pool water samples can be consider as excellent but samples 2 and 4 has good water quality status while all others are classified as poor water quality. For all the swimming pools investigated the pH should be adjusted slightly to 7.5 to make the chlorine more effective. Routine and periodic surveillance of swimming pools to guarantee optimum health and wellbeing of users is recommended.

Acknowledgements

The authors are grateful to the Authorities of Ladoke Akintola University of Technology Ogbomoso, Oyo State, Nigeria for full supports leading to the success of this study.

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Appendix

Appendix A: Mean values of the parameter measured from the various swimming pools.

PARAMETER	Hotel 1	Hotel 2	Hotel 3	Hotel 4	Hotel 5	WHO	CDC
TEMP (⁰ C)	29.5	29.6	29.7	28.5	30.7	26-30	Not exceed 40
TDS (mg/l)	489	491	862	455	55	500-1500	1500-2500
Turbidity (NTU)	0.3	0.0	0.2	0.1	0.4	≤ 0.5	0.5
ACIDITY (mg/l)	360	155	255	325	385	Below 200	
ALKALINITY (mg/l)	15	20	20	45	35	80-200	60-180
SALINITY (mg/l)	0.00064	0.00063	0.00097	0.00061	0.00006		
BOD (mg/l)	115	160	102	141	100		
COD (mg/l)	130	180	110	162	120		
pH	6.8	7.2	7.1	6.0	7.0	7.2-7.8	7.0-7.8
Free residual chlorine (mg/l)	5	3	3	5	4	1-3	1-4
E. Coli (cfu/100 ml)	5	2	4	8	4	≤1/100ml	≤1/100ml