International Journal of Innovative Environmental Studies Research 12(3):165-173, July-Sept., 2024

© SEAHI PUBLICATIONS, 2024 www.seahipublications.org ISSN: 2354-2918

DOI: 10.5281/zenodo.13756160

Assessment of Bacteriological and Sanitary Condition of Selected Swimming pools in Ilorin metropolis of Kwara State

[1]Adiama, B.Y Ph.D; [2] Sakariyau, A. O.; [3]Opasola, A.O. & [4]Ganiyu, M.A

[1,3]Department of Environmental Health Science,
Faculty of Allied Health Science,
Kwara State University, Malete, Nigeria

[2]Centre for Ecological and Environmental Research Management and Studies,
Kwara State University, Malete, Nigeria

ABSTRACT

Swimming pool water provides a source for the spread of many dangerous microorganisms which have led to epidemics of illnesses linked to recreational water. This study aimed to assess the bacteriological and sanitary condition of selected swimming pools in Ilorin metropolis of Kwara State. Mixed method which involves cross-sectional designs and experimental approach were employed. Six swimming pool facilities and 50 respondents employed, 17 physico-chemical and microbiological parameters analyzed. Based on the findings of this study, male participate in swimming activities more than female. Public pools are more common in the study area and chlorination is the most used method of disinfection. Respondents are knowledgeable about Hygiene and Sanitary Conditions with p-values less than $\alpha = 0.05$. There is absence of E. coli and Total coli form count in all samples (0*10^). There is presence of Total Bacterial Count and Total Fecal Coliforms in Sample C. It is concluded that the pools are not contaminated with faecal matter. Presence of Total Bacterial Count and Total Fecal Coliforms in Sample C suggests a contamination. It is recommended to investigate the possible sources of contamination and take appropriate measures to address them.

Keywords: Swimming Pool, Bacteriological Assessments, Sanitary Condition, Disinfection

INTRODUCTION

Recreation is an important part of everyday life, it plays an important role in the health, well-being, and quality of life of individuals and communities (Gulam., 2016). Recreation plays an important role through the values and benefits it provides as a major element in maintaining a healthy lifestyle.

Swimming as an outdoor water-related recreational activity, has been noted as an excellent way to get the physical and health benefits needed for a healthy life. Swimming is so good that researchers said it may even reduce risk of death. Compared with inactive people, swimmers have about half the risk of death. Some other studies have shown that swimming may help lower blood pressure and control blood sugar (Marcin, 2017).

A swimming pool is a water-filled concrete tank or an artificial basin used for recreation, rehabilitation, and athletics (WHO, 2015). Presently, swimming as a recreational activity within the city of Ilorin, is mostly embarked upon using artificial water embodiments such as swimming pool. Most swimming pools

found within Ilorin are located either in amusement parks or hotels or in the houses of wealthy men in the city. Swimming pools found in hotels are majorly used for water-related recreational activities by the local population. The shift from natural water bodies to artificial pools could be to avert the danger of drowning as well as other negative vices associated with using natural marine water bodies for water-related recreation. Due to heterogeneous nature of the city, there is no doubt that change in taste for modern facilities may have also contributed to the shift.

In addition to being used, swimming pool water provides a source for the spread of many dangerous microorganisms, including bacteria, viruses, protozoa and fungi, which have led to epidemics of illnesses linked to recreational water (UNICEF, 2016). These diseases are transmitted through ingestion, inhalation, and contact with contaminated pool water and environment (CDC, 2019).

A recreational water-associated outbreak has been causing morbidity and mortality, globally. Evidence shows that in the year 2011–2012, 90 outbreaks resulted in at least 1,788 cases, 95 hospitalizations, and one death in the United States due to treated and untreated recreational water (Hlavsa *et al*., 2015).

Swimming pool water-associated outbreaks are a significant public health concern in Nigeria. Studies have highlighted the presence of various pathogens and contaminants in swimming pool water, posing risks to users (Nahar *et al*., 2019). Additionally, investigations in Nigeria have assessed the bacteriological quality of swimming pool water, revealing the presence of Staphylococcus aureus and Bacillus cereus, indicating microbial contamination in these recreational waters (Onosakponome *et al*., 2020). Furthermore, studies have shown that swimming pool water can harbor pathogens like Cryptosporidium and Giardia, which are known to cause outbreaks and gastrointestinal illnesses (Adam *et al*., 2016). Cryptosporidium outbreaks associated with swimming pools have been reported in various regions, emphasizing the importance of maintaining water quality to prevent such incidents (Nnabugwu & Amadi, 2019).

Contamination of recreational waters has remained common and persistent problem impacting public health, local and national economies. It is reported that, the presence of pathogenic agents, such as E.coli, Salmonella, Shigella and Campylobacter, can cause waterborne diseases in swimming pools worldwide. Waterborne diseases like cryptosporidiosis, giardiasis, and various bacterial infections can spread through contaminated swimming pool water. In places with inadequate sanitation infrastructure, the risk of such outbreaks may be higher. To prevent such outbreaks, it's essential for swimming pool operators to maintain proper disinfection levels, ensure regular cleaning, and enforce hygiene practices. Additionally, swimmers should avoid swallowing pool water and should practice good personal hygiene to minimize the risk of spreading or contracting waterborne illnesses.

Regulatory bodies like the World Health Organization (WHO) have established guidelines to ensure the safety of swimming pool water (Reyes-Batlle *et al*., 2021; Mellou *et al*., 2022). Compliance with these regulations, including monitoring physicochemical parameters, residual disinfectant content, and microbial presence, is essential to minimize health risks associated with swimming pool use.

Therefore the aim of this study is to assess the bacteriological and sanitary conditions of swimming pools in Ilorin Metropolis and the objectives are to identify the class of the pool in Ilorin Metropolis, to know the characteristics of the pools, to know the hygiene and sanitary condition of the pool and to determine the microbial qualities of swimming pools water.

MATERIALS AND METHODS

Study Area

Ilorin is the state capital of Kwara State in North Central part of Nigeria. As of the 2006 census, it had a population of 777,667, making it the 7th largest city by population in Nigeria. (National Population Commission, 2006). Ilorin the study area located approximately on latitude 8˚30’0.000” N of the equator and long. 4˚ 32’0.000” E of the Greenwich Meridian has an area of about 100km.

Ilorin is characterized by hot rainy season and hot dry season. The annual rainfall is 52inches (1320mm), which lasts for a period of eight months beginning from March to October (Olaniran, 2012). . Ilorin has been described as one of the fastest growing urban centres in Nigeria, has a population of 40,990 in 1952, 208,546 in 1984 (Oyegun, 2015). By 1991 census the city’s population has increased to 552,088 and 780,771 in year 2005.

Aderamo (2012) highlighted some of the reasons for such growth to include the centrality of Ilorin city, the creation of states in 1967 and 1976, the rapid growth of commerce, industrialization and other social aspects.

Procedures

The study employed a purposive sampling technique to select a diverse range of swimming pool facilities in terms of size, location (urban, suburban, rural), and type (public, private, hotel-based). The participants include instructors. The study encompasses six recreational water facilities across three Local Government Areas in Ilorin metropolis of Kwara State for experimental analysis. A total of 50 respondents were sampled.

Six water samples were collected for water quality analysis. The water samples were collected in swimming pools and labelled 1-litre plastic bottles after severe stirring of the pool for composite mixture. The samples were labelled A, B, C, D E and F. Water samples were immediately transported to Central Research Lab. for laboratory analysis in accordance with USEPA (2006) recommendations.

Water samples were collected from various depths and locations within each selected pool. The samples was analyzed (17) parameters of physical and chemical and microbiological parameters, including E coli, Total Bacterial Count (TBC), Total Coliform Count (TCC), Total Faecal Count (TFC), D.O, BOD, Alkalinity, Salinity, Total hardness, COD, pH, E.C, TDS and other indicators of water contamination, following standard methods recommended by United States Environmental Protection Agency (USEPA, 2006).

Determination of Alkalinity

Alkalinity was assayed following the method outlined by Bartram and Ballance (1996). 25.0 ml of the sample was mixed with three drops of phenolphthalein indicator in a conical flask over a white surface. In the absence of no colour, the phenolphthalein alkalinity content of the sample was taken zero. Upon indication of pink or red colour, the alkalinity was determined by titrating with standard acid until the pink colour disappeared. In similar way, methyl orange and mixed indicator was used to test the alkalinity of the samples.

Calculation:

Phenolphthalein alkalinity as CaCO3 (mg/L) =

100000 x A x M/ V

Total alkalinity (mg/L) =

100000 x B x M/ V

where A = volume of standard acid solution (ml) to reach the phenolphthalein end-point of pH 8.3, B = volume of standard acid solution (ml) to reach the end-point of methyl orange or mixed indicator, M = concentration of acid (mol/t.), V = volume of sample (ml)

Estimation of Total Hardness

25.0 ml of the water sample was pip-petted out into a clean conical flask. 5.0 ml ammonia buffer and 2 drops of Eriochrome Black T indicator were added and titrated against 0.01M EDTA solution from the burette. The end point was the change of colour from wine red to steel blue. Calculation:

Total hardness (mg/L) = Volume of EDTA solution consumed X1000 /Volume of Sample used.

Determination of Organic Carbon Principle

The determination of organic carbon is based on the Walkley-Black chromic acid oxidation method. Oxidisable matter in the sample is oxidised by 1 N $K_2Cr_2O_7$ solution. The reaction is assisted by the heat generated when two volumes of H_2S0_4 are mixed with one volume of the dichromate. The remaining dichromate is titrated with ferrous sulphate. The titre is inversely related to the amount of C present in the sample.

Organic carbon was determined according to the method outlined in GLOSOLAN Manual (2019). Briefly, accurately 1.0 g of the samples was weighed into conical flasks and 10.0 ml of 1 N $K_2Cr_2O_7$ solution added to it. This was gently swirled to mix well. 20.0 mL of concentrated H2SO4 was added to the mixture and the solution swirled again gently. These was heated at 135°C for half a minute and allowed to cool. Upon cooling, the volume of the solution was diluted to 200 ml with distilled water. 25.0 ml of the aliquot was titrated with 0.4N $FeSO_4$ $7H_2O$ to a dark-green end point using ferroin indicator. The blank was equally set. Organic carbon in the soil samples was calculated as follows:

Calculations

From the equation:

$2Cr_2O_7^{2-} + 3C + 16H^+ \rightarrow 4Cr^{3+} + 8H_2O + 3CO_2$

1 ml of 1 N dichrornate solution is equivalent to 3 mg of carbon. Where the quality and normality of the acid/dichromate mixture used are as stated in the method, the percentage carbon is determined from the following

Organic carbon (%) = 3N(1-T/S) ÷ W

Where,

N = Normality of $K_2Cr_2O_7$ solution
T = Volume of $FeSO_4$ 7H20 used in sample titration (ml)
S = Volume of FeSO4.7H20 used in blank titration (mL)
W = Weight (g) of sample used

Statistical Tools Used

The obtained data were coded and then subjected to descriptive statistical analysis such as mean, standard deviation, coefficient of variation, table, range as well as inferential statistics like correlation and regression. Correlation analysis was used to verify the relationship between examined parameters with the aid of IBM-SPSS (v27). The mean and coefficient of variance was used to show the degree of variation in the examined variables. Correlated parameters were subjected to regression analysis model and their scatter diagram plotted to show the actual degree of association between examined parameters.

RESULTS

Table 4.1: Socio-Demographic Profile of Respondents (N=50)

Variables	Level	Count	Percentage (%)
	Male	48	96%
Gender	Female	2	4%
	Total	**50**	**100%**
	15-25 years	20	40%
Age	26-35 years	28	56%
	36 years+.	2	4%
	Total	**50**	**100%**
	Yoruba	41	82%
Tribe	Hausa	0	0%
	Igbo	9	18%
	Total	**50**	**100%**
Marital Status	Single	40	80%
	Married	10	20%
	Divorce	0	0%
	Total	**50**	**100%**
Religion	Islam	21	42%
	Christianity	27	54%
	Traditional	2	4%
	Others	0	0%
	Total	**50**	**100%**
Working Experience	Below one year	4	8%
	One year	20	40%
	Two years & above	26	52%
	Total	50	100%

According to Table 4.1, 96% of the respondents were men, and 4% were women. The data also show that 40% percent of respondents were between the ages of 15 and 25 years, 56% percent were between the ages of 26 and 35 years, and four (4) percent were between the ages of 36 and beyond. The data also found that the majority of respondents (82% were Yorubas), 0% were Hausa, and 18% were Igbo. According to the findings, 80% of respondents were single, 20% were married, and 0% was divorced.

Table 4.2: Classification of the Pool (N=50).

Variables	Count	Percentage (%)
Private (Residential)	8	16%
Public (Commercial)	42	84%
Total	**50**	**100%**

The results in table 4.2 revealed that majority of pools are public 42 (84%) compared to private 8 (16%).

Table 4.3: Characteristics of the Pool (n=50).

Research Statement Response Counts (%)				
RQ ID	**Outcomes**	**10x20feet**	**20x40 feet**	**18x36 feet**
	Pool Dimension	16 (32%)	28 (56%)	6 (12%)
RQ ID	**Outcomes**	**Chlorination**	**Hydrogen Peroxide**	
	Method of disinfection	33 (66%)	17 (34%)	
RQ ID	**Outcomes**	**One year**	**Two years +**	
	Age of the Pool	26 (52%)	24 (48%)	

Based on the results in table 4.3. The majority of pools are 20 x 40 feet in size, and their method of disinfection is chlorination and the age of the pool is two years and above.

Table 4.6: Hygiene and Sanitary Condition of the Pool (N=50).

RQ ID	Outcomes	Response Counts				P-value	Decision
		Yes (%)	No (%)	Prop.	DF		
RQ 9	Do you clean pool frequently	48 (0.96)	2 (0.04)	0.96	1	2.2e-16	Reject the null
RQ 9	Is there availability of wardrobe for each swimmer	48 (0.96)	2 (0.04)	0.96	1	2.2e-16	Reject the null
RQ 9	Is there availability of life guard in the pool	50(1.00)	(0.00)	1.00	1	2.2e-16	Reject the null
RQ 9	Is there a particular number of people that are allowed into the pool at a specific time	41(0.82)	9(0.18)	0.82	1	0.000	Reject the null
RQ 9	Is there any availability of shower room	48(0.96)	2(0.04)	0.96	1	2.2e-16	Reject the null
RQ 9	Do swimmer take shower before swimming	48(0.96)	2(0.04)	0.96	1	2.2e-16	Reject the null
RQ ID	**Outcomes**	**10x20feet**	**20x40 feet**	**18x36 feet**			
	Pool Dimension	16 (0.32)	28 (0.56)	6 (0.12)			
RQ ID	**Outcomes**	**Chlorination**	**Hydrogen Peroxide**				
	Method of disinfection	33 (0.66)	17(0.34)				

df: Degree of freedom; **Prop.:** Proportion

Based on response counts and one-sample test of proportion p-values in Table 4.6, the test p-values are less than = 0.05, the null hypothesis was rejected, and it is clear that a greater proportion of the respondents are knowledgeable about Hygiene and Sanitary Conditions" in the study population.

Table 4.7: Bacteriological measurement

Sample	TBC	E.coli	TCC	TFC
A	7	0	0	1
B	3	0	0	0
C	64	0	0	4
D	13	0	0	2
E	4	0	0	0
F	9	0	0	0

Total Bacteria Count (TBC): The TBC results indicate the total number of bacteria present in water samples. Sample C has the highest TBC of 64 x 10^7, suggesting relatively poor sanitary conditions compared to other samples. High TBC values may indicate insufficient disinfection or poor pool maintenance (WHO 2017).

E. coli: The absence of *E. coli* (Escherichia coli) in all samples is a positive sign as it presence in pool water is a strong indicator of faecal contamination and a sanitary standard health hazard. The E.coli values meet with WHO Standard.

Total Coliform Count (TCC): The absence of total coliforms in all samples indicate that the pools is free from faecal contamination. TCC meet with WHO sanitary standard.

Total Faecal Coliforms (TFC): Samples C shows the highest TFC values of 4x10^6, indicating some level of faecal contamination.

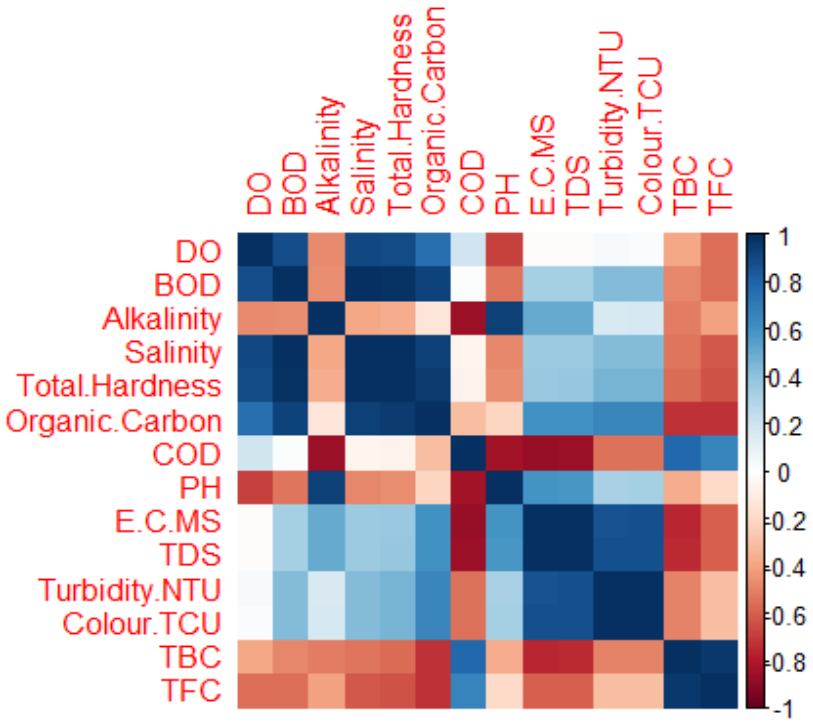

Fig 3: Correlation plot of Physiochemical and Bacteriological Measurement

Figure 3: describe the bacteriological and physio-chemical measurements base on their correlation. It was observed that DO and BOD, DO and SALINITY, DO and TOTAL HARDNESS, DO and ORGANIC CARBON, BOD and SALINITY, BOD and TOTAL HARDNESS, BOD and ORGANIC CARBON, ALKALINITY and PH,SALINITY and DO, SALINITY and BOD, SALINITY and TOTAL HARDNESS, SALINITY and ORGANIC CARBON,TOTAL HARDNESS and DO, TOTAL HARDNESS and BOD, TOTAL HARDNESS and SALINITY, TOTAL HARDNESS and ORGANIC CARBON, ORGANIC CARBON and DO, ORGANIC CARBON and BOD, ORGANIC CARBON and SALINITY, ORGANIC CARBON and TOTAL HARDNESS,COD and TBC,E.C.MS and TURBIDITY NTU, TDS and TURBIDITY NTU, TFC and COD were strongly positively correlated.

DISCUSSION

The results from table 4.1 shows that 96% of the respondents were men and 4% were women. The data also show that 40% percent of respondents were between the ages of 15 and 25 years, 56% percent were between the ages of 26 and 35 years, and four (4) percent were between the ages of 36 and beyond. This study revealed that male uses swimming pool more than female and more frequently by young adult. This results in line with findings of Elzbieta Biernat, 2012 who reported that swimming was often undertaken by young residents and practiced relatively more often by men than by women. The reasons for such differences between male and female in the access and freedom of choice of recreation may be attributed to low financial independence, family roles assigned to women and recently increase in women's professional activities.

The results in table 4.2 revealed that majority of pools are public 42 (84%) compared to private 8 (16%). The classification is based on the usage. Public swimming pools that serves diverse group of people are more common than private. This may be attributed to socio-economic characteristics of study area.

Based on the results in table 4.3. The majority of pools are 20 x 40 feet in size which are in line with WHO recommendation for recreational pool. The common method of disinfection is chlorination the choice may be connected to ease accessibility and being the most satisfactory method of pool disinfection. This is in agreement with the recommendation of American Public Health Association (APHA).

Tables 4.5 reveal that respondents are knowledgeable about Hygiene and Sanitary Conditions with p-values less than $\alpha = 0.05$. The results indicate that a greater proportion of instructors are knowledgeable about hygiene and sanitary conditions in the study population, which is a positive finding for the safety of swimmers. This result agrees with previous studies conducted by Elmar *et al*. (2017) and Petterson *et al*. (2021), which also revealed that swimming instructors are knowledgeable about hygiene and sanitary conditions of the pool.

The correlation plot in Figure 3: helps visualize the relationships between physiochemical and bacteriological. The absence or presence of bacterial contaminants from a water source is one of the major determinants for classifying water as potable (safe) or not portable source of drinking water. According to WHO guidelines, swimming pools must not contain any bacteria, giardia worms, viruses, Entamoeba histolytica, and other opportunistic Pathogens like Klebsiella pneumoniae (WHO, 2011).

Finally, Table 4.6 provides bacteriological measurements for different pool samples, indicating the absence of E.coli and Total coliform count are in standard with WHO requirement while there is presence of total bacterial counts (TBC) and fecal coliforms (TFC). The study contradicts the study of Sule *et al*., (2010), where the following bacteria: Lactobacillus, Bacillus, Citrobacter, Corynobacterium, Micrococcus, Aeromonas, Staphylococcus aureus, Pseudomonas, E. coli, and Klebsiella. However, TBC and TFC presence is worrisome, as the microorganisms that cause recreational water illnesses (RWIs) can be spread when swallowing water that has been contaminated with fecal matter (CDC, 2022). Based on the high Total Bacterial Count (TBC) and the presence of Total Fecal Coliforms (TFC) in Sample C Table 4.6, it suggests that there might be a contamination issue in the swimming pool water.

CONCLUSION

Based on the findings of this study, male participate in swimming activities more than female in Ilorin metropolis. Public pools are more common in the study and chlorination is the most used method of disinfection. The absent of E. coli and Total coli form count in all samples (0*10^7) is a positive suggesting that the pools are not contaminated with faecal matter and meeting with basic sanitary standard of WHO and are satisfactory. However, Total Bacterial Count (TBC) and the presence of Total Fecal Coliforms (TFC) in Sample C which suggests that there might be a contamination issue in the swimming pool water. These findings raise concerns about water quality and potential health risks. It is crucial to investigate the possible sources of contamination and take appropriate measures to address them.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made:

a. Total Bacteria Count (TBC) of less than 100 CFU/mL (colony-forming units per millimeter) should be work toward to mitigate potential health risks of bacteria.
b. Swimming pool owners and instructors should maintain Total Fecal Coli forms of 0 CFU/100mL (colony-forming units per millimeter) to reduce the presence of fecal coli forms to safer levels.
c. The pools owners and instructors should maintain proper hygiene practices in and around the pools, perform regular maintenance on the pool and its equipment, check and worn-out or damage parts to enable safety from water associated infections

REFERENCES

Al-Kkhatib I A, Salah S. (2020). Bacteriological and chemical quality of swimming pools water in developing countries: A case study in the West Bank of Palestine. *Int. J. Environ. Health Res*;13(1):17-22

Amala S E, &Aleru CP. (2016). Bacteriological quality of swimming pools water in Port Harcourt Metropolis. Natural Science. 8:79-84.

Bathija, G. and Narasimha, R. (2019). A cross-sectional study on health related behaviors among swimming pool users and sanitary conditions of swimming pools in hubballi city. International Journal of Community Medicine and Public Health, 6(12)

Carter, R. and Joll, C. (2017). Occurrence and formation of disinfection by-products in the swimming pool environment: a critical review. Journal of Environmental Sciences, 58, 19-50.

Centers for Disease Control and Prevention (2009). Healthy housing reference manual, chapter 14: residential swimming pools and spas.CDC.gov. Department of Health and Human Services, pp. 1-11.

Doménech-Sánchez, A., Laso, E., & Berrocal, C. (2021). Water loss in swimming pool filter backwashing processes in the balearic Islands (Spain). Water Policy, 23(5), 1314-1328.

Dudziak, M., Wyczarska-Kokot, J., Łaskawiec, E., & Stolarczyk, A. (2019). Application of ultrafiltration in a swimming pool water treatment system. Membranes, 9(3), 44.

Elmar Y., Klapes NA., Vesley D. (2017). Rapid Assay for in Situ Identification of Coagulase-Positive Staphylococci Recovered by Membrane Filtration from Swimming Pool Water. Applied and Environmental Microbiology. 52:589-590.

Esinulo, A. C., &Ogbuagu, D. H. (2016). Quality Assessment of Selected Public Swimming Pools in Owerri Metropolis, Nigeria

Harper KS, & Anderson O., (2016). Bacteriological Quality Assessment of Swimming Pools in Osu-Labadi Area, *Accra. Journal of Natural Science Research*. 4:126-129.

Indabawa, I. I., Ali, S., & Mukhtar, M. D. (2015). Assessment of Microbiological and Physico-Chemical Quality of some Swimming pools in Kano Metropolis. *International Conference of on Biological , Chemical and Environmental Sciences*, 41.

Khan N & Ahmed H. (2017), Identification of Bacterial Flora in the Water of Swimming Pools throughout the Year. *Japan Journal of Physical Education Health and Sports Sciences*. 2010; 51:1-9.

Masoud, G., Abbass, A., Abaza, A., & Hazzah, W. (2016). Bacteriological quality of some swimming pools in alexandria with special reference to *staphylococcus aureus.* Environmental Monitoring and Assessment, 188(7).

Okoruwa, A., C, N., & Ukpene, A. (2023). Bacterial associated with swimming pool water in Benin city, Nigeria. African Journal of Health Safety and Environment, 4(1), 1-9.

Olalekan R. M., Adeolu A. T., Chris E. E., Awogbami S. O. (2018). Assessment of Air Quality Indices And Its Health Impacts In Ilorin Metropolis, Kwara State, Nigeria. *Science Park Journals*. Vol. 4(4), pp. 060-074. DOI: 10.14412/SRI2018.074

Onosakponome, E., Adedokun, A., & Dick, A. (2020). Monitoring the presence of bacteria, fungi and parasitic pathogens associated with swimming pools in port Harcourt metropolis. South Asian Journal of Research in Microbiology, 31-38.

World Health Organisation (WHO) (2006). Microbial Hazards. In: Guidelines for Safe Recreational Water Environments. Swimming Pools and Similar Environment, Volume 2, WHO Press, Geneva, 26-59 (Chapter 3