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RESEARCH ARTICLE

ASSESSMENT OF SWIMMING POOLS WATER QUALITY INDEX IN KANO METROPOLIS, NIGERIA

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ABSTRACT

Swimming pool is one of the recreational facilities patronized by different classes of people for pleasure in some of the hotels and residential houses in Kano Metropolis. However, the swimming pools may harbor infectious disease from contaminated water sources or from untreated water of the swimming pools. Pollution in swimming pools is therefore not uncommon as it is a serious public health issue affecting people globally. This study focused on assessment of swimming pools water quality in Kano Metropolis, Nigeria. Stratified random sampling technique was used to select seven swimming pools from hotels, restaurant and private residence. Mean temperature, pH, electrical conductivity, chloride, phosphate, nitrate, total dissolved solid, total coliforms E. coli and shigella were tested in the laboratory using American public health association (APHA) method. Water quality index (WQI) was computed using Weighted Arithmetic Water Quality Index (WAWQI) to evaluate the quality of water in each of the seven sampled swimming pools. Likert scale was used to rank each swimming pool water quality. The result shows that 28% of the swimming pools water are unsuitable for recreational purpose. Furthermore, the study also shows that the swimming pools did not comply with world health organization (WHO) and environment protection agency (EPA) recreational standards for chlorine. Therefore, the study recommends that the relevant stakeholders need to ensure that standards are maintained at the various swimming pools through regular surveillance and strict enforcement of regulations

Keywords: Water quality, recreation, swimming pools, index.

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INTRODUCTION

Water as a great sustainer of life could be a medium of transmission of various deadly diseases like cholera, typhoid, diarrhea and other endemic infection that are not treated properly. Provision of qualitative water supply and sanitation is significant to people all over the World. In recognition of its relevance, WHO has made water supply and sanitation as a component of Primary Health Care Delivery System to achieve for the people of the World by the year 2000 AD. WHO (2006) set basic water requirements to be 60 liters per person per day for all the people of the World. The quality of water influences the health status of any populace, Hence, analysis of water for physical, biological and chemical properties including trace element contents are very important for public health studies (Shalom, *et al* 2011).

According to Udom, *et al*. (2018) and Fashola, *et. al*., (2013) highlighted the need to ascertain the quality of water used by humans has become very intense in the past decade and it is difficult to imagine any programme for human development that does not require a readily available supply of water. Besides the need of water for drinking, water resources play a vital role in various sectors of economy such as agriculture, livestock production, industrial activities, hydropower generation, fisheries, transportation and recreational activities (such as swimming pools) (Shweta,*et al* 2013).

A swimming pool is a body of water of limited size contained in a holding structure. It is also an artificially enclosed body of water intended for swimming and water based recreation. Swimming pools designated for public use are called public pools while private pools are those used exclusively by a few people or in homes. The water is generally of portable quality and is treated with additional disinfectants such as chlorine compound (Berlin and Jeremy 2011).

Saba and Tekpor (2015) reported that those who normally take care of these swimming pools have little knowledge about the importance of maintaining the pools to meet both the microbiological and physiochemical standards. Some operators may be tempted to economize chemicals used for sanitizing the pools as a result of their scarcity or perhaps over chlorinate the pools due to little knowledge of the recommended quantities to apply and hence compromise the quality of the swimming pools (Saba and Tekpor, 2015). Therefore, the current study assessed swimming pools water quality index based on the international standard.

Although there is no globally accepted composite index of water quality; several countries have only resulted to using aggregated water quality data in the development of water quality indices (Banda and Kumarasamy, 2020). For water quality standards, there are a number of standard including the World Health Organization (WHO), Environmental Protection Agency (EPA), Standard Organization of Nigeria (SON) and Department of Petroleum Resources (DPR) standards amongst others. Table 1 shows the WHO and EPA water quality standards

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for selected parameters in relation to safe recreational water environments. Therefore, the current study assessed swimming pools water quality index based on the international standard.

Table 1: International Standard for Physicochemical and Some Microbial Parameters

S/N	Parameter	WHO and EPA standards for recreational waters.
1	pH	7.2–7.8
2	Temperature (°C)	22-26(°C)
3	Turbidity (NTU)	0.6
4	Nitrate mg/1	1-5 mg/1
5	Electrical conductivity mg/1	1000μs/cm
6	Total Dissolved Solid mg/1	500 mg/1
7	Phosphate mg/1	1-10 mg/1
8	Chloride mg/1	1-3 mg/1
9	Dissolved oxygen mg/1	9-10 mg/1
10	Total hardness	150 mg/1
11	Escherichia coliform CFU/100ml	<100 Colonies
12	Coliform Count MPN/100ml	<100 Colonies

Source: EPA (UK) and WHO (2006)

Description of the Study Area

Kano Metropolis is located between latitude 11°59'59.57''N to 12°02'39.57''N and longitude 8°31'19.69''E to 8°33'19.69''E, the area covers (8) local government areas which include, Kano Municipal, Dala, Tarauni, Nassarawa, Fagge, Gwale, Kumbotso and Ungoggo Local Government. (Fig. 1) Geologically the study area is underlain by the rocks of Basement Complex of Pre-Cambrian origin and consists of metamorphic rocks that have been subjected to chemical and other form of weathering that produce clay regolith. (Olofin, *et al.* 2008; Mustapha, et al 2014). The mean maximum temperature of the area is between 27-35° C and the mean minimum temperature is between 16-21° C.

The annual rainfall varies from 1200mm in the south to 650mm in the north but the mean annual rainfall is about 800 mm around Kano Metropolis. It has two seasonal periods, which are rainy season that starts by May or June and ends in October or November while dry season is from November to April (Adamu et al, 2013). According to Hannington *et al* (2016), gravitational flow of water mainly depends on groundwater which in turn depends on the quality of recharged water, atmospheric precipitation, inland surface water and sub-surface geochemical processes. This implies that same factors which influence groundwater quality also influence atmospheric precipitation.

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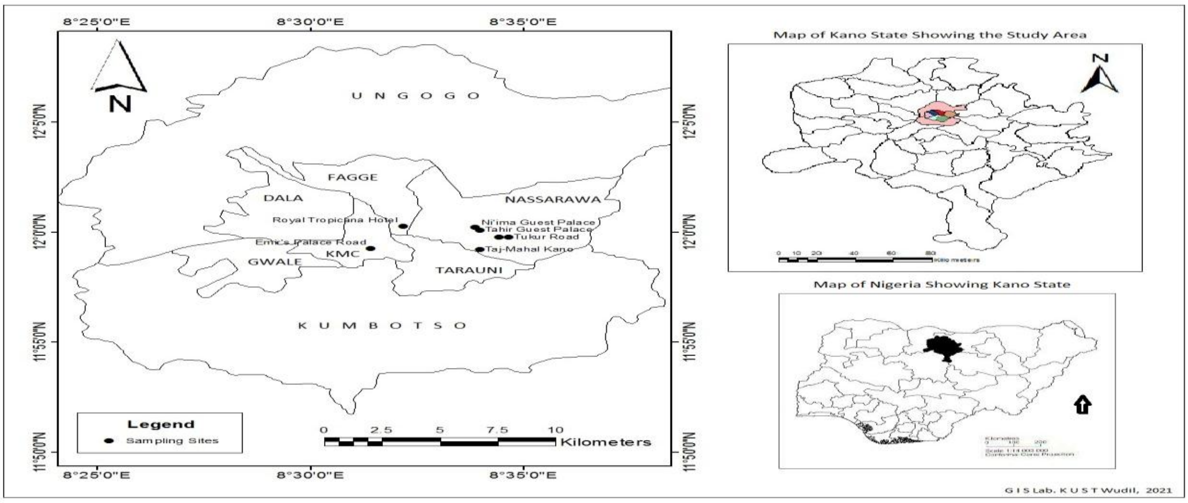

Source: G.I.S Lab KUST Wudil (2021)
Fig 1: Study Area Location

MATERIALS AND METHODS

Data types, sources and techniques

Both primary and secondary data were used in this research. The primary data was sourced through key informant interviews and laboratory analyses of water quality in the study, an estimate of nine (9) Hotels and three (3) restaurants that are with swimming pools were identified by the Kano State Tourism Management Board. Ten (10) residential houses were also identified from the study area. Stratified random sampling was used for the identification of the variable based on their clusters; the variables were categorized into three clusters; hotels, restaurants, and private residents for easy sampling. In each cluster, 30% of the swimming pools were selected as a sample whereby 3, 1, and 3 swimming pools were selected for hotels, restaurants, and private residents respectively (Table.2).

This was adopted from Rilwanu (2014) in Arlosorof *et al* (1987) and Hagget *et al* (1977) established that 20 to 30 percent of the total population is adequate as a sample for a small population and 10 percent for a large population. For the selection of individual swimming pools systematic sampling was adopted using a list of the entire swimming pools that were arranged alphabetically (sampling frame). These selected swimming pools are Niima Guest palace (A) Tahir Guest Palace (B) Royal Tropicana Hotel (C) Taj-Mahal (D) Emir palace road (E) NO 6B Tukur Road (F) and NO 31 Tukur Road (G). Swimming pools A, B, C are the Hotels which part of the public swimming pools and Swimming Pool D is a Restaurant which is also part of the public swimming pools. While swimming pools E, F, and G are the private residence swimming pools.

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Table 2; Sample size of Swimming Pools

S/N	Cluster	Total Swimming Pools	Sampled Swimming Pools
1	Hotels	9	3
3	Restaurants	3	1
3	Private Residence	10	3
	Total	22	7

Source: Author's analysis.

Swimming pools water were collected in triplicates using standard procedure for water samples. Every collected samples were kept in a plastic bottle clearly marked and labeled with references to the sampling points. Similarly, to eliminate differences in the swimming water quality that could arise due to variation in the timing, all the samples were collected during the same period of the day. Mean temperature, pH, electrical conductivity, chloride, phosphate, nitrate, total dissolved solid total coliform, E. coli, and shigella were analyzed in the laboratory using established procedures. The water quality index is a valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues. Nevertheless, 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. Moreover, water quality indices have been known to vary from season to season even at low concentrations (Kachroud et al., 2019).

The water quality index (WQI) was computed using Weighted Arithmetic Water Quality Index (WAWQI) method originally developed by Brown et al., (1972) who categorizes the water quality according to the extent of cleanness taking into consideration `n the generally frequently considered indicators using the formula in equation i. The computed water quality index value is then evaluated according the category which it falls as presented in.

Table 3; Water Quality Rating Based on WAWQI Method

S/N	WQI Value	Evaluation of Water Quality	Category
1	0-25	excellent water quality	A
2	26-50	Good water quality	B
3	51-75	Poor water quality	C
4	76-100	Very Poor water quality	D
5	Above 100	Unsuitable for recreational purpose	E

Source: (Brown et al., 1972)

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Data collection procedure and analysis

Water quality samples were collected from the swimming pools of the selected hotels, restaurants, and privet residences using bottles. The bottles were placed into a cooler with ice for immediate delivery to the laboratory for analysis. The samples were collected for four (4) months in year 2021 and 2022 respectively. Physicochemical parameters and microbial parameters of the swimming pools were tested in the laboratory to determine the level of parameters concentration and presence of pathogens in the water samples.

Table 4; Mean Value of Physicochemical and microbial Parameters

Parameters	A	B	C	D	E	F	G	WHO&EPA Standard
Temperature (°C)	20.0	21.3	21.5	21.6	21.9	21.6	21.5	22-26(°C)
pH	7.2	7.3	7.3	7.5	7.1	7.3	7.3	7.2–7.8
Electrical conductivity (EC) (mg/l)	931.5	913	1959	1158.5	949	2089.5	519	1000μs/cm
Total dissolve solid (TDS)(mg/l)	554.5	552.5	1163	693	577.5	1295	311	500 mg/1
Chloride (mg/l)	6.2	6.4	11.4	7	6.2	14	4.3	1-3 mg/1
Phosphate (mg/l)	20.62	9.4	19.11	23.04	24.66	20.83	18.98	1-10 mg/1
Nitrate (mg/l)	2.8	3.5	4.2	2.8	2.8	2.8	3.5	1-5 mg/1
COLIFORM (MPN/ml)	0	0	0	0	0	93	0	<100Colonies
E.COLI	0	0	0	0	0	2	0	<100Colonies
SHIGELLA	0	0	0	0	0	1	0	<100Colonies

Key: swimming with less than 100 bacterial counts is recommended for 100ml of water sample by EPA 2020

Source: Author's lab analysis (2021/2022)

The study used Weighted Arithmetic Water Quality Index (WAWQI) method to compute water quality index of the swimming pools water using equation (i to iv). The laboratory results of water quality parameters per sampled swimming pool were used as input in water quality index computation.

$$WQI = \frac{\sum QiWi}{\sum Wi} \quad \text{...} \quad (i)$$

The quality evaluation scale (Qi) for each indicator is computed with the function in equation ii:

$$Qi= \left(\frac{Vi-Vo}{SI-Vo}\right)100 \quad \text{...} \quad (ii)$$

Where, Vi is approximate level of ith indicator from laboratory analysis
Vo is the real value of this indicator in uncontaminated sample Vo = 0 (except pH =7.0 and DO
= 14.6 mg/l), while Si = allowable limit of ith indicator.

The respective weight (Wi) for each indicator is computed with the function in equation iii:

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$$Wi = \frac{K}{Si} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (iii)$$

Where K = mathematical constant and is computed with the function in equation iv:

$$K = \frac{1}{\Sigma(\frac{1}{si})} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (iv)$$

Bottom-up approach is used in the computation of water quality index through the following step:
Step 1: Determination of (K) using equation (iv)
Step 2: Computation of the unit weight (Wi) using equation (iii)
Step 3: Computation of the quality rating scale (Qi) using equation (ii)
Step 4: Determination of water quality index (WQI) using equation (i)

Table 5; Determination of (K) and Computation of the unit weight (WI) using equation iii and iv

S/N	Parameters	**Step 1** Determination of (K) using equation 4	**Step 2** Computation of the unit weight (Wi) using equation 3
1	Temp	$\frac{1}{\Sigma(\frac{1}{26})} = \frac{1}{0.038}$ =26	$\frac{26}{26}$ = 1
2	Ph	$\frac{1}{\Sigma(\frac{1}{7.8})} = \frac{1}{0.128}$ =7.8	$\frac{7.8}{7.8}$ = 1
3	EC	$\frac{1}{\Sigma(\frac{1}{1000})} = \frac{1}{0.001}$ =1000	$\frac{1000}{1000}$ = 1
4	TDS	$\frac{1}{\Sigma(\frac{1}{500})} = \frac{1}{0.002}$ =500	$\frac{500}{500}$ = 1
5	Cl	$\frac{1}{\Sigma(\frac{1}{5})} = \frac{1}{0.3}$ =3.3	$\frac{3.3}{3}$ = 1.1
6	PO4	$\frac{1}{\Sigma(\frac{1}{10})} = \frac{1}{0.1}$ =10	$\frac{10}{10}$ = 1
7	NO3	$\frac{1}{\Sigma(\frac{1}{5})} = \frac{1}{0.2}$ =5	$\frac{5}{5}$ = 1
8	Coliform	$\frac{1}{\Sigma(\frac{1}{100})} = \frac{1}{0.01}$ =100	$\frac{100}{100}$ =1
9	E.coli	$\frac{1}{\Sigma(\frac{1}{100})} = \frac{1}{0.01}$ =100	$\frac{100}{100}$ =1
10	Shigella	$\frac{1}{\Sigma(\frac{1}{100})} = \frac{1}{0.01}$ =100	$\frac{100}{100}$ =1
	Total (Wi)		10.1

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Step 3: Computation of the quality rating scale (Qi) for each parameter in all the seven (7) sampled swimming pools using Equation 2.

Table 6: Computation of the Quality Rating Scale (Qi) of Pool A using Equation ii

S/N	Parameter	Computation of the quality rating scale (Qi) using equation 2 Computation (Qi)
1	Temp	$\frac{20-0}{26-0}$ = 0.77 x 100 = 77
2	pH	$\frac{7.2-7.0}{7.8-7.0} = \frac{02}{08}$ = 0.25 x 100 = 25
3	EC	$\frac{931-0}{1000-0}$ = 0.93 x 100 = 93
4	TDS	$\frac{554-0}{500-0}$ =1.11 x 100 = 111
5	Cl	$\frac{6.2-0}{3.1-0}$ = 2.1 x 100 = 210
6	PO4	$\frac{20.62-0}{10-0}$ =2.1 x 100 = 210
7	NO3	$\frac{2.8-0}{5-0}$ = 0.56 x 100 = 56
8	Coliform	$\frac{0}{100}$ = 0
9	E.coli	$\frac{0}{100}$ = 0
10	Shigella	$\frac{0}{100}$ = 0

Table 7; Computation of the Quality Rating Scale (Qi) for of Pool B using Equation ii

S/N	Parameters	Computation of the quality rating scale (Qi) using equation 2 Computation (Qi)
1	Temp	$\frac{23.3-0}{26-0}$ = 0.8 x 100 = 80
2	Ph	$\frac{7.3-7.0}{7.8-7.0} = \frac{0.3}{0.8}$ = 0.38 x 100 = 38
3	EC	$\frac{913-0}{1000-0}$ = 0.9 x 100 = 90
4	TDS	$\frac{552-0}{500-0}$ = 1.1 x 100 = 110
5	Cl	$\frac{6.4-0}{3-0}$ = 2.1 x 100 = 210
6	PO4	$\frac{9.4-0}{10-0}$ = 0.94 x 100 = 94
7	NO3	$\frac{3.5-0}{5-0}$ = 0.7 x 100 = 70
8	Coliform	$\frac{0}{100}$ = 0
9	E.coli	$\frac{0}{100}$ = 0
10	Shigella	$\frac{0}{100}$ = 0

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Table 8: Computation of the Quality Rating Scale (Qi) for of Pool C using Equation ii

S/N	Parameter	Computation of the quality rating scale (Qi) using equation 2 Computation (Qi)
1	Temp	$\frac{21.5-0}{26-0}$ = 0.83 x 100 = 83
2	pH	$\frac{7.3-7.0}{7.8-7.0} = \frac{0.3}{0.8}$ = 0.38 x 100 = 38
3	EC	$\frac{1959-0}{1000-0}$ = 1. 9 x 100 = 190
4	TDS	$\frac{1163-0}{500-0}$ = 2. 3 x 100 = 230
5	Cl	$\frac{11.4-0}{3-0}$ = 3.8 x 100 = 380
6	PO4	$\frac{19.11-0}{10-0}$ = 1.9 x 100 = 190
7	NO3	$\frac{4.2-0}{5-0}$ = 0.84 x 100 = 84
8	Coliform	$\frac{0}{100}$ = 0
9	E.coli	$\frac{0}{100}$ = 0
10	Shigella	$\frac{0}{100}$ = 0

Table 9: Computation of the Quality Rating Scale (Qi) for Pool D using equation ii

S/N	Parameter	Computation of the quality rating scale (Qi) using equation 2 Computation (Qi)
1	Temp	$\frac{21.6-0}{26-0}$ = 0.83 x 100 = 83
2	pH	$\frac{7.5-7.0}{7.8-7.0} = \frac{0.5}{0.8}$ = 0.63 x 100 = 63
3	EC	$\frac{1158.5-0}{1000-0}$ = 1.2 x 100 = 120
4	TDS	$\frac{693-0}{500-0}$ = 1.4 x 100 = 140
5	Cl	$\frac{7-0}{3-0}$ = 2.3 x 100 = 230
6	PO4	$\frac{23-0}{10-0}$ = 2.3 x 100 = 230
7	NO3	$\frac{2.8-0}{5-0}$ = 0.56 x 100 = 56
8	Coliform	$\frac{0}{100}$ = 0
9	E.coli	$\frac{0}{100}$ = 0
10	Shigella	$\frac{0}{100}$ = 0

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Table 10: Computation of the Quality Rating Scale (Qi) for Pool E using Equation ii

S/N	Parameter	Computation of the quality rating scale (Qi) using equation 2 Computation (Qi)
1	Temp	$\frac{21.9-0}{26-0} = 0.8 \times 100 = 80$
2	pH	$\frac{7.1-7.0}{7.8-7.0} = \frac{0.1}{0.8} = 0.13 \times 100 = 13$
3	EC	$\frac{949-0}{1000-0} = 0.95 \times 100 = 95$
4	TDS	$\frac{577.5-0}{500-0} = 1.15 \times 100 = 115$
5	Cl	$\frac{6.2-0}{3-0} = 2.07 \times 100 = 207$
6	PO4	$\frac{24.66-0}{10-0} = 2.46 \times 100 = 246$
7	NO3	$\frac{2.8-0}{5-0} = 0.56 \times 100 = 56$
8	Coliform	$\frac{0}{100} = 0$
9	E.coli	$\frac{0}{100} = 0$
10	Shigella	$\frac{0}{100} = 0$

Table 11: Computation of the quality rating scale (Qi) for swimming pool F using equation ii

S/N	Parameter	Computation of the quality rating scale (Qi) using equation 2 Computation (Qi)
1	Temp	$\frac{21.6-0}{26-0} = 0.83 \times 100 = 83$
2	pH	$\frac{7.3-7.0}{7.8-7.0} = \frac{0.3}{0.8} = 0.38 \times 100 = 38$
3	EC	$\frac{2089.5-0}{1000-0} = 2.89 \times 100 = 289$
4	TDS	$\frac{1295-0}{500-0} = 2.59 \times 100 = 259$
5	Cl	$\frac{14-0}{3-0} = 4.67 \times 100 = 467$
6	PO4	$\frac{20.83-0}{10-0} = 2.08 \times 100 = 208$
7	NO3	$\frac{2.8-0}{5-0} = 0.56 \times 100 = 56$
8	Coliform	$\frac{93-0}{100-0} = 0.93 \times 100 = 93$
9	E.coli	$\frac{2}{100} = 0.02 \times 100 = 2$
10	Shigella	$\frac{1}{100} = 0.01 \times 100 = 1$

Table 12: Computation of the Quality Rating Scale (Qi) for Pool G using Equation ii

S/N	Parameter	Computation of the quality rating scale (Qi) using equation 2 Computation (Qi)
1	Temp	$\frac{2.5-0}{26-0} = 0.83 \times 100 = 83$
2	Ph	$\frac{7.3-7.0}{7.8-7.0} = \frac{0.3}{0.8} = 0.38 \times 100 = 38$
3	EC	$\frac{519-0}{1000-0} = 0.52 \times 100 = 52$
4	TDS	$\frac{311-0}{500-0} = 0.62 \times 100 = 62$
5	Cl	$\frac{4-3}{3-0} = 1.4 \times 100 = 140$
6	PO4	$\frac{18.98-0}{10-0} = 1.89 \times 100 = 189$
7	NO3	$\frac{3.5-0}{5-0} = 0.7 \times 100 = 70$
8	Coliform	$\frac{0}{100} = 0$
9	E.coli	$\frac{0}{100} = 0$
10	Shigella	$\frac{0}{100} = 0$

Step 4: Computation of the water quality index for all the seven (7) sampled swimming pools using Equation 1.

$$WQI = \frac{\sum QiWi}{\sum Wi}$$

Water quality index for swimming pool A

$$\frac{(77x1)+(25x1)+(93x1)+(111x1)+(210x1.1)+(210x1)+(56x1)+(0x1)+(0x1)+(0x1)}{(1+1+1.1+1+1+1+1+1+1+1)}$$

$$\frac{(77)+(25)+(93)+(111)+(231)+(210)+(56)}{(10.1)} = \frac{803}{10.1} = 79.5$$

$$WQI = \frac{\sum QiWi}{\sum Wi}$$

Water quality index for swimming pool B

$$\frac{(80x1)+(38x1)+(90x1)+(110x1)+(210x1.1)+(94x1)+(70x1)+(0x1)+(0x1)+(0x1)}{(1+1+1+1+1.1+1+1+1+1+1)}$$

$$\frac{(80)+(38)+(90)+(110)+(231)+(94)+(70)}{10.1} = \frac{713}{10.1} = 70.59$$

$$WQI = \frac{\sum QiWi}{\sum Wi}$$

Water quality index for swimming pool C

$$\frac{(83x1)+(38x1)+(190x1)+(230x1)+(380x1.1)+(190x1)+(84x1)+(0x1)+(0x1)+(0x1)}{(1+1+1+1+1.1+1+1+1+1+1)}$$

$$\frac{(83)+(38)+(190)+(230)+(418)+(190)+(84)}{10.1} = \frac{1233}{10.1} = 122.07$$

$$WQI = \frac{\sum QiWi}{\sum Wi}$$

Water quality index for swimming pool D

$$\frac{(83x1)+(63x1)+(120x1)+(140x1)+(230x1.1)+(230x1)+(56x1)+(0x1)+(0x1)+(0x1)}{(1+1+1+1+1.1+1+1+1+1+1)}$$

$$\frac{(83)+(63)+(120)+(140)+(253)+(230)+(56)}{10.1} = \frac{945}{10.1} = 93.56$$

$$WQI = \frac{\sum QiWi}{\sum Wi}$$

Water quality index for swimming pool E

$$\frac{(80x1)+(13x1)+(95x1)+(115x1)+(207x1.1)+(246x1)+(56x1)+(0x1)+(0x1)+(0x1)}{(1+1+1+1+1.1+1+1+1+1+1)}$$

$$\frac{(80)+(13)+(95)+(115)+(227.7)+(246)+(56)}{10.1} = \frac{832.7}{10.1} = 82.45$$

$$WQI = \frac{\sum QiWi}{\sum Wi}$$

Water quality index for swimming pool F

$$\frac{(83x1)+(38x1)+(289x1)+(259x1)+(467x1.1)+(208x1)+(56x1)+(93x1)+(2x1)+(1x1)}{(1+1+1+1+1.1+1+1+1+1+1)}$$

$$\frac{(83)+(38)+(289)+(259)+(513.7)+(208)+(56)+(93)+(2)+(1)}{10.1} = \frac{1542.7}{10.1} = 152.7$$

$$WQI = \frac{\sum QiWi}{\sum Wi}$$

Water quality index for swimming pool G

$$\frac{(83x1)+(38x1)+(52x1)+(62x1)+(140x1.1)+(189x1)+(70x1)+(0x1)+(0x1)+(0x1)}{(1+1+1+1+1.1+1+1+1+1+1)}$$

$$\frac{(83)+(38)+(52)+(62)+(154)+(189)+(70)}{10.1} = \frac{684}{10.1} = 67.7$$

DISCUSSION OF RESULTS

The water quality index for seven sampled swimming pools in Kano metropolis, Nigeria was based on seven physicochemical water quality parameters of temperature, pH, electrical conductivity, chloride, phosphate, nitrate, and total dissolved solid. The microbial indicators were computed for Total coliforms, E. coli and Shigella. There is absence of microbial indicators in all the sampled except swimming pool F which shows low level of compliance stipulated by WHO (2006). This finding coincide with the report by Ibanga et al (2020) which indicate Absence of microbial indicators in all the sampled swimming pools in Warri metropolis, delta state. In contrast a related study of swimming pools in Shahrekord City, Iran had microbiological indicators higher than acceptable limit set by regulatory authorities (Fadaei and Amiri, 2015).

The mathematical constant (K) for temperature was (26), pH was (7.8), EC (1000), (chlorine 3.3), TDS (500), PO_4 (10), NO_3 (5) coliforms (100), E. coli (100), shigella (100). the K factor for all the parameters found in this study is higher than the value reported by Ibanga et al (2020) while evaluating water quality used for swimming pools in Warri metropolis, delta state. The unit weight (Wi) for temperature was (1), pH (1), EC (1) chlorine (1.1), (TDS) 1, PO_4 (1), NO_3 (1) coliforms (1), E. coli (1), shigella (1).

For the compilation of Qi swimming pool (A) had (77) for temperature, (25) for pH (93) electrical conductivity, (111) for TDS, (210) for chlorine, (210) for phosphate (56) for nitrate (0) coliforms, (0) for E. coli and (0) for shigella. For swimming pool (B) the result shows (80) for temperature, (38) for pH (90) electrical conductivity, (110) for TDS, (210) for chlorine, (94) for phosphate (70) for nitrate (0) coliforms, (0) for E. coli and (0) for shigella. Swimming pool (C) had (83) for temperature, (38) for pH (190) electrical conductivity, (230) for TDS, (380) for chlorine, (190) for phosphate (84) for nitrate (0) coliforms, (0) for E. coli and (0) for shigella.

Swimming pool (D) resulted in Qi to have (83) for temperature, (63) for pH (120) electrical conductivity, (140) for TDS, (230) for chlorine, (230) for phosphate (56) for nitrate (0) coliforms, (0) for E. coli and (0) for shigella. Swimming pool (E) had (80) for temperature, (13) for pH (95) electrical conductivity, (115) for TDS, (207) for chlorine, (246) for phosphate (56) for nitrate (0) coliforms, (0) for E. coli and (0) for shigella. Swimming pool (F) had (83) for temperature, (38) for pH (289) electrical conductivity, (259) for TDS, (467) for chlorine, (208) for phosphate (56) for nitrate (93) coliforms, (2) for E. coli and (1) for shigella. Swimming pool (G) had (83) for temperature, (38) for pH (52) electrical conductivity, (62) for TDS, (140) for chlorine, (189) for phosphate (70) for nitrate (0) coliforms, (0) for E. coli and (0) for shigella. The water quality index of the seven sampled swimming pools is summarized in table (12)

Table 12; Computed Water Quality Index of the Sampled Swimming Pools.

S/N	Samples	WQI	Standard Value	Classification
1	A	79.5	75-100	Very Poor water quality
2	B	70.59	51-74	Poor water quality
3	C	122.07	>100	Unsuitable for recreational purpose
4	D	93.56	75-100	Very Poor water quality
5	E	82.45	75-100	Very Poor water quality
6	F	152.7	>100	Unsuitable for recreational purpose
7	G	67.7	51-74	Poor water quality

Source: Author's laboratory analysis (2021/2022)

The result revealed that only swimming pools C and F are classified with the water quality that is unsuitable for recreational purpose this is because their value exceeds 100 in the classification of water quality index, this is as a result of high level of TDS and Cl, (Table 4) total coliform of 93mpn/ml presence of E. coli and shigilla in swimming pool F (Table 4). A related study by (Fadaei and Amiri, 2015) in Shahrekord City, Iran shows that microbiological indicators are higher than acceptable limit set by regulatory authorities which makes the water unsuitable for recreational purpose.

The result also corroborates with the report by Osei-Adjei et al, (2014) where all the microbiological indicators in sampled swimming pools in Osu-Labadi, Accra, Ghana were above WHO (2006) standards. Swimming pools A (79.5), D (93.56) and E (82.45) are classified with very poor water quality index, while B and G possess poor water quality due to high concentration of TDS and Cl (Table 4). The high levels of chlorine in the swimming pools approve the result by (Ajadi *et al* 2016), which reports the excessive chlorine levels comes from super chlorination in order to cover for bad management or ineffective mixing of the pool water.

CONCLUSION

The quality of swimming pools water in many Nigerian cities cannot be neglected because of the risk and implications to human health. This study was aimed to find the ingenuity offered by water quality index framework to provide a distinct score to the water quality of swimming pools in private residence and hotels in Kano metropolis. From the lab analysis done it can be understood that chlorine is the one main disinfectant product used in higher amounts in the swimming pool waters in order keep the water free from pathogens and to prevent the spread of water borne diseases.

It was found from all the samples the chlorine content was very high and it greatly exceeded the standards and limits set by internationally standard. The result also shows presence of total coliforms, E. coli and shigilla in swimming pool F which exceed the acceptable standard by (WHO). There is an urgent need by the managements to treat the water for the excessive concentration of chlorine and other parameters in other to avoid risk of contracting health issues such as asthma, chronic respiratory illness, skin and eye irritations, and cholera.

Competing Interest

The authors have declared that no conflicting interest exist in this manuscript.

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