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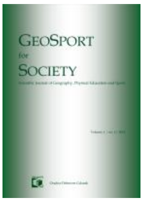

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Application of Water Quality Index in Assessment of Swimming Pools Water Quality in Hotels in Emerging Africa Littoral Metropolis of Warri, Delta State, Nigeria

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Abstract: Swimming pools in guest houses and hotels in many cities in sub-Saharan Africa have been labelled 'beautiful irritation' or hazard zones for public health issues due to the unwholesomeness of water. Pollution in swimming pools is therefore, not uncommon and it is a serious public health issue both at the global, regional, national and local levels. This study focused on application of water quality index in assessment of swimming pools water quality in hotels in emerging Africa littoral metropolis of Warri, Delta State, Nigeria. It used stratified random sampling technique to select five hotels with swimming pool in Warri for assessment. Temperature, pH, turbidity, free (residual) chlorine, total heterotrophic bacteria, total heterotrophic fungi, Escherichia coli and Staphylococcus aureus tested in the laboratory using scientific method of sampling. Water quality index (WQI) was computed using Weighted Arithmetic Water Quality Index (WAWQI) to evaluate in general, the quality of water in each of the five sampled swimming pools. A five-point scale (excellent, good, poor, very poor and unsuitable) was used to rank each swimming pool quality. Result showed that Wellington Hotel had the value of 2.52 and considered excellent in terms of water quality index value. Also, Brook View and Best Western Plus Hotels were classified as good water based on water quality index values of 36.9 and 39.9 respectively while BB swimming pool was ranked poor due to water quality index of 51.4. In contrast, Oasis Place Hotel swimming pool was declared unsuitable for recreational purpose due to a water quality index of 102.1. The study recommended routine and periodic surveillance of swimming pools and other recreational water sources to guarantee optimum health and wellbeing of users.

Keywords: Water quality, index, swimming pool, hotels, Warri Metropolis

Introduction

It is an established fact that water has several utilitarian values such as for recreation, drinking, fisheries, agriculture and industry. Water – based recreation is of vital importance to human life and the mortality rate is two times higher among non-swimmers than active swimmers (Chase et al., 2008; Anciaes et al., 2020). It is always enjoyable when compared with non-water related adventures (Lotshaw et al., 2007; Barnett et al., 2018) and critical antidotes for several persistent ailments including arthritis through enhance utilization of affected bodily parts devoid of aggravating pains (Westby, 2001; Stott, 2019). In spite of its usefulness, recreational water bodies in general and swimming poll in particular, are always vulnerable to various forms of pollutants. Polluted water is not healthy for drinking, bathing, industry, agriculture (United Nations-Water, 2014; Boelee et al., 2019) not to talk of its fitness for swimming and other recreational activities. Guest house and hotel pools, however, are oftentimes labelled 'beautiful irritation' or hazards. Pollution in swimming pools is not uncommon and it is a serious public health issue both at the global, regional, national and local levels.

Swimming pool has been described as a container filled with water intended for swimming or water-based recreation. It can be constructed either above or in the ground, using concrete materials (Eze et al., 2015; Godfrey, 2019). Swimming pools designated for public use are called public pools while private pools are those used exclusively by a few people or in homes. Hot tubs and spas are pools with hot water, used for leisure or rehabilitation and are common in homes, hotels, clubs and massage parlours (Eze et al., 2015). Tourism and hospitality practitioners, fitness centers, health clubs and private clubs often incorporate swimming pools into their businesses as value – added services to capture customers' interest, boost patronage and quick returns for investment.

Empirical evidence show that about 20% swimmers urinate in swimming pools, 23% of users are worried about the hygiene and sanitation status of the public pools while about 35% of swimmers do not bath before jumping into the pool (Agbagwa and Young-Harry, 2012). Majority of swimmers contaminate pool water with large amounts of microorganisms as a result of various secretions from skins, mouths, noses and throats, urines or by contaminated objects and clothes, making water a possible vehicle for the dissemination of infectious diseases among swimmers (Dirtu et al., 2016). From the skin alone uncountable bacteria are rinsed during swimming and if the water is untreated, these microorganisms will build up and increase the chance of transmission to swimmers (Rabi et al., 2008; Bonadonna and La Rosa, 2019).

Swimming pool contamination can also come from pets especially dogs that occasionally wander around unprotected pools as well as from debris already around the properties. It could also be as result of the direct animal contamination including flying birds (Pesewu et al., 2015). It is therefore, essential to be able to evaluate the risks associated with a pool. The risks associated with pool drowning, impact injuries, physiological, infection and poisoning, toxicities and other conditions that may arise from long-term chemical exposures, contact with, inhalation or ingestion of algal toxins (Eze et al., 2015). In Nigeria and many other countries in sub-Saharan Africa, statistics on water quality of swimming pools are lacking. A lot of attention is given to surface and groundwater quality for drinking purpose by most researchers (Aghoghovwia, 2011; Fovwe et al., 2014; Asadu, 2016).

Currently, there is no data about infections and outbreak of diseases related to swimming pools in hotels in emerging African littoral metropolis of Warri, Delta State, Nigeria. The strategic importance of Warri in the economy of Nigeria as one of the oil producing metropolis and as a destination to many tourists, fun and pleasure seekers as well as investors around the world should have motivated researchers to explore water quality in swimming pools. Stakeholders also appear to ignorantly believe that all is well in Warri in terms of water quality in swimming pools. Compliance, governance and regulatory frameworks concerning the business and operation of swimming pools in the metropolis may also unable to meet with the emerging challenges of water quality. Public health, good sanitation and personal hygiene practices are other challenging issues surrounding water quality in swimming pools.

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). All these issues have unquantifiable consequences and impact to sustainable users' welfare and tourism development. Thus, it is not a simple thing to say "that water is good" or "that water is bad." The determination of water quality is typically made relative to the purpose of the water – in this case for recreational (swimming pool).

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. The assessment of these parameters is capable of establishing and tracking alterations in water quality while verifying its suitability for the wellbeing of recreational users and one of the emerging frameworks uses is water quality index.

However, water quality index (WQI) has often been misconstrued to mean water quality standards (WQSs). Although both are concepts used in water quality monitoring and assessment, they are fundamentally different. Water quality index has therefore been seen as priceless and matchless evaluation set up to depict the overall water quality status in a single term that is helpful for the selection of right management modus operandi to meet the concerned issues (Tyagi et al., 2013). Conversely, water quality standards are governance frameworks covering specific uses and water quality criteria to save uses from gratuitous harm (United States Environmental Protection Agency - USEPA, 2016).

The decisive factor espoused and integrated into the standards are the tolerable concentration of pollutants in states, territories and certified clannish waters. The environmental watch dog argued that these norms are corresponding: each is premeditated to save users from harm from particular specie of micro organisms or environmental systems from the unpleasant outcome of contamination. Water quality norms are formulated autonomously based on the best available scientific data and scientific judgments. The criteria are generally listed at some threshold concentration that, if exceeded, would cause harm to aquatic life, wildlife or human health (USEPA, 2016). Thus, while water quality index portrays the combined influence of diverse water quality indicators and conveys water quality issues to the public and legislative decision makers (Tyagi et al., 2013), water quality standards depicts the scientifically established targets approved by regulatory agencies for different water uses (World Health Organization - WHO, 2018).

Till date, there is also 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 them including the World Health Organization (WHO), Australia, Brazil, Canada, India, Tanzania, the United States, the Federal Environmental Protection Agency (FEPA), Standard Organization of Nigeria and Department of Petroleum Resources standards amongst others. Table 1 shows the WHO water quality standards for selected parameters in relation to safe recreational water environments.

Table 1. WHO Standards for Swimming Pools and Similar Environments
Source: WHO (2006)

Parameters	**Maximum Allowable Limit**
Temperature	$26^0 – 30^0$C
Turbidity	≤ 0.5 NTU
pH	7.2 – 7.8
Free residual chlorine	1 – 3 mg/l
Heterotrophic plate count (HPC)	≤ 200 cfu/ml
Escherichia coli	≤ 1/100 ml
Staphylococcus aureus	≤ 100/100 ml

According to the Department of Environment and Climate Change (DECC), Government of Newfoundland and Labrador (2016), a water quality index is a means by which water quality data is summarized for reporting to the public in a consistent manner. Empirical evidence point to the fact that water quality index is accredited to the work of Horton (1965) among the most commonly used water quality variables include dissolved oxygen (DO), pH, coliforms, specific conductance, alkalinity and chloride etc. and has been widely applied and accepted in European, African and Asian countries (Chandra et al., 2017). In the computation of water quality index, a stepwise procedure which relies on indicators of public health importance has been proposed. The initial step involves the choice of water quality indicators. This is the exclusive responsibility of water quality governance authorities and its resource persons and within its jurisdiction. At this step, specific emphasis is given to the concentrations of DO, healthiness implications, physicochemical features as well as suspended mineral salts capable of interfering with the biological activities in the water source (Dunnette, 1979; Scannone, 2016).

The second step entails the establishment of functional relationship among indicators and statistical normalization of all indicators into unitless scale (Fritzsche et al., 2014). The rationale for statistical normalization of all indicators is based on the fact that various water quality indicators are measure on specific scientific unit that is entirely different from others. The final step involves the summing together of all water quality indicators to arrive at a single value otherwise referred to as index (Garcia et al., 2018).

In practice, the water quality index is calculated by comparing the water quality data to established guidelines for water quality. Water quality index measures the scope, frequency, and fluctuations in the level of water quality and then combines the three measures into one score. This calculation produces a score between 0 and 100. The higher the score, the better the quality of water and the scores are then ranked into one of the five categories (DECC, 2016). The 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 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 Weighted Arithmetic Water Quality Index (WAWQI) method originally developed by Brown et al., (1972) categorizes the water quality according to the extent of cleanness taking into consideration`n the generally frequently considered indicators using the formula in equation 1.

$$WQI = \sum QiWi \,/\, \sum Wi \tag{1}$$

The quality evaluation scale (Qi) for each indicator is computed with the function in equation 2:

$$Q = 100[(Vi - Vo \,/\, Si - Vo)] \tag{2}$$

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)
Si = allowable limit of ith indicator.

The respective weight (Wi) for each indicator is computed with the function in equation 3:

$$Wi = K / Si \quad (3)$$

Where K = mathematical constant and is computed with the function in equation 4:

$$K = \frac{1}{\sum(1/Si} \quad (4)$$

The computed water quality index value is then evaluated according the category which it falls as presented in Table 2. Remarkably, the advantage and disadvantages of WAWQI framework has been documented as summarized in Table 3. The major underlying principle for evolution water quality index is pivoted by transforming multifarious indicators of water quality into well-articulated, clear, simple and credulous information of the water source to all users (Akoteyon et al., 2011; Balan et al., 2012; Bora and Goswami, 2016).

Table 2. Water Quality Rating Based on WAWQI Method
Source: (Brown et al., 1972)

WQI Value	Evaluation of Water Quality	Category
0-25	Excellent water quality	*A*
26-50	Good water quality	*B*
51-75	Poor water quality	*C*
76-100	Very Poor water quality	*D*
Above 100	Unsuitable for drinking purpose	*E*

Table 3. Advantages and Disadvantages of WAWQI Framework
Source: (Yogendra and Puttaiah, 2008; Akoteyon et al., 2011; Tyagi et al., 2013)

Advantages	Disadvantages
1. Incorporate data from multiple water quality parameters into a mathematical equation that rates the health of water body with number. 2. Less number of parameters required in comparison to all water quality parameters for particular use. 3. Useful for communication of overall water quality information to the concerned citizens and policy makers. 4. Reflects the composite influence of different parameters i.e. important for the assessment and management of water quality. 5. Describes the suitability of both surface and groundwater sources for human consumption.	1. Water quality index may not carry enough information about the real quality situation of the water. 2. Many uses of water quality data cannot be met with an index. 3. The eclipsing or over-emphasizing of a single bad parameter value 4. A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. 5. Water quality index based on some very important parameters can provide a simple indicator of water quality.

Unfortunately, drinking water quality in Nigeria and other developing countries is questionable not to talk about that of recreational water facilities like swimming pools. This aspect of research has not enjoyed considerable patronage until in recent years. Again, despite the advantages of the approach, empirical evidence on application of water quality index in swimming pools water quality assessment in hotels in emerging African littoral metropolis of Warri, Delta State is lacking. Whereas, water quality index framework have been applied in both surface and groundwater quality assessment all around the world since the last few decades (Kumar and Dua, 2009; Rocha et al., 2015; Bora and Goswami, 2016; Egun and Ogiesoba-Eguakun, 2018; Soleimani et al., 2018).

Based on the significant role played by recreational water activities to health and vitality in general, and the key value of swimming pools to the hospitality and tourism industry, the need to fill these knowledge gaps becomes essential. The study therefore, seeks to analyze the water quality of hotels swimming pools in emerging African littoral metropolis of Warri, Delta State to using water quality index with the view to establish the extent of contamination. The application of water quality index in this study will provide an easy way to understand the status of water quality in swimming pools in Warri and the information will be useful to the public in general, pool operators, planners, managers, and policy makers.

Methodology

Geography of Warri Metropolis

This study was carried out in one of the emerging African littoral metropolis of Warri, Delta State, Nigeria. Warri metropolis is spatially situated between latitudes 5O 27’ 50.468” – 5O 36’ 39.937” North of Equator and longitudes 5O 42’ 34.5” – 7O 49’ 44.431” East of Greenwich as seen in Figure 1. Warri metropolis has constituent parts in Warri South, Udu and Uvwie Local Government Areas. It has also grown to engulf the surrounding towns of Effurun, Ekpan, Enerhen, Orhuwhorun, Ogunu, Jakpa, Ovwian-Aladja and Ugbomro in the last few decades (Efe and Efe, 2002). Warri is one of the rapidly growing metropolis in Nigeria, with the population increasing rapidly from 280,000 in 1980 to 363,382 in 1991, 536,023 in 2006 and subsequently to 814,000 at the end of 2019 (Macrotrends LLC, 2019). Warri thus, has a high population density, concentrated in the areas of the city, including Warri-Sapele road, Agbassa, Okere, Okumagba Avenue, Igbudu, Iyara, Jakpa, Airport road, Petroleum Training Institute (PTI), Udu and Ekpan.

The climate of Warri metropolis falls within the tropical rainforest with frequent influence of tropical continental and maritime air masses. The high-resolution time-series (TS) gridded climatic data of month-by-month variation in climate (version 4.03 - January 1901 - December 2018) released by the University of East Anglia-Climatic Research Unit, Harris and Jones (2019) indicate that temperature is as low as 22.1°C in January and as high as 33.6°C in February in Warri metropolis. Rainfall pattern is bi-modal with the first peak of 507.8 mm in June with a short dry season in August and the second peak of 493.1 mm in September and a total about 3745.7 mm per annum. Relative humidity is generally high due to abundance of rainfall and it ranged from 94% in April to 97% in August with a dry season average of about 80%. Annual potential evapotranspiration is about 57.1 mm with highest value of 5.8 mm observed in February and lowest value of 3.5 mm noticed in July. Mean wind speed is about 2.3 meters per second and may sometime exceed 5 meters per second in peak rainy season.

With respect to the relief, Warri metropolis is generally a low-lying area which situate within the Niger – Delta plain. Digital elevation model (DEM) is a representation of the general relief of the area. DEM represent continuous elevation values over a topographic surface by a regular array of z-values, referenced to a common datum. DEMs are typically used to represent terrain relief. Average elevation is about 10.1 meters and ranged from 2 meters to 29 meters above sea level.

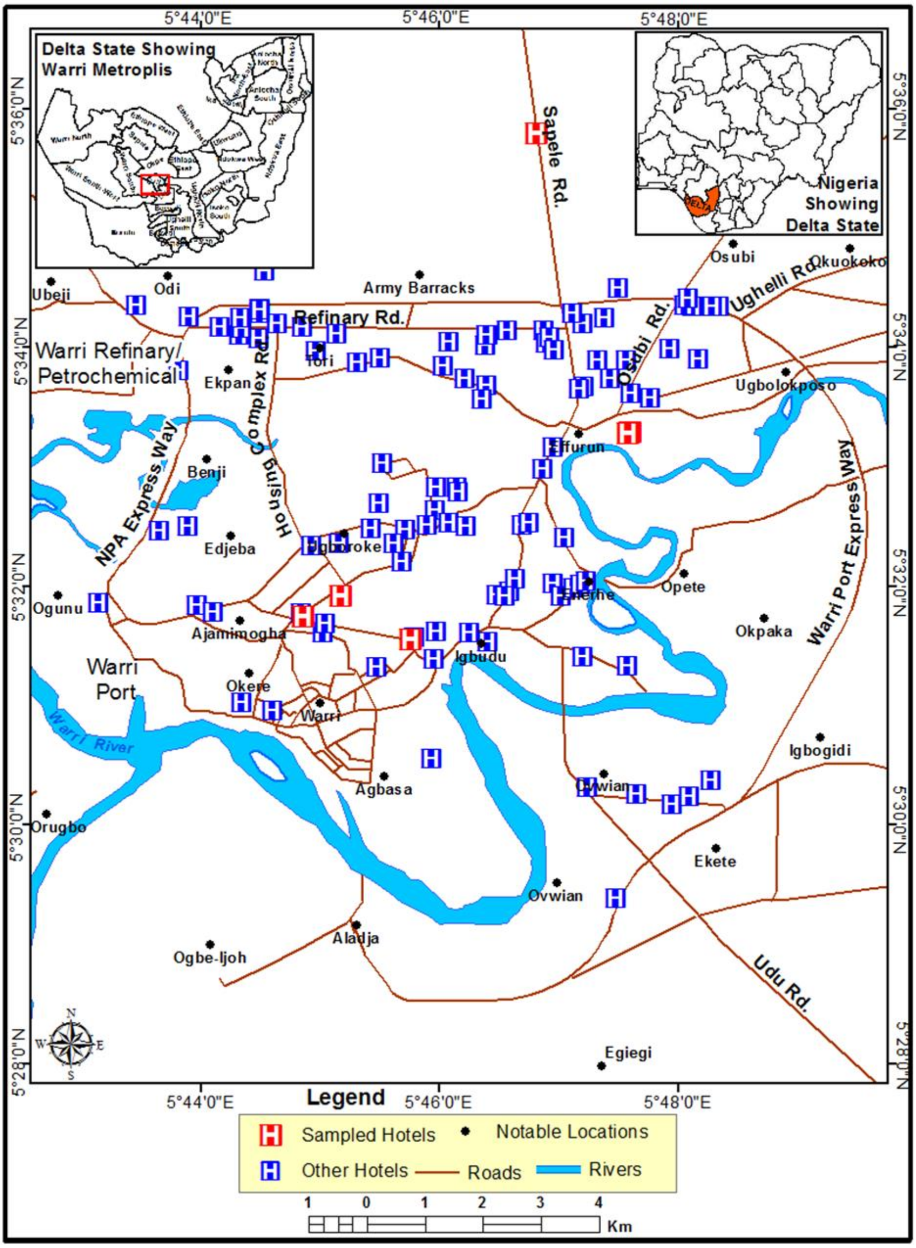

Figure 1. Warri Metropolis Showing Sample Hotels with Swimming Pools

Vegetation in Warri metropolis is characteristic fresh water intermingled with mangrove swamp forest which represents the most luxuriant, complex and diverse terrestrial ecosystem in sub-Saharan Africa. The socio-economic activities in Warri metropolis can be classified into primary, secondary and tertiary activities. The primary activities include agricultural activities and animal husbandry. Secondary activities include several manufacturing and processing activities carried out by firms and oil companies in the metropolis while tertiary activities include activities and services carried out by servicing firms and individuals. Warri metropolis is also an administrative centre, with the headquarters of Warri South LGA, Udu and Uvwie LGA located in it.

Datasets, Sources, Methods of Analyses

This research adopted experimental approach to elucidate information on swimming pool water quality in Warri metropolis. The physical properties of swimming pool water that were investigated include temperature and turbidity. Free (residual) chlorine and pH constituted the chemical parameters while total heterotrophic bacteria (THB), total heterotrophic fungi (THF), Escherichia coli and Staphylococcus aureus made up the microbiological quality parameters. Based on the research objective, these variables were of particular importance to this study. As seen the literature, they are most relevant as far as public health and safety is concerned. According to Delta State Hotels and Tourism Board (DSHTB), there are 214 hotels in Warri based on 2016 records. Out of this figure, 15 of them have functional swimming pools (DSHTB, 2016) representing 7% of the hotels in the town. Stratified random sampling (Kaplan, 2014) based on room rate per night (Table 4) was deployed in selection of five hotels with swimming pools.

Table 4. Stratification of Hotels Based on Room Rate per Night
(Source: Fieldwork, 2019)

S/No	Charges Interval per Night (₦)	Number of Hotels (Frequency)	Description
1	1,000.00 – 5,000.00	4	Very Low
2	5,100.00 – 10,000.00	6	Low
3	10,100.00 – 15,000.00	4	Moderate
4	15,100.00 – 20,000.00	1	High
5	20,100.00 – 25,000.00	1	Very High
		N =16	

Standard procedures were adopted in water sample collection and laboratory analysis in line with the requirements specified by WHO, the American Society for Testing and Materials (ASTM), United States Environmental Protection Agency (USEPA) and American Public Health Association (APHA).The water was obtained from five sampled swimming pools from hotels in Warri metropolis for laboratory investigation during peak period (weekend). In-situ analyses were immediately carried out to determine the following parameters with short holding time; temperature, pH, turbidity, and Free (residual) chlorine. Water samples for microbiology analysis (THB, THF, E. coli and S. aureus) were collected in 200 ml plastic containers, acidified with 10% HNO_3 stored in cooler at 4°C+0. 2°C and immediately transported to the laboratory for analysis using the techniques described in Esinulo and Ogbuagu (2016).

Computation of Water Quality Index (WQI) Swimming Pools

This study used Weighted Arithmetic Water Quality Index (WAWQI) method to compute water quality index of hotels' swimming pools water quality in Warri metropolis. Thus, with the aid of Equations 1 – 4 earlier stated the laboratory results of water quality indicators per sampled swimming pool were used as input in water quality index computation. However, this study adopted a bottom – up approach in the computation of water quality index through the following step:

Step 1: Determination of K for pH, temperature, turbidity and free (residual) chlorine using Equation 4.

$$pH = K = \frac{1}{\sum(1/7.8)} = \frac{1}{0.128} = 7.813$$

$$Temperature = K = \frac{1}{\sum(1/30)} = \frac{1}{0.033} = 30.303$$

$$Turbidity = K = \frac{1}{\sum(1/0.5)} = \frac{1}{2} = 0.5$$

$$Free\ (residual)\ chlorine = K = \frac{1}{\sum(1/0.5)} = \frac{1}{2} = 0.5$$

Step 2: Computation of the unit weight (*Wi*) for pH, temperature, turbidity and free (residual) chlorine using Equation 3.

$$pH = W\,i = \frac{K}{Si} = \frac{7.813}{7.8} = 1.002$$

$$Temperature = Wi = \frac{K}{Si} = \frac{30.303}{30} = 1.0101$$

$$Turbidity = Wi = \frac{K}{Si} = \frac{0.5}{0.5} = 1$$

$$Chlorine = Wi = \frac{K}{Si} = \frac{3.03}{3} = 1.01$$

Step 3: Computation of the quality rating scale (*Qi*) for each parameter in all the 5 sampled swimming pools using Equation 2.

<u>Brook View Hotel</u>

$$pH = Qi = \left[\frac{Vi-Vo}{Si-Vo}\right]100 = \left[\frac{6.40-7.0}{7.8-7.0}\right]100 = -75$$

$$Temperature = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{25-0}{30-0}\right]100 = 83.3$$

$$Turbidity = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{0.63-0}{0.5-0}\right]100 = 126$$

$$Chlorine = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{0.4-0}{3-0}\right]100 = 13.3$$

Oasis Hotel

$$pH = Qi = \left[\frac{\mathrm{Vi-Vo}}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{6.60-7.0}{7.8-7.0}\right]100 = -50$$

$$Temperature = Qi = \left[\frac{\mathrm{Vi-Vo}}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{25-0}{30-0}\right]100 = 83.3$$

$$Turbidity = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{1.85-0}{0.5-0}\right]100 = 370$$

$$Chlorine = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{0.2-0}{3-0}\right]100 = 6.67$$

BB Hotel

$$pH = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{6.20-7.0}{7.8-7.0}\right]100 = -100$$

$$Temperature = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{25-0}{30-0}\right]100 = 83.3$$

$$Turbidity = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{1.08-0}{0.5-0}\right]100 = 216$$

$$Chlorine = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{0.2-0}{3-0}\right]100 = 6.67$$

Wellington Hotel

$$pH = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{6.10-7.0}{7.8-7.0}\right]100 = -112.5$$

$$Temperature = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{25-0}{30-0}\right]100 = 83.3$$

$$Turbidity = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{0.16-0}{0.5-0}\right]100 = 32$$

$$Chlorine = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{0.2-0}{3-0}\right]100 = 6.67$$

Best Western Hotel

$$pH = Qi = \left[\frac{Vi-Vo}{\mathrm{Si-Vo}}\right] 100 = \left[\frac{6.30-7.0}{7.8-7.0}\right]100 = -87.5$$

$$Temperature = Qi = [\frac{Vi-Vo}{\mathrm{Si}-\mathrm{Vo}}]\ 100 = [\frac{29-0}{30-0}]100 = 96.67$$

$$Turbidity\ \ = Qi = [\frac{Vi-Vo}{\mathrm{Si}-\mathrm{Vo}}]\ 100 = [\frac{0.72-0}{0.5-0}]100 = 144$$

$$Chlorine\ \ = Qi = [\frac{Vi-Vo}{\mathrm{Si}-\mathrm{Vo}}]\ 100 = [\frac{0.2-0}{3-0}]100 = 6.67$$

Step 4: Computation of the water quality index for all the five sampled swimming pools using Equation 1.

(a) Water quality index for Brook View Hotel Swimming Pool

$$\frac{(-75 \mathrm{X}\ 1.002)+(83.3 \mathrm{X}\ 1.0101)+(126 \mathrm{X}\ 1)+(13.3 \mathrm{X}\ 1.01)}{(1.002+1.0101+1+1.01)} = \frac{(-75.15)+(84.14)+(126)+(13.433)}{(4.0221)} = 36.9$$

(b) Water quality index for Oasis Hotel Swimming Pool

$$\frac{(-50 \mathrm{X}\ 1.002)+(83.3 \mathrm{X}\ 1.0101)+(370 \mathrm{X}\ 1)+(6.67 \mathrm{X}\ 1.01)}{(1.002+1.0101+1+1.01)} = \frac{(-50.1)+(84.14)+(370)+(6.74)}{(4.0221)} = 102.1$$

(c) WQI for BB Hotel Swimming Pool

$$\frac{(-100 \mathrm{X}\ 1.002)+(83.3 \mathrm{X}\ 1.0101)+(216 \mathrm{X}\ 1)+(6.67 \mathrm{X}\ 1.01)}{(1.002+1.0101+1+1.01)} = \frac{(-100.2)+(84.14)+(216)+(6.74)}{(4.0221)} = 51.4$$

(d) WQI for Wellington Hotel Swimming Pool

$$\frac{(-112 \mathrm{X}\ 1.002)+(83.3 \mathrm{X}\ 1.0101)+(32 \mathrm{X}\ 1)+(6.67 \mathrm{X}\ 1.01)}{(1.002+1.0101+1+1.01)} = \frac{(-112.73)+(84.14)+(32)+(6.74)}{(4.0221)} = 2.52$$

(e) WQI for Best Western Hotel Swimming Pool

$$\frac{(-87.5 \mathrm{X}\ 1.002)+(96.6 \mathrm{X}\ 1.0101)+(144 \mathrm{X}\ 1)+(6.67 \mathrm{X}\ 1.01)}{(1.002+1.0101+1+1.01)} = \frac{(-87.7)+(97.6)+(144)+(6.74)}{(4.0221)} = 39.9$$

This produced a score (value) ranging from 0 to 100. Using Table 2, each swimming pool was categorized based on quality. DECC (2016) however asserted that a higher score depicts poor water quality while a lower value is an indication of high water quality.

Results and Discussion

The computation of water quality index of five sampled hotels' swimming pools in emerging African littoral metropolis of Warri, Delta State, Nigeria was based on four physicochemical water quality parameters of pH, temperature, turbidity and chlorine. The microbiological indicators were not computed for since their concentration was not observed in the water samples. Absence of microbiological indicators in all the sampled swimming pools in Warri metropolis is a pointer to high level of compliance stipulated by WHO (2006). Nevertheless, this finding contradicts earlier 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. A related study of swimming pools in Shahrekord City, Iran also had microbiological indicators higher than acceptable limit set by regulatory authorities (Fadaei and Amiri, 2015). In contrast, the finding corroborates the finding of Amala and Aleru (2016) where E. coli and S. aureus were conspicuously not discovered in all 10 sampled swimming pools in Port Harcourt metropolis. The authors further argued that this level can only be maintained with routine screening to avert possible contamination.

Similarly, it was found that the mathematical constant (K) for pH was 7.813, temperature (30.303), turbidity (0.5) and free (residual) chlorine (0.5). Although empirical evidence on the use of water quality index in assessing swimming pool water quality is lacking for result synthesis, the K factor for pH found in this study was higher than the value reported by Soleimani et al., (2018) while evaluating water quality used for consumption and irrigation in Kurdistan, Iran. With respect to unit weight (Wi) pH was 1.002, temperature (1.0101), turbidity (1) and free (residual) chlorine (1.01). Regarding Qi in Brook View Hotel, pH was – 75, temperature (83.3), turbidity (126) and Chlorine (13.3). Oasis Hotel recorded Qi of – 50 for pH, temperature (83.3), turbidity (370) and Chlorine (6.67).

BB Hotel had Qi of –100 for pH, temperature (83.3), turbidity (216) and Chlorine (6.67). In Wellington Hotel recorded Qi of –112.5 for pH, temperature (83.3), turbidity (32) and Chlorine (6.67). Wellington Hotel resulted in Qi of –87.5 for pH, temperature (96.67), turbidity (144) and Chlorine (6.67). Again, the unit weight (Wi) for pH and turbidity discovered in this study was relatively higher than 0.322 for pH and 0.005 for turbidity report by Kumar and Dua (2009) while deploying water quality index in the evaluation of water quality of River Ravi, Madhopur, India. Also, Qi for free (residual) chlorine found in this work was higher than 0.105 reported by Rocha et al., (2015) while investigating the portability of water in Orós Reservoir (Northeast of Brazil) for drinking purpose.

The overall water quality index of the five sampled swimming pools as summarized in Table 5 showed that swimming pool located in Wellington Hotel had water quality index value of 2.52 and considered excellent in terms of water quality.

Table 5. Computed Water Quality Index of Sampled Hotels' Swimming Pools in Warri
Source: Fieldwork, 2019

S/No	Sampled Hotel	WQI	Standard Value	Classification
1.	Brook View	36.9	26 – 50	Good water quality
2.	The Oasis Place	102.1	> 100	Unsuitable for recreational purpose
3.	BB Hotel	51.4	51 – 75	Poor water quality
4.	Wellington Hotel	2.52	0 – 25	Excellent water quality
5.	Best Western Plus	39.9	26 – 50	Good water quality

Also, Brook View Hotel with water quality index of 36.9 and Best Western Plus with water quality index of 39.9 were categorized as good water quality. The excellent and good water quality observed in three out of the five sampled swimming pools may not be unconnected to the maintenance of high hygiene and sanitation standards by operators and swimmers. This implied that swimmers would have very little or no health hazard in any event of accidental swallowing of the swimming pool water. This finding corroborates with that of Egun and Ogiesoba-Eguakun (2018) who reported excellent water quality (9.17-10.40) between February-June 2016 in Okhuaihe River, Edo State, Nigeria.

On the contrary, poor water quality (51.4) was reported in swimming pool owned and operated by BB Hotel while the swimming pool in The Oasis Place Hotel was categorized unsuitable for recreational purpose based on the water quality index of 102.1. Similarly, poor water quality, which was believed to have been caused by noticeable coloration, turbidity and dissolved salts, had previously been reported at the upper course of Orós Reservoir (Rocha et al., 2015). Concerted efforts are therefore needed by operators of these hotels to work on measures to improve the quality of water in the swimming pools in order to meet with established standard and fit for recreational purposes.

Conclusion

The quality of recreational water in many Nigerian cities cannot be neglected because of the risk and implications to human health. The prime motivation for carrying out this study was deploy the ingenuity offered by water quality index framework to provide a distinct score to the water quality of swimming pools in hotels in Warri metropolis. Water quality index facilitated the transformation of several indicators and their concentration present in a sample into a single value. These water quality index scores consecutively provided far-reaching explanation of the quality of water and its suitability for recreational purposes. One swimming pool water quality was categorized excellent, two were graded good, one each was ranked poor and unsuitable for recreational purpose whereas. The categorization of water quality of hotels' swimming pools water quality in Warri metropolis was facilitated by the deployment of Weighted Arithmetic Water Quality Index (WAWQI) framework.

At first sight, potential tourist, fun seekers, policy makers and other stakeholders can know the status of each swimming through the water quality index scores. Operators and managements of individual hotel and swimming pool can also use the index in facility-based evaluation of the extent of success and/or failure recorded so far while also exploring opportunities for improvement and sustainable water quality maintenance. The study therefore recommends routine and periodic surveillance of swimming pools and other recreational water sources to guarantee optimum health and wellbeing of users. This can be achieved through massive enlightenment by appropriate media and regulatory authorities. Also, effective institutional arrangement and governance framework capable of handling issues related to policies, proper legislation, enforcement, right systems, etc. should be put place in Warri metropolis and other emerging cities in Nigeria.

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