International Journal of Innovative Environmental Studies Research 4(1):28-34, Jan.-Mar. 2016

© SEAHI PUBLICATIONS, 2016 www.seahipaj.org ISSN: 2354-2918

Quality Assessment of Selected Public Swimming Pools in Owerri Metropolis, Nigeria

A.C. ESINULO* & D.H. OGBUAGU
Department of Environmental Technology,
Federal University of Technology, PMB 1526, Owerri, Nigeria
***Corresponding author, e-mail: e.amanna@yahoo.com**

ABSTRACT
A total of 42 water samples were collected from 7 swimming pools in Owerri for 3 months in 2015. Samples were collected in sterile 250mL bottles from 4 points in each pool and composited each time in the morning (after pool treatment) and evening (after pool use) on high-visit days from about 1ft water depth. *In situ* measurements were made for pH and temperature. Standard laboratory methods were used to analyze samples for both physicochemical parameters and coliforms. Variation plots, ANOVA, Duncan Multiple Range Test and correlation (r) were used to analyze data. Mean water temperature, pH and Total Dissolved Solids (TDS) were all within the approved American National Standard Institute (ANSI) recommendations of <40ºC, 7.2-7.8 and <1500 mg/L respectively in all the pools, while mean total alkalinity, Ca hardness, Cl_2 and *E. coli* counts were below the respective 60-180 mg/L, 150-1000 mg/L, 1.0-4.0 mg/L and <2 MPN/100 mL ANSI recommended standards. Mean concentrations of TDS, total alkalinity and Ca hardness differed significantly (F=0.015, 0.032 and 0.045 respectively) across the pools at P<0.05. TDS correlated with *E. coli* counts (r=0.318) at the 95% confidence limit. Observed parameters which exceeds recommended bathing loads in several of the pools appeared to introduce many dissolved solids in water, and this in turn depleted residual chlorine sanitizer applications, and so, encouraged the growth of coliform bacteria that were also introduced by the bathers.
Keywords: Swimming pools, Quality Parameters, Bathing Load, Coliforms, Sanitizers

INTRODUCTION

Recreational use of water can deliver important benefits to health and well-being of humans. Yet, there may also be adverse health effects associated with it if the water is polluted or unsafe. A swimming pool is a potential disease zone as it could house many pathogenic microorganisms, including bacteria, viruses, fungus etc that are generated from human use and the environment, and which can cause adverse health effects. Research has confirmed at least 36 infectious diseases that probably can be transmitted directly by water (Akhionbare, 2009).

Common sources of contamination in pool water quality include the water source, bather-derived chemicals, and pool maintenance chemicals (Jandik, 1977; WHO, 2006). It has been estimated that a swimmer will lose about two pints of sweat per hour if active in pool water at 75^0F with the ambient temperature at approximately 100^0F (Kuno, 1956). The management of swimming pool facilities is therefore critical for contamination control and will check the introduction of contaminants, inactivate introduced harmful micro-organisms and control the number of users (WHO, 2006; BSI, 2003).

In West Africa, information on extensive survey of swimming pool water quality is scarce (Abd El-Salam, 2012; Van Heerden et al., 2005; Courage and Saviour, 2015) and data on swimming load is almost nonexistent. A few scholars have carried out research and publications on pool water quality and most reveal that there was poor compliance to pool water standards especially in Nigeria (Sule and Oyeyiola, 2012; Agbagwa and Young-Harry, 2012). Record on indicator organisms like *Escherichia coli* which shows evidence of fecal contamination in swimming pools (ANSI, 2009) and the risk of disease outbreak

they pose are unavailable. This is besides the poor monitoring of swimming pools by health officers, lack of documentation of information on infections and outbreaks, as well as non-enforcement of regulations guiding the operations of public swimming pools. Many swimming pool operators and managers are either untrained or poorly trained. There is therefore the need to look into the operations of public swimming pools with a view of investigating their health and hygiene, as to ascertain the level of risk they pose, the level of compliance when compared to international standards for swimming pool water quality, and possible recommendations for improvement.

METHODOLOGY

Field Sampling

A total of 42 water samples were collected from swimming pools belonging to 7 Hotels in Owerri in May, August and September, 2015. Samples were collected in sterile 250mL bottles from 4 points in each pool and composited each time in the morning (after pool treatment) and evening (after pool use) on high-visit days (usually weekends) from about 1ft water depth. They were thereafter transported in ice box to the laboratory. *In situ* measurements were made for pH and temperature using a pH meter (from Rex Instrument Factory Shanghai) and mercury-in-glass Thermometer. Colour was determined using Nessleriser and comparison with standard disc NSA was made.

Laboratory Analysis

The Lovibond Comparator Method was used to determine free chlorine; Calcium hardness was determined using EDTA titration method; Total alkalinity was determined by titrating samples against standard acid with methyl orange as indicators; while Total dissolved solids was determined by evaporating filtered samples on weighed dishes at 105^{o}C to constant weight and taking the difference in weight over the empty dish.

Bacteriological Analysis

The multiple tube test method with Mac Conkey Broth was used to enumerate total coliforms. Tubes were incubated at 37^{o}C for 48 hours and the Most Probable Number of presumptive coliform bacilli per 50ml of sample was estimated from the MPN table of McCrady. For *Escherichia coli*, positive tubes from the presumptive tests in total coliform analysis was sub-cultured into Brilliant Green Lactose Bile Broth and incubated at 44^{o}C for 24 hours. The MPN of *E. coli* per 50ml of sample was calculated by means of the MPN tables from the positive test streaks made on Endo Agar, Mac Conkey Agar and Eosin Methylene Blue Agar, and incubated at 44^{o}C for 24 hours. Counts were expressed in MPN/100 mL.

Statistical Analysis

Data were analyzed with the SPSS© v. 22.0 and MS Excel© 2007 softwares. Variation plots were used to represent mean levels of the quality parameters of the pools sampled. One-Way ANOVA was used to determine homogeneity in mean variance of the parameters across the sampling locations, and post-hoc mean separation done with the Duncan Multiple Range Test (DMRT) at $P<0.05$. The Pearson correlation coefficient (r) was used to explore possible relationships between the parameters.

RESULTS

Bathing Loads of Pools

Table 1 shows maximum bathing loads of the swimming pools sampled, in relation to the British Standard Institute (BSI) specifications (BSI, 2003), shown in Table 2. Most of the swimming pools (5 out of 7) have unacceptable bathing load, with almost double their ideal number of swimmers. They included pools sampled in Links Hotels (83 against 36 bathers), Concorde Hotels (186 against 123 bathers), Ideal Suite Hotels (73 against 42 bathers), Owerri Hotel Plaza 81 against 48 bathers) and Lobic Meridian Hotels (66 against 37 bathers). However, only two swimming pools, belonging to The Legend Hotels and All Seasons Hotels had bathing loads that ware within acceptable limits.

Table 1. Dimensions and maximum bathing loads for selected swimming pools in Owerri

Pools Code	Pools Dimensions				Max. allowable use (persons)	Actual use (Sunday average) (persons)
	Length(m)	Width(m)	Average depth(m)	Area(m^2)		
A	**16.67**	**8.48**	**1.97**	**141.36**	**36**	**83**
B	**13.64**	**7.58**	**1.67**	**103.39**	**26**	**25**
C	**25.43**	**13.03**	**1.5**	**331.35**	**123**	**186**
D	**14.04**	**8.05**	**1.5**	**113.02**	**42**	**73**
E	**17.40**	**10.86**	**1.67**	**315.57**	**48**	**81**
F	**16.18**	**9.10**	**1.83**	**147.24**	**37**	**66**
G	**11.00**	**6.43**	**1.37**	**96.90**	**27**	**11**

A=Links Hotels, B=The Legend Hotel, C=Concorde Hotels, D=Ideal Suite Hotels, E=Owerri Hotel Plaza, F=Lobic Meridian Hotel, G=All Seasons Hotel

Table 2: Swimming Pools Maximum Bathing Loads

Water Depth (m)	Maximum Bathing Load (m^2)
<1.0	1 bather per 2.2
1.0-1.5	1 bather per 2.7
>1.5	1 bather per 4.0

(Source: BSI, 2003)

Quality parameters of pools

Figures 1, 2 and 3 show mean physicochemical and bacteriological quality parameters of the pools studied. Mean air temperature varied from 25.8 ºC in Links Hotel to 26.9 ºC in Owerri Hotel Plaza, water temperature varied from 25.5 ºC in The Legend Hotels to 26.9 ºC in Owerri Hotel Plaza, and pH varied from 7.44 in The Legend Hotels to 7.68 in the Concorde Hotels (Fig. 1). Mean TDS varied from 45.05 mg/L in Owerri Hotel Plaza to 158.5 mg/L in Links Hotels, total alkalinity varied from 22.5 mg/L in All Seasons Hotels to 44.33 mg/L in Owerri Hotel Plaza and Ca hardness varied from 16.71 mg/L in The Legend Hotels to 61.41 mg/L in The Links Hotels (Fig. 2). However, residual chlorine contents varied from 0.08 mg/L in The Legend Hotels to 0.1 mg/L in both The Links Hotels and All Seasons Hotels, while *Escherichia coli* counts varied from 3.00 MPN/100mL in All Seasons Hotels to 7.33 MPN/100mL in Concorde Hotels (Fig. 3).

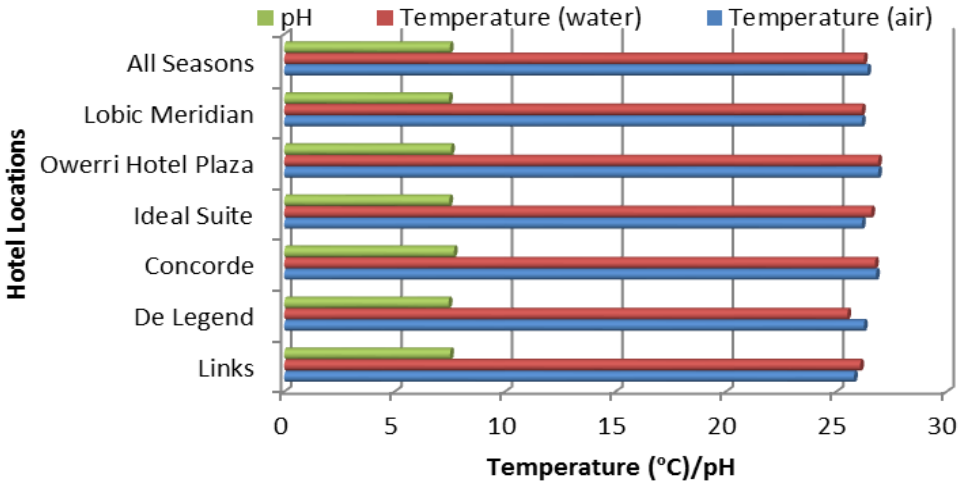

Fig. 1. Mean variations in quality parameters of selected swimming pools in Owerri, Imo State

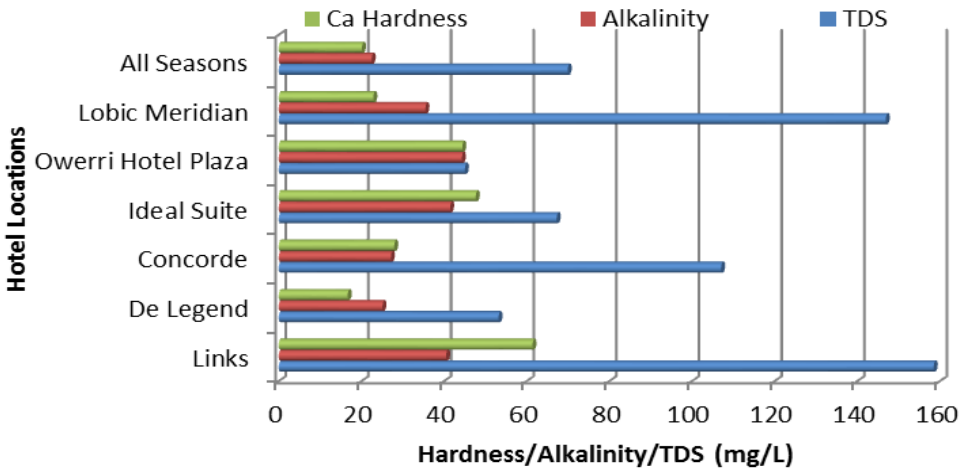

Fig. 2. Mean variations in quality parameters of selected swimming pools in Owerri, Imo State

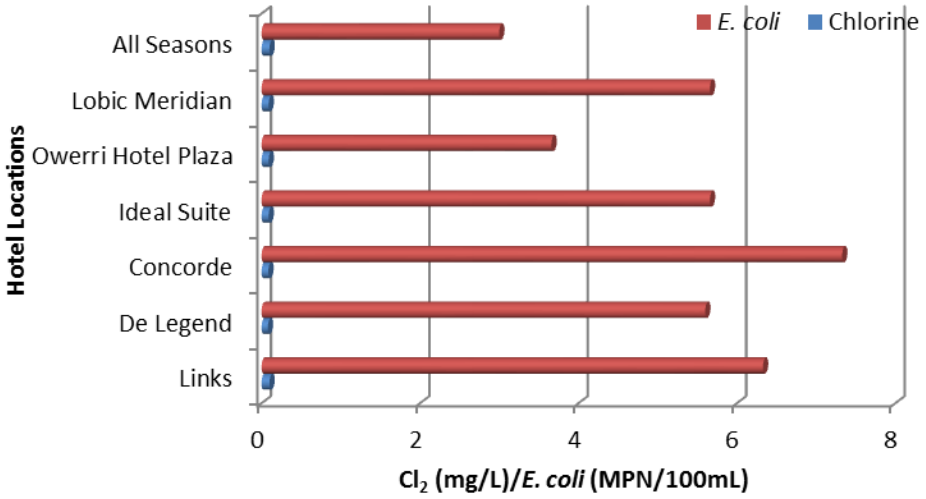

Fig. 3. Mean variations in quality parameters of selected swimming pools in Owerri, Imo State

Of these parameters, mean water temperature, pH and Total Dissolved Solids (TDS) were all within the approved American National Standard Institute (ANSI) (ANSI, 2009) standard values of <40ºC, 7.2-7.8 and <1500 mg/L respectively in all the pools. However, the mean concentrations of total alkalinity, Ca hardness, residual Cl_2 and *E. coli* were below the respective 60-180 mg/L, 150-1000 mg/L, 1.0-4.0 mg/L and <2 MPN/100 mL ANSI recommended standards.

The One-Way Analysis of Variance (ANOVA) test indicate that only the mean concentrations of TDS, total alkalinity and Ca hardness differed significantly (F values = 0.015, 0.032 and 0.045 respectively) across the pools at P<0.05. The Duncan Multiple Range Test (DMRT) revealed that mean TDS values differed significantly between Links Hotels and The Legend Hotels, Ideal Suite Hotels, Owerri Hotel Plaza and All Seasons Hotels at P<0.05 (Table 3). Total alkalinity values were significantly different between Owerri Hotel Plaza and All Seasons and The Legend Hotels. Ca hardness levels were significantly different between Links Hotels and The Legend Hotels and All Seasons Hotels.

The Pearson correlation revealed that only TDS correlated significantly with *E. coli* (r=0.318) at P<0.05.

Table 3. Mean separation in quality parameters of the selected swimming pools in Owerri using Duncan Multiple Range Test (DMRT) (P<0.05)

Parameters	Pools locations						
	A	B	C	D	E	F	G
Air temperature	25.83^{a}	26.25^{a}	26.83^{a}	26.17^{a}	26.92^{a}	26.17^{a}	26.42^{a}
Water temperature	26.08^{a}	25.50^{a}	26.75^{a}	26.58^{a}	26.92^{a}	26.17^{a}	26.25^{a}
pH	7.51^{a}	7.45^{a}	7.68^{a}	7.48^{a}	7.56^{a}	7.47^{a}	7.50^{a}
TDS	174.68^{a}	53.20^{c}	107.08^{abc}	67.28^{bc}	83.38^{bc}	146.93^{ab}	65.95^{bc}
Alkalinity	40.50^{ab}	25.17^{bc}	27.17^{abc}	41.50^{ab}	44.33^{a}	33.83^{abc}	22.50^{c}
Ca Hardness	61.41^{a}	16.71^{c}	27.97^{abc}	47.72^{abc}	44.44^{abc}	53.91^{ab}	20.15^{bc}
Cl_2	0.09^{a}	0.10^{a}	0.09^{a}	0.09^{a}	0.09^{a}	0.09^{a}	0.10^{a}
E. coli	6.33^{a}	5.67^{a}	7.33^{a}	5.67^{a}	3.67^{a}	5.67^{a}	3.00^{a}

Values with same superscripts along same rows are not significantly different at P<0.05, A=Links Hotels, B=The Legend Hotel, C=Concorde Hotels, D=Ideal Suite Hotels, E=Owerri Hotel Plaza, F=Lobic Meridian Hotel, G=All Seasons Hotel

DISCUSSION

In this study, the number of users per pool varied according to the size of the pool. It is however not clear if the observed compliance with bathing loads in the two swimming pools was deliberate or forced by lack of patronage. Similar to the current work, Al-Khatib et al (2003) had observed that overcrowded public swimming pools are almost normal features in many developing countries.

As more bathers introduce microorganisms and body oils, sanitizer demand increased while pH decreased (ANSI, 2009; Burry et al., 2001; Elizabeth, 2012). Therefore in cases of high number of bathers, pH and sanitizer should be checked more frequently. An elevated microbial load was obviously associated with increased number of bathers in the pools studied. Bathing nonetheless introduced many dissolved solids in the pools, and this in turn encouraged the growth of coliform bacteria, which are also introduced by bathers.

According to WHO guidelines for safe recreational water environments, a cause-effect relationship has been established between ingestion of bather-derived contaminated pool water by swimmers (which is a regular occurrence that depends upon a range of factors including experience, age, skill and type of activity), and several adverse health conditions.

The non-compliance of alkalinity and calcium hardness to recommended standard creates worry, giving the importance these parameters in maintaining pH, swimmer comfort, sanitizer efficacy, water balance and clarity (ANSI, 2009). Residual chlorine, a very critical parameter was deficient in all the pools. This conforms with the results of earlier researches that also associated poor sanitation of public swimming pools with decreasing sanitizer contents (Sule and Oyeyiola, 2012; Agbagwa and Young-Harry, 2012; Elizabeth, 2012). The implication of this was the presence of *Escherichia coli* in all the pools, indicating fecal contamination and risk of contracting other pathogenic microorganisms in the swimming pools. Elsewhere, this had led to the outbreak of diseases from swimming pools globally (CDC, 2001; Brewster et al., 1994; Hildebrand et al., 1996).

CONCLUSION

This research revealed that majority of the swimming pools sampled did not comply with the British Standard Institute's recommended bathing loads for pools. Several pools did not comply with water quality standard of the American National Standard Institute in levels of total alkalinity, calcium hardness, free chlorine contents and coliform bacteria counts.

RECOMMENDATIONS

There is urgent need to develop an effective surveillance program for health officers to better monitor public swimming pools for strict compliance with operational standards. Furthermore, there is need to develop a comprehensive standard practice and regulation to address such grey areas as situations that could call for immediate pool closure, registration and approval of sanitizers, pool water testing frequency, water replacement interval and bathing load

REFERENCES

Akhionbare, S.M.O. (2009). *The Environment*. MC Computer Press, Nnewi, Nigeria. P.193, 177

Jandik, J. (1977). Studies on Decontamination of Swimming Pool Water with Consideration of Ozonation of Nitrogen Containing Pollutants. *Dissertation*, Technical University Munich.

WHO (2006). Guidelines for Safe Recreational Water Environments, Volumes 1 & 2: Swimming Pools and Similar Environments. Geneva, World Health Organisation.

Kuno, Y. (1956). Human Perspiration, C.C. Thomas Springfield, IL. Referenced in G.C. White, Handbook of Chlorination, 1st ed. 1972 and ANSI, *American National Standard for Water Quality in Public Pools and Spas*, ANSI/ANSP -11 2009.

British Standard Institute (BSI) (2003). *Management of Public Swimming Pools-Water Treatment Systems, Water Treatment Plan and Heating and Ventilation Systems-Code Practice*, Publicly Available Specification (PAS) 39.

Abd El-Salam, M.M. (2012). Assessment of water quality pools: A case study in Alexandria, Egypt. *Environ. Monit. Assess*., 184: 7395-7406

Van Heerden, J., Ehlers, M.M. and Grabow, W.O.K. (2005). Detection and Risk Assessment of Adenoviruses in Swimming Pool Water. *J. Applied Microbiol.*, 99: 1256-1264.

Courage, K.S.S. and Saviour, K.T. (2015). Water Quality Assessment of Swimming Pools and Risk of Spreading Infections in Ghana. *Research Journal of Microbiology*, ISSN 1816-4935

Sule, I.O. and Oyeyiola, G.P. (2012). Bacteriological Assessment of Some Swimming Pools Within Ilorin Metropolis, Kwara, Nigeria. *Bioresearch Bulletin*, 1: 41-45.

Agbagwa, O.E. and Young-Harry, W.M. (2012). Health Implications of Some Public Swimming Pools Located in Port Harcourt, Nigeria. *Public Health Research*, 2(6): 190-196American National Standards Institute (ANSI) (2009). *American National Standard for Water Quality in Public Pools and Spas*, ANSI/ANSP -11 2009.

Al-Khatib, I. and Salah, S. (2003). Bacteriological and chemical quality of swimming pools water in developing countries: A case study in the West Bank of Palestine. *International Journal of Environmental Health Research*, 13(1): 17-22.

Burry, J., Coulson, H.F. and Roberts, G. (2001). Circadian Rhythms in Axillary Skin Surface pH. *International Journal of Cosmetic Science*, 23(4): 207-210

Elizabeth, O. O. (2012). Assessment of Microbiological Quality and Sanitary Status of Swimming Pools in Ibadan, Nigeria. *Keynote Conference*, pp. 1-6

CDC (2001). Shigellosis Outbreak Associated with an Unchlorinated Fill and Drain wading pool_Iowa. *Morbidity and Mortality Weekly Report*, 50(37): 797-800.

Brewster, D.H., Brown, M.I., Robertson, D., Houghton, G.L., Brimson, J. and Sharp, J.C.M. (1994). An Outbreak of Escherichia Coli 0157 Associated With a Children's Paddling Pool. *Epidemiology and infection*, 112: 441-447

Hildebrand, J.M., Maguire, H.C., Halliman, R.E. and Kangesu, E. (1996). An Outbreak of *Escherichia coli* 0157 Infection Linked to Paddling Pools. *Communicable Disease Report Review*, 6:R33-R36