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Analysis of Chemical and Microbial Contents of Public Swimming Pools' Water in Akwa Ibom State, Nigeria

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ABSTRACT: This study assessed the chemical and microbial contents in the water of public swimming pools in Akwa Ibom State, Nigeria. A total of 16 public pools were selected through probability sampling from the 32 pools that existed in the five urban areas of Akwa Ibom State. Water samples were collected from the sampled pools and tested in the laboratory for chemical and microbial contents. Results showed that the chemical contents of most pools in the study area were less than the values recommended for effective disinfection of the pools. Average free chlorine ranged from 0.05 mg/L to 1.15 mg/L <2 mg/L to 4 mg/L recommended, except for sites L and M that had 2.31 mg/L and 2.42 mg/L. Total bromine ranged from 1.3 mg/L to 3.2 mg/L <4 mg/L to 6 mg/L except for sites L and M with 5.4 mg/L and 4.4 mg/L, respectively. Microbial contents of most swimming pools in the study area were higher than permissible values for swimming pools. Mean heterotrophic bacteria ranged from 2.8×104 - 8.1×104 Cfu/ml >200 Cfu/ml permissible, except for pools L and M, with 1.8×102 Cfu/ml and 1.7×102 Cfu/ml, respectively. Mean fecal coliform ranged from 2.0×103 Cfu/ml to 4.4×103 Cfu/ml >10 Cfu/100 ml permissible, except for pools L and M, with 0.0 Cfu/ml. It could therefore be concluded that only one out of every eight public swimming pools in Akwa Ibom State meet the minimum requirement for both chemical and microbial contents. This simply implies that most public swimming pools in the study area are not safe for users.

Keywords: chemical content, microbial content, swimming pool

INTRODUCTION

A swimming pool is an artificial basin, chamber or tank, used or intended to be used for swimming, diving, or recreational bathing, but does not include baths where the main purpose is the cleansing of the body, nor individual therapeutic tubs (Health System Accountability and Performance-HSAP, 2014). Pools, apart from adding beauty to property and enhancing aesthetics, are used for bathing, relaxation, therapy, swimming, military training and exercise, socializing, water sports, as well as for the training of lifeguards and astronauts (Haraldsson and Cordero, 2014). The great Greek philosopher Plato felt that every child needed to learn to swim as part of a proper education along with mathematics, writing, astronomy, and so on (Bellis, 1997). In fact, it was standard education dating all the way back to 400 BC to teach children to swim in pools. Recently, swimming has become a prerequisite for employment in certain sectors like aviation, marine, oil drilling and prospecting. More people are also learning to swim because of the health benefits associated with swimming. Sadly, swimming pools have a wide variety of microorganisms which are introduced in different ways, and

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pool users inadvertently ingest a substantial amount of the water while using the pool (Evans *et al*., 2001). This enhances the transmission of plagues and other epidemics causing pools to be dreaded by many. WHO (2006) and Nichols (2006) link the risk of illness or infections in recreational waters to fecal contamination by bathers and animals, or a contaminated source of water. Water contamination can result in a number of casualties. For instance, cases of outbreak of cryptosporidiosis were reported in London, Autralia, the UK and Iran (Brewin, 2009; Aljanahi, 2013; Alia *et al*., 2014). The outbreak of cryptosporidiosis associated with swimming pools in the UK was also reported by Joce *et al*. (1991) where 67 confirmed cases occurred following ingress of sewage from a faulty plumbing pipe into the pool. Approximately 10–20% of the general population worldwide is infected by *dermatophytes* (Sima *et al*., 2012). *Dermatophytes* are a type of fungus that can live on external skin, within hair follicles, and in skin lesions. They can be transmitted to others through direct contact such as water in a swimming pool, wrestling mats, and physical contact in sports (Mattei *et al*., 2014). Other pathogens that could be found in swimming pools include: *Pseudomonas aeruginosa, Staphylococcus aureus*, *Staphylococcus epidermidis*, *Penicillium sp, Rhizopus sp, Aspergillus, Fusarium sp, Trichophyton mentagrophytes* and *Mucor sp* (Itah and Ekpombok, 2004; Tate *et al*., 2003; Somekh *et al*., 2003; Schets *et al*., 2004; Braue *et al*., 2005; WHO, 2006).

Many of the outbreaks related to swimming pools could have been prevented or reduced if the pools had been well managed. Pool water should be of potable quality and is mostly treated with addition of disinfectants like chlorine, bromine and ozone, as well as the use of a recirculating system for proper filtration and disinfection of the water. In addition to these, the physical and chemical conditions of the water, such as pH and residual chlorine levels within the pools are very important. Disinfectants are not just added haphazardly into pools, else they will become problems. For instance, whenever the free chlorine level is below 0.04 mg/L and the pH level measures 6.9 to 8.9, the activity of microorganisms in the swimming pools increases, because by increasing the pH, only a low percentage of residual chorine changes into hypochlorous acid (Sima *et al*., 2012). The addition of disinfectants in pools also alters the chemical balance within the pool. It may lower or raise the acidity of pool water. If the water is too acidic, it will corrode metallic equipment, cause etching on the surface of the materials, and cause skin irritation. If the water is too alkaline, it can cause scaling on the pool surface and plumbing equipment, and will cloud the water. Maintaining the proper balance of chemicals in the pool should be a continuous process, because any new element (oils from a swimmer's body, a shot of chlorine, stuff that falls in the water) changes the chemical composition of the water. When chlorine reacts with these nitrogen-containing objects, chloroamines are formed. Chloroamines are nuisance chemicals that lower the effectiveness of chlorine in the pool and cause eye, nose and skin irritation, asthma and other respiratory problems. The prevalence of recreational water illnesses contracted through the use of swimming pools is a global public health concern. The fact that swimming is gradually gaining popularity, especially among the young people even in Nigeria, cannot be disputed.

It is therefore imperative to ensure that public swimming pools are well maintained and properly disinfected to reduce the risk of infections, but sadly, the culture of maintenance in Nigeria is poor (Ikpo, 2006; Egboluchi, 2009; Folu, 2009; Iwarere and Lawal 2011; Kola, 2011). This, therefore, triggers the need to ascertain the state of public swimming pools in Akwa Ibom.

MATERIALS AND METHODS

This study was a laboratory-based descriptive study. It covered only public swimming pools in Akwa Ibom State. There were 32 public swimming pools in the study area at the time of this study, and 16 pools were selected through probability sampling to test for chemical and microbial contents. The pools were tagged A to O for easy identification. The water samples were analyzed in Akwa Ibom State Science and Technology Laboratory, Uyo. Water samples were collected from each of the 16 swimming pools into sterile bottles containing 0.1 ml of 3% sodium thiosulphate solution, as recommended by the American Public Health Association-APHA (2005). This ensured that the contents of the water were unaltered until the laboratory tests were conducted. A total of 16 samples were collected for both chemical and microbial analysis. As much as possible, samples were collected during periods of peak use when swimmers were in the water. Samples were stored in an ice box after collection and analyzed for microbial content (*Faecal Coliform, Heterotrophic Bacteria, Enterococcus Faecalis Staphylococcus aureus*, and *Pseudomonas aeruginosa*) and chemical content (free chlorine, combined chlorine, total bromine, pH, total alkalinity, calcium hardness and cyanuric acid), as stipulated by APHA (2005). Data obtained were analyzed using descriptive statistics.

THE STUDY AREA

This study was carried out in Akwa Ibom State, Nigeria. Akwa Ibom State is located in the coastal South-Southern part of the country, as shown Figure 1. Akwa Ibom State lies between latitudes 4°32′ and 5°33′ North, and longitudes 7°25′ and 8°25′ East. The state is bordered on the east by Cross River State, on the west by Rivers State and Abia State, and on the south by the Atlantic Ocean and the southernmost tip of Cross River State, and has a land mass of 6,900 square kilometres (Ekpenyong, 2013). The climate is characterized by a rainy season from March to October, while dry season stretches from November to February. Akwa Ibom State had five major urban areas, which are Ikot Ekpene, Uyo, Ikot Abasi, Eket and Oron. This research covered these five urban areas.

RESULTS AND DISCUSSION

Chemical Analysis of Water Samples Taken from Swimming Pool Water

The results of the chemical analysis of the sampled swimming pools water in the study area are presented in Table 1, while Table 2 shows the standard recommendation for chemical contents in swimming pools. It can be seen from the results that, the average free chlorine for the sites sampled ranged from 0.05 mg/L to 1.15 mg/L, which was less than the recommended values of 2 mg/L to 4 mg/L (HSAP, 2014), except for sites L and M that had 2.31 mg/L and 2.42 mg/L, respectively. The combined chlorine that should be 0 mg/L (HSAP, 2014) had values that ranged from 0.01 mg/L to 0.25 mg/L. Total bromine ranged from 1.3 mg/L to 3.2 mg/L, and did not comply with the recommended values of 4 mg/L to 6 mg/L, except for sites L and M that had 5.4 mg/L and 4.4 mg/L, respectively. Total alkalinity ranged from 44.1 mg/L to 62.9 mg/L, and was less than 80 mg/L to 100 mg/L recommended, except for sites L, M and O that had 85.3 mg/L, 84.6 mg/L and 82.4 mg/L, respectively. The recommended pH of 7.2 to 7.8 was met only in sites L and M that had 7.24 and 7.21, respectively.

a

b

Fig. 1. Maps showing (a) location of Akwa Ibom State in Nigeria and (b) Akwa Ibom State

Table 1. Chemical contents of swimming pools

S/N	Free Cl_2 (mg/L)	Combined Cl_2 (mg/L)	Total Br_2(mg/L)	Total Alkalinity (mg/L)	Total Hardness (mg/L)	Cyanuric Acid (mg/L)	pH
A	0.16	0.05	2.4	44.2	71.0	27.6	5.24
B	0.07	0.03	2.8	48.8	59.6	20.8	6.60
C	1.18	0.24	2.5	53.7	118.5	18.1	6.82
D	1.05	0.18	3.2	56.2	101.9	13.4	6.96
E	0.05	0.02	1.3	62.9	145.3	12.8	6.99
F	0.17	0.04	1.6	48.5	139.2	8.94	6.32
G	0.24	0.16	1.8	58.2	145.3	12.9	6.96
H	0.21	0.05	1.7	48.6	153.4	10.2	6.41
I	0.12	0.06	1.5	53.7	146.3	18.1	6.82
J	0.71	0.51	1.4	62.8	145.3	12.8	6.99
K	0.80	0.45	1.5	44.1	103.2	28.2	5.13
L	2.31	0.01	5.4	85.3	200.3	22.4	7.24
M	2.42	0.01	4.4	84.6	204.1	21.1	7.21
N	0.51	0.06	1.8	58.4	123.3	12.9	5.13
O	0.43	0.25	1.3	82.4	136.7	10.4	7.01

Table 2. Recommended standards for a swimming pool's chemical contents

Parameters (ppm)	Recommended standards (mg/L)
Free Chlorine	2-4
Combined Chlorine	0
Total Bromine	7.2-7.8
PH	4-6
Total Alkalinity	80-100
Calcium Hardness	200-400
Cyanuric Acid	30-50

Source: Public Swimming Pool and Spa Pool Advisory Document (2013)

Swimming pools' microbial content

The results of the microbial load of the water samples collected from swimming pools in Akwa Ibom State are shown in Table 3. Swimming pool H was found to be the highest contaminated with a total microbial count of 6.7×10^4 Cfu/ml, while pool M was the least contaminated with a microbial load of 1.7×10^2 Cfu/ml. The minimum permissible value of ≤200 Cfu/ml total viable count in recreational water is recommended by APHA (2005), and is presented in Table 4. Hence, it was deduced that only pools M and L had values within permissible ranges. Results in Table 3 also revealed that swimming pool I had the highest coliform counts of 4.4×10^3 Cfu/ml, while swimming pools M and L had the least coliform counts of 0.0 cfu/ml each. A coliform count of up to 10 Cfu/100 ml is permissible, provided that the aerobic colony count is less than 10 Cfu/ml, and the residual disinfectant and pH values are within recommended ranges. Again, the results of mean *E. faecalis*; mean *S. aureus* and mean *P. aeruginosa* had values that ranged from 0.0 Cfu/ml to 2.8×10^2 Cfu/ml; 0.0 Cfu/ml to 4.2×10^3 Cfu/ml, and 0.0 Cfu/ml to 3.7×10^3 Cfu/ml, respectively. APHA (2005) allowed up to 10 *P. aeruginosa* per 100 ml, while *E. coli* should be absent in a 100 ml sample (Table 4). From the foregoing, it can be deduced that only pools M and L satisfied the conditions required of swimming pool water. *E. coli* are normally present in the feces of most humans, animals and birds. It is widely used as a specific indicator of fecal contamination, as it is unable to grow within the environment. The presence of *E. faecalis* in swimming pool water is an indication that fecal material has entered the pool water from contaminated skin, or from fecal material that has been accidentally or deliberately introduced. It also indicates that the treatment has failed to remove this contamination.

It can be seen from the above results that only pools L and M pass in all parameters. This could probably be as a result of management having trained pool attendants and a maintenance expert. The pool attendants might have keen on insisting on bathing before swimming, and did not allow people with health issues to enter the pools, while the maintenance experts ensured a proper chemical balance in the pools. These could have helped in reducing the microbial loads of pools L and M.

Table 3. Swimming pools' microbial content

Sample code	Mean Heterotrophic Bacteria (Cfu/ml)	Mean Faecal Coliform (Cfu/ml)	Mean Enterococcus Faecalis (Cfu/ml)	Mean Staphylococcus aureus (Cfu/ml)	Mean Pseudomonas aeruginosa (Cfu/ml)
A	4.8×10^{4}	2.1×10^{3}	1.6×10^{2}	2.5×10^{3}	2.0×10^{3}
B	3.5×10^{4}	2.0×10^{3}	2.1×10^{2}	1.2×10^{3}	1.0×10^{3}
C	5.8×10^{4}	1.4×10^{3}	2.5×10^{2}	2.4×10^{3}	1.3×10^{3}
D	6.2×10^{4}	2.2×10^{3}	0.0	3.1×10^{3}	2.2×10^{3}
E	6.4×10^{4}	3.4×10^{3}	2.3×10^{2}	4.2×10^{3}	2.3×10^{3}
F	4.4×10^{4}	2.1×10^{3}	0.0	2.4×10^{3}	1.5×10^{3}
G	5.8×10^{4}	3.1×10^{3}	2.8×10^{2}	3.4×10^{3}	2.7×10^{3}
H	6.7×10^{4}	2.6×10^{3}	3.4×10^{2}	2.7×10^{3}	1.2×10^{3}
I	7.1×10^{4}	4.4×10^{3}	0.0	1.8×10^{3}	3.0×10^{3}
J	6.2×10^{4}	3.6×10^{3}	1.1×10^{-2}	2.9×10^{3}	2.4×10^{3}
K	8.1×10^{4}	4.3×10^{3}	2.0×10^{-2}	2.8×10^{3}	3.7×10^{3}
L	1.8×10^{2}	0.0	0.0	0.0	0.0
M	1.7×10^{2}	0.0	0.0	0.0	0.0
N	3.5×10^{4}	3×10^{3}	2.1×10^{-2}	2×10^{3}	1×10^{3}
O	2.8×10^{4}	0.3×10^{3}	0.0	1×10^{3}	2.1×10^{3}

Table 4. Permissible microbial contents in swimming pools

Microbes	Allowable Microbial Load
Mean heterotrophic bacteria	≤ 200 Cfu/ml
Mean fecal coliform	≤ 10 Cfu/100ml
Mean *Enterococcus faecalis*	0
Mean *Staphylococcus aureus*	≤ 10 Cfu/100ml
Mean *Pseudomonas aeruginosa*	≤ 10 Cfu/100ml

Source: APHA (2005)

CONCLUSION

A wide variety of microorganisms are introduced in different ways into swimming pools, and pool users unintentionally ingest substantial amounts of the water while using the pool (Evans *et al.*, 2001), and this enhances the transmission of plagues and other epidemics. The results of the chemical analysis of most public pools in the study show that the chemical contents of most pools were less than the values recommended for effective disinfection of the pools. For instance, the average free chlorine for most pools ranged from 0.05 mg/L to1.15 mg/L <2 mg/L to 4 mg/L recommended. On the other hand, microbial contents of most swimming pools in the study area were higher than values permissible for swimming pools. Mean heterotrophic bacteria ranged from 2.8×104 to 8.1×104 Cfu/ml >200 Cfu/ml allowable. This shows that users of pools other than pools L and M are vulnerable to recreational water illnesses, as WHO (2006) and Nichols (2006) link the risk of illness or infections in recreational waters to contamination caused by bathers.

On the basis of these findings, it is therefore recommended that public swimming pool owners in the study area should ensure they own and effectively use a swimming pool maintenance manual, as this will give them a proper guide to chemical dosing. Again, government should set up a monitoring team to control the maintenance operations in public swimming pools.

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