

Bacteriological Assessment of Water Quality of Public Swimming Pools in the Accra Metropolis, Ghana

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Abstract: Water is essential for life and in most parts of the world including Ghana it is used for various activities such as drinking, bathing and recreational purposes. The objective of this study was to assess the bacteriological quality of swimming pools' water in the Accra Metropolis. Five swimming pools were selected randomly and a research team visited the pools to collect water samples and at the same time administer short questionnaires about the characteristics of the pools. The average number of swimmers, swimming bathing loads, average age group of pool users, methods of disinfection, type of chlorine used, recycling, and treatment of the water before and after use were investigated. During the visit, water samples were collected for total coliform, *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* counts using the Membrane Filtration (MF) method and cultured on chromogenic media. Most (60%) of the selected swimming pools had a bathing load ≤ 20 per day. The operators of the pools disinfect their pools' water with chlorine but majority (60%) of the pool operators chlorinated their pools manually with powdered chlorine. The 20 water samples investigated show that 48% of swimming pools water was contaminated with *S. aureus*, 30.4% with *Ps. aeruginosa*, 20.9% with total coli form and 0.7% with *E. coli*. The *E. coli* count found in this study was very low indicating that the selected swimming pools were not fecally polluted at the time of sampling. It is recommended that future studies should use large sample sizes.

Keywords: Bacterial contamination, *Pseudomonas aeruginosa*, staphylococci, water

INTRODUCTION

Water occupies about 70% of the earth surface and is considered the largest natural resource around us. The importance of water includes drinking, washing, cooking, swimming, and also cooling the ecosystem. Therefore, its importance to humans cannot be overlooked. But in spite of the awareness to safeguard our waters, the resource is still contaminated by pathogenic microorganisms.

Ghanaians tend to visit the beaches and swimming pools most especially on public holidays and during the weekends for exercising the body and also for leisure. However, previous epidemiological studies have indicated that bathing or swimming in contaminated water can be a potential health risk (Vesaluoma *et al.*, 1995; Cabral, 2010). There are also reports that swimming pools can be vehicles for the transmission of infectious diseases throughout the world (Sule *et al.*, 2010). This means that with all the excitements the

average Ghanaian attaches to swimming and the health benefits derived from using the swimming pools, if care and additional precautions are not taken, they could be exposed to harmful microbes. It is known that, unsafe water, inadequate sanitation and insufficient hygienic conditions account for the global burden of diseases and of all deaths which includes drinking water and recreational waters (Cabral, 2010). Therefore the importance of microbiologically analysing swimming pool water in the city of Accra Metropolis cannot be over emphasized. In many cases, the risk of illness or infection has been linked to faecal contaminations in other countries (Wade *et al.*, 2006). Microorganisms detectable in swimming pools water usually originate from the skin, mucous membranes, clothing and faeces released by swimmers. Contamination can also come from pets especially dogs that occasionally wander around these swimming pools as well as from debris already around the properties. It could also be as result of the direct animal contamination (e.g., from birds).

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Sections of the population in Accra are still very poor despite being in the country's capital city. Waste management, sanitary and sewage conditions are very poor in most areas and residents are sometimes inclined to use inhabited lands or buckets for the discharge of faeces and human waste. Sometimes the contents of the buckets are discharged into the open-drainage systems. And during heavy rain falls, since most of these communities get flooded, these polluted water overflow and runoff and sometimes contaminate open-pools with poor boundaries. It is usually impractical to test for the many and diverse pathogenic microorganisms known to be associated with swimming pool contaminations, hence, microbiological indicators have been designed primarily to monitor water safety and quality. These indicators have been statistically associated with water contaminated diseases (Wade *et al.*, 2003). Previous reports have indicated that there are three main types of microorganisms that can be found in water namely, bacteria, viruses and protozoa (Vesaluoma *et al.*, 1995). These organisms can either occur naturally or as a result of contaminations from human or animal waste. The traditional role assigned to indicators was to show the presence or absence of faecal contamination in water supplies. Gastrointestinal indicators including, *Escherichia coli*, faecal streptococci, total coli form and non-gastrointestinal indicators such as *Pseudomonas* and *Staphylococcus* species are now usually monitored during water quality assessment. Therefore, as long as contamination of our water bodies remains a threat, more and more people are at risk of exposure to waterborne microbial pathogens as increasing numbers of people visit the swimming pools. The health effects of exposure to disease causing pathogens in swimming pool water are varied. Most commonly, manifestation of waterborne illness is gastrointestinal upset including nausea, vomiting and diarrhoea. Exposure to pathogens can occur during swimming or through other recreational activities like water volleying via ingestion, inhalation or direct contact with polluted swimming pools. The main purpose of treating water especially drinking and swimming pool water is to remove or kill these organisms to reduce the risk of illness associated with these water sources. Although the Ghana Standard Authority (GSA) in collaboration with the Water Research Institute (WRI) of the Council for Scientific and Industrial Research (CSIR) carries out water quality monitoring programs which include the analysis of water samples and reporting on the swimming pool characteristics. There is still the need for an independent investigation to ascertain the profile of bacteria associated with our swimming pools water quality because of the importance attached to this recreational facility. Therefore, this study was designed to evaluate the bacteriological water quality of some swimming pools in the Accra Metropolis by isolation and identification of the coliform group used as

indicators for faecal contamination of water bodies and the non-traditional indicators of water quality such as *Pseudomonas* and *Staphylococcus* species.

MATERIALS AND METHODS

Sample collection and transportation: This study was conducted between March and August, 2013. Before sampling a pre-tested data collection were done through the direct observation of the environment of the selected swimming pools, interview with swimming pool operators to get information on the average number of swimmers, swimming bathing loads and average age group of pool users. The operators of the swimming pools were also interviewed for information about recycling of the swimming pool water, treatment methods of swimming pool water and disinfection and type of chlorine used. This was done in the form of questionnaire survey.

The actual sample collection for the study covered 5 swimming pools, representing swimming pools in the Accra Metropolis which made themselves available for the study. For anonymity the selected swimming pools were coded KG, TSC, CH, MLSC and KSP. One of the pools was children's pool while two of them were competition pools with lanes and markings and the other two were semi-public pools (i.e., pool operators only allow in-house clients in their hotels for use for leisure). Before sampling, the average depth of each pool was measured. A total of 20 different samples were collected from the selected pools for the study. The first set of 10 water samples were collected on a sunny day between the hours of 8:20 and 11:00 am while the second set of 10 were also collected on a rainy day between the hours of 9:00 and 11:20 am. Participating swimming pools were not notified of precise sample collection days and time to make sure the samples remained as random as it could be and that the pool operators would not treat or disinfect their pools water before the sample collection team arrive. To ensure an average results truly representing the study period, 3 weeks space was allowed between the first sampling day and the second sampling day. Also to ensure uniformity of water quality throughout the pool and to get a more representative sample from each pool, each water sample was collected at a depth of 30 cm of the water surface and from different parts of the pools in accordance with the Standard Methods for the Examination of Water and Wastewater by the American Public Health Association (1998). The collected water samples were taken in 350 mL sterile plastic bottles containing sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) to neutralize chlorine disinfectant action against the bacteria after sampling and transported refrigerated in an ice chest containing ice to the Microbiology Laboratory (ML) of the Council for Scientific and Industrial Research (CSIR), Accra, for bacteriological analysis. The samples were analysed immediately upon arrival.

Bacteriological analysis:

Total heterotrophic counts: The total heterotrophic bacterial counts of the swimming pool water samples were done using the Membrane Filtration (MF) technique and incubated for the presence *E. coli* or total coliform, *S. aureus* and *Ps. aeruginosa*. The water samples were removed from storage and allowed to warm to room temperature. The incubation chamber for the analyses was cleaned with ethanol to prevent contamination. The porous plate of the membrane filtration unit and the forceps were sterilised by being applied with 98% alcohol which was burnt off in a Bunsen flame. The sterile forceps were then used to transfer the sterile membrane filter (47 mm diameter, with 0.45 µm pore size: Merck Millipore, USA) onto the porous plate of the membrane filtration unit with the grid side up and a sterile meshed funnel placed over the receptacle and locked in place. One hundred (100) mL of the water samples was added to the membrane filtration unit using the funnel measure. The flame from the Bunsen burner was kept on throughout the whole analyses and the forceps was flamed intermittently to keep it sterile. Water samples were filtered through the membrane filter under partial pressure created by an electric vacuum pump fitted to the filtration unit. Filtrates were discarded and the funnel unlocked and removed. In each case sterile forceps was then used to transfer the membrane filter and then rolled over the surface of a Petri dish containing selective cultured medium carefully making sure that air-bubbles were not trapped between the filters and the medium.

The mean colony counts of Total coli form and *E. coli* were evaluated by rolling the membrane filters on prepared Harlequin Chromogenic Agar (HCA; Oxoid Limited, Basingstoke, UK) and incubated at 37°C for 24 h. Coli forms were detected as rose-pink colonies on the HCA plate and *E. coli* as blue-green colonies. The

total numbers of colonies appearing on each plate were counted and recorded.

For *S. aureus*, the MF was removed with the aid of a sterile forceps and rolled gently on Gelatin Mannitol Salt Agar (GMSA; Oxoid Limited, Basingstoke, UK) and incubated at 37°C for 24 h after which growth were observed for colonies of white, surrounded by yellow zone. The colonies were counted and recorded.

Mean colony counts of *Ps. aeruginosa* were determined by rolling the MF gently on prepared Cetrimide Agar (CA; Oxoid Limited, Basingstoke, UK). The plates were incubated at 37°C for 24 h after which growth was observed. The colonies that were yellowish green were counted and recorded.

Statistical analysis: The results obtained from the experiments were entered into a database and analysed statistically using the Statistical Package for Social Sciences (SPSS) version 20 statistical software for Microsoft Windows and a summary was presented using the descriptive statistics such as means and percentages. Also, the student's t-test was used to find out significant differences between the parameters studied. p-values > 0.05 were taken as statistically insignificant difference.

RESULTS

In all a total of 20 samples, 4 from each of the 5 selected swimming pools in the Accra Metropolis were investigated. Most (60%) of the selected swimming pools had a bathing load ≤ 20 per day. It was observed from the study that all the swimming pools operators claim to disinfect their pool water with chlorine; but majority (60%) of the pool operators chlorinated their

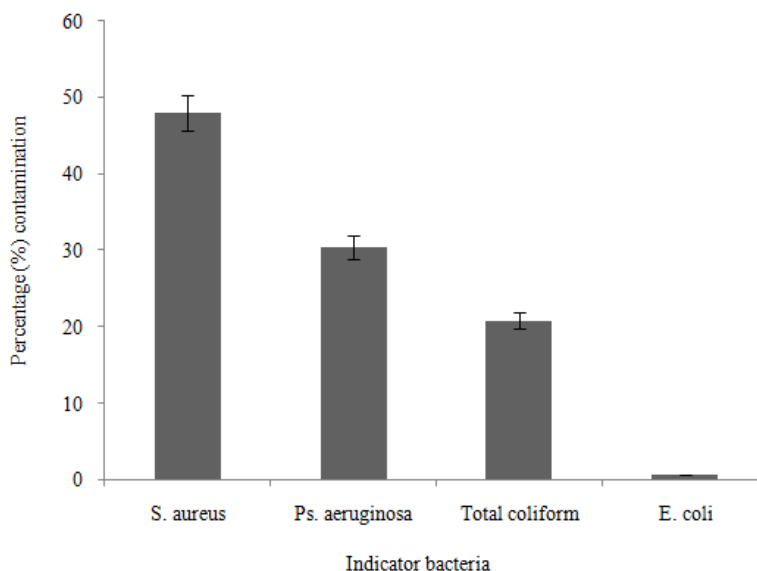


Fig. 1: Percentage (%) bacterial contamination of the surveyed swimming pools against the various indicator bacteria monitored

Table 1: The comparative means (CFU/100 mL) of the indicator bacteria among the surveyed swimming pools water samples

Pools	Total coliform	<i>E. coli</i>	<i>Ps. aeruginosa</i>	<i>S. aureus</i>
KG	0.000	0.00	16.00	105
TSC	0.000	0.00	13.50	2
CH	43.50	9.75	39.75	69
MLSC	0.000	0.00	4.250	40
KSP	232.5	0.00	328.5	419

Table 2: Comparative means (CFU/100 mL) of Total coliforms in shallow and deep points of the surveyed swimming pools water samples

Pools	Shallow	Deep	t-test	p-value
KG	0	0	—	—
TSC	3.5	0	3.6890	0.006*
CH	34.5	72.5	40.056	0.001*
MLSC	0	0	—	—

*p-value was considered significant

Table 3: Comparative means (CFU/100 mL) of *E. coli* in shallow and deep points of the surveyed swimming pools water samples

Pools	Shallow	Deep	t-test	p-value
KG	0	0.00	—	—
TSC	0	0.00	—	—
CH	9	10.5	1.581	0.153
MLSC	0	0.00	—	—

Table 4: Comparative means (CFU/ 100 mL) of *Ps. aeruginosa* in shallow and deep points of the surveyed swimming pools water samples

Pools	Shallow	Deep	t-test	p-value
KG	0.00	3.50	3.689	0.006*
TSC	13.5	0.00	5.270	0.001*
CH	40.5	35.5	14.23	0.001*
MLSC	0.00	0.00	—	—

*p-value was considered significant

Table 5: Comparative means (CFU/100 mL) of *S. aureus* in shallow and deep points of the surveyed swimming pools water samples

Pools	Shallow	Deep	t-test	p-value
KG	0	0	—	—
TSC	1.5	2.5	0.0220	0.982
CH	49	87	40.032	0.001*
MLSC	3	0	3.1620	0.013*

*p-value was considered significant

pools manually with powdered chlorine. All swimming pools were free from floating material during all visits and were clean during the sampling period.

The comparative means of the indicator bacteria among the surveyed public swimming pools water in Accra Metropolis are presented in Table 1. It can be observed from Table 1 that all the water samples were contaminated with two or more bacterial contaminants. However, water samples from swimming pools coded KSP and CH have the highest bacterial contamination (Table 1). The most commonly isolated bacteria from the swimming pools water samples was *S. aureus* (48%) followed by *Ps. aeruginosa* (30.4%), total coliform (20.9%) and *E. coli* (0.7%), as presented in Fig. 1. In the present investigations, strains of *Enterobacter*, *Citrobacter* and *Klebsiella* were classified as the total coliform group. Also, Table 2-5

shows the comparative means of indicator bacteria in shallow and deep sampling points of the selected swimming pools water used in the study. It can be observed from the tables that there were significant differences in the isolation of indicator bacteria such as *S. aureus*, *Ps. aeruginosa* and total coliform in the deep and shallow sampling points (p-value<0.05) of the selected swimming pools.

DISCUSSION

In the present investigations, the MF technique was used because it is considered highly reproducible and yields numerical results rapidly (Arvanitidou *et al.*, 1998; Itah and Ekpombok, 2004). The most predominant bacteria found to contaminate the swimming pools water in the Accra Metropolis was *S. aureus* according to the present study (Fig. 1). According to a proposal by Mackereth *et al.* (1978) and also reported by Itah and Ekpombok (2004), a standard fewer than 100 *S. aureus* per 100 mL in swimming water samples should be considered safe for recreational purposes. However, with this standard it can be observed that two of the swimming pools (coded KG and KSP) were above the proposed standard (Table 1). It is known that some bacteria can survive longer in halogen environments. It was with this rationale, that these pools were monitored for the presence of *S. aureus*. Although it is a public health concern, it must be noted that the *S. aureus* is an opportunistic pathogen found living in the nasopharynx and on the skin of up to 50% of normal people (Enright, 2003). Therefore the high frequency of the bacterium found in this study may be attributed to the bacterium being present as a normal flora of humans and can contaminate the swimming pool water as a result of the bacterium being constantly shed from the skin and oro-nasal areas of swimmers. Therefore, it is suggested that pool operators should drain the water from the pools and do disinfection after use.

From Table 1 and 2, it can be observed that all swimming pools were polluted with *Ps. aeruginosa* at a point. *Ps. aeruginosa*, just like *S. aureus*, can withstand high concentrations of chlorine. The bacterium can cause a range of infections but rarely causes serious illness in healthy individuals without some pre-dispositions. Basically, it is a common environmental bacterium and can be found in soil, faeces, water and sewage (Tate *et al.*, 2003). Therefore, shedding from infected humans is the predominant source of *Ps. aeruginosa* in pools, though the surrounding environment can also be a source too (Tate *et al.*, 2003). The high *Ps. aeruginosa* count found in this study can be as a result of the growth of *Ps. aeruginosa* being supported by the warm, moist environment on decks and floors as previously reported by the Saskatchewan Ministry of Health (2010).

The World Health Organization (WHO, 2001) and the US Environmental Protection Agency (USEPA, 2003) reported standards of zero CFU/100 mL of water samples for total coliforms. With this, two of the swimming pools (coded KG and KSP) with total coliform counts of 43.5 CFU/100 mL and 232.5 CFU/100 mL, respectively, can be described to have exceeded the standard. Total coliforms were not seen in the first sampling of these pools. However, four cases were recorded in the second sampling. Several factors might account for the fact that *E. coli* was not isolated in any of the 20 swimming pools water samples analysed except in two of the water samples which were collected from the same pool on the same day and time. Rabi *et al.* (2007) have shown that there is a significant association between swimming pool's contamination and the time of water sample collection. The results of the present study are similar with Rabi *et al.* (2007) because at the time of the sampling (8:30-11:20 am), the average swimmer load was 2 in the pools hence pollution with *E. coli* and total coliform will be minimum. It was also observed that the 2 samples contaminated with *E. coli* were collected from the same swimming pool. This can be attributed to the fact that this pool operator employs others to disinfect the swimming pools at their own schedule. It has been previously reported that there is a significant association between pool contamination and free residual chlorine concentration (Shittu *et al.*, 2008). However, even though the chlorine levels were not measured in this study, all results for the total coliform and *E. coli* counts can be attributed to the level of free residual chlorine concentrations in the swimming pools water.

CONCLUSION

The microbiological qualities of some swimming pool water in Accra were investigated. Though swimming pool owners and operators in the Accra Metropolis indicated that they monitor, maintain and disinfect their pools using appropriate chemicals and qualified personnel, the results of the study show that the swimming pools were contaminated with *S. aureus*, *Ps. aeruginosa*, total coliform and *E. coli*. The non-traditional indicators, *S. aureus* and *Ps aeruginosa* were higher than counts for faecal indicators; *E. coli* and total coliform in this investigation. It is recommended that further studies on the relationships of free residual chlorine, temperature and bacterial count should be done to help us know the disinfection level necessary to limit the bacterial effects on swimmers before a disease outbreak is caused.

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