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Bacteriological Quality Assessment of swimming pools in the Osu-Labadi Area, Accra

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Abstract
Bacterial contamination of swimming pool water poses public health risks to swimmers and others who come into direct contact with such pools. There has been an increase in the patronage of swimming pools in Ghana for sports and recreation and therefore the need to investigate the pools compliance with sanitary standards. This study examined the bacteriological and physicochemical (pH, temperature and residual chlorine) levels of swimming pool water in Osu-Labadi, Accra, Ghana to determine the levels of bacterial pollution. Six outdoor swimming pools were randomly selected for this cross-sectional study. Microbiological examination was conducted on a total of 18 samples collected monthly in the evening after the pools had been used. This took place over a 3 month period, from March to May 2014, using standard microbiological and analytical methods. The results of the study indicated that the total viable bacteria count of all the pool water exceeded the acceptable limits. All 6 pools were contaminated by *E. coli*, *Enterobacter faecalis* and *Klebsiella pneumonia,* as well, 5 out of the 6 pools were contaminated by *Enterobacter cloacae*, *Staphylococcus aureus*, and *Streptococcus agalactiae*. The residual chlorine level in all the pools was below the recommended level of 1.0 mg/liter. Statistical analysis showed significant association between water contamination with microbial indicators and physicochemical aspects such as pH, temperature and residual chlorine ($p<0.05$). The high microbial load count and the isolation of pathogenic bacteria from the pools is an indication of the need to improve monitoring by pool health authorities, improve pool disinfection standards and educate swimmers on hygiene before entering pools.
Key words: swimming pool, microbial load, residual chlorine, bacterial contaminants

1.0 Introduction
There has been an increase in the use of public swimming pool facilities in Ghana for sports and recreational activities. The increase can be attributed to the pollution of the beaches in the study area by fecal matter and other solid waste materials. This current increase in patronage has been identified as posing some public health risks to users, due to the contamination of pool water. Bacterial contamination of the pool water can result in pathogenic microorganisms; causing infections to swimmers. These contaminants can be introduced into pool water from swimmers, from the pool filters or occasionally from defects in pool engineering.
Infections caused by swallowing the water contaminated by bacteria and fungi have been reported in recent years, in swimmers (Brewster et al., 1994; Kiyohara et al., 2006). Diseases related to the drinking of contaminated water include diarrhoea, typhoid, hepatitis and cholera (WHO, 2004). Recent improved surveillance data from the United States and Europe shows that microbial recreational water-related illnesses are on the rise (Yoder et al., 2004).
The presence of *Pseudomonas* in pools can result in skin rashes and ear infections. *Pseudomonas* could be introduced by swimmers, but may also be indicative of natural contamination (CDC, 2013). To reduce risks, the CDC recommends that all swimmers shower with soap before swimming, after changing baby diapers and avoid the pool entirely when they have diarrhoea (CDC, 2013). The presence of *Escherichia coli* in swimming pool water is an indication that faecal material has entered the pool water from contaminated skin, or from faecal material that has been accidentally or deliberately introduced. It also indicates that the treatment has failed to remove this contamination. *E. coli* should be absent in a 100 ml sample.
CDC (2004) reported an outbreak of gastroenteritis in children, whose only common exposure was attendance at a swimming club the previous weekend. Fifty-three people reported illness, and norovirus was isolated from a number of cases. An undetected accidental faecal release was suspected, and poor pool water quality monitoring and maintenance contributed to the outbreak. The pools in the study area were all manually disinfected. This study is designed to investigate the presence of bacteria that contaminate pools leading to pool-related illnesses and the pools compliance with disinfection standards.

2.0 Materials and Methods
2.1 Study Area
The study was carried out in the Osu-Labadi area in Accra, the capital of Ghana, which lies along the coast. Microbiological analysis was carried out at Accra Polytechnic Microbiology Laboratory.

2.2 Sample Collection

The study involved six outdoor swimming pools randomly selected for this study. Some of the pools were restricted, so only those that gave consent in the study area were used. Microbiological and physicochemical examination was conducted on a total of 18 samples collected monthly in the evening after the pools had been used, over a 3 month period from March to May 2014, using standard microbiological and analytical methods (GS955, 2009; APHA, 1972).

2.3 Method

Microbiological samples were taken at a depth of 200mm below the surface of the pool using 250ml sterilized wide- mouthed bottles. The physicochemical tests were performed on site at the time of sample collection. A DPD kit was used to determine the residual chlorine levels. A different sample was sent to the laboratory in a cool box for microbiological analysis within 2 hours of collection using Plate Count Agar, MacConkey agar and Uriselect4 agar and incubated at 37°C for 24 hours.

Microbiological and physicochemical data were expressed as an average of the total samples for each pool analyzed. The significance of differences ($p<0.05$) of the mean microbial count among the pool water was evaluated with one-way ANOVA using SPSS for windows version 16.

3.0 Results and Discussion

3.1 Results

The analysis of variance for pH, temperature, residual chlorine and microbial load of pool water at 95% confidence interval shows that there is significant difference $F(5,17)= 7.698$, $p<0.05$, $F(5,17)= 7.800$, $p<0.05$, $F(5,17)= 5.025$, $p<0.05$ and $F(5,17)= 6.680$, $p<0.05$ respectively (Table 1.0). The pH and residual chlorine level of all six pools was between 7.0 - 8.0 and less than 1.0 mg/liter (Figure 1.0) respectively. The total viable count (TVC) exceeded 5 per 100ml of pool water in all six pools with Pool 1 recording the highest count of 84 per 100ml. *Escherichia coli*, *Enterobacter faecalis* and *Klebsiella pneumonia,* were isolated from all 6 pools, while

Table 1.0. Analysis of variance (ANOVA) for parameters analysed.

Parameters analysed		Sum of Squares	Df	Mean Square	F	Sig.
pH of Pool water	Between Groups	1.176	5	.235	7.698	.002
	Within Groups	.367	12	.031		
	Total	1.543	17			
Temperature of Pool water	Between Groups	26.000	5	5.200	7.800	.002
	Within Groups	8.000	12	.667		
	Total	34.000	17			
Residual Chlorine	Between Groups	.112	5	.022	5.025	.010
	Within Groups	.053	12	.004		
	Total	.165	17			
Microbial Load	Between Groups	1.441E8	5	2.882E7	6.680	.003
	Within Groups	5.177E7	12	4314277.778		
	Total	1.959E8	17			

Enterobacter cloacae, *Staphylococcus aureus*, and *Streptococcus agalactiae* was isolated from 5 out of the 6 pools studied.

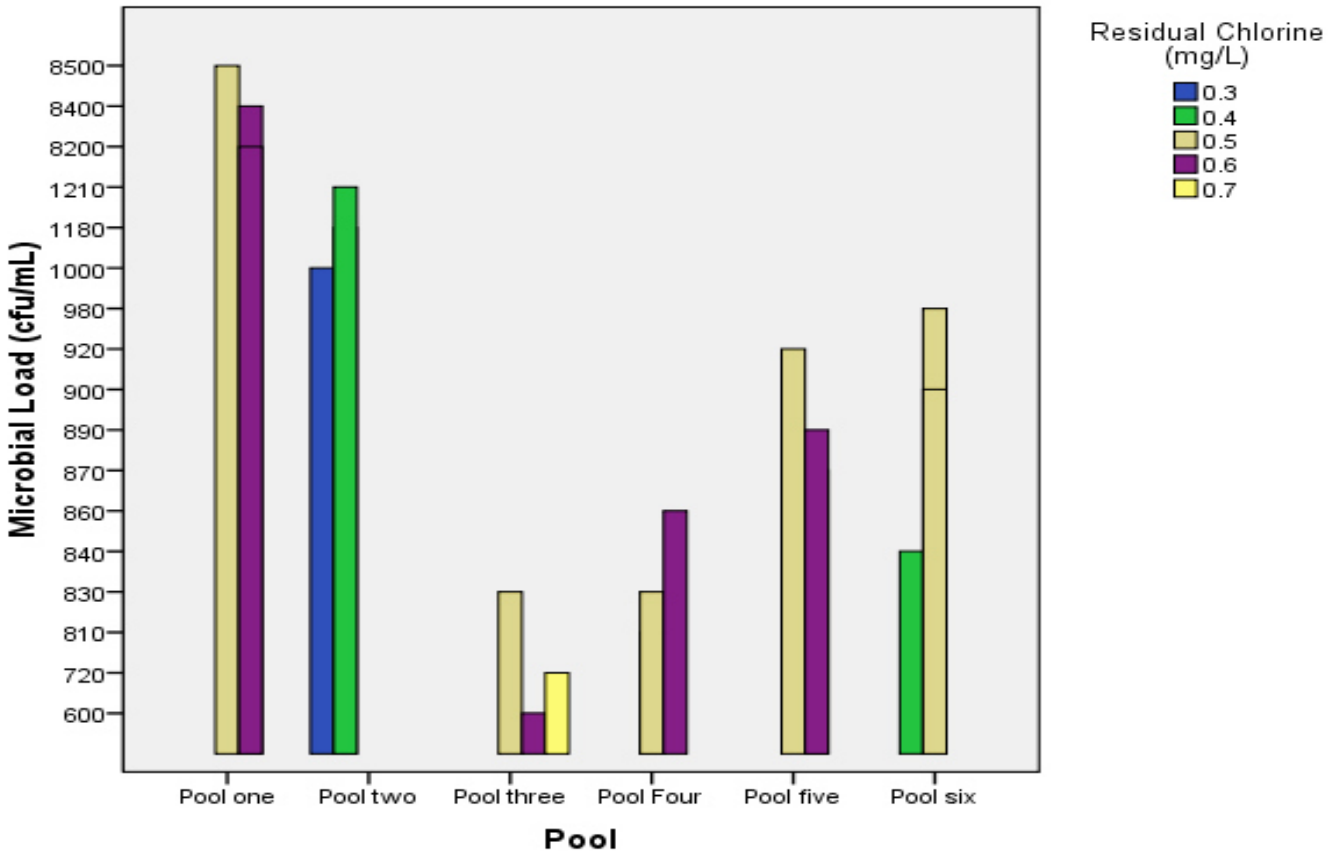

Figure 1.0 Microbial load and residual chlorine level of pools

3.2 Discussion

The TVC of the pool water examined and the isolation of pathogenic bacteria indicates the need for increased monitoring. Microbial contaminants in recreational water are mostly controlled by disinfection. Improper maintenance of public and semi-public facilities frequently fails to protect the public against chlorine-sensitive pathogens (Yoder et al., 2004).

The high TVC can be attributed to the low residual chlorine level in the pools. Similar findings were made by Maida (2008), which claimed that the quality of water depends on chloride concentration and the number of swimmers attending the pool. Rasti et al., (2012) also reported significant difference between the residual chloride in contaminated and non-contaminated swimming pools.

The pH of the pools ranged from 7.0-8.0. As pH rises, the power of chlorine to act on foreign particles is lost. At pH 8.0 the pool can only use 20% of the chlorine used as it combines with carbonates and forms scale. The pool water becomes cloudy and irritates the skin. However, in this study, there was no relationship between the pH and the microbial load of the pool water. The mean temperature range of 25°C to 28°C for all six pools was within the acceptable limits. Microbial growth increases when there is as increase in swimming pool water temperature as reported by Leoni et al., (2001) and Martinys et al., (1995).

The isolation of pathogenic enteric bacteria and *Staphylococcus aureus* from this study is an indication of poor bather hygiene and poor compliance of the standards. Therefore, there is a need to increase monitoring of the recreational facilities, increased bather hygiene education, as well as pool staff education and improved pool circulation. Further studies should be carried out on other microbial contaminants apart from bacteria that contaminate swimming pool water and also on pool architecture and bather population that contribute to poor compliance of the standards.

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