Potential Infections Linked to the Microbiological Quality of Swimming Pools _Kumasi, Ghana, West Africa

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Authors' contributions

This work was collaborated by both authors. Both authors designed the study and performed the statistical analysis. Author VN wrote the protocol and author LAA wrote the first draft of the manuscript and managed literature searches. Author VN managed the analyses of the study and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The risk of infections associated with microbiological quality of swimming pools in Kumasi was investigated. A variety of microorganisms can be found in swimming pools and similar recreational water environments which may be introduced in a number of ways. In many cases, the risk of illness or infection has been linked to faecal contamination of the water. Many of the outbreaks related to swimming pools would have been prevented or reduced if the pool had been well managed. Sixty (60) samples were collected from five hotels within three months, five samples in the afternoon and five samples in the morning. The samples were analyzed for the presence of \textit{Staphylococcus} spp, \textit{Pseudomonas} spp, \textit{Enterococcus} spp, \textit{Salmonella} spp, \textit{Shigella} spp, total heterotrophic bacteria count, \textit{Vibrio cholerae}, \textit{Escherichia coli}, total coliform and faecal coliform using Plate Count Method and Multiple Tube Fermentation-Most Probable Number method respectively. Almost all the water

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samples were contaminated with *Staphylococcus* spp ranging from $7 \times 10^1$ cfu/ml to $16 \times 10^1$ cfu/ml, *Pseudomonas* spp ranging from $4 \times 10^1$ cfu/ml to $19 \times 10^1$ cfu/ml, *Enterococci* spp ranging from $12 \times 10^1$ cfu/ml to $14 \times 10^1$ cfu/ml, Total Heterotrophic bacteria count ranging from $6 \times 10^1$ cfu/ml to $13 \times 10^1$ cfu/ml, Total and Faecal coliform ranging from 4 to 6 MPN/100 ml and 0-4 MPN/100 ml respectively. *Salmonella* spp, *Shigella* spp and *Vibrio cholerae* were not detected in all the water samples. *E. coli* was isolated in one swimming pool of the hotels while *Enterococcus* spp were isolated in two swimming pools. There were differences in bacteriological quality of the water samples obtained from the swimming pools.

**Keywords:** Swimming pool; hotels infections; contamination; microbiological quality; Kumasi; pathogenic organisms.

### 1. INTRODUCTION

A swimming pool, swimming bath, wading pool, or simply a pool, is a container or concrete tanks, large artificial basins or large paved hole filled with water intended for swimming or water-based recreation [1,2]. Pools that may be used by the general public are called public, while pools used exclusively by a few people or in a home are called private pools. They can be of any size and shape. The types of swimming pools also include, Children's pools, Competition pools, Exercise pools, Hot tubs and Spa pools, Athletic Pools. In-ground Pools, Above-Ground Pools, Lap Pools and Kiddies Pools [3]. Other are Ocean pools, Infinity pools, Natural pools and ponds, Zero-entry swimming pools [4]. Swimming pools are used for pleasure, diving and other water sports, as well as for the training of lifeguards and astronauts [1]. Swimming pool water should meet potable water standard possessing the properties of; Transparency, Odourless, Tasteless, having a freezing point of 0°C and a boiling temperature of 100°C [2].

Natural waters are major sources of swimming pool water. Frequently changing the water and use of disinfectant such as chlorine guarantees the safety of the swimming pool. Pathogenic contaminants are of greatest concern in swimming pools as they have been associated with numerous recreational water illnesses (RWIs) [5]. Swimming pools are transmission vehicle for infectious disease throughout the world. Infectious disease which can be transmitted by recreational water include skin, eye and ear infections and gastroenteritis, consequently the microorganisms in recreational water are important for indexing the health hazard associated with swimming [6]. Other illnesses commonly occurring in poorly maintained swimming pools include otitis external, commonly called swimmers ear, skin rashes and respiratory infections. Public health pathogens can be present in swimming pools as viruses, bacteria, protozoa and fungi. Diarrhoea is the most commonly reported illness associated with pathogenic contaminants, while other diseases associated with untreated pools are Cryptosporidiosis and Giardiasis [7]. Swimming pool contaminants are introduced from environmental sources and swimmers. Contaminants introduced by swimmers can dramatically influence the operation of indoor and outdoor swimming pools. Sources include micro-organisms from infected swimmers and body fluids and oils including sweat, cosmetics, suntan lotion, urine, saliva and faecal matter. It is reported that sweat and urine react with chlorine and produce trichloramine and cyanogen chloride, that are dangerous to human health [8]. In addition, the interaction between disinfectants and pool water contaminants can produce a mixture of chloramines and other disinfection by-products.

The best indicator in the assessment of the safety of the swimming pool water is through the microbiological quality of the swimming pools by using bacteria that indicate faecal contamination as faecal coliform and enterococci, while others consider that the risk of infection is more associated with microorganisms derived from the skin, mouth, and the upper respiratory tract of bathers rather than the faecal contamination [9]. Another important factor to assess bathing water quality is related to density of the bathers. High density of swimmers leads to a risk of contact with pathogens that are similar to the risk involved in bathing in water considered improper because of faecal pollution [10-12]. The risk of infections has been associated to faecal contamination of the water as a result of faeces released by bathers or from contaminated water source [13].
The main objective of this research is to determine the level of contamination by microorganisms in the swimming pool. The findings of this study could be used to enhance effective control measures to reduce the contamination and ensure the health and safety of the users.

2. MATERIALS AND METHODS

2.1 Study Area

The research was carried out in the Southern part of the country precisely Kumasi in the Ashanti region. It was conducted using five swimming pools at five different hotels in Kumasi. People go to these pools to swim and relax. Occasionally, parties are also being held at these pools. As a result of swimming in these pools, microorganisms get into the water from body sweat, urination and from the skin.

2.2 Sample Collection from Pools

750 ml of water samples were collected from each pool using a sterilized container and each container was labeled. Samples were taken in the morning and in the afternoon fortnightly from February to April.

2.3 Bacteriological Analysis / Isolation of Pathogenic Microorganisms

Bacteriological isolation and characterizations were determined as described by [14]. The Most Probable Number-Multiple tube technique was used for coliform enumeration. Total coliform were incubated at 37°C for 24 hours while Fecal coliform was incubated at 44°C for 24 hours. Salmonella-Shigella agar and Thiosulphate citrate bile salt sucrose agar were used to determine heterotrophic bacteria, salmonella and shigella and Vibrio cholera respectively. Pour plate method and growth on pseudomonas agar, mannitol salt agar, Hicrome agar, Slanezt and Bartley agar were used to determine the presence of Pseudomonas spp., Staphylococcus spp., Escherichia coli and Enterococci species respectively. All the plates were incubated at 37°C for 24 hours. Presumptive colonies were confirmed by gram staining and biochemical reactions and each plate was given a positive or negative score. Isolates were confirmed by some conventional biochemical test [15].

3. RESULTS AND DISCUSSION

The results of bacteriological analysis of swimming pool water samples taken in the morning are presented in Table 1, Pseudomonas spp had the highest counts of 65 x 10^3 cfu/ml, Staphylococcus spp and Enterococcus spp had 53 x 10^3 cfu/ml and 26 x 10^3 cfu/ml respectively whiles Salmonella spp, Shigella spp and Vibrio cholerae were not found in the five swimming pools samples collected. Total heterotrophic bacteria had 42 x 10^3 cfu/ml. Total coliform and faecal coliforms ranged from 2 to 4 MPN/100 ml and 0 MPN/100 ml respectively. In table 2, the bacteria isolated from the pool water in the morning are shown. Pseudomonas sp and Staphylococcus sp were isolated in the pool samples, while Enterococcus spp were isolated in two pool water samples. E. coli, Salmonella spp and Shigella sp were not found in the five swimming pools water sample.

In Table 3, Staphylococcus recorded 62 x 10^3 cfu/ml, Pseudomonas spp and Enterococcus spp were 61 x 10^3 cfu/ml and 25 x 10^3 cfu/ml respectively while Salmonella and Shigella were not found in the five swimming pools collected in the afternoon from the hotels sampled. Heterotrophic bacteria count was 53 x10^3 cfu/ml, Total coliform and Fecal coliform counts ranged from 4 to 6 MPN/100 ml and 4MPN/100 ml respectively. From Table 4, the bacteria isolated from the pools in the afternoon are shown. Pseudomonas sp and Staphylococcus sp were isolated in the five pool samples while Enterococcus spp were isolated in two pool water samples. E. coli was isolated in one pool water sample. Salmonella spp, Shigella spp and Vibrio cholerae were not found in all the swimming pools water samples.

Analysis shown in the result proved that almost all the swimming pools from the sampled hotels were contaminated mostly with Pseudomonas spp and Staphylococcus spp. The rate of contamination of Enterococcus spp, Total coliform and Faecal coliform were less while Salmonella spp and Shigella spp were absent in all samples. The two selected bacterial indicators Staphylococcus and Pseudomonas species were isolated from the sample taken before and after swimming. Their presence however indicates non-faecal contamination. Studies have found that Staphylococcus aureus may be introduced into the pool by swimmers under all conditions of swimming and the bacteria can be found on surface film of pool water [16]. The presence of S. aureus in swimming pools is believed to have resulted in skin rashes, wound infections, urinary tract infections, eye infections, otitis external, impetigo and other infections [17,18].
Table 1. Mean bacterial counts for the swimming pool water samples (Taken in the morning)

| Sample morning | Pseudomonas spp cfu/ml x 10^3 | Staphylococcus spp cfu/ml x 10^3 | Enterococci spp cfu/ml x 10^3 | Salmonella spp cfu/ml x 10^3 | Shigella spp cfu/ml x 10^3 | Total heterotrophic bacteria cfu/ml x 10^3 | Total coliform MPN/100 ml | Faecal coliform MPN/100 ml | Vibrio cholera Counts cfu/ml x 10^3 |
|----------------|-----------------------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|---------------------------------------------|--------------------------|---------------------------|----------------------------------|
| A              | 17 x 10^3                   | 11 x 10^3                   | 14 x 10^3                   | NIL                        | NIL                         | 2                                           | NIL                      | NIL                       | NIL                              |
| B              | 14 x 10^3                   | 7 x 10^3                    | 16 x 10^3                   | NIL                        | NIL                         | 2                                           | NIL                      | NIL                       | NIL                              |
| C              | 12 x 10^3                   | 16 x 10^3                   | NIL                         | NIL                        | 11 x 10^3                   | 4                                           | NIL                      | NIL                       | NIL                              |
| D              | 7 x 10^3                    | 12 x 10^3                   | NIL                         | NIL                        | 9 x 10^3                    | NIL                                         | NIL                      | NIL                       | NIL                              |
| E              | 5 x 10^3                    | 7 x 10^3                    | 12 x 10^3                   | NIL                        | NIL                         | 12 x 10^3                           | NIL                      | NIL                       | NIL                              |

Table 2. Bacterial Isolates from water samples in the morning

| Bacterial Isolates | Swimming pool water samples |
|--------------------|-----------------------------|
|                    | A                           | B                           | C                           | D                           | E                           |
| Pseudomonas sp     | +                           | +                           | +                           | +                           | +                           |
| Staphylococcus sp  | +                           | +                           | +                           | +                           | +                           |
| Enterococcus sp    | +                           | -                           | -                           | +                           | +                           |
| Salmonella sp      | -                           | -                           | -                           | -                           | -                           |
| Shigella sp        | -                           | -                           | -                           | -                           | -                           |
| E. coli            | -                           | -                           | -                           | -                           | -                           |
| Vibrio cholera     | -                           | -                           | -                           | -                           | -                           |

Legend: + = Present; - = Absent

Table 3. Mean bacterial counts for the swimming pool water samples (Taken in the afternoon)

| Sample afternoon | Pseudomonas spp cfu/ml x 10^3 | Staphylococcus spp cfu/ml x 10^3 | Enterococci spp cfu/ml x 10^3 | Salmonella spp cfu/ml x 10^3 | Shigellasp spp cfu/ml x 10^3 | Total heterotrophic bacteria cfu/ml x 10^3 | Total coliform MPN/100 ml | Faecal coliform MPN/100 ml | Vibrio cholera cfu/ml x 10^3 |
|------------------|-------------------------------|---------------------------------|--------------------------------|----------------------------|----------------------------|---------------------------------------------|--------------------------|---------------------------|----------------------------|
| A                | 12 x 10^3                     | 16 x 10^3                       | 12 x 10^3                      | NIL                        | NIL                        | 12 x 10^3                           | 4                         | NIL                       | NIL                       |
| B                | 14 x 10^3                     | 14 x 10^3                       | NIL                            | NIL                        | NIL                        | 11 x 10^3                           | 4                         | NIL                       | NIL                       |
| C                | 19 x 10^3                     | 12 x 10^3                       | NIL                            | NIL                        | NIL                        | 11 x 10^3                           | 6                         | 2                         | NIL                       |
| D                | 12 x 10^3                     | 11 x 10^3                       | NIL                            | NIL                        | NIL                        | 9 x 10^3                            | NIL                      | NIL                       | NIL                       |
| E                | 4 x 10^3                      | 9 x 10^3                        | 12 x 10^3                      | NIL                        | NIL                        | 9 x 10^3                            | NIL                      | NIL                       | NIL                       |
Infections of *S. aureus* acquired by recreational waters may not become apparent until 48 hours after contact. There have suggestion that recreational waters with a high density of bathers present a risk of staphylococcal infection that is comparable to the risk of gastrointestinal illness involved in bathing in water considered unsafe because of faecal pollution [19]. 50% or more of the total staphylococci isolated from swimming pool water samples are *S. aureus* [19,20]. Coagulase-positive *Staphylococcus* strains of normal human flora have been found in chlorinated swimming pools [21]. In Italy, however, a study on chlorinated pools where the free chlorine level varied between 0.8 and 1.2 mg/l, *S. aureus* was not recovered from water samples [22]. The moist environment of the floor around the pool is ideal for the growth of *Pseudomonas* spp. It is likely that swimmers pick the organisms on their hands and feet which contaminates the water whiles swimming. *Pseudomonas aeruginosa* causes a variety of illnesses when associated with recreational swimming, but the most common manifestation is “swimmer’s ear and a variety of skin infections. The bacteria is commonly present in the environment, but grows well in warm water environments such as hot tubs and spas, since heat often breaks down the disinfection ability of pool chemicals. In the health care setting, *Pseudomonas aeruginosa* is the second most common source of nosocomial infection in intensive care units. When associated with recreational swimming, it is the source of skin rash often called “hot tub folliculitis”. The skin rash often takes on the appearance of chicken pox. Even healthy individuals who are exposed to the bacterium in contaminated water sources such as hot tubs, whirlpools, spas and water parks may develop symptoms. It has been suggested that warm water supersaturates the epidermis, dilates dermal pores and facilitates their invasion by *Pseudomonas aeruginosa* [23].

There are some indications that extracellular enzymes produced by *Pseudomonas aeruginosa* may damage skin and contribute to the bacteria’s colonization [24].

A variety of microorganisms can be found in swimming pools and similar recreational water environments, which may be introduced in a number of ways. In many cases, the risk of illness or infection has been linked to faecal contamination of the water. The faecal contamination may be due to faeces released by bathers or from a contaminated water source or, in outdoor pools, may be the result of direct animal contamination (e.g. from birds and rodents). Faecal matter is introduced into the water when a person has an accidental faecal release – AFR (through the release of formed stool or diarrhoea into the water) or residual faecal material on swimmers’ bodies is washed into the pool [13]. Though *E. coli* was not isolated in all the samples taken except from a sample thus signifying the possible absence of enteric pathogenic bacteria. It is also indicative that there was no recent faecal contamination hence reducing the risk of public health hazard. This may be as a result of proper treatment of the pool with disinfectant. The sample contaminated with faecal coliform was taken in the afternoon and it may be that a swimmer contaminated the pool while swimming and there was not adequate protection for the pool water. Low total coliform counts, faecal coliform counts and *Escherichia coli* in the pools during the morning may be due to the lesser number of people who swim in the morning and the pools had been cleaned in the morning as compared with the afternoon. The Total heterotrophic plate count values were below the WHO standards of less than 200 per ml (1.0 x 10^2 cfu/ml) thus signifying that the pool has been adequately disinfected. The presence of Total Heterotrophic Bacteria in the pool may be due to the fact that microorganisms are found everywhere and it is indicative of high organic and dissolved salts. The primary sources of these bacteria contamination include surface runoff, pasture, natural soil and plant bacteria, animal and human wastes [25]. High number of total heterotrophic bacteria in water may not cause any serious infections; it is just to show the level of some the contaminants.

**Table 4. Bacterial Isolates from water samples in the afternoon**

| Bacterial Isolates   | Water samples | A | B | C | D | E |
|----------------------|---------------|---|---|---|---|---|
| *Pseudomonas sp*      | +             | + | + | + | + | + |
| *Staphylococcus sp*   | +             | + | + | + | + | + |
| *Enterococcus sp*     | -             | - | - | + | + | - |
| *Salmonella sp*       | -             | - | - | - | - | - |
| *Shigella sp*         | -             | - | - | - | - | - |
| *E. coli*             | -             | - | + | + | - | - |
| *Vibrio cholerae*     | -             | - | - | - | - | - |

**Legend:** + = Present; - = Absent

This study therefore recommends improvement in the personal hygiene of swimmers by encouraging them to pre-swim shower before swimming to remove traces of sweat, faecal matter, cosmetics and urine from swimmers body...
in order to minimize the introduction of microorganisms into the pool. Toilets, shower and urinal should be provided to enable swimmers to conveniently ease themselves before entering the pool. Also, it is advised that the continuous disinfection of the swimming pool should be done regularly to enhance more safety for swimmers by following WHO suggestions for public swimming pools which states that “a minimum concentrations of free chlorine of 1 mg/L and a maximum concentrations of 2 mg/L” [8].

4. CONCLUSION

After the study, it was indicated that all the five swimming pools from the hotels sampled were contaminated especially with Pseudomonas, Staphylococcus sp. Enterococci. Total and Faecal coliform present and isolated in some hotels while E. coli, Salmonella and Shigella were virtually absent from all the samples. The study also revealed the difference in bacteriological quality of swimming pool water in hotel. Ineffectiveness of personal hygiene of swimmers contributes to the number of bacteria isolated in the pool.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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