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Microbiological Quality Monitoring of Water from a Lake Associated with Varying Human Activity

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Abstract: **Water is the most important substance for human survival and well-being, healthy ecosystems and sustainable development. The water quality used for irrigation is essential for the yield and quantity of crops. Pollution of water with deleterious microbes, including bacteria, viruses, parasites, as well as fungi, has been on steady increase globally.**

The bacterial quality of water from the lake at Lakeside Marine Park was assessed to ascertain whether it met International microbiological standards for safe human usage, since it used for recreational purposes, for irrigation and other human uses of water by people living in the surrounding communities. The water samples were tested for the presence of the following bacterial water quality indicators: total viable count, total coliform count and faecal coliform count. Water samples of the lake were collected at five different sites along the lake and sent for microbiological laboratory analysis. The various sites for the water sampling had faecal coliforms which exceeded the 10^3 per 100 mL of water to be used in irrigation of vegetables that are eaten uncooked.

The presence of coliform bacteria in the lake poses a significant potential health risk depending on how the cultivated vegetables may be handled before use and how frequently children and the youth use the lake for recreational purposes.

***Keywords*: faecal coliforms, human health, water samples, irrigation.**

I. INTRODUCTION

Water is essential for human survival and well-being and plants need water for growth. It typically makes up 80 – 95% of the mass of growing plant tissues. It is a key priority issue for economic growth, employment, social development and environmental sustainability. It is a resource that is vital to communities both for their own survival and their contribution to societal needs. Access to clean water is therefore the foundation of any sustainable community [1]

Pollution of water with deleterious microbes, including bacteria, viruses, parasites, as well as fungi, has been on steady increase globally [2]. The impact of river and lake pollution on human health depends mainly on the water uses, as well as the concentration of pathogens in the water [3] These have contributed to the observation that, infectious diseases continue to be one of the leading causes of mortality globally [4]. Waterborne pathogens present a greater health risk to people using river or lake water for drinking, bathing, washing, construction, irrigation of crops eaten raw, fishing, and recreational activities [5]. Water quality, particularly for irrigation, is of international importance because products exposed to microbiologically contaminated water may put consumers at risk locally and internationally [6]. In order to reduce waterborne disease outbreaks, the World Health Organization (WHO) developed microbiological quality guidelines for each intended water use. Faecal coliforms have been used in developing such human health-based regulatory standards or quality guidelines, since they are a common indicator of both faecal contamination and microbial water quality for recreational and agricultural water systems [7]. The WHO guidelines stipulate that faecal coliform load

(FC) should not exceed 10^3 per 100 mL of water to be used in irrigation of crops that are eaten uncooked [8], [9]. Additionally, water for direct human use, such as swimming and washing should be largely free of faecal coliform. Faecal coliforms are considered a sub-group of Gram-negative, non-spore forming, rod-shaped facultative anaerobes that are part of the family *Enterobacteriaceae* [10]. Approximately 10% of all intestinal microorganisms including *Escherichia coli* fall into the coliform group. *Escherichia* coli is a bacterium typically found in the intestines and the faecal matter of warm-blooded animals like pigs, deer, birds, and cattle. For surface waters, the presence and loads of total coliforms, faecal coliforms and *Escherichia coli* are used to indicate the possible presence of harmful pathogens, the major source of which are faecal matter of humans and other mammals.

Using irrigation as an example, the limited availability of water of the appropriate quality for each of the uses it may be put is described. The quality of water used for irrigation is essential for the yield and quantity of crops and protection of the environment [11]. The use of potable water is expensive and there are difficulties in conveying it to the farms due to the lack of infrastructure [12]. Therefore, albeit potable water might be available, its use can nevertheless be restricted. The alternative option is the use of adjacent surface water such as from rivers, streams and lakes. However, the use of these alternative water sources poses potential risks due to the presence of microbial pathogens that may be natural habitants or may have entered the water body via the faeces of infected livestock or human hosts that interact with the water body [13]. In Ghana, the use of potable water for urban/peri-urban crop production is constrained by high tariffs, and limited availability making it uneconomical and nonviable [14]. Due to poor sanitation in urban areas of low income countries such as Ghana, water from such water bodies have been heavily polluted but are still used for irrigation [15]. Amoah *et al.*, [16] found that some irrigation water used on urban vegetable farms in Ghana had high levels of microbial contamination that exceeded World Health Organization (WHO) recommendations for unrestricted irrigation [9], [17] and this poses high health risks [18].

The bacterial quality of water from the lake at Lakeside Marine Park was assessed to ascertain whether it met international microbiological standards for safe human usage, since it used for recreational purposes, for irrigation and other human uses of water by people living in the surrounding communities. The water samples were tested for the presence of the following bacterial water quality indicators: total viable count, total coliform count and faecal coliform count.

II. METHODOLOGY

Study area:

The study area was Lakeside Marina Park, Ashaley Botwe in the Greater Accra Region of Ghana. The park has a lake that serves as a source of water for a number of human and animal related activities. Water samples were collected at five different points along the banks of the lake and the following were observed at each of the sites. Sample S1: Regular washing of cars, minimal growth of vegetation in the water; Sample S2: Pumping of water for irrigation, washing of cloth, minimal washing of cars, swimming, low amount of vegetation in the water; Sample S3: Washing of cloths, low amount of vegetation in the water; Sample S4: Fetching of water by truck, washing of cloths, washing of cars, cattle drinking source and main access to the lake, very limited vegetation in the water and Sample S5: Pit Laterin location close to the bank.

Sample Collection Method:

Sterilized bottles were used to collect water samples, which were used in determining colony counts by the serial dilution (10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6}) and plating on three different media according to standard procedure; Plate Count Agar, Violet Red Bile agar and Eosin Methylene Blue agar, all of which were prepared aseptically. The inoculated media were left to solidify and then incubated at 37^0C for 24 hours. The isolated colonies were counted promptly after the incubation period. Only plates with 30-300 colonies were counted and the colony forming unit (CFU) determined per mL.

III. RESULTS

Observations at sample collection points:

The level of filth and the level of human activity at each of these sample collection sites were categories on a scale of 1 to 5, where 5 is the filthiest and the most intense of human activity (Table I). The specific human activities at each of these sites are described in Table I.

Table I: Level of human interaction with the lake at each of the sample collection sites

Collection points	Filth	Level of activity	Activities
Site 1	5	3	Regular washing of cars, minimal vegetation in the water.
Site 2	2	4	Pumping of water for irrigation, washing of cloth, minimal washing of cars, swimming, low amount of vegetation in the water
Site 3	3	2	Washing of cloths, , low amount of vegetation in the water
Site 4	3	5	Fetching of water by truck, washing of cloths, washing of cars, cattle drinking sources and main access to the lake, very limited vegetation in the water.
Site 5	2	1	Pit Laterin location close to the bank

Bacterial Load of Water Samples:

The distribution of the total viable bacteria count (TVC) of the five different locations at the banks of the lake was varying. Site 3 (on the east side of the lake) recorded the highest bacterial load with a mean of 6.7 (SE ± 0.57) x 10^5 CFU/mL, followed by site 2 (on the north-eastern side of the lake) with bacterial load of 2.2 (SE ± 0.25) x 10^5 CFU/mL. The bacterial load at site 1 (southern side of the lake) was 0.870 (SE ±0.05) x 10^5 CFU/mL. Site 4 (North-western side) and site 5 (western side) recorded the lowest bacterial loads of 0.12 (SE ±0.003) x 10^5 CFU/mL and 0.122 (SE ±0.001) x 10^5 CFU/mL respectively (Fig. 1).

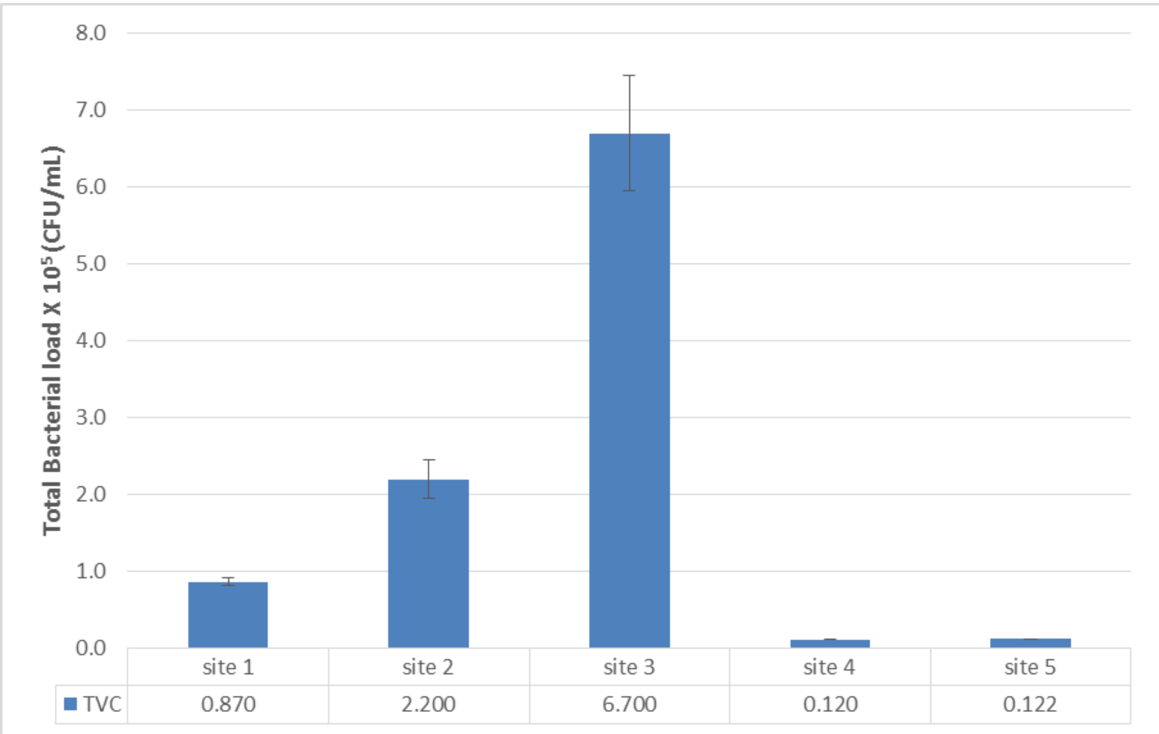

Fig. 1: The bacteria load of water obtained from different locations along the banks of the lake.

For each of these sites the total coliform count (TCC) and faecal coliform count (FCC) were determined. Site 3 recorded the highest TCC of 1.8 (SE ±0.2) x 10^5 CFU/mL and the highest FCC of 0.033 (SE ±0.0035) x 10^5 CFU/mL. Site 1 recorded the next highest TCC of 0.480 (SE ±0.03) x 10^5 CFU/mL and an FCC of 0.028 (SE ±0.003) x 10^5 CFU/mL. The TCC and FCC obtained for the water from site 5 were the same, which was 0.011 (SE ±0.00075) x 10^5 CFU/mL. Sites 2 and 4 recorded only TCC and these were 0.06 (SE± 0.0065) x 10^5 CFU/mL and 0.042 (SE ±0.007) x 10^5 CFU/mL respectively (Fig. 2).

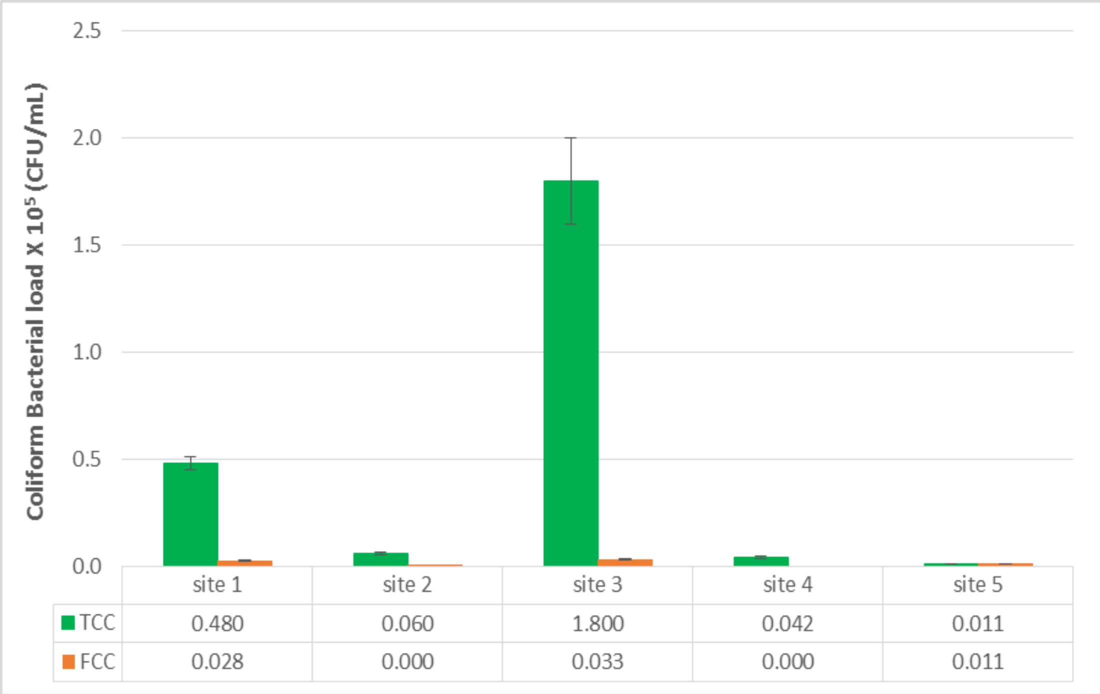

Fig. 2: The total coliform (TCC) and faecal coliform (FCC) load of water obtained from different locations along the banks of the lake

The total coliforms count (TCC) of site 1 constituted 55.2% of its total viable bacteria count (TVC) while the TCC of site 4 constituted 35.0% of its TVC; For site 3, its TCC was 26.9% of its TVC. For the others sites 2 and 5, their TCC were 2.7% and 8.6% of their TVC respectively. Interestingly, all the TCC of site 5 were FCC, while for the other sites, their FCC were less than 7.0% of their TCC (Table II).

Table II: The proportion of TVC that were TCC and the proportion of TCC that were FCC

Sample collection points	TCC as a % of TVC	FCC as a % of TCC
site 1	55.2	5.8
site 2	2.7	0.2
site 3	26.9	1.8
site 4	35.0	0.0
site 5	8.6	100.0

Relationship between Level of Activity and Bacterial Load:

Table III shows that the level of human activity correlated lowly and reversely with the TVC (R^2 = -0.258), but moderately and negatively with FCC (R^2 = -0.552). However, it correlated lowly but positively with TCC as a percentage of TVC (R^2 = 0.214). Furthermore, the level of filth at the sites correlated moderately and positively with the TCC and FCC (R^2 = 0.237, 0.598 respectively), and highly and positively with TCC as a percentage of TVC (R^2 = 0.959). Furthermore, TVC correlated highly with TCC (R^2 = 0.928) but moderately with FCC (R^2 = 0.606).

Table III: Correlation of the bacterial loads and the human interaction with the lake

	Level of activity	Filth	TVC	TCC
TVC	-0.25803			
TCC as a % of TVC	0.214416	0.95902		
TCC	-0.34737	0.23783	0.928524	
FCC	-0.55183	0.59829	0.605916	0.81854

IV. DISCUSSION

In this study, we assessed the microbiological quality of a lake that serves as a source of water for irrigation, recreation and a number of human and animal related activities at Ashaley Botwe Lakeside Marina Park. The total viable count, total coliform count and faecal coliform count differed in all the five sampling sites (Figs 1 and 2). This results were similar to those of a study carried out in Kenya that assessed the variation in the quality of water from the catchment areas of river Sosiani where sampling sites were selected in anticipation that the samples would vary in water quality in the vicinity and upstream of the sampling points [1]. The faecal coliform count for sites 1, 3 and 5 (280 x 10^3 cfu/mL, 330 x 10^3 cfu/mL and 110 x 10^3 cfu/mL respectively) were extremely higher than the guidelines stipulated by WHO, which is, faecal coliforms (FC) should not exceed 1 x 10^3 cfu per 100 mL of water to be used in irrigation of crops that are eaten uncooked. Additionally, since faecal coliform count of water for recreational and the other human uses are expected to be even lower [19], the findings of this study suggest that the water from this lake is not safe for irrigation and much more unsafe for the other direct uses such as swimming and washing. This adds to the observation that over the last decade, studies on the quality of many Ghanaian water bodies revealed an increase in pollution levels [19], [20] Studies in Ghana and Senegal also have shown that the bacteriological contamination of urban water sources generally exceeds irrigation standards, and can contribute significantly to crop contamination [21],[22]. According to UNICEF [23], faecal coliform bacteria are living organisms, unlike the other conventional water quality parameters and multiply rapidly when conditions are good for growth and die in large quantities when they are not. When the faecal coliform counts are high (over 200 colonies/100 ml of a water sample) in a body of water, there is a greater chance that disease causing organisms are also present.

Pertaining to the various sites and the level of filth generated and the level of activity as well, Site 1(Regular washing of cars, minimal vegetation in the water) which exhibited the highest level of filth and a minimal level of human activity recorded quiet a high level of total coliform count and faecal coliform count agreeing with the findings.

The reverse relationship observed with the correlation of the human activities and the bacterial counts is explainable by the fact that these activity include washing of cloth and cars with soaps and detergents, and these are disposed into the lake at the banks. Since these are able to reduce bacterial survival the more intense the level of human activity was, the lesser the bacteria count was. Additionally as expected, the extent of filth correlated very well with the level on TCC that was a proportion of TVC and the level of FCC, since the main source of TCC and FCC in water bodies is filth. Therefore, while some human activities (such as washing) is changing the bacterial population at some sites along the bank of the lake, other activities such as littering is inducing an increase coliforms in the lake. Such changes are likely to lead to changes in the ecosystem of the lake and may threaten the survival of the lake.

V. CONCLUSION

The findings of the study indicated that water sources such as those from lakes may be undergoing significant bacterial population changes due to human activities and thereby making the use of water from such water bodies increasingly unsafe for irrigation and other purposes. The presence of coliform bacteria in the lake poses a significant potential health risk depending on how the cultivated vegetables may be handled before use and how frequently children and the youth use the lake for recreational purposes.

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