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Intriguing case of ecosystem dynamics in the Lake Victoria: Water Hyacinth (*Eichhornia crassipes)* and *Escherichia coli*

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Abstract
Water hyacinth (*Eichhornia crassipes)* is a noxious weed with immense impact on the health and the livelihoods of communities' in the tropical sub-Saharan African countries. This study was aimed at assessing the effects of water hyacinth on *Escherichia coli* levels in Kenyan Lake Victoria. Sampling was done in waters infested by water hyacinth (roots and mats) and in open water areas (devoid of the weed). Membrane filtration method was used to enumerate *Escherichia coli* at 44.5 ºC for 18-24 h. Results showed that *E. coli* levels were higher in water hyacinth infested areas compared to areas in the open waters and those under water hyacinth mats. The levels of *E. coli* in the open water areas ranged from undetectable levels to 1140 cfu/100 ml. Whereas, levels of *E. coli* from areas under water hyacinth mats ranged from 10 cfu/100 ml to 1549 cfu/100 ml while *E. coli* levels from waters from water hyacinth roots ranged from undetectable levels to 6387 cfu/100 ml. Therefore, general marked differences in levels of *E.coli* in hyacinth thriving areas with regard to free areas indicate potential ability of the plant to harbor microbiological contaminants and if its spread is left unchecked, incidences of water borne related diseases like the cholera may increase incredibly among the riparian communities with consequent loss of many lives. It is therefore imperative that a plan of action is put in place to control the spread of water hyacinth in Lake Victoria.

Keywords: Water hyacinth (*Eichhornia crassipes)*, *Escherichia coli*, L. Victoria.

1. Introduction
Lake Victoria is the world's second largest freshwater lake in the world. It is bordered by Tanzania, Kenya and Uganda. Lake Victoria stretches 412 km from north to south, between latitudes 0°30´ N and 3°12´ S, and 355 km from west to east between longitude 31° 37´ and 34° 53´E It is situated at an altitude of 1334 m above sea level, and has a volume of 2,760 km^3 [1]. Freshwater bodies constitute a vital component of a wide variety of living environments and they have been regarded as key strategic resources essential for sustaining human livelihood, promoting economic development and maintaining the environment [2]. Utilization of freshwater resources includes use as source of drinking water, fishing activities, sites for effluent discharges, recreation and transportation activities. Domestic and industrial wastewater, solid wastes, sediments from soil erosion in the catchment areas, agricultural wastes and atmospheric deposition are the major nutrient sources to the Lake Victoria.
The presence and spread of aquatic macrophytes such as the noxious Water hyacinth (*Eichhornia crassipes*) in Lake Victoria are a manifestation of excessive nutrients that flow into the lake from the watershed. Water hyacinth, described as one of the worst aquatic weeds in the world [3], was first reported in the Kenya waters in 1990 [4, 5]. The weed is very photosynthetic and grows rapidly causing serious threats to water ecosystems throughout the world [6]. Its explosive growth is considered unfavorably in natural water bodies. There are several threats posed by water hyacinth invasion including: destruction of biodiversity, oxygen depletion and reduced water quality, there is also the issue of water ways blockage and also the weed act as breeding ground for pests and vectors. Floating mats of water hyacinth support organisms that are detrimental to human health. For instance, the ability of its mass of fibrous, free-floating roots and semi-submerged leaves and stems to decrease water currents increases breeding habitat for the malaria causing anopheles mosquito as evidenced in Lake Victoria [7].

Water hyacinth has also been implicated in harboring the causative agent for cholera. For example, from 1994 to 2008, Nyanza Province in Kenya, which borders Lake Victoria accounted for a larger proportion of cholera cases than expected given its population size (38.7% of cholera cases versus 15.3% of national population). Yearly water hyacinth coverage on the Kenyan section of the lake was positively associated with the number of cholera cases reported in the Province [8]. The densities of microcontaminants from the occurrence of water hyacinth can be evaluated by use of various indicator organisms.

The most common indicator organisms are enteric bacteria, such as fecal coliforms and *Enterococcus* [9] .These bacteria are excreted in feces and are usually harmless, more plentiful and easier to detect than pathogens [10].Fecal coliforms group comprise of *Escherichia coli*, *Klebsiella pneumoniae* and *Enterobacter aerogenes*. *Enterococci* on the other hand are a subgroup of fecal *Streptococci* and include four species: *Streptococci faecalis*, *S. faecium*, *S. gallinarum* and *S. avium*. Indicator organisms vary in their ability to reliably predict potential risks to human health. Some indicators have been shown to have a greater statistical relationship to disease than others [11]. Several studies since 1986, reviewed by Environmental Protection Agency (EPA) shows that there is a correlation between fecal streptococci and gastrointestinal illness [12]. This study was aimed at assessing the effects of water hyacinth on *Escherichia coli* levels in Lake Victoria (Kenyan side) and a plan of action to be put in place to control the spread of the weed.

2. Materials and Methods

2.1 Study area

The study focused on the Kenyan side of Lake Victoria including stations within the gulf and in the open waters in December 2013. A total of 20 stations were sampled (Fig. 1). Four stations devoid of water hyacinth were also sampled: Kisumu pier, Homa bay, Asembo Bay and Bridge Island were sampled for purposes of comparison with the weed-covered stations.

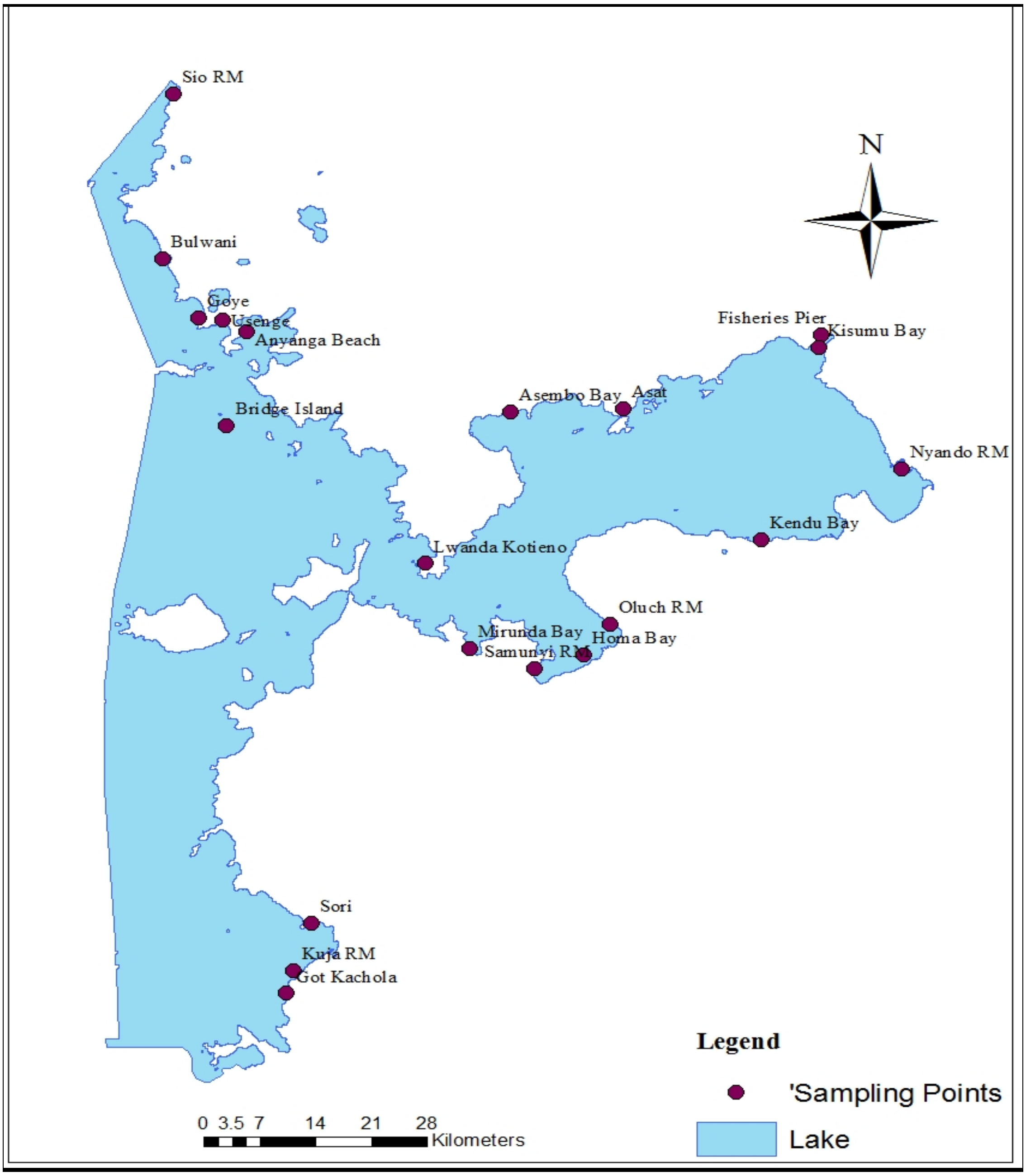

Fig 1: Map of Lake Victoria (Kenyan side) showing sampled stations during the study.

2.2 Sample collection and enumeration of *E. coli*

Membrane filtration technique was used to determine levels of *E. coli* [13]. Sterile water sampling cup was used to collect water samples. At each station, water samples were collected from 20 stations. Open waters (OP) where there was no occurrence of the weed, water hyacinth infested areas where growth of the weed thrived abundantly and water hyacinth roots were sampled. Sampling was done in duplicates in which a volume 1 ml to 100 ml depending on the turbidity of water was filtered through 0.45 µm pore size sterilized membrane filter pad and the filter placed face up on the culture plate containing lauryl membrane sulphate broth and incubated at 18 – 24 h at 44 ˚C with the use of Del agua water testing kit (OXFAM Delagua). After which the *E. coli* counts were established, respectively. Discreet colony forming units were counted manually with the help of the grids and geometric mean used to interpret the data.

2.3 Data analysis

The coliform counts per colony forming units of microbial cells were analyzed per 100 ml and expressed as geometric mean and results visualized in histograms. Statistical analysis was also performed using Minitab version 14. Descriptive statistics was first done to determine the central tendency and dispersion of the data.

3. Results

It was observed that *E.coli* levels were higher in waters from water hyacinth roots compared to levels from water hyacinth mats and the open waters. The levels of *E. coli* counts in the open waters ranged from undetectable levels to 1140 cfu/100 ml. Fisheries pier recorded the highest count of 1140 cfu/100 ml followed by Homa Bay with 1095 cfu/100 ml. Stations: Mirunda, Anyanga, Usenge and Bridge recorded no counts of *E. coli* (Fig 2). In the waters within water hyacinth mats, the range of *E. coli* counts was between 10 cfu/100 ml to 1549 cfu/100 ml with Kuja River Mouth (RM) recording the highest count while Usenge had no detectable counts. Lwanda Kotieno and Bulwani stations had 1442 cfu/100 ml and 1000 cfu/100 ml respectively (Fig 2). Levels of *E. coli* from waters with hyacinth roots ranged between undetectable levels to 6387 cfu/100 ml. Kuja RM recorded a high of 6387 cfu/10 ml. Sori also had high levels with a count of 4673 cfu/100 ml (Fig 2). From the Kruskal–Wallis test, it is established that *E. coli* levels were influenced by presence of water hyacinth (p=0.006).

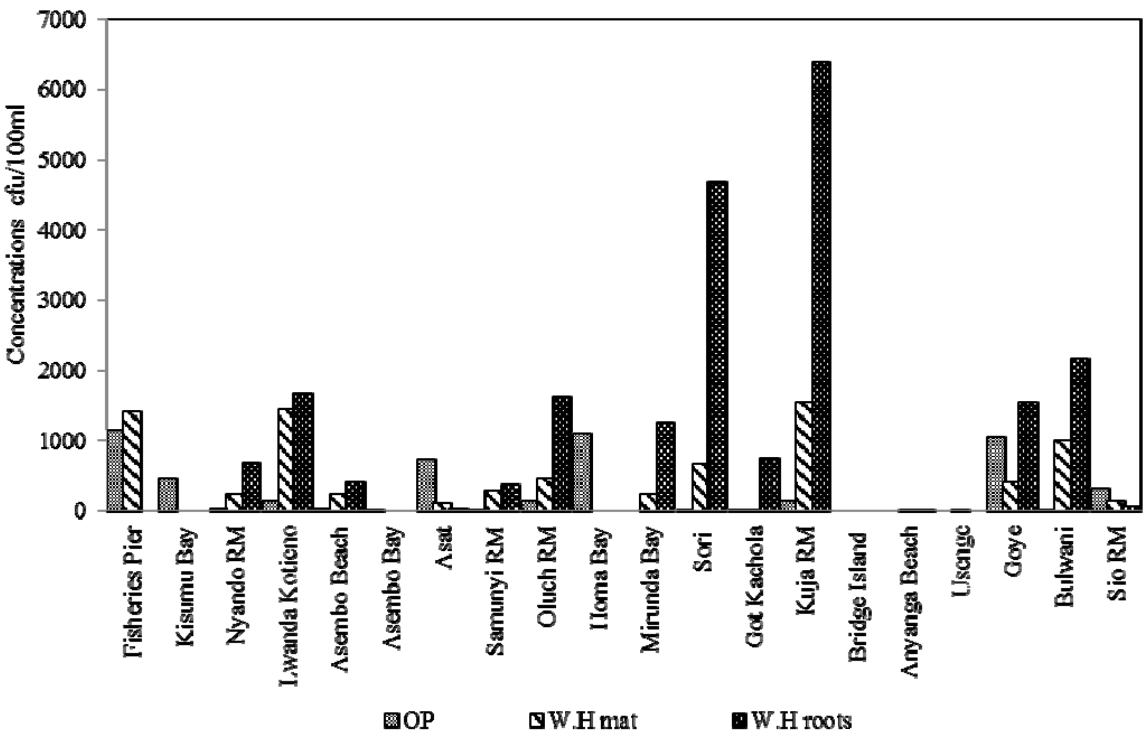

Fig 2: Sampling stations showing concentrations of *E. coli* cfu /100 ml in open waters (O.P), Water hyacinth-mat (W.H mat), and water hyacinth roots (W.H roots).

4. Discussion

From the results it was observed that the levels of *E. coli* were higher in areas invaded by water hyacinth as compared to areas devoid of the weed. In particular, water sampled from the roots showed higher concentrations than water sampled from the waters covered with hyacinth and from open areas. Several studies have found that coliforms, fecal coliforms, and *Salmonella* tend to concentrate in sediments of natural waters [14]. Therefore, this could explain the concentration patterns observed, to which the microorganisms could attach to the weed. Filtration and attachment of microbes in the plant root surfaces is thought to be another process leading to increased levels of *E.coli* on the roots of the weed. Study by Karim [15], showed that, there was fecal coliforms reduction along water column on ponds grown with water hyacinth in this case the sediments had greater counts of microbes than in the water column. He suggested that microbes on the sediments could be having a longer survival rates due to the greater content of organic matter present in the sediments. In contrast, stations like Kisumu Pier and Homabay which were only sampled for the open waters (devoid of weed) but had high levels of *E. coli* this could be explained by the fact that they are located in areas of urban sewage and industrial effluent [16].

One of the negative impacts of water hyacinth infestation is micro-habitat for a variety of disease vectors. Large quantities of these bacteria in water are not harmful according to some authorities, but may indicate a higher risk of pathogens being present in the water [17]. Some waterborne pathogenic diseases that may coincide with fecal coliform contamination include ear infections, dysentery, typhoid fever, viral and bacterial gastroenteritis, and hepatitis A. The presence of fecal coliform tends to affect humans more than it does aquatic creatures, though not exclusively. Apart from water hyacinth being associated with pathogenic organism, several researchers have demonstrated success in the use of natural water hyacinth in the phytoremediation process [18]. There is also the effect on the environment; untreated organic matter that contains fecal coliform could be harmful to the environment as a result of aerobic decomposition of organic material can lead to reduced dissolved oxygen levels if waters, consequently reduced oxygen level enough to kill fish and other aquatic life. The present study also reveals that water hyacinth can be used for the purpose of wastewater treatment by sedimentation for the accumulation of significant concentrations of pathogens.

5. Conclusion

The study showed that water hyacinth occurrence affects the concentrations of microcontaminants in Lake Victoria. This is mainly because the source of microcontaminants is organic matter which plays a major role in water hyacinth growth, hence the relationship. There is therefore need to:

- Sensitize the communities on the health risk posed by use of the waters with water hyacinth infestation.
- Sensitize the communities on water use (drinking) best practices i.e. boil water and use innovative bio filtration initiatives to enable riparian communities to access clean drinking water
- Water hyacinth can be used for the purpose of wastewater treatment by sedimentation for the accumulation of significant concentrations of pathogens
- Ensure control of water hyacinth to reduce incidences of cholera outbreaks due to *E. coli*
- Engage in activities aimed at reducing the amount of nutrients that fuel rapid growth of Water hyacinth in Lake Victoria

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