EFFECTS OF FISH CAGE AQUACULTURE ON WATER QUALITY IN LAKE VICTORIA, KENYA.

1.0 Introduction

Aquaculture is one of the practices that is projected to contribute to food security and the realization of UNDP SDG 2: Zero Hunger, by 2030. However, developing countries of which Kenya is no exception, are faced with the challenge of the impact of aquaculture practices on the environment (FAO, 2006). High amount of discharges which include waste food and faeces, nutrients, and in some instances medication and pesticide residues are released from cage farms. The impact of these effluents on the receiving environment depend largely on the quantity of waste discharged, the time period at which the discharge takes place, the ability of the environment to absorb the discharges and the rate at which the receiving water body is able to flush the effluent. The sediments beneath the cages may be organically enriched, as a result the activity of the benthic organisms such as the microbes and macroinvertebrates may be affected (Findlay *et al.*, 1995).

Environmental impacts associated with cage culture are primarily because production involves large input of high-quality artificial feeds to fish cages of which only a portion is consumed and assimilated by the cultured species. Lake Victoria, Kenya is the largest tropical lake and with its consistent year-round warm temperatures, has many cage farms located on it. The number of new commercial farms on the lake that are into intensive tilapia cage culture continue to increase at a fast rate whilst existing ones like African Blue in Siaya, Victory & Jiwlett Farms in Homa Bay and Lake Tilapia in Mfangano have expanded their operations.

Gondwe *et al.* (2011) reported that about (81 - 90) % of carbon is released from cages into the recipient environment in tilapia cage culture; this could threaten the cultured fish (Effendie *et al.*, 2005). Waste food and metabolic waste from the cage culture can also be an important source of organic matter and nutrient enrichment of the sediment. This enrichment often promotes the growth of microorganisms in the water and sediment. There has not been any consistent monitoring of the physico-chemical and microbiological aspects of the lake. It therefore becomes a challenge to establish trends in water quality since the proliferation of cage farms in Lake Victoria, Kenya. This study looks at the possible effects of cage culture practices on the quality of water of Lake Victoria, Kenya.

2.0 Methodology

2.1. Sample Collection

Water samples were collected from 14th – 20th March 2022 from selected cage culture sites. The sampling stations were divided into two; low intensive and highly intensive sites based on the number of cages in a specific site (n± 100). The sampling points were divided into four; Point A before the nearest cage from the shoreline, Point B in the middle of the cages, Point C after the farthest cage and Control point at approximately 50m inshore from point C. The four sampling points in each site comprised of a transect and the number of transects was determined by the number of cages in each site. One transect was adequate for low intensive cage culture sites and up to three transects for highly intensive cage culture sites.

2.2 Water quality determination

Water samples for bacteriological assessment were collected directly into 500 ml aseptic plastic bottles for the bacteriological quality assessment. Each bottle was corked and labelled with full details of the site, time and date of collection and brought to KMFRI Kisumu laboratory in a cool box for analysis.

2.3. Laboratory analysis

The following water quality bacteriological parameters were analysed; Total coliforms and Fecal coliforms. All water quality measurements and sample collection were made between 09:00 and 15:00 EAT and analyzed using standard methods for the examination of water and wastewater (APHA, 2012).

2.4 Statistical analysis

The data collected were analyzed using R software v4.1.2. Descriptive statistics was used to determine the mean and range for the various parameters. Paired t-test was used to test for the level of significance. A probability value of 5% was assumed. Pearson correlation factor was used to determine the correlation between the concentration of total coliforms and fecal coliforms.

3.0 Results and Discussion

3.1 Microbiological quality of the study area

The histogram of total coliform is presented in Fig.1.

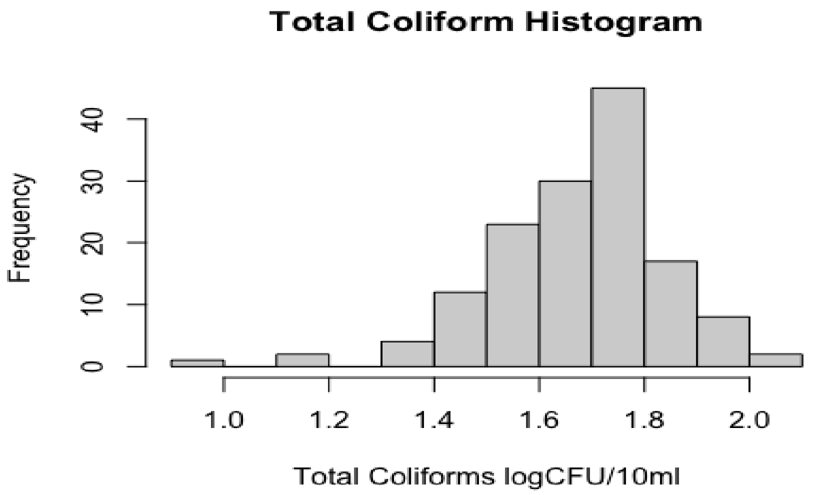

Fig. 1. Total Coliform histogram

Summary: (log Total Coliforms: Min. ~ 0.9542, Median ~1.7033, Mean ~1.6770, Max. ~ 2.0253. A log value >1.0 indicate counts of more than 10cfu/10ml.)

The mean Total coliforms for the sampled stations ranged from 9 – 160 CFU/10ml.

The histogram of fecal coliform is presented in Fig. 2.

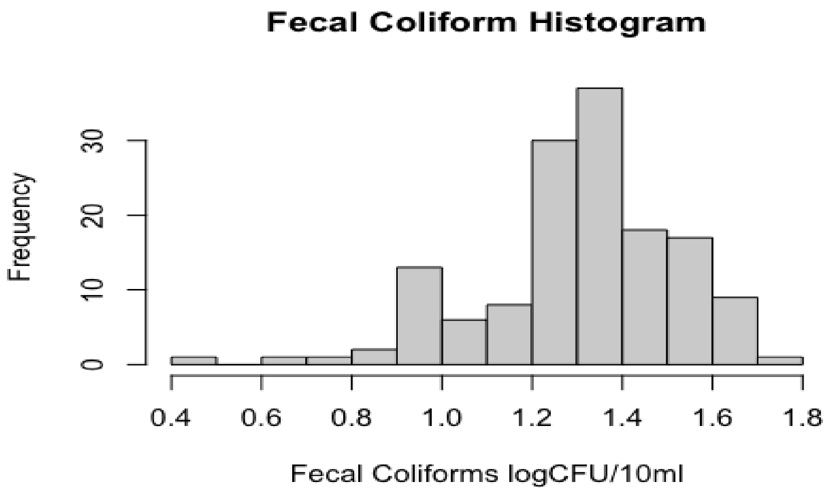

Fig. 2. Fecal Coliform histogram

Summary: (log Fecal Coliforms: Min. ~ 0.4771, Median ~1.3222, Mean ~1.3043, Max. ~ 1.7324. A log value >1.0 indicate counts of more than 10cfu/10ml.)

The mean Fecal coliforms for the sampled stations cage ranged from 3 – 54 CFU/10ml.

The mean log counts of total coliforms for different counties are shown in Figure 3.

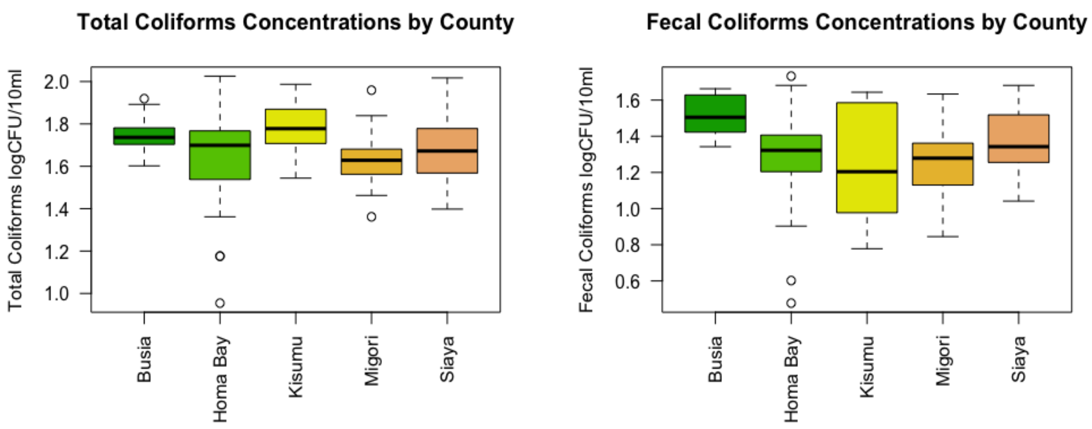

Fig. 3. Mean log Total and Fecal coliforms cfu counts per county
(Summary:

Variations in the concentrations of both Total coliforms and Fecal coliforms in different counties was not significant ($p < 0.05$). At 5% significance level and 95% confidence interval, in Figure 4 below, four out of five counties have $P < 0.05$ which means 95 out of every 100 data there is a statistically strong evidence in favor of alternate hypothesis that if total coliforms concentrations change there will be change in fecal coliforms too. The only exception is Busia county and this could be attributed to the few numbers of cage culture sites (3) recorded. There is a strong positive correlation in *R-values* indicating two variables that move in the same direction.

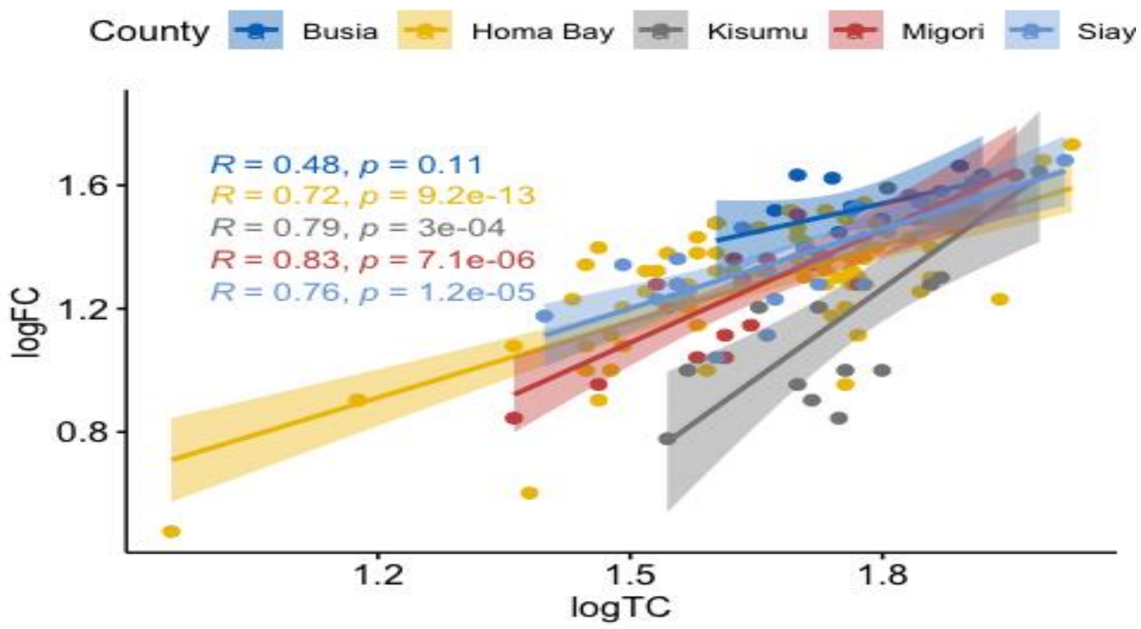

Fig. 4. Pearson correlation between Total coliforms and Fecal coliforms by county

The mean log counts of total coliforms for different counties are shown in Figure 5.

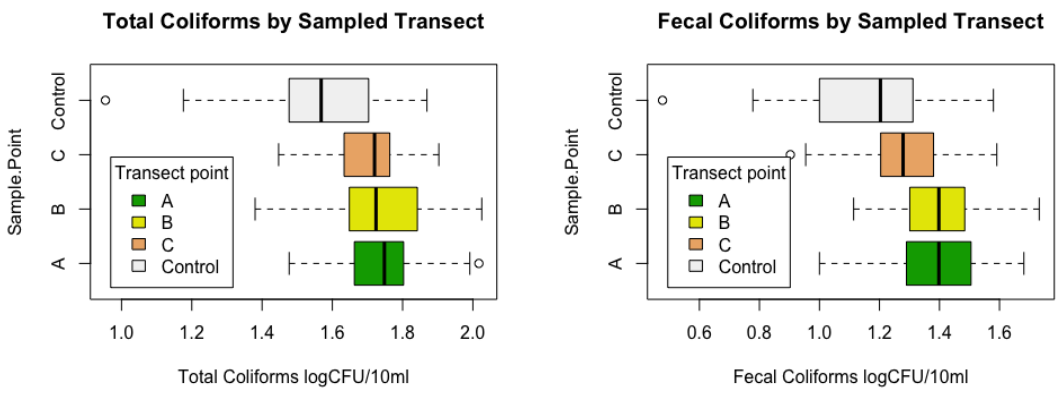

Fig. 5. Mean log Total and Fecal coliforms cfu counts per sampled transect points (Summary:

Variations in the concentrations of both Total coliforms and Fecal coliforms in different sampled points was not significant ($p < 0.05$). At 5% significance level and 95% confidence interval, in Figure 4 below, four out of five counties have $P < 0.05$ which means 95 out of every 100 data there is a statistically strong evidence in favor of alternate hypothesis that if total coliforms concentrations change there will be change in fecal coliforms too. The only exception is sample point C (end of farthest cage inshore) and this could be attributed to the missing values for point C from several stations in Homa Bay and Siaya counties. There is a strong positive correlation in *R-values.*

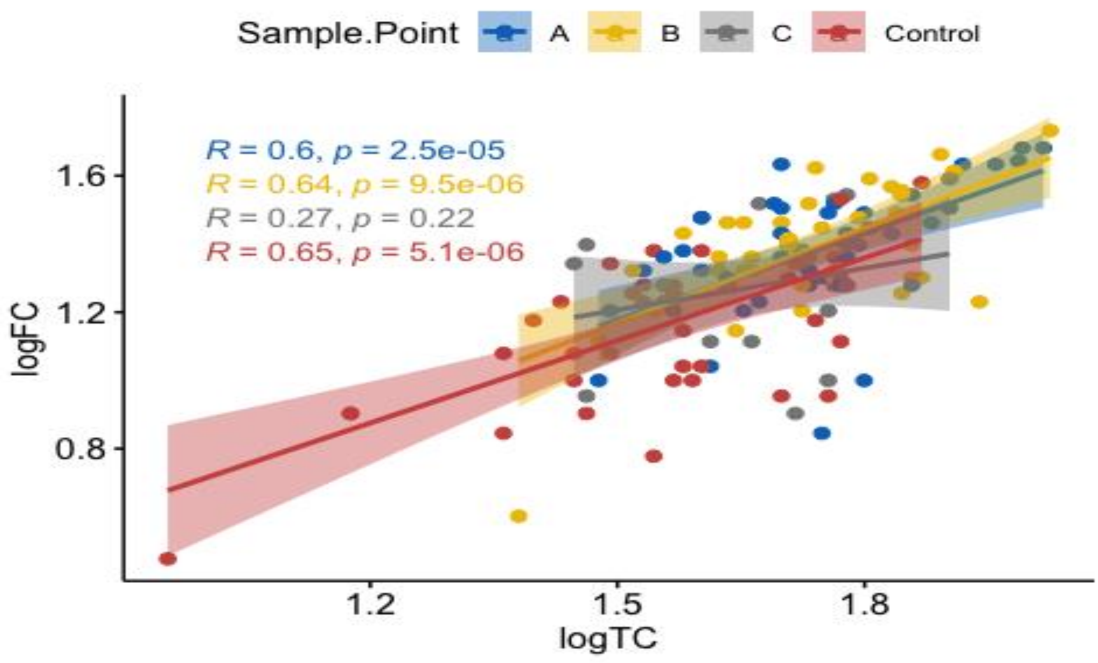

Fig. 6. Pearson correlation between Total coliforms and Fecal coliforms by transect points

The Total coliforms counts observed in all counties in this study may be due to anthropogenic activities such as tourism and sewage from the villages around the area. The people living along the lake depend on it for domestic purposes and a means of recreation such as swimming. The mean counts range was 9 – 160 cfu/10ml and the mean value (48 cfu/10ml). Some stations had values above the Water Resources Authority recommended limit of <100cfu/10 ml of total coliforms for aquaculture. Kisumu recorded the highest median total coliforms counts (56 cfu/10ml) that could be attributed to the high pollution and effluent discharge from people and industries within Kisumu City and the sheltered Winam Gulf thus limiting the ability of the water mixing up to flush the effluent.

The mean Fecal coliforms counts range was 3 – 54 cfu/10ml and the mean value (20 cfu/10ml) was above the Water Resources Authority recommended limit of <1cfu/10 ml of fecal coliforms for aquaculture. This indicates that the microbiological quality of the water at the study area, as shown by counts of fecal coliform, were unusually high.

The increase in coliform numbers recorded in Lake Victoria, Kenya depicts the cultivation of fish in net cages which requires the use of large quantity of alimentary inputs resulting in a discharge of large amounts of alimentary residues to the environment which can influence the microbiological quality of water (Gorlach-Lira *et al.,* 2013). Also, the high temperature of the water observed and the neutral and alkaline pH are favorable for the growth of bacteria (Gorlach-Lira *et al.,* 2013). Such conditions were observed in this study where the water temperature ranged from 25 - 30ºC and the majority of samples showed a pH of over 7.00 during the period of study. The high counts of fecal coliforms may be due to open defecation by the people and livestock in the area and also the discharge of sewage from the human settlement along it.

4.0. Conclusion

The mean count of total coliforms in the water samples was not statistically significant and generally did not exceed the limits recommended for aquaculture. However, the mean count of fecal coliforms in the water samples was quite high and statistically significant and exceeded the limits recommended for aquaculture. Therefore, there should be regular monitoring of not only the physico-chemical parameters, but also the microbiological parameters which are often not included in the monitoring of fish farm water quality. Proper hygiene and sanitation of the communities in the riparian counties annexing the lake, clean water access for fisherfolk and livestock living around the lake's beaches to limit open defecation in the lake, increased access to public toilets at the landing sites to limit open defecation, proper treatment of sewage effluent and regular monitoring of waste water discharge points.

References

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