FEASIBILITY OF CAGE CULTURE IN LAKE VICTORIA, TANZANIA SIDE

By

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Introduction

Cage farming involves keeping fish in any type of enclosure and involves holding them captive within an enclosed space whilst maintaining a free exchange of water eg in pond, Lake or ocean. A cage is a totally enclosed on all, or all but the top, sides by mesh or netting. Cages are usually floated in rafts, and either anchored to the lake/reservoir/river bottom, or alternatively connected to shore by a wooden walkway. Before establishing a suitable site for cage farming, the following pre-requisites are a must: Temperature –the site must be with limited temperature variation; Depth – shallow/low water depth for easily access (1- >8m); Legal aspects-right of possession to site; Salinity – depend on fish species tolerance; Shelter – not exposed to strong current, wind and storm ; Access- easy reachable; Pollution – site must be pollution free; Substrate –must have low organic decomposition so as to avoid the possibility of eutrophication; Security –safe from vandalism/poaching; Suspended solids –must be low to facilitate visual feeder fish; Currents-free from strong current 10-20cm/sec; Proximity to markets-close to market; Algal blooms –free; Disease organisms /pathogens-free; and enough free water exchange.

Fish farming in Africa started in 1920s and intensified thereafter when pond fish culture trials of tilapia established in Central Africa by 1940s (Powles, 1987; Beveridge et al., 2010). Cage culture of tilapia however, has relatively short history in Africa compared to pond culture system (FAO, 2010). It started by fishermen as means for holding suitable quantity of fish caught alive until market (Masser, 1988). Osofero et al. (2007) and Brummett et al. (2008) reported cage culture to have been first introduced in most of the tropical and subtropical regions of Africa in the 1970s. The system has many advantages including being operated in existing public water bodies (lakes, rivers, reservoirs, and costal sheltered areas). Also, it can be an alternative activity to communities with scarce land and disrupt breeding cycle in tilapiines culture, enabling rearing of mixed-sex populations and reduced over-crowding and stunting, which are major constraints in tilapia pond culture system.

Experience has shown that some form of permit or licensing system is essential if cage culture is to be effectively monitored and managed. This is because of their negative impact to environment through pollution and problem with ownership associated to public water resource allocation (Penczak et al, 1982; Phillips et al, 1983). In Tanzania like many other countries in the world, restricts cage fish culture practices in public waters including a shared Lake Victoria (Tanzania Fisheries Act, 2003). Of recently, however, Kenya and Uganda started both medium and large-

scale cage culture operations on Lake Victoria (Halwart et al., 2004). The initiatives are probably an outcome of declining fish catches reported at many landing sites of the lake (LVFO, 2011; Welcomme, 2012). The decline is mainly a result of high fishing pressure fuelled by increasing demand of fish protein required to feed an increasing human population of over 30 million people residing in the Lake Victoria Basin. The rampant use of illegal fishing gears and methods, and poor management of the fisheries resources also are mentioned as the contributing factors (Ogutu-Ohwayo, 2006; Silva, 2006).

Tanzania, on the other hand, has never practiced cage culture in the freshwater despite having enormous potentials. Designing a study on cage culture for observation of among other things, its feasibility in regard to mechanisms to undertake it and environmental impact assessment would be appreciated as highly important especially now when many of its water bodies (highly suitable for cage culture) have few fish.

A feasibility study on cage fish farming in Lake Victoria was initiated by TAFIRI. This study aimed at conducting Nile tilapia cage culture trials using the waters of Shirati Bay of Lake Victoria. The purpose of this study was to determine the growth of Nile tilapia in cages and suggesting the best optimum stocking density as well as impact of cage culture on the lake water environment. The findings and recommendations of this study, among other impacts, also are expected to have a break through towards initiating cage culture in Tanzania in the lake zone.

The following is a summary of the work carried out by TAFIRI on cage culture of tilapia. The report is soon being published in an international journal

Materials and Methods

Nine cages of 2m × 2m × 2m and of 1.5 cm mesh sizes were constructed for Nile tilapia cage trials in January 2013. The cages were set at 1^{0}8’3.78” S and 33^{0}59’45.46” N nearby to the shore of TAFIRI-Sota station, Shirati Bay, Lake Victoria, Tanzanian waters (Figure 1).

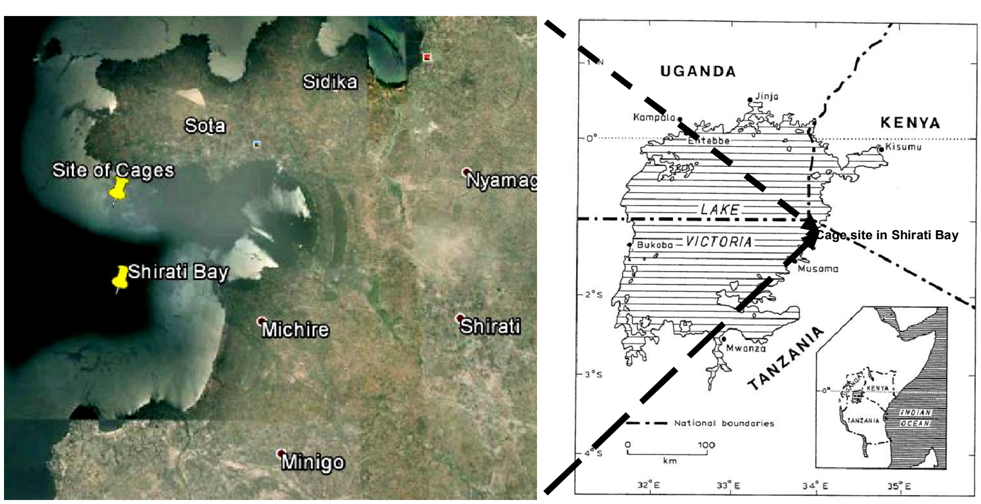

Figure 1: Site for Nile tilapia cage culture trials in Shirati Bay of Lake Victoria, Tanzania.

The setting was at mean depth of 6.1 ± 0.8 m and about 75 m offshore for exposing them to wave actions. Nine cages of 2m x 2m x 2m in triplicates were stocked with fish of mean weights of 18.0±2.1 g, 19.9±14.7 g, and 18.5 ± 8.0 g at stocking densities of 70, 100, and 130 fish/ m^3, respectively. The fish were fed on 25% crude protein (Ugachick feed imported from Uganda) at feeding ration of 5% per body weight three times a day at 1000 hrs, 1300 hrs and 1600 hrs East African time. Each set of cages with stocking densities of 70, 100 and 130 fish/ m^3 was referred to as treatments I, II, and III, respectively. In every month, 30 fish were randomly sampled from each cage totaling to 90 fish per each stocking density for obtaining an average monthly increment of weights and lengths. Dissolved oxygen, pH level, temperature and transparency were monitored weekly at 9.00 hrs while aater samples for the analysis of nutrients namely Ammonia, SRP, Total Nitrogen, Nitrates, Total phosphorus and Chlorophyll-a, was taken using a 1-litre Van Dorn water sampler from the surface, mid, and 0.4 meter above the lake bottom on monthly basis and preserved on ice pending analysis in the laboratory. Macro benthos were sampled using an Ekman grab sampler. Two hauls of the grab sampler was mixed to make one composite sample and then using a net of 500µm to separate organisms from the sediments.
The collected data were analysed using MINITAB version 13.1 (2000) for windows while comparison of mean weights of fish between treatments over the study period was made using a paired t-test. Analysis of variance (ANOVA) was used to compare means weight of fish as well as physical and chemical parameters as elaborated in Steel and Torrie, (1980). The macro-invertebrates were identified and analyzed according to Brown (1994) and Mandahl-Barth (1958, 1973 & 1988).

Results

Fish growth

A total of 7041 Juveniles Nile tilapia were stocked in cages in Shirati Bay and reared for six months period. After the six months, the measured fish survival in the respective treatments indicated highest survival in the treatment I (41.7%), followed by treatment II (30.4%), and the least in treatment III (19.3%) as indicated in Table 1.

Table 1: Growth of Nile tilapia in cages sited on Lake Victoria, Tanzania waters

	Treatment I	**Treatment II**	**Treatment III**
Stocking density	**70 fish/m^3**	**100 fish/m^3**	**130 fish/m^3**
Number of fish restocked	1521^a	2400^b	3120^c
Average weight at stocking (g)	18.0±2.1^a	19.9±14.7^a	18.5 ± 8.0^a
Average weight at harvest (g)	374.1±59.8^a	194.8 ± 63.7^c	273.2±20.6^b
Grow-out (days)	172^a	167^a	159^a

Biomass Growth Rate (kg/day)	1.03[b]	0.56[a]	0.67[a]
No. fish at harvest	644[a]	729[b]	606[a]
Survival (%)	41.7[c]	30.4[b]	19.3[a]
Specific Growth Rate (SGR)	1.03[b]	0.65[a]	0.66[a]
Food conversion ratio (FCR)	1.7[a]	3.6[c]	2.9[b]
Production (kg/cage)	210.2[c]	94.2[a]	106.7[b]
Yield (kg/m^3)	26.3[c]	11.8[a]	13.3[b]
Production rate (kg/day) or ADG	1.0[b]	0.6[a]	0.7[a]
Relative biomass production (kg/m^3)	29.7[c]	17.8[a]	20.6[b]

Note: Values followed by different superscripts (a, b and c) in a row are significantly different at $p<0.05$

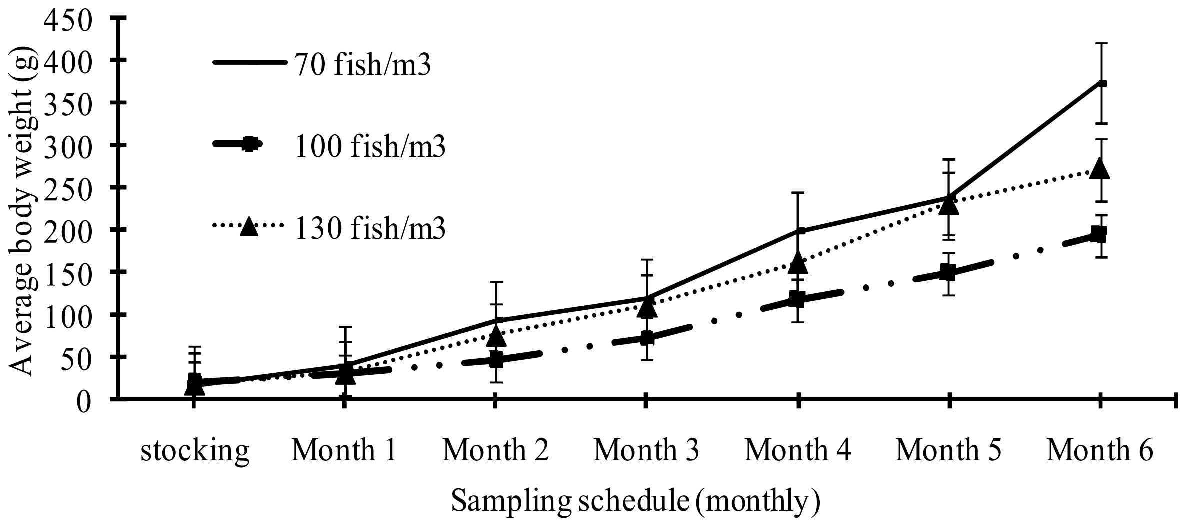

Figure 2: Growth performance of Nile tilapia stocked in cages in Lake Victoria, Tanzania waters

In treatment I fish increased at a specific growth rate (SGR) of 1.03 and this value was significantly deferent ($p<0.05$) from SGR of fish in treatments II (0.52) and III (0.50). Although an average daily growth (ADG) of fish in treatment I was the highest (1.0kg/day), but no significant difference ($p>0.05$) from the rest treatments II and III was noted (Table 1). Fish production was highest in treatment I (210.2 kg) and was significantly different ($p<0.05$) from productions in treatments II (94.2 kg) and III (106.7 kg). It was also observed that feed conversion ratio (FCR) was the lowest (1.7) and significantly different (p<0.05) from the observed values in cages for fish in treatment II (3.6) II and III (2.6).

Water quality management

Physical and chemical parameters of water were sampled for DO (mg/l), pH level, transparency, and temperature (^{0}C). Dissolved oxygen and transparency indicated slight decrease near and inside the cages and increased towards the offshore location (control) (Figure 3).Temperature was higher within the cage area and decreased gradually towards the offshore location. The pH level showed trivial decrease with increasing depth.

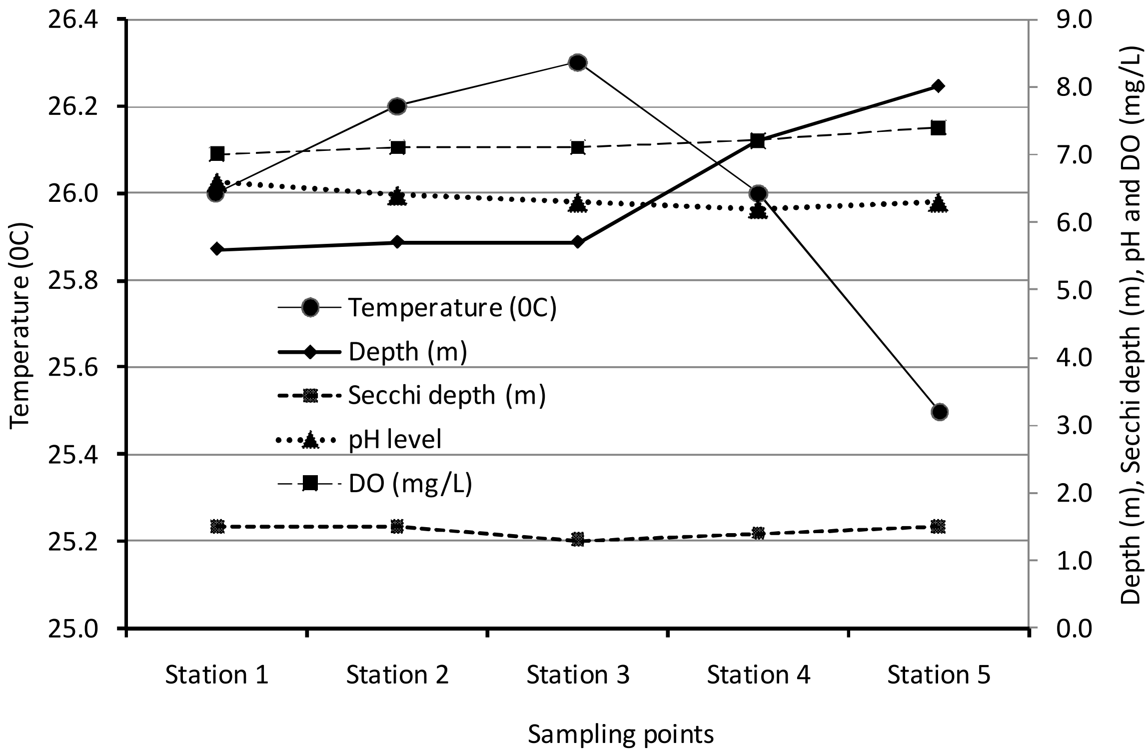

Figure 3: Physical and chemical parameters of water recorded from five sampling points

Figure 4 shows changes in depth (m), DO (mg/l), pH level, transparency and temperature (^{0}C) over the sampling period from February to August 2013. The One Way ANOVA for the test of significance in differences of the measured initial and final physical and chemical parameters indicated insignificant differences at p> 0.05.

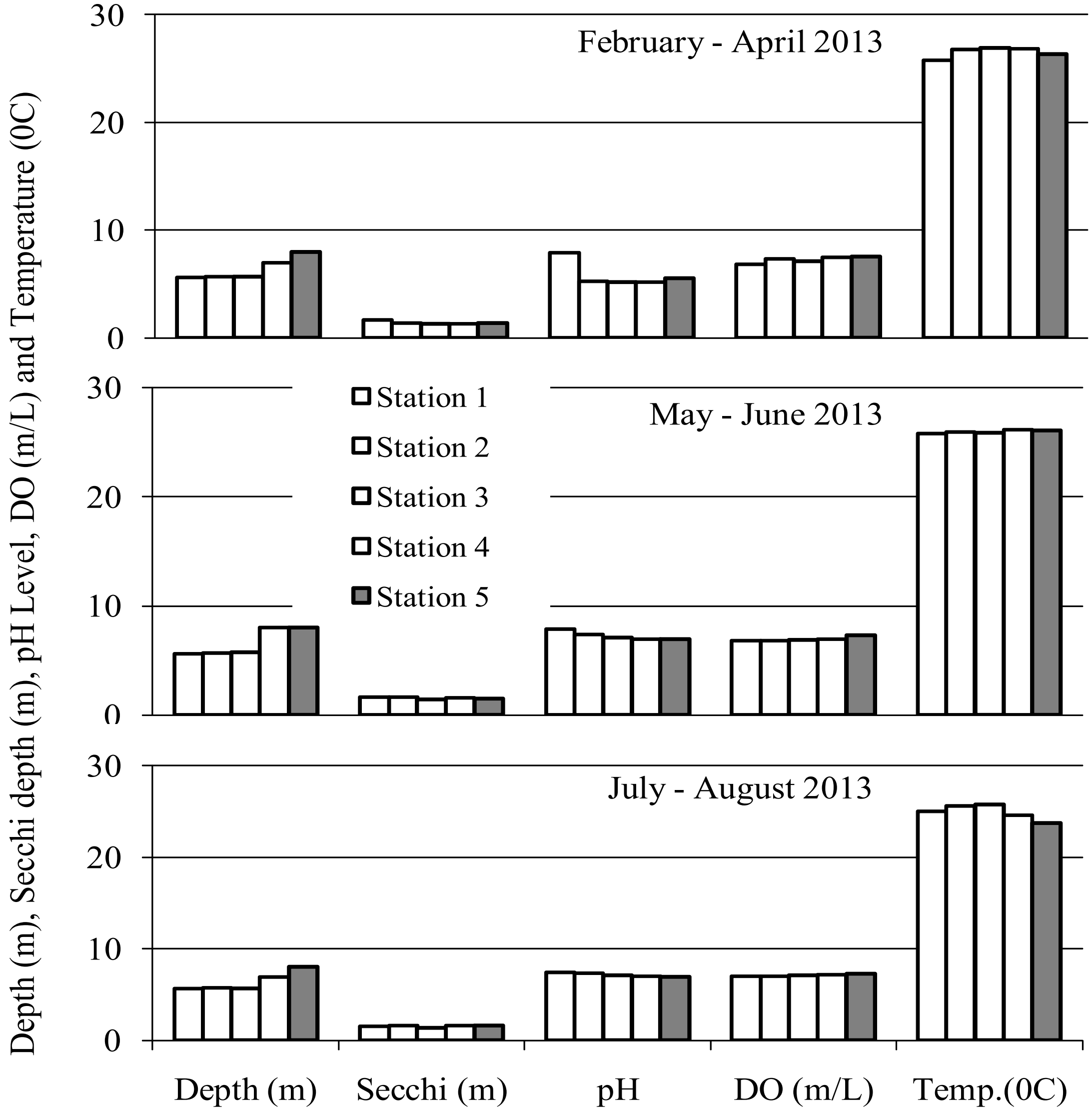

Figure 4: Changes in physical and chemical parameters of water recorded during cage fish culture trials in Lake Victoria, Tanzania from February to August 2013.

A notable increase was observed in Total nitrogen (TN) from 482µg/l±3.1 to 1034.5µg/l ±282, Total Phosphorus (TP) from 89.8µg/l ± 3.7 to 106.8µg/l ±24.5, and Ammonia (NH4-N) doubled from 168.3µg/l ±22.0 to 365µg/l 126.2. On the other hand, an increase in invertebrate community particularly bivalves and gastropods was also noted. However, these changes were within ranges usually caused by local seasonal variations and not necessarily a result of fish cage culture systems.

Discussion

Fish farming is done to maximize fish production from aquaculture systems while maintaining the best ecosystem services of water. Cage with treatment I indicated the highest performance in terms of weight gain and survival. Weight gain in fish is associated among others with the accretion of water, proteins, carbohydrates, fats, and minerals; and when fish growing at different rates will deposit nutrients at different rates and, consequently, have different feed requirements (Zaikov and Hubenova, 2008). These amount of components deposited per unit of live weight gain is not constant but rather changes with fish species and size, and feed used. Within a same species, different families or groups of individuals (strains) have different genetic make up and often differ in terms of growth potential (Bureau, 2000).

The Feed conversion ratio (FCR) is the amount of feed required to produce 1 kg of fish. This value was lower for fish in treatment I (1.7) than in the other treatments. The differences in FCR among treatment resulted from complex factors that are taking place in the water environment, which include abiotic and biotic factors. The major factors that influence FCR in fish is temperature and quantity of dissolved oxygen in water, the type of food, and the age of fish (Ofori, *et al.*, 2009). With exception of treatment I, FCR of treatments II and III were above 2.5, which is the maximum value attained by most tilapia cage aquaculture systems in Africa (Ofori, *et al.*, 2009). Other reasons for high FCR in treatment II and III may be extensive feed wastage due to poor control of feed delivery and other numerous parameters still not under control, such as survival, the impact of natural productivity, and variation in appetite of the fish. In this study, fish attained a mean weight of 374.1 g under treatment I and 273.2 g in cages of treatment III conforming to their FCR values. These mean weights of fish attained are within the range of 200 to 500 g, which is the size of Nile tilapia targeted in most of West African countries (Ofori *et al.*, 2009).

Generally, fish survival was low in all the treatments (averaging 30.5%) and much lower in the treatment III (20%). The finding might be attributed to stress associated with fish transport, and generally handling. Also, stress at stocking and regular monthly sampling and measurements. The much lower survival of treatment III is probably a result of increased stress due to highest stocking density in this treatment. Although there are many possible causes of fish mortality, most cage fish kills are usually a result of low dissolved oxygen and will not result in the complete elimination of fish populations, but many small fish will usually survive (Marianne and Leland, 2003).

Water quality management is a key to successful fish cage culture venturing. Wastes from cage fish farms including uneaten food, faecal and urinary wastes are normally freely released in the water environment (Beveridge and Phillips, 1993). In order to allow health ecosystem services, cages with net baskets of 2 m deep were sited at mean water depth of 6.1 ± 0.8 m. This left an allowance of about 4 m for free movements of wastes from cages and free circulation of dissolved oxygen required to support good growth and health of fish.

In this study, the values of DO and transparency indicated a slight decrease from nearby to inside the cages, indicating the influence of wastes release from cages. According to Barica (1976) and Beveridge (1984) changes in water quality parameters of the water column may be indicative of pollution and self-inflicted water quality-related problems, affecting cage farms in lakes and reservoirs. Values of dissolved oxygen and transparency in the offshore sampling point (control) were bit higher as compared to those near the cages implying that there was some cage impact on the parameters. According to Beveridge *et al*. (1997), a minimum of three parts per million (3 ppm) or maintain 5 mg/l of DO at temperature between 25^0C-30^0C is suggested to be an ideal temperature for Nile tilapia farming in fresh waters. This facts need to be taken into considerations especially when cage production increases and there is intensification of production methods.

Temperature and secchi depth recorded in this study ranged from 24 to 27^0C and 1 to 2 m, respectively. Temperature range was within the ideal range for good tilapia growth, which is between 25 to 30^0C (Beveridge *et al*., 1997; Ofori *et al*., 2009). Despite the declining trend of transparency as compared from points inside and outside the cages, generally, variations throughout the sampling period were small. This fact implies that there were relatively low quantity of suspended soil, organic material (detritus), and the plankton (floating or suspended microscopic plants and animals) within and away from the cages site. It is known that, high water turbidity reduces light penetration and it should not fall beyond 100 ppm to avoid fish kills when upwelling of anoxic hypolimnetic waters occurs during mixing (Beveridge and Muir, 1997).

In this study, pH level declined trivially with increasing depth (ranged from 5.6 to 9.8). The values recorded, though, slightly deviated from the best pH range of 6 to 9 for tilapiine to positively survive; we think the variations had no negative impacts as the range can extend between 5 and 10 (Thomas and Michael, 1999). Generally, we think, the recommendable values of physical and chemical parameters in this study is a result of the cages being located in a good site with water currents from 10-20 cm/ sec as suggested by Costa-Pierce, (1996). This range of water current has good effect on the oxygen supply of fish and can ensure permanent water exchange between the water body inside and outside of the cage contrary to that, cages could have negatively influenced the environment and recommended as unsuitable. In this regards, selection of site for sitting cages, is of paramount important for its feasibility.

Nutrients (Ammonia, Total Nitrogen, Nitrate, Nitrites, Total Phosphorus, and Chlorophyll-a) varied during the study period possibly due to local seasonal conditions however, they were within the values recorded from other parts of the lake. The changes noted in this study may therefore, not necessarily be a result of fish cage farming ad no negative impacts to environment as they were within tolerable ranges.

Conclusion

Of the three stocking densities, Nile tilapia grew better in cages with low stocking density of 70 fish/ m^3 than in the higher stocking densities tested in this study. Generally, cages did not have alarming negative impacts to the environment because the values recorded at the end of trial were within ranges found elsewhere in the lake. However, factors such as water quality, water currents, physical and chemical parameters of water volume have to continual be monitored to ensure that they are within recommendable values.

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