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Full Length Research Paper

A Comparative Study of Cage and Earthen Pond Culture of Oreochromis Jipe, In Lake Jipe, Taita/Taveta District, Kenya.

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The study focuses on cage culture of a tilapine fish *Oreochromis jipe* in Lake Jipe, Taita Taveta District. Tilapia fish performance in aquaculture is largely earthen pond based. Due to the increased salinity in the soil of the lake, predation and prolific production of the fish, cage culture will be preferred. Tilapia are excellent culture species partly because, they grow well on a variety of natural food organisms including plankton, benthic organisms and decomposing organic matter. *Oreochromis jipe* is one of the most tolerant species to most environmental water quality parameters such as high salinity, water temperature, low dissolved oxygen and high ammonia concentration. 4 fish cages measuring 5mx5mx2m depth and 4 earthen ponds of similar size were used for the study and were stocked with 5gm fish fingerlings at the average stocking density of 6 fingerlings per square meter of water. The cages were then covered with a silk mesh net cover on top to prevent predatory by aquatic birds. The fish fed daily at 5% body weight for a period of 8months when they were harvested. Water quality was assessed fortnightly so as to check on pollution in line with APHA,AWWA (2005) guidelines on water quality assessment. Socio-economic studies were conducted. The results of the study indicated a faster average growth of fish in the cages(182.11gm) than in the earthen ponds(165.18gm). The water quality is within normal range and devoid of heavy metals and is thus safe for domestic and wildlife use. Socio-economically the community depends of fisheries and its activities for livelihood.

Keywords: Cage and Earthen pound, *Oreochromis Jipe*, Lake Jipe, Pond culture in kenya

INTRODUCTION AND BACKGROUND

Lake Jipe is a small shallow lake measuring 12km long and 3m depth, covering an area of 30km2 llying along the Kenya-Tanzania border, to the East of the Northern Pare Mountains of Tanzania.

The lake has been the main fisheries source in the Taita-Taveta region and a biological spot in a semi-arid area. The lake receives its main inflow from River Lumi in Tahnzania. The other main inflow is River Muvulani from the Pare Mountains. The lake has one outflow, the River Ruvu located in Tanzania.

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The lake is surrounded by a dense cover of Typha domingensis which has been reported to be expanding by the local community. The lake had a booming fishery in the 1960s dominated by *Oreochromis jipe* and Clarias gariepinus along with Barbus spp. and labeo as minor components. *Oreochromis jipe* was later displaced by Oreochromis esculantus reportedly introduced from lake Nyumba ya Mungu downstream, when a decline in the fishery was noted (Twong'o and Sikoyo, 2002). Subsequently, the fishery of the lake jipe collapsed and the fishermen and stakeholders in the various ancillary services left the lake. Resident communities around the lake recall the fishery as the most important resource the lake has had because it provided them with food and income. Overfishing, predation and lack of control on fishing methods were probably the main causes of the decline in fishery of the lake.

The lake and its wetlands are of international importance, both as a shared resource and as a home to a diverse fauna and flora. The biodiversity rich ecosystem is known for its water birds and is one of the few places in East Africa where the lesser jacana, the purple gallinule are common and where the Madagascar Squacco heron, Black heron, Africa darter and African skimmers are often seen. It is also a habitat of other aquatic life forms like hippos and crocodiles. The lake supports livelihoods of more than one hundred and twenty thousand inhabitants both in Kenya and Tanzania who depend on it. The lake ecosystem is at risk from environmental degradation owing among other factors, the diversion of the rivers flowing into the lake, particularly the Lumi River on the Kenyan side. This phenomenon has led to siltation and coupled with drought and reduced run off has created conducive conditions for the rapid growth and spread of the macrophytes which have colonized more than half of the lake.

Socio-economically, Lake Jipe is important to both Kenya and Tanzania for agriculture and fisheries as well as a biodiversity rich habitat in terms of fauna and flora. Also the lake provides water supply for domestic uses, reeds for fishing gears, irrigation, livestock uses, and attraction for wildlife tourism, building and roofing materials and for artifacts.

Location

Lake Jipe is situated to the southeast of Mt. Kilimanjaro in Taveta District (CoastProvince) of Kenya and in the Kilimanjaro region of Manga District in Tanzania.

It lies between 3035' south and 37045" east. The open water of the Lake is about 10km long, 3km wide and 2m deep.LakeJipe straddles the border of Kenya and Tanzania with a wide drainage. The catchment and basin stretches from the eastern part of Mt. Kilimanjaro and Pare mountains towards Lumi river in Kenya.

Due to high evaporation rates, the water of the lake is highly saline.

Geology and Soils

The lake Jipe catchment area has sedentary soils of metamorphic origin, while the northern and southern parts have sedimentary alluvium soil, products from the incoming rivers. Volcanic foothills and lava flow occurs although topographically it is lowland. Some of the lava flows are believed to have originated from Mt. Kilimanjaro. The rocks are mainly basalts, phonolites and tuffs. Fertile soils have developed on volcanic rocks and ashes (Were,1986,4). Mt. Kilimanjaro region is covered with Quaternary lavas, pyroclastics and debris flow deposits and fluviatile and lacustrine volcanic sediments (Omenge 1993, Toya et al,1973).

The geology of the area has caused an increase in lake level, leading to an expansion of the lake to the south. Deeply weathered soils are widespread in the sub-district, with highly fertile vertisols (black cotton soils) characteristic of this region, particularly in plains and depressions. Vertisols contain mainly clay that hardens and cracks during the dry season.

Climate and Rainfall

The climate in the basin is arid to semi-arid except in the highlands where it receives substantially more rainfall than the lowlands. The long rains are between March and May, whereas the short rains are between November and December. The annual average rainfall is 350 to 750mm per year. The temperature around the basin ranges between 21°C and 38°C and potential evaporation is 1950 mm per year. This area has a high ground water table.

Hydrology

The main source of water of lake Jipe is springs and rainfall and to a small extent the snowmelt from Mt. Kilimanjaro. The major springs are Saite, Little Lumi and Njoro Kubwa springs. Several springs and the River Lumi drain into the lake. River Lumi is also fed by subsurface waters from Mt. Kilimanjaro. The lake has one outflow, the River Ruvu, situated in Tanzania to the south of River Lumi, the main inflow. Taveta District has a high groundwater table and substantial water resources due to its proximity to Mt. Kilimanjaro and Pare mountains. The rainfall at the slopes of Mt. Kilimanjaro is often heavy and runoff is high causing floods.

Table 1. Average Monthly Physico-Chemical analysis of Water in Lake Jipe

PARAMETER	APR	MAY	JUN	JUL	AUG	SEP	OCT
Water temperature	24.3	23.1	23.6	25.9	26.7	26.9	27.2
Dissolved oxygen	6.9	7.4	7.4	6.1	6.0	5.7	5.3
PH	6.8	6.4	6.2	7.1	7.6	6.9	6.9

Table 1. Weight and length measurements of fish in earthen pounds

Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	**Average**
Weight(gm)	5	46.3	119.5	184.7	191.2	227.3	252.8	294.7	**165.18**
Length(cm)	7.5	8.4	9.1	10.3	12.4	13.9	15.1	17.2	**11.73**

Table 2. Weight and length measurements of fish in cages

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	**Average**
Weight(gm)	5	66.3	137.7	194.1	213.8	246.5	287.2	306.3	**182.11**
Length(cm)	7.5	9.8	11.4	13.3	15.7	16.9	17.8	18.4	**13.85**

Table 3.a) Average Water quality assessment of Lake Jipe

S.No.	Parameter	Average
1	Air Temperature	25.4^0C
2	Water Temperature	18.9^0C
3	Dissolved Oxygen	10.2 mg/l
4	PH	7.02
5	TDS	678ppm
6	Conductivity	1.4mv

Table 3.b) Average Water quality assessment of Lake Jipe earthen pounds

S.No.	**Parameter**	**Average**
1	Air Temperature	25.8^0C
2	Water Temperature	19.2^0C
3	Dissolved Oxygen	8.4 mg/l
4	PH	7.0
5	TDS	693ppm
6	Conductivity	1.7mv

Table 4. Heavy Metals Analysis of the water of Lake Jipe

S.No.	Parameter	Average
1	Copper (Cu)	-0.424mg/l
2	Zinc (Zn)	-0.224mg/l
3	Cadmium (Cd)	-0.286mg/l
4	Magnesium (Mg)	6.255mg/l
5	Lead (Pb)	-0.027mg/l
6	Manganese (Mn)	0.078mg/l

Vegetation

The lake Jipe area is covered by arid and semi-arid lands (ASAL) vegetation comprising of grasslands, woodlands and shrubs with savanna species (Acacia, commiphora sp.). The lake is surrounded by a dense cover of Typha domingensis upto about 1 km wide along the southern, western and eastern shores, narrowing to less than 50m along the north shore. The lake Jipe macrophytes mainly Typha and Papyrus sp. locally known as Makuruvira and Mabulla respectively were first spotted in the area in the early 1950s. As years passed on, they became more visible and permanent. Where the ground water is high, riverine wetland vegetation types of A.xanthophloea, Millicia excelsa, Albizia sp. and Ficus species occur.

Biodiversity

Lake Jipe ecosystem is rich in biodiversity and is the main watering point for elephants and other Wild animals from Tsavo west national park. The lake is home to crocodiles, Hippos, various species of water birds, elephants, zebras, impalas and gazelles. The extensive cover of Typha and Cyperus swamps covering the 4045 ha surface area of the lake is habitat to several bird species and is a breeding area for fish such as *Oreochromis jipe*. This fish thrives in the lake and hence supports the local fishing industry.

The vegetation of the lake and its associated wetlands is dominated by bulrush (Typha domingensis) locally known as 'Gugu maji' that grows out from the lake show and forms floating islands as well as lining the lake edges. On the land ward side of the rushes are swards of Cyperus laevigatus, Sporobolus spicatus and Sporobolus macranthus and also papyrus as the major plants. The distribution of individual plant species seems to follow closely, the moisture conditions and the chemical nature of the soils.

A diverse population of fauna inhabits the lake and its ecosystem. Wildlife migrates from the Tsavo National park to the wetland in pursuit of pasture and water. Herbivores, carnivores, Ungulates, reptiles, and other wildlife have adapted to the environment around the lake Jipe catchment area.

Among water birds, (Avifauna), there is the lesser jacana, the purple gallinule, the Madagascar squacco heron, the black heron, the African darter and the African skimmers are common. Lake Jipe is one of the few places along the Eastern Africa region where, the Lesser Jacana and the Purple Gallinule are found. The fish include, the endemic tilapia (*Oreochromis jipe*), a mudfish (Clarias mozambicas, and a sardine (Rastineobola argentae). Also present are crocodiles, Hippopotamus, water monitors and otters amongst others. The lake is important to the fauna around it, because it is a permanent source of water and green vegetation throughout the dry season. The southern part of the lake in Kenya is in Tsavo West National park where it is both a watering and feeding resource for elephants, buffaloes and other ungulates.

Literature Review

Cage culture dates back to the 13th century in the Yangtze River delta in China (Hu, 1994). This system of fish culture also has a long history in South East Asia (Ling, 1977) and various modifications have been developed for intensification of commercially important species (Coche, 1982). However, the culture of tilapia in cages has a relatively short history, only going back to the 1960's in the United States, where *Oreochromis aureus* was selected as an initial candidate for cage culture (Pagan, 1969). In Africa, the first cases of tilapia cage culture are reported from Ivory Coast with Oreochromis niloticus (Coche, 1982).

It is from such humble beginning that cage culture of tilapia spread progressively to several other regions

worldwide, though in many developing countries such as Kenya, the main culture systems remained semi-intensive earthen pond culture systems (Wortfarth and Hulata, 1983). Problems associated with cage culture include degradation of aquatic ecosystems emanating from use of protein rich diets and subsequent discharge of the nutrient-rich effluents into the natural ecosystems accelerating global problem of eutrophication (Beveridge, 1984).

In aquaculture, feeding rates are often a function of factors such as fish size, biomass and time of the day, dissolved oxygen levels, temperature and other water quality variables. Under semi-intensive culture of tilapias, it is not advisable to feed fish in the morning when the lowest dissolved oxygen levels occur. In re-circulating aquaculture systems, where oxygen is continuously supplied, fish can be fed at nearly any time (McElwee, 1999). It has been observed that the feeding rates of tilapia fishes in cages decline and feeding rates should be reduced proportionally. Lovell (1989) observed that at optimal water temperatures, fish weighing <5g required feeding rates of upto 10% body weight, whereas fish weighing more than 200g grew well even on daily feeding rates of less than 2 % body weight.

Water quality management remains one of the most important operations in the successful culture of any fish species and most periods of poor growth, disease and parasite outbreaks or fish kills are often associated with poor water quality (Boyd, 1990).

METHODOLOGY

Cages

The cages were constructed using PVC pipes melted with hot electric drills to fit (Figures.3 and 4).
Two metal rafts with wooden walk ways each carrying two cages of approximately five meters long and 5m meters width and 2m deep were constructed with metal frames,on wooden walk ways and floaters fixed and netting mesh (Ndogoni and Mwachiro, 2007)

Middle -Landed cages with floaters seen as shinning objects – Kenyan side of the Lake. Infront- A canoe/boat carrying materials (Galvanized binding wire) used for fixing and strengthening the cages.

Earthen Ponds

Six earthen ponds measuring 5m x5m x2m were constructed along the edges of the lake. Four of these ponds were used in the study. The earth was compacted and grasses planted on the sides to prevent soil erosion. The ponds were filled with water from the lake and allowed to settle for two weeks. Fish fingerlings of *Oreochromis jipe* weighing 5gms were then introduced. Feeding was done at regular intervals with fish meal. Monitoring of water was done regularly at intervals of two weeks.

Stocking of Fingerlings in Cages and Earthen Ponds

The cages after landing and fixing were left for two week to stabilize and remove any fumes that might have been present in the materials used.

This period removed fears of the material's fumes from choking the fish fingerlings when breathing.
Each cage measuring 5x5x2m was stocked with fingerlings at the rate of 6 fingerlings per square metre volume of water.

A total of 300 fingerlings of 5gm each were stocked per cage and per pound.

Feeding

Feeding was based on "four fixes" i.e

> Fixed feed quality- fresh and palatable with a high nutritive value
> Fixed feed quantity- fixed amount of feed every day to avoid poor digestion, poor absorption and slow growth
> Fixed feeding time- 10.00am and 4.00pm
> Fixed feeding location- At the same place at each feeding e.g. feeding platform.

The fingerlings after stocking were given one week to acclimatize before feeding.

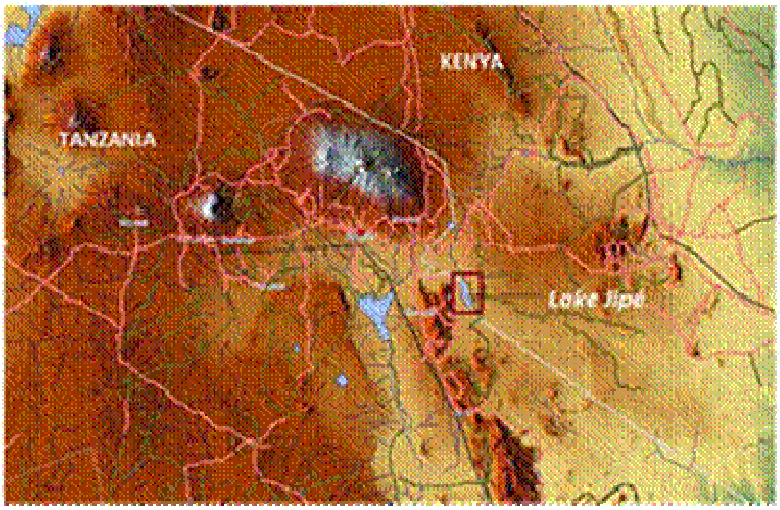
5% body weight feed was used to feed the fingerlings.
Growth was monitored monthly with the amount of feeds adjusted according to the weight of the fingerlings upto 10% body weight.

The fishes were observed to grow practically throughout the study period in a linear pattern. Initially the growth was slow, with an increasing slope, representing an increasing rate of growth. Thereafter, the curve was observed to rise with a decreasing slope, representing a continuing decline in the rate of growth.
The fingerlings were fed twice in a day, in the morning when oxygen levels were expected to be low and in the evening.

The fingerlings were fed daily for a period of eight months.
Every month, weight was taken and amount of feeds adjusted upto a maximum of 10% body weight.

INTRODUCTION AND BACKGROUND

The Cage Culture of *Oreochromis jipe* project is one of the research projects funded by the Ministry of Higher



Size of this preview: 800 × 530 pixels. Other resolutions: 320 × 212 pixels | 640 × 424 pixels.
Figure 1. Lake Jipe

Figure 2. PVC pipes, Wood and metal bars (Materials for fabrication of cages and walkway)

Figure 3. PVC materials ready for cutting to size and melting for fabrication of cages

Figure 4. A Technician melting a pvc pipe to fix during fabrication of cages

Figure 5. An incomplete cage undergoing fabrication.

Figure 6. A complete cage 5x5x2m ready for fitting of netting material and landing

Figure 7. A cage fitted with netting material ready for landing

Figure 8. An artisan fixing a landed cage

Figure 9. Cages having been landed in water with artisans fixing them at the desired depth

Figure 10. Far front- The Pare mountains in Tanzania.

Figure 11. Communitty members engaged in ponds excavation adjacent to Lake Jipe

Figure 12. Women actively involved in excavation

Figure 13. Community members taking a break during the excavation process

Figure 14. Two of the six ponds excavated being compacted and partly filled with water

Figure 15. A member of the research team supervising ponds being constructed and compacted

Figure 16. A community members appreciates the ponds constructed at Jipe through the project

Figure 17. Fingerlings of *Oreochromis jipe* being stocked into the cages and earthen ponds.

Figure 18. Supplemental fish feeds for the fingerlings.

Figure 19. More supplemental feeds for the fingerlings.

Figure 20. Large table size tilapia harvested from the cages and earthen ponds

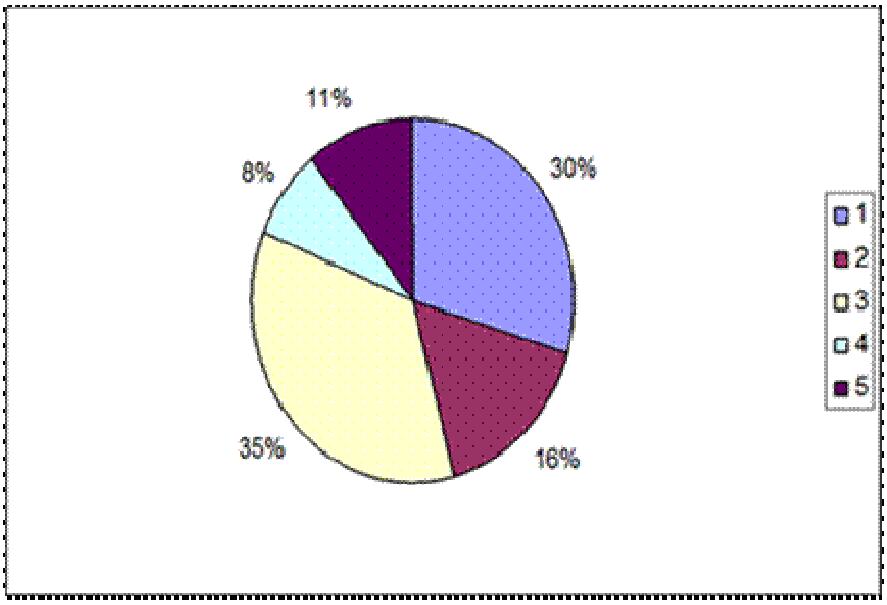


Figure 21. Age composition of Jipe residents by age groups
Key: **1**: 15-25yrs **2:** 26-35yrs **3:** 36-45yrs **4**: 46-55 **5**: 56 and above

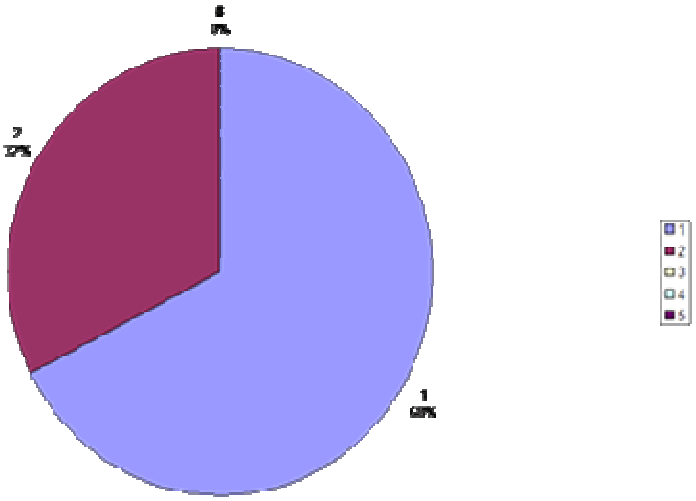


Figure 22: Sex of the jipe residents in percentage
1. Male **2**. Female

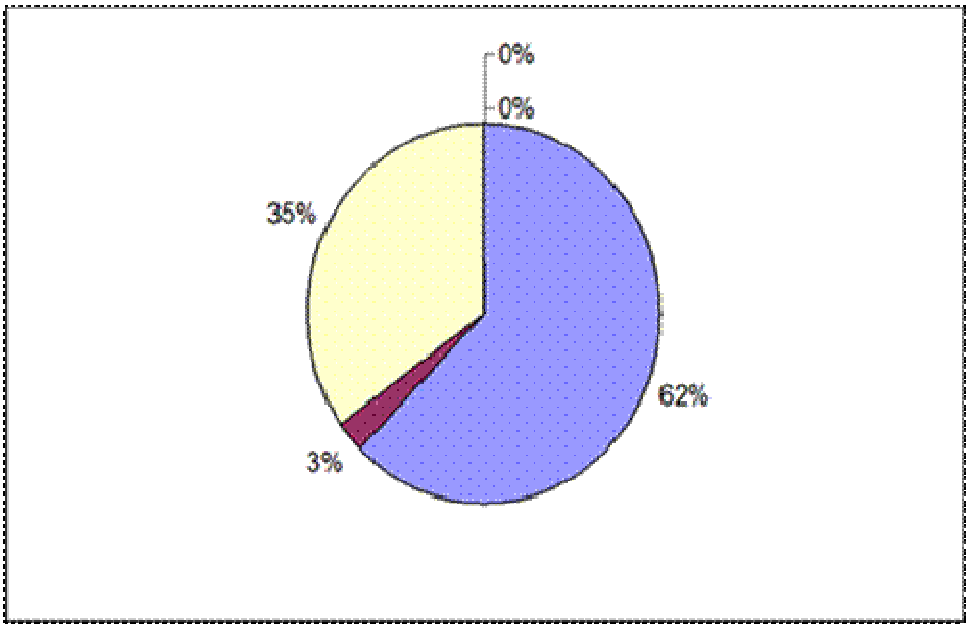


Figure 23. Economic activities of Jipe residents
Key: 1 – Fishermen – 62% 2- Farmers – 3% 3- Fish dealers – mama karanga/suppliers – 35%

Education, Science and Technology through the National Council for Science and Technology. The project aims at making findings on the success of rearing the tilapia species in Jipe under cage culture.

The project also had a socio-economic component under which the survey has been done. The purpose of the survey is to get data on the nature of economic activities being undertaken by the residents in Jipe as well as the average returns from the identified activities. Also being surveyed is the issue of gear use and ownership among the fishermen, an indicator of the state of poverty among the fishers in any fishing ground. Access to credit and saving services was also investigated as the people with a saving culture tend to move out of the vicious cycle of poverty much faster and easier than those with no access to such services.

The project also through this survey seeks to know if there are any other projects around Jipe that had been implemented in the area to improve fish production in the lake and also look in the ways of improving the current project to achieve better results socially.

Cage culture is not a new phenomenon in the country though its practice has been low among many fishing communities. Trials of cage culture have been carried out in small scale in various parts of the coast region; however the fabrication and installation of cages in Lake Jipe is one of the first and its successful posting of results will be keenly watched.

The rearing of fish under cages has several advantages among them increased or improved stocking density, easiness in harvesting as well as assessment of fish growth, higher maturity rates, there is free contact with the normal environment among others.

METHODOLOGY

The socio-economic studies were done through oral interviews and use of questionnaire. Statistical data was analysed using SPss Version 11.

RESULTS AND DISCUSSION

The results of the baseline survey for the socio-economic situation of the people living in Jipe area of Taveta indicate that of the population sampled, 67.6% of the population are male while the rest are females. This shows that over 2/3 of the sampled population are males.

The ages of the population in Jipe which was sampled ranged from 15 years to above 50years with a majority of the sample population ranging between 36-45years; this was represented by 35.1%; the other age group that follows in majority is 15-25 years standing at 29.7%

The majority of the people living in Jipe are directly dependent on the lake for their survival. 62.2 % of the

population in Jipe is dependent directly on the lake as fishermen while 35.1% also deal on fish marketing and related business. Only 2.7% of the population do crop farming in the area.

Out of the total population in jipe which deals with fishing, 45.9% own fishing gears which are in form of boats and fishing nets. This means a majority of the fishermen in the area depend on gears which are either hired or borrowed from other fishermen.

Water Quality Assessment

INTRODUCTION

Water, the vital resource of life has adversely been affected both qualitatively and quantitatively by human activities.

Increasing human populations, industrialization, urbanization and developmental activities have subsequently polluted water.

Sewage, domestic waste and agricultural effluents contain substances, some of which are very toxic to life.

Man has tried to cope up with this scenario, by monitoring the chances of pollution in various water bodies in an effort to counteract this increasing phenomenon.

A number of parameters signifying the quality of water have been proposed.

The lake Jipe surrounded by the Pare mountains of Tanzania and the Tsavo West national park of Kenya provides a site where water monitoring is necessary because of human settlements and wildlife.

In the current study, Physico-chemical and biological parameters which are likely indicators of pollution will be monitored.

Water and Air temperatures, Dissolved oxygen, PH, TDS, Electrical conductivity and nutrients including heavy metals were determined.

METHODOLOGY

Water temperature, Air temperature, TDS, PH, Conductivity and were determined using Adwa, AD, portable water sampler from Romania, Europe.

Heavy metals were determined using the Atomic Absorption Spectrophotometer (AAS) – PG 990 at Pwani University Biology laboratory donated by National Council For Science and Technology, Nairobi. TDS was also determined by use of Waterproof TDS tester.

RESULTS

The results of the study are as follows;

DISCUSSION

Lake Jipe is surrounded by the Pare Mountains to the West and the Tsavo West National park in the East. Earthen ponds nd cages were constructed and stocked with 5gm fingerlings of *Oreochromis jipe.* Feeding was done based on the four fixes, i.e. Fixed feed quality, Fixed feed quantity, Fixed feeding time and Fixed feeding location. The results obtained after 8 months of feeding both in the earthen ponds and cages indicated a faster growth(182.11gm) in the cages than in the earthen ponds(165.18gm). This probably is as a result of free movement of water in the open lake , availability of additional natural food in the lake and increased oxygen circulation. In the ponds, water movement was restricted as opposed to the water in the cages where flow of water was freely observed. Decomposed food remains were also observed in the ponds as opposed to the cages where food remains were washed away by water currents. The length of the fish also showed a similar trend, with longer fish (13.85cm) observed in the cages than in the earthen ponds(11.73cm).

Water quality was within normal ranges for almost all parameters measured. Heavy metals were not recorded in the lake, making it safe for domestic and wildlife use.

Socio-economically, the community depends so much on the lake for their livelihood. A large percentage (62%) are fishermen or fish related activities with majority of them being male(68%).

According to the above results, the water of Lake Jipe is warm with average dissolved oxygen level of 10.2mg/l.

The PH of the Lake is within normal average levels of 7.02.

Heavy metal status of the Lake indicate that most heavy metals are not traced in the lake.

CONCLUSION

The waters of Lake Jipe have no indication of pollution at the current status and can be rated as Clean water with moderate levels of eutrophication.

The water of the Lake is fit for fish farming and even for domestic use. The wildlife from the Tsavo East National park which uses the water of the Lake for drinking purposes are out of danger from any kind of pollution from the lake.

RECOMMENDATIONS

The water of the Lake is currently not polluted as such; it is safe and so can be used for purposes of fish farming as well as for domestic use.

The Kenya Wildlife service's who monitor the activities of the lake should continue with their vigil to ensure that the lake remains uncontaminated.

The water of Lake Jipe is safe and free from heavy metal contamination, so it is not a health risk both for human beings as well as for wildlife around the area.

Since the Lake is not polluted, measures should be taken both by the local community and the other stakeholders to monitor and ensure that the water of the lake remains safe and out of possible pollution.

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