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Assessment of Some Invasive Aquatic Weeds and Water Hyacinth Effect on Fishery and Other Aquatic Biota in Lake Tana, Amhara Region, Ethiopia

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ABSTRACT

The study was conducted from July 2014 to December 2017 in Lake Tana. Sampling sites chosen from Fogera, Libokemkem, Dembia, Bahirdarzuria and Takusa Woredas and purposive sampling sites were selected from each Woreda based on invasive weed infested areas. Plant sample was collected from infested areas using quadrant and different parameters were recorded using sensitive balance and tape meter. Dissolved Oxygen (DO), pH, specific conductance (K_{25}), Total Dissolved Solids (TDS), salinity (sal) and Temperature (T) were measured *in situ* using YSI 556 multi-probe system. Measurements of ammonia (NH_3-N), phosphate (PO_4-P), nitrate (NO_3-N) and total hardness were carried out using a portable water analysis kit (Wagtech International, Palintest transmittance display photometer 5000). Water samples were collected from each sampling station up to a depth of 1 m using a bucket of known volume. Zooplankton and phytoplankton samples were collected by 80 µm and 50 µm mesh net filtering device. Identification and enumeration of invasive weeds and planktons was made using standard procedures. As a result Water hyacinth, Azola, *Potamogeton foliosus* and water lettuce were investigated. In the case of water hyacinth hundred four plants/m^2 and 8.22 ± 0.45 kg fresh weight/m^2 which equals to 82.16 tons/ha fresh weight could be harvested during the dry season of a year. But, 583 plants/m^2 (27.0 ± 0.61 kg fresh weight/m^2) which equals 270 tons/ha fresh weight could be harvested during the wet season of a year. The present assessment also noted that no major management strategy had been employed in the infested water body areas, despite many efforts had been applied by the community and the government.

Keywords: Control strategies, Impact, Integrated approach, Macrophytes, Nutrient load

INTRODUCTION

Water hyacinth (*Eichhornia crasspies*) is widely recognized as the world's worst aquatic weed. Originally exported from its native Amazonian basin because of its attractive flowers, the species rapidly established and spread throughout tropical, subtropical and warm temperate regions of the world [1]. It was indicated that this weed forms a dense impenetrable mats across water surface, limiting access by man, animals and machinery. Moreover, navigation and fishing are obstructed, and hydropower, irrigation as well as drainage systems become blocked. The weed was first introduced into Africa through Egypt sometimes between 1879 and 1882. It has been recognized as the most damaging aquatic weed in Ethiopia since its first presence in 1965 [2,3]. It has been recognized its presence in Lake Tana in 2011 [4]. Even though several efforts have been made by different parties, its expansion increased year after year. Therefore, there is a need to study some of its biology, impact on water quality, biota and current management options.

OBJECTIVES

- To examine some biology and biomass at different periods of a year.
- To identify its impact on water quality, fishing activities and over all socio-economic challenges in the community.
- To identify current management options and ways taken by the assigned parties and check its effectiveness and identify its drawbacks.

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- To identify its distribution, area coverage and direction from water hyacinth inception area perspective.

MATERIALS AND METHOD

The study was conducted from July, 2014 to December, 2017 in the North-Eastern and Western part of lake Tana Sampling Sites chosen from Fogera, Libokemkem, Bahirdarzuria, Takusa and Dembia woreda and in the case of water hyacinth impact study two sampling sites were selected from north-eastern part of each woreda based on water hyacinth infested and water hyacinth free area. Plant sample was collected from infested areas using quadrant and different parameters were recorded using sensitive balance and tape meter.

Measurement of physico-chemical parameters

Dissolved Oxygen (DO), pH, specific conductance (K_{25}), Total Dissolved Solid (TDS), Salinity (sal) and Temperature (T) were measured *in situ* using YSI 556 multi-probe system.

Measurements of Ammonia (NH_3-N), Phosphate (PO_4-P), Nitrate (NO_3-N) and Total hardness were carried out using a portable water analysis kit (Wagtech international, Palintest transmittance display photometer 5000). Nutrient analyses were made in the shore area immediately after sample collection using water samples filtered through Whatman GF/C.

Plankton sampling

Water samples were collected from each sampling station up to a depth of 1 m using a bucket of known volume. Zooplankton and phytoplankton samples were collected by 80 µm and 50 µm mesh net filtering device. Collected specimens immediately fixed with 4% formalin and were fixed using Lugol's iodine solution respectively. Identification and enumeration of planktons was made using standard procedures. GPS readings, structured questionnaire, focuses group discussion, rapid rural appraisal, key informants have been used.

STATISTICAL ANALYSIS

Descriptive statistics, SAS, Landsat software and means were compared by means of one-way Analysis of Variance (ANOVA).

RESULTS AND DISCUSSION

This research investigated invasive weeds established at different intensities in Lake Tana at different sites Water hyacinth (*Eichhornia crassipes*) in the eastern and northern part of the lake as well as down streams in the blue Nile system, Azola (*A. filiculoides*) weed has been found every corner of the lake except the western part but highly infested in all areas possibly associated with water hyacinth in north east and eastern part of Lake Tana. On top of these it is abundantly found in pocket areas around extreme southern gulf of the lake around Bahirdar town. Water lettuce found at Fogera plain associated with *A. filiculoides*. The last one named leafy pondweed (*Potamogeton foliosus*) found in the western part especially around Delgy area **(Figures 1 and 2)**.

Figure 1. Leafy pond weed (*Potamogeton foliosus*).

Figure 2. Azola and water lettuce around Fogera flood plain.

During dry season sampling in 1 m × 1 m=1 m^2 there was 13 batches/m^2 area of water hyacinth with in a batch there was 8 individual plants which implies 104 plants/m^2 and 8.216 ± 0.45 kg fresh weight/m^2 this equals 82,160 kg/ha=82.16 tones/ha fresh weight can be harvested during the dry season of a year. In the contrary during the wet season with in 1 m × 1 m=1 m^2 it is found that 55 batches and 27 ± 0.61 kg fresh weight/m^2 was recorded. In each batch there were a mean number of 10.6 plants. 583 plants/m^2. 270,000 kg/ha=270 tones/ha fresh weight can be harvested during the wet season of a year. Dry weight of water hyacinth has been analyzed following the procedures of solar drying system. As a result batches of water hyacinth root, leaf and petioles part has been dried and its dry weight found to be 84.36%, 62.5% and 92.11%, respectively.

The highest plant population count (308 plants/m^2) was recorded in Koka Dam followed by Lake Koka (298 plants/m^2), Lake Ellen (274 plants/m^2), Lake Elletoke (268 plants/m^2), Afer Gedeb (261 plants/m^2), Tare and Awash (211 and 186 plants/m^2) according to Firehin et al. [5] **(Tables 1 and 2)**.

Table 1. Root, leaf and petioles measurement of water hyacinth during dry and wet seasons of a year.

Period	Different plant part measurements						
	Root mean length (cm)	Root mean weight (g)	Leaf mean length (cm)	Leaf mean width (cm)	Leaf mean weight (g)	Petioles mean length (cm)	Petioles mean weight (g)
Dry season	76 ± 2.12	222 ± 6.11	9.5 ± 1.23	12.3 ± 3.32	48.5 ± 5.43	19.6 ± 1.19	287.6 ± 1.55
Wet season	58 ± 3.21	1840 ± 7.62*	8.7 ± 2.33	12.1 ± 2.23	172 ± 4.22*	17.1 ± 1.13	725 ± 12.62*

**P<0.05*

Table 2. Physico-chemical analysis.

Parameters	Weed Infested site	Non-infested site	P value
	Mean ± SD	Mean ± SD	
Temp (°C)	25.57 ± 3.4	24.12 ± 1.95	0.346
pH	7.64 ± 0.56	7.61 ± 0.34	0.915
DO(mg/l)	5.34 ± 0.87	5.99 ± 0.67	0.140
S. Cond. (K25) (µs/cm^3)	168.57 ± 43.7	138.7 ± 44.6	0.230
TDS (g/l)	0.109 ± 0.03	0.092 ± 0.03	0.306
Sal (g/l)	0 .0757 ± 0.022	0.064 ± 0.022	0.356
PO_4 (mg/l)	1.31 ± 1.25	0.46 ± 0.39	0.184
NO_3 (mg/l)	1.49 ± 0.65	1.53 ± 0.51	0.908
NO_2 (mg/l)	0.0066 ± 0.005	0.0196 ± 0.023	0.210
TH (mg/l)	92.5 ± 21.1	91.2 ± 43.9	0.950
SO_4 (mg/l)	3.83 ± 2.9	2.4 ± 1.3	0.351
H_2S (mg/l)	0.030 ± 0.014	0.023 ± 0.024	0.578
Alk. (mg/l) as $CaCO_3$	87.5 ± 29.4	74.0 ± 32.6	0.489
NH_3 (mg/l)	0.046 ± 0.076	0.096 ± 0.14	0.469

Socio-economic impacts of water hyacinth

There are costs that result from the presence of water hyacinth in fresh water lakes like Lake Tana costs are associated with: Preventing, managing or eradicating, and Ecological impacts of those actions. In agreement with a study by the most direct impacts are: Access for fishing ground and fish catch ability, navigation and recreation; and difficult to pump water for recession agriculture **(Figures 3 and 4)**.

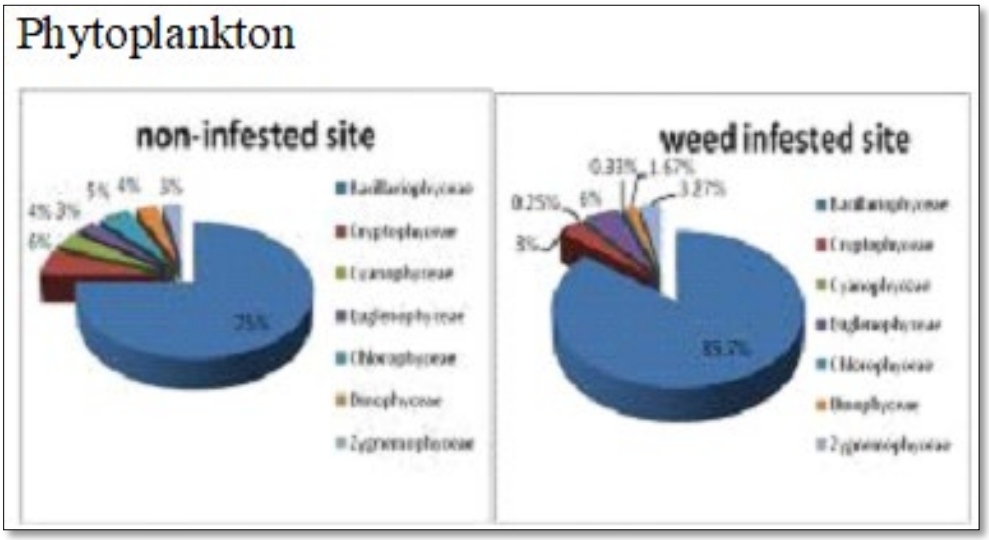

Figure 3. Higher species diversity was observed in non-infested sites, while in the weed infested site, higher density of the majority of identified phytoplankton taxa.

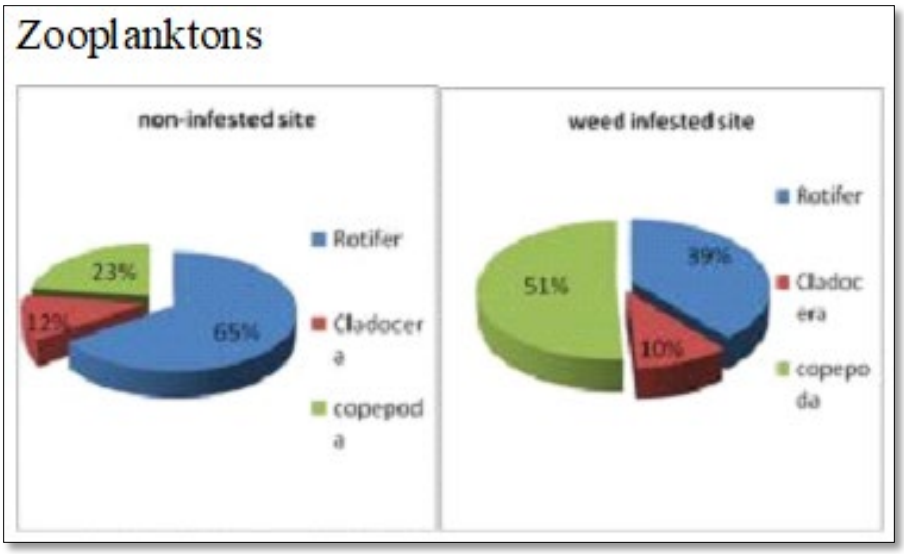

Figure 4. Rotifers contributed 65% in the non-infested sites followed by copepod and cladocera, but, in the weed infested sites copepod contributed 51% followed by Rotifer and Cladocera.

Impacts of water hyacinth on fishing

Water hyacinth provides highly complex habitat structure by restricting the growth of other submersed macrophytes. Modification at the surface of the water adds habitat complexity that likely affect fish assemblage. Cost of controlling water hyacinth infestations is a function of: the rate of removal, cost of labor and cost of equipment and the frequency of treatment **(Table 3 and Figure 5)**.

Table 3. Water hyacinth impact on the livelihoods of the surrounding community.

	N	Min.	Max	Mean	Std. Dev.
Extra hour for detaching from the gear and boat	20	1	12	5	3.528
How much you incur for fishing gear damaged	16	200	5000	1721.7	1470.072
Birr you allocate for purchase animal feed	18	300	5000	1240	1223.461
How much you incur for cow medication	20	50	200	120	63.509
How many times you clean your farm land for sow Teff	20	1	5	2.7	0.946
Labor required to clean “timad” of land per day	20	4	60	19.2	17.651

Figure 5. Thick mats and wide coverage of water hyacinth at its blooming period blocks all access to open water of Lake Tana (October, 2017).

Water hyacinth can greatly affect fish catch rates because mats of water hyacinth in the way that blocks access to fishing grounds, clogging and damaging eye of net and increasing costs (effort and materials) of fishing. Furthermore, water hyacinth tear gillnets and damage boat's motor which accrue to cost of fishing. Fishers invest extra time on detaching water hyacinth parts from gillnet after catching. Fishers put gillnet in non-infested area but when the wave starts the fishing gear becomes covered by water hyacinth as a result loss of gillnet occurs that leads to additional labor and fuel cost for finding their fishing gear and repair damaged gillnet. In the area of severe infestation fishing is difficult especially around the shore area; this could strongly affect fishers that use artisanal fishing boat. In general area infested by water hyacinth reduces efficiency of fishing **(Table 3)**.

Impacts of water hyacinth on livestock

The study areas are known by potentially rich dairy cattle breeds known as Fogera cattle breeds. The shore area of Lake Tana was reach in submersing grass (including hippo grass) which feeds lots of cattle before invasion history of the area. But now a day due to expansion of water hyacinth, the submerging grasses becomes devastated. These affects benefit obtained from cattle **(Figure 6)**. According the study, some respondents are purchasing supplementary feeds for their livestock after the freely grazing land have been infested by water hyacinth and devastated.

Figure 6. Grazing land and shore side of a lake infested by water hyacinth.

Impacts of water hyacinth on crop production

The collected water hyacinth (heap) has noticeable effect of farm management because of they took large place and make the farmland fragile. Farmers in the study areas sow crops when the water starts to shrink with simple adjustment of the plot. Unlike the last five years, managing the farm lands for cropping becomes labor intensive After the water become shrunk water hyacinth stay on the farm by penetrating its long root to the ground. Therefore, farmers clean their farm land for planting crop by family and employed laborers. Based on the survey, 19 laborers in average are required to clearing 0.25 hectare of land. The other challenge associated with infestation of water hyacinth is where to put the collected water hyacinth. A farmer put the collected water hyacinth as a terrace from many places and makes the plot fragile and makes the plot difficult to manage **(Figure 7)**. In addition, mat of water hyacinth and azolla during flooding and wave time makes rice production frustrating by totally covering the rice. Most of the interviewed farmers agree that water hyacinth makes the farmland more compacted by its long root so that difficult to plough the farm land.

Figure 7. Farmlands overcrowded by heap of removed water hyacinth.

Ecosystem impacts

Restricting the growth of other submersed or emergent macrophytes. Loss of native habitat as a result affects diversity, distribution and abundance of life in aquatic environments. High density of invasive weeds leads to de-oxygenation of the water, thus affecting all aquatic organisms. On top of these it is known that a dense cover of water hyacinth enhances evapo-transpiration The death and decay of water hyacinth vegetation in large masses create anaerobic conditions and production of toxic gases **(Figure 8)**.

Figure 8. When the collected water hyacinth burned after dried.

CONCLUSION

In addition to water hyacinth infestation in Lake Tana there are other invasive weeds which may negatively impact the resources of the lake if and only if appropriate management practices could not be timely applied. Due to anthropogenic impacts which induce to climate change, water bodies worldwide are susceptible to worsen phenomenon like invaded by invasive weeds. As a result continues monitoring and taking possible appropriate measures are mandatory. Water hyacinth which was ca. 80-100 ha in 2011, eventually, it spread into eastern part of the lake and reaches ca. 50,000 ha. The impact of water hyacinth on water quality was not significant at this moment. The present assessment also noted that no major management strategy had been employed in the infested water body areas, despite many efforts had been applied by the community and the government. *Eichhornia crassipes* remains a major Lake Tana ecosystem problem, especially in fisheries, irrigation, transportation, hydropower and ecotourism sectors.

RECOMMENDATIONS

- Multidisciplinary research should be carried out on:
  a) Their effects on the aquatic systems;
  b) Potential benefits to both humans and other organisms;
  c) Relationship with submersed vegetation, cattle health and farm productivity.
- Invasive weeds control strategies should take into account to reduce potential effects on the flora and fauna found in Lake Tana.
- Manual control method which currently applied should be revised based on the biological nature of each invasive weed.
- Integrated approach has to be implemented such as manual, mechanical, chemical and biological methods through scientific procedures.
- There is need for improvement of land use management in the catchment and along the rivers so as to reduce silt and nutrient loads.

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