Assessment of Invasive Aquatic Weeds and its Effect on Fishery and other Aquatic Biota in Lake Tana, Amhara Region, Ethiopia

Dereje Tewabe* and Erkie Asmare

Bahirdar Fisheries and Other Aquatic Life Research Center, Amhara Regional Agricultural Research Institute (ARARI), Bahir Dar, Ethiopia

*Corresponding Author: Dereje Tewabe, Bahirdar Fisheries and Other Aquatic Life Research Center, Amhara Regional Agricultural Research Institute (ARARI), Bahir Dar, Ethiopia.

Received: September 14, 2018; Published: April 29, 2019

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 1m 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/m² and 8.22 ± 0.45 kg fresh weight/m² which equals to 82.16 tons/ha fresh weight could be harvested during the dry season of a year. But, 583 plants/m² (27.0 ± 0.61 kg fresh weight/m²) 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 crassipes) 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 (Friend, 1989). 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 has 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.

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Objectives of the Study

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

Material and Methods

The study was conducted from July, 2013 to July, 2015 in the North-Eastern part of lake Tana Sampling Sites chosen from Fogera, Libokemkem and Dembia woreda and two sampling sites were selected from 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 (K25), Total Dissolved Solid (TDS), Salinity (sal) and Temperature (T) were measured in situ using YSI 556 multi-probe system
- Measurements of Ammonia (NH3-N), Phosphate (PO4-P), Nitrate (NO3-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 1m 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

Figure 1: Leafy pondweed Potamogeton foliosus.

During dry season sampling in 1m x 1m = 1m² there was 13 batches/m² area of water hyacinth with in a batch there was 8 individual plants which implies 104 plants/m² and 8.216 ± 0.45 kg fresh weight/m² 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 1m x 1m = 1m² it is found that 55 batches and 27 ± 0.61 kg fresh weight/m² was recorded. In each batch there were a mean number of 10.6 plants. 583 plants/m². 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/m²) was recorded in Koka Dam followed by Lake Koka (298 plants/m²), Lake Ellen (274 plants/m²), Lake Elleteoke (268 plants/m²), Afer Gede (261 plants/m²), Tare and Awash (211 and 186 plants/m²) according to Firehun., et al[5].

Trends of water hyacinth coverage

Area coverage of water hyacinth has been increased in alarming rate. It’s coverage at the inception period in 2011 was about 80 ha to 100 ha [4]. After a year it can able to cover about 20,000 ha (BoEPLAU, 2012). Even if tremendous amount of human labour, time and money has been exerted each year by both surrounding community and government it’s coverage continues to escalate up to 50,000 ha in the subsequent years (Wassie Anteneh., et al. 2014). This may probably due to lack of knowledge about the biology of the plant as a result failed in complete clearance including individual plant fragments tissues and lack of appropriate site selection for deposition of the biomass.

The input of fertilizer drained from the catchment area from crop cultivated land and homestead fuels water hyacinth to over dominate other floras in shore areas of the lake which would be important for fish breeding grounds and livestock forage source in the vicinity.

**Citation:** Dereje Tewabe and Erkie Asmare. “Assessment of Invasive Aquatic Weeds and its Effect on Fishery and other Aquatic Biota in Lake Tana, Amhara Region, Ethiopia”. *EC Agriculture* 5.5 (2019): 216-226.
**Figure 3:** Water hyacinth infestation coverage was ca. 80-100 ha during 2011 in Lake Tana [4].

**Figure 4:** Map showing water hyacinth infestation during July 2012 estimated ca. 20000 ha (source: BoEPLAU, 2012).

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Figure 5: A map showing the 50,000 ha water hyacinth infestation kebeles and woredas during August 2014 survey (Wassie Anteneh., et al. 2014).

Figure 6: Water hyacinth infestation current status on the shore of Lake Tana estimated to be ca. 34500 ha (May, 2015).

<table>
<thead>
<tr>
<th>Period</th>
<th>Root mean length (cm)</th>
<th>Root mean weight (gm)</th>
<th>Leaf mean length (cm)</th>
<th>Leaf mean width (cm)</th>
<th>Leaf mean weight (gm)</th>
<th>Petioles mean length (cm)</th>
<th>Petioles mean weight (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry season</td>
<td>76 ± 2.12</td>
<td>222 ± 6.11</td>
<td>9.5 ± 1.23</td>
<td>12.3 ± 3.32</td>
<td>48.5 ± 5.43</td>
<td>19.6 ± 1.19</td>
<td>287.6 ± 1.55</td>
</tr>
<tr>
<td>Wet season</td>
<td>58 ± 3.21</td>
<td>1840 ± 7.62*</td>
<td>8.7 ± 2.33</td>
<td>12.1 ± 2.23</td>
<td>172 ± 4.22*</td>
<td>17.1 ± 1.13</td>
<td>725 ± 12.62*</td>
</tr>
</tbody>
</table>

* P < 0.05.

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

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### Table 2: Physico-chemical analysis.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Weed Infested site</th>
<th>Non-infested site</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp (°C)</td>
<td>25.57 ± 3.4</td>
<td>24.12 ± 1.95</td>
<td>0.346</td>
</tr>
<tr>
<td>PH</td>
<td>7.64 ± 0.56</td>
<td>7.61 ± 0.34</td>
<td>0.915</td>
</tr>
<tr>
<td>DO (mg/l)</td>
<td>5.34 ± 0.87</td>
<td>5.99 ± 0.67</td>
<td>0.140</td>
</tr>
<tr>
<td>S.Cond. ($K_25$) (µs/cm²)</td>
<td>168.57 ± 43.7</td>
<td>138.7 ± 44.6</td>
<td>0.230</td>
</tr>
<tr>
<td>TDS (g/l)</td>
<td>0.109 ± 0.03</td>
<td>0.092 ± 0.03</td>
<td>0.306</td>
</tr>
<tr>
<td>Sal (g/l)</td>
<td>0.0757 ± 0.022</td>
<td>0.064 ± 0.022</td>
<td>0.356</td>
</tr>
<tr>
<td>PO₄ (mg/l)</td>
<td>1.31 ± 1.25</td>
<td>0.46 ± 0.39</td>
<td>0.184</td>
</tr>
<tr>
<td>NO₃ (mg/l)</td>
<td>1.49 ± 0.65</td>
<td>1.53 ± 0.51</td>
<td>0.908</td>
</tr>
<tr>
<td>NO₂ (mg/l)</td>
<td>0.0066 ± 0.005</td>
<td>0.0196 ± 0.023</td>
<td>0.210</td>
</tr>
<tr>
<td>TH (mg/l)</td>
<td>9.25 ± 21.1</td>
<td>9.12 ± 43.9</td>
<td>0.950</td>
</tr>
<tr>
<td>SO₄ (mg/l)</td>
<td>3.83 ± 2.9</td>
<td>2.4 ± 1.3</td>
<td>0.351</td>
</tr>
<tr>
<td>H₂S (mg/l)</td>
<td>0.030 ± 0.014</td>
<td>0.023 ± 0.024</td>
<td>0.578</td>
</tr>
<tr>
<td>Alk (mg/l) as Ca CO₃</td>
<td>87.5 ± 29.4</td>
<td>74.0 ± 32.6</td>
<td>0.489</td>
</tr>
<tr>
<td>NH₃ (mg/l)</td>
<td>0.046 ± 0.076</td>
<td>0.096 ± 0.14</td>
<td>0.469</td>
</tr>
</tbody>
</table>

**Figure 7:** 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 8:** 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.
Socio-economic impacts of water hyacinth

- There are benefits and costs that result from the presence of water hyacinth.
- Costs are associated with:
  - Preventing
  - Managing or eradicating, and
  - Ecological impacts of those actions.
- In agreement with a study by (Kateregga and Sterner, 2009) the most direct impacts are:
  - Access for fishing ground and fish catch ability
  - Navigation and recreation; and
  - Difficult to pump water for recession agriculture.

**Figure 9:** Thick mats and wide coverage of water hyacinth at its blooming period blocks all access to open water of Lake Tana (October, 2017).

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 (Meerhoff, et al. 2003).
- Cost of controlling water hyacinth infestations is a function of:
  - The rate of removal
  - Cost of labour
  - Cost of equipment and the frequency of treatment.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Min.</th>
<th>Max</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra hour for detaching from the gear and boat</td>
<td>20</td>
<td>1</td>
<td>12</td>
<td>5</td>
<td>3.528</td>
</tr>
<tr>
<td>How much you incur for fishing gear damaged</td>
<td>16</td>
<td>200</td>
<td>5000</td>
<td>172.17</td>
<td>1470.072</td>
</tr>
<tr>
<td>Birr you allocate for purchase animal feed</td>
<td>18</td>
<td>300</td>
<td>5000</td>
<td>1240</td>
<td>1223.461</td>
</tr>
<tr>
<td>How much you incur for cow medication</td>
<td>20</td>
<td>50</td>
<td>200</td>
<td>120</td>
<td>63.509</td>
</tr>
<tr>
<td>How many times you clean your farm land for sow Teff</td>
<td>20</td>
<td>1</td>
<td>5</td>
<td>2.7</td>
<td>.946</td>
</tr>
<tr>
<td>Labour required to clean “timad” of land per day</td>
<td>20</td>
<td>4</td>
<td>60</td>
<td>19.2</td>
<td>17.651</td>
</tr>
</tbody>
</table>
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- Water hyacinth can greatly affect fish catch rates because mats of water hyacinth:
  - 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 == loss gillnet.
- 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.

**Figure 10:** Water infested by water hyacinth that hinders swimming and boat.

**Impacts of water hyacinth on livestock**

- The study areas are known by potentially rich dairy cattle breeds known as fogera breeds.
- The shore area of Lake Tana was reach in submersing grass (including hippo grass) which feeds lots of cattle.
- But now a day due to expansion of water hyacinth, the submerging grasses becomes devastated. These affects benefit obtained from cattle.
- 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 11:** 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???
- Farmers put the collected water hyacinth as a terrace from many places
- Makes the plot fragile and makes the plot difficult to manage.
- 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.
- Difficult to plough the farm land.

Figure 12: Farmlands overcrowded by heap of removed water hyacinth.

Ecosystem impacts

- Restricting the growth of other submersed or emergent macrophytes. Loss of native habitat.
- Affect diversity, distribution and abundance of life in aquatic environments.
- Lead to de-oxygenation of the water; thus affecting all aquatic organisms.
- It is known that a dense cover of water hyacinth enhances evapotranspiration
- The death and decay of water hyacinth vegetation in large masses create anaerobic conditions and production of lethal gases.

Discussion

Monitoring the water quality of receiving environments for aquatic biota is very important. Microbiological analysis of these are ongoing, but initial results showed that limits in terms of these criteria were not satisfied at some points in the aquatic biota. If authorities do not take necessary measures, urbanization and activities such as recreation around the aquatic biota will result in contamination from anthropological activities. Waste of livestock around the villages in the basin is also a source of unwanted contamination [6].

Conclusion

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. 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:
  - Their effects on the aquatic systems;
  - Potential benefits to both humans and other organisms;
  - Relationship with submersed vegetation, cattle health and farm productivity.
- Control strategies should take into account the potential effects on the flora and fauna found in the water body.
- Harvested water hyacinth have to put into valuable way.
- Manual control method which currently applied should be revised based on the biological nature of the plant.
- 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.

Bibliography


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