



Research Article

Economic Importance, Impacts and Possible Mitigation Measures of Aquatic Water Hyacinth (*Eichhornia crassipes* Martius)

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ABSTRACT

Water hyacinth is one of invasive weed species which belongs to family Pontederiaceae which was characterized by a free-floating perennial aquatic weed and one of the major challenging problems in water bodies of the tropics and sub-tropics. Therefore, the aim of this article is to identify the distribution, impacts and beneficial effects as well as the possible management practices of water hyacinth. Water hyacinth was introduced in the water bodies of the Rift Valley in 68 years ago and currently, the weed is distributed Lake Tana, Lake Abaya, Lake Koka, Koka Dam in Ethiopia. The weed affected water resources, fisheries, transportation and social structure. The wide distribution and abundance of water hyacinth has led to decreased water availability and sustainable water biodiversity in Ethiopian lakes. Water hyacinth in water bodies and nearby areas of local stakeholder has negative impact on environment and also impact on aquatics biodiversity. In contrast to these, Water hyacinth is rich sources of different nutrients that provide feed for animals. Water hyacinth can be controlled by mechanically by machine or manual which was environmentally safe as compared to other methods. Physical control includes automatic mowers and dredgers. Biological method by using bio agents' weevils which involves long term strategy and chemical involves by using herbicides 2,4-D, Diquat and Glyphosate that can be implemented by accomplished operator. Therefore, sustainable long term management strategies should include prevention in newly infested areas. To contain the further spread and buildup of this weed for future infestation, these weeds should be utilized for composting and feed purposes. Besides, extensive mass awareness and community campaign specially to uproot should be implemented. Therefore, it can be summarized that human intervention is considered current problem of water resource in the country and further study is needed to sustain the water resource to keep water hyacinth at economic thresh hold level.

Key words: Caused, Dense mats, Problems, Reported, Water hyacinth

INTRODUCTION

Water hyacinth (*Eichhornia crassipes* Martius) is one of invasive weed species which was characterized by a free-floating perennial aquatic weed and one of the major challenging problems in water bodies of the tropics and sub-tropics. International Union for Conservation of Nature lists these species as one of the 100 most dangerous invasive species and as the top ten worst weeds in the world (Patel, 2012). The weed is characterized by wide spreading competences, extensive dispersal mechanism, rapid reproductive potential and harsh environment tolerance adaptability (Zhang *et al.*, 2010). Water hyacinth was appeared in Ethiopia about 53 years ago in 1965 at koka reservoir and in the Awash River. According to Fessehaie

(2005) and Taye *et al.* (2009) other infestation in the country includes Gambela Regional state, the Blue Nile from just below Lake Tana into Sudan and Lake Ellen near AlemTena. Water hyacinth caused wastage of water through excessive evapo-transpiration, recreational use of aquatic ecosystem, and poses of mechanical damage to hydroelectric systems. It is also responsible for drastic changes in the fisheries communities of water environments and acts as an agent for the spread of serious diseases in water bodies. Yirefu *et al.* (2017) found that Wonji sugar estate which estimated about 100,000 US\$ from 2005 to 2015 for the control of these weed. An action-implemented management program which involving mechanical, manual and chemical measures was integrated. Although in some of the infested areas these management

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practices were implemented, the spread of water hyacinth in the rift valley of Ethiopia was continued (Taye *et al.*, 2009). Despite the presence of effective weevil and highly virulent fungal pathogen against water hyacinth, none of them have been utilized to control this invasive weed in Ethiopia up till now (Firehun *et al.*, 2013). Mass awareness and community campaign specially to uproot the weed needs extensive work. Therefore, human intervention is considered as the current problem of water resource in the country and further study is needed to sustain the water resource to keep water hyacinth at economic thresh hold level. Therefore, the aim of this paper was to identify the distribution, impacts and beneficial effects as well as the possible management practices of water hyacinth.

The Biology and Ecology of the weed the biology of the plant

Water hyacinth belongs to family Pontederiaceae which has nine genera including *Eichhornia*, which has eight species of freshwater aquatics including water hyacinth (*Eichhornia crassipes*). Water hyacinth is a permanent, aquatic plant, free floating or anchor in low water. It can grow 100 –200 mm submerge, expand to 1 meter while increasing in thick mats. The roots of balanced plants are long and feathery. Vegetation of water hyacinth is sparkly dim green in color, in rosettes with characteristic upright engorged bladder-like petioles. The name water hyacinth refers to its aquatic habitat and the resemblance of the flower color to that of the garden hyacinth. The mature WH consists of roots, rhizomes, stolons, leaves, flower and fruit in cluster as indicated in figure below.

Ecology and distribution

Water hyacinth imposed ecological impact of the in Lake Tana such as dis articulation of biodiversity through deprivation of water quality and smothering of habitat by wide-ranging, permanent water hyacinth swathe. Jafari (2010) reported that Water hyacinth has invaded fresh water systems in over 50 countries on five continents. Melese and Samuel (2018) declared that it is especially pervasive throughout Southeast Asia, the Southern United States, Central, East and Western Africa and Central America. Invasive water hyacinths are of a large apprehension in Ethiopia, affectation exacting problems lakes, rivers, power dams, water ways, roadsides and urban green spaces with great economic and ecological consequences. In recent years, water hyacinth has spread faster, and the most serious infestation is in Ethiopia particularly in Lake Tana. One of the top ten ecologically dangerous and worst invasive weed, water hyacinth (*Eichhornia crassipes* Martius) is aggressively infesting Lake Tana (Melese and Samuel, 2018).

Propagation methods

Water hyacinth reproduces vegetatively through the formation of stolons, and is also sexually propagated through seeds, which can survive in water for six years making water hyacinth difficult to control. Under suitable growth conditions, the number of water hyacinths can double in one week. Akinwande *et al.* (2013) studied the water hyacinth bio mass in Nigerian waters which ranged from 28.8 to 33.2 t/ha dry matter per year. The water hyacinth has a well-developed root system and can absorb

nutrients in the growing environment. Therefore, its material composition is closely related to the growth environment. Poddar *et al.* (1991) reported that water hyacinth growing in swampland areas with a nitrogen content of 2.40 mg/L had a nitrogen content of approximately 1.78%. The nutrient composition in stems and roots is generally lower than in the leaf (Abdelhamid and Gabr, 1991).

Harmful effects of the weed harmful effects on ecology

Water hyacinth persistent species are extensively conventional as one of the foremost causes of biodiversity loss and can have momentous possessions on resource accessibility and can restrain or improve the comparative great quantity of inhabitant species, without unavoidably being the powerful force behind community change. The recent times in regional city Bahir Dar, in Lake Tana one of the recorded in world aquatic Biosphere Reserve in Ethiopia (Seid and Getnet, 2017). Water hyacinth one of the floating aquatic weed and the biosphere greatest destructive weed because of its harmful possessions on marine living organism in the lakes living the water body like fisheries, frogs, other and people's livelihoods from the surrounding lakes great influences on financial especially hindering problems on water transport activity, societal, healthiness related to reduced water quality of the lake and ecological. Water hyacinth has caused severe environmental defeat of freshwater water bodies (Gichuki and Odhiambo, 1994).

Due to its establishment, the water hyacinth also hinders the growth of vital phyto plankton and ultimately affects fisheries and other vital aquatic animals (Villamagna and Murphy, 2010). Lake of Tana created various employment opportunities for local dwellers. This lake is a good created job opportunity for the fishing industry in the town of Bahir Dar areas. Water hyacinth was marked to encouragement destructively on the fitness of water side communities. Alteration of oxygen levels in the water creates and atmosphere unsuitable for fish existence consequently resulted in dropping species.

Impacts of water hyacinth to agriculture and fisheries

Heavy infestations of water hyacinth limit water flow in rivers and irrigation channels interfere with irrigation equipment and have been known to cause structural damage to bridges (Jones, 2009). Decreased irrigation flow can indirectly cause loss on field crops but there can also be direct loss on paddy crops by suppressing the crop, inhibiting germination and interfering with harvesting (Patel, 2012).

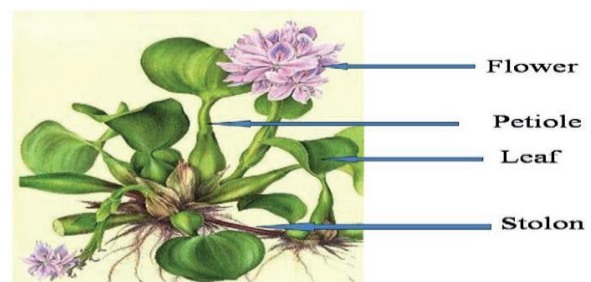


Fig. 1: Morphology of water hyacinth.



Fig. 2: Impact of Water hyacinth on ecology. Source: Asmare (2017)



Fig. 3: Fishing net entangled by water hyacinth at the landing site (a) and fishing at area free from water hyacinth (b). Source: Photo Asmare (2017).

Water hyacinth slows water flow by 40 to 95% in irrigation channels (Jones, 2009). In India in the Brahmaputra River, it has also blocked irrigation channels and obstructed the flow of water to crop fields (Patel, 2012). Moreover, in West Bengal, water hyacinth causes an annual loss of paddy rice by directly suppressing the crop, inhibiting germination and interfering with harvesting. According to the report of Rakotoarisoa (2017) at Lake Alaotra, rice fields were invaded, inhibiting the germination, suppressing the crop.

Impacts of water hyacinth on hydro power plants

Water hyacinth causes high water losses through evapotranspiration and blocking turbines. The Owen Falls hydro power scheme has suffered from the impact of the weed, hence plenty of time and money has been invested to clear and prevent the weed from entering the turbines, which may create harm and power disruption. On Owen Falls hydro power scheme, water hyacinth caused damage to water coolers and generators, prompting the power utility company to switch off generators for maintenance, and about 15 Megawatts of electricity were lost causing power cut in an urban area of Ethiopia (Yirefu *et al.*, 2017). Many large hydro power schemes are suffering from the effects of water hyacinth. It is now a major problem in some of the world's major dams. Dams feeding the city of Harare have pronounced infestations of the weed (Mujere, 2016). The hydropower dams on the Shire River in Malawi also frequently forced to stop production due to clogging of the water-cooling system by this weed (Wise *et al.*, 2017). The Kariba dam which straddles the Zambia - Zimbabwe boundary on the Zambezi River and *Koka Lake* hydro power dam in Ethiopia suffer from the rapid reproduction of water hyacinth (Senayit *et al.*, 2004). In addition, Ethiopian Electric Power Corporation has reported this plant as a problem and disrupting their operation at the

three hydro power stations located along the Awash River (Tegene and Ayele, 2014).

Impacts of water hyacinth on human health

Floating dense mats of water hyacinth support organisms that are harmful to human health. The ability of its mass of fibrous, free-floating roots and semi submerged leaves and stems decrease water currents and helps increase breeding habitat for malaria causing anopheles mosquito. *Mansonioides* mosquitoes, the vectors of human lymphatic disease causing nematode *Brugia*, breed on this weed (Varshney and Shushilkumar, 2008). Snails serving as a vector for the parasite of *Bilharzia* reside in the tangled mat of this weed. The weed also blocks access to water points and has been linked to an increase in cholera and typhoid. For example, from period of 1994 to 2008, Nyanza Province in Kenya, which borders Lake Victoria accounted for a larger proportion of cholera cases than expected given its population size 38.7% of cholera cases versus 15.3% of national population (Feikin *et al.*, 2010). The increased incidences of crocodile attacks have been attributed to the heavy infestation of the weed which provides cover to the reptiles, poisonous snakes, crocodiles and hippos (Patel, 2012).

Impacts of water hyacinth on water transport and recreation

Access to harbors and docking areas can be seriously hindered by mats of water hyacinth. Canals and fresh water rivers can become impassable as they clog up with densely intertwined carpets of the weed (Ndimele *et al.*, 2011). The entire Abo and Moundja Moussadi creeks have been rendered and impassable by the mats of the weed which leads to a complete halt in all the socioeconomic activities. Based on the study of Mujere (2016) water hyacinth was becoming a serious hazard to lake transport on Lake Victoria as large floating mats of water hyacinth form and this causes difficulty in navigation. This has grave implications such as failure to transport essential commodities from one landing site to another. In Uganda, residents of some islands such as Kasanje and Busi depend on water transport to take the sick to hospitals located in the mainland, for example, in Entebbe but when the weed blocks the way, deaths are common (Mujere, 2016).

Chemical composition of water hyacinth

The composition of WH is characterized by low dry matter and high CP and ash contents. Light green leaves and petioles of the immature plant are softer and contain a higher proportion of protein than those of the mature plant. The leaf protein content is higher than sweet potato leaf while the protein content in whole plant is considerable higher than grasses such as elephant grass (Harley *et al.*, 1996) and can be used as a protein supplement of low-quality diets. Protein in leaves contains most essential amino acids and is particularly rich in glutamine, asparagine and leucine. Chemical composition of WH varies with season, habitat (Poddar *et al.*, 1991) as well as with harvesting frequency. Protein concentration is high in the immature forage but declines with advancing maturity. Lignin, followed by silica and cutin, are the primary limiting factors of digestibility. Lignin content of WH in

the range from 7 to 10% has been reported while silica has varied widely from 0.5 to 5% (Abdelhamid and Gabr, 1991).

Importance of water hyacinth animal feed

Water hyacinth is an important animal feed that can be used as fresh or wilted to animals. The entire plant was chopped in to smaller sizes can be used as feed stuffs for both ruminants and monogastrics animals. Fresh WH has been utilized as partial substitution of Para grass (*Brachiaria mutica*) in diets to cattle (Thu, 2011) and has given better growth than after wilting when fed to goats (Aregheore and Cawa, 2000). Supplementation of wilted WH in a rice straw-based diet had positive effect on intake and growth of beef cattle. Daily live weight gain was approximately 500 g when 30% dried WH has been included in the basal diet of wheat straw at a fixed amount of concentrates (Parashar *et al.*, 1999). As water hyacinth has low dry matter content, wilting is generally preferred to reduce silage losses (Donald *et al.*, 2011). Water hyacinth can be successfully ensiled with the addition of molasses, rice bran and cassava root as well as with organic acids and the silages have been accepted by ruminants. An ensiled mixture of WH, rice straw, urea and molasses has been fed to dairy cattle resulting in an increase of milk yield. Although wilted WH has not been recommended as a sole feed for sheep, it can replace up to 50% of the concentrates in complete diets (Abdelhamid and Gabr, 1991). Water hyacinth residues after mechanical extraction of the juice can be used in the diet of fattening buffalo calves. Water hyacinth accounted for 35% of diet, while the remaining was concentrates (61%), molasses (2%) and a mineral mixture (1%). Feed conversion efficiency was higher with the WH residues compared to a similar level of Egyptian clover (*Trifolium alexandrinum*).

In Vietnam, a replacement of concentrates in pig diets by cooked or fresh WH reduced organic matter digestibility and digestible energy content without affecting feed intake and performance but the use of concentrates were reduced up to 6% in pig diets (Manh *et al.*, 2002). Manh *et al.* (2002) also found that WH at a 15% DM content was successfully preserved by adding 4.5% of molasses on a Farmyard basis. Due to its low cost, ensiled WH could be economically acceptable by small holder farms.

Water purification

Water hyacinth has a capacity to remove contaminants from polluted bodies of water. Many contaminants such as total suspended solids, dissolved solids, nitrogen, phosphorous, heavy metals, etc. as well as biochemical oxygen demand have been minimized using WH (Gupta *et al.*, 2012). Nitrogen and phosphorus removal capacity from dairy waste water was found to be fastest in WH, followed by *Lemna minor* and *Azolla pinnata* (Tripathi and Upadhyay, 2003). Nitrogen removal by WH, *Lemna minor* and *Azolla pinnata* were 72, 63 and 60%, respectively, while 63, 59 and 56% of phosphorus were removed by these macrophytes. When WH growing in wetlands receiving domestic and industrial waste water, concentrations of Cu, Cd, Ni, Pb and Zn in the roots were 3 to 15 times higher than those in the shoots. This showed that roots may act as a natural biosorbent (Low *et al.*, 1994).

Control methods mechanical control

Mechanical, chemical and biological control methods are commonly used to control WH but no one method is suitable for all situations. Mechanical control includes harvesting by hand or machine (Villamagna and Murphy, 2010). The use of machinery to remove WH from water bodies is the most effective non-polluting control method especially in critical areas such as hydro-electric dams and ports. The main advantage to the use of mechanical harvesting is the simultaneous removal of nutrients and pollutants from the water body and may therefore act as a means of slowing or even reversing eutrophication. Mechanical harvesting of WH has also resulted in rapid increases in dissolved oxygen and improved suitability of the habitat to support fish. However, it requires recurring efforts involving machine and labor inputs. Mechanical removal with harvesters is also slow and therefore not suitable for large mats. Studies have shown that costs of mechanical harvesting are on average US\$ 600 to 1,200 per hectare about six times more expensive than chemical treatment using glyphosate.

Biological control

Biological control is a long-term direct practice and is suggested for its consumer friendly and provides a sound financial and sustainable management way of WH. These techniques involve the host precise established challenger to decrease the inhabitant's attentiveness of the weed. Reports of Cilliers *et al.* (1996) indicated that numerous insects like weevils, moth and fungi are use as control agents for the water hyacinth. In Australia, the technique has been successful through ordinary discharge of the weevils *Neochetina eichhorniae*, *Neochetina bruchi* and the moth *Sameodes albiguttalis* effectively reduced the inhabitants' density of water hyacinth. Similarly, Lake Victoria organic control under surveillance and regular monitor has been productively practical to defeat water hyacinth.

Physical control

Physical control method is regularly worn roughly the humankind. It is very select to be appropriate and use equipment such as automatic mowers and dredgers. The method can only resolve little infected areas hence are not a sustainable long-term solution. It requires fleet of motor vehicle to move immense quantities of water hyacinth after it has being impassive and the mats of water hyacinth can have a density of up to 200 tons per acre (Harley *et al.*, 1996).

Chemical control

This method uses herbicides such as 2, 4-D, Diquat and Glyphosate to manage water hyacinth. It is most excellent for little invasion area not big areas. Appliance is ready each on the earth or air with accomplished operator. The technique has ecological and healthiness alarm as herbicides can be injurious predominantly source used for expenditure and wash. Apart from the three control methods, Harley *et al.* (1996) recommended to if the amount of nutrients incoming any water body is decrease, this continual reduce the invasion and expansion of the water hyacinth.

Conclusion

Water hyacinth is one of invasive weed species which was characterized by a free-floating perennial aquatic weed and one of the major challenging problems in water bodies of the tropics and sub-tropics. It had impact on social, environmental and economy that hinders fishing operation. The major influencing negative factors include; hindrance to water transport, blockage of irrigation canals and rivers, disrupting of electric power operation, increase loss of water due to evapotranspiration, causing flooding and human health problem, interference fishing activities, navigation, irrigation, livestock watering, and reduction of water biodiversity. Despite of its impact, Water hyacinth provides economic importance of compost making and rich sources of different nutrients. It is palatable and consumed by many animals in well prepared forms. Recent findings indicated that the use of bio control agent is the most effective, economical and sustainable management approach for water hyacinth. In Ethiopia, management of this invasive weed is still under initial stage. However, the use of biological control agent to reduce the level of water hyacinth at the national level has received a big attention and researchers have become engaged in conducting research. Therefore, sustainable long term management strategies should include prevention in newly infested areas. To contain the further spread and buildup of this weed for future infestation, these weeds should be utilized for composting and feed purposes. Besides, extensive mass awareness and community campaign especially to uproot should be implemented. Therefore, it can be concluded that human intervention is considered as the current problem of water resource in the country and further study is needed to sustain the water resource to keep water hyacinth at economic threshold level. Moreover, human intervention is considered as the current problem of water biodiversity in the country and further investigation is needed to sustain natural biodiversity.

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