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REVIEW ARTICLE

Aquatic Weeds Diversity in India and its Management by Composting: A Review

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ABSTRACT

According to UNDP, about 70% of the global natural wetlands have been lost during the last decade. The continual decrease in the amount of fresh water available to humans for use is a cause of major concern today. In India also, diminishing freshwater bodies, decreasing ground water levels, increasing anthropogenic activities and pollution are posing challenges to the management of water bodies. In recent years, lot of research and efforts have been made worldwide to reclaim the depleting water resources. Continuous and increasing infestation of water bodies with aquatic weeds is one of the leading causes of its deterioration and vanishing. Within this context the present review was undertaken with the aim to understand the diversity of the aquatic weeds in India and composting as a management option to control the growth of the aquatic weeds.

Keywords: Aquatic weeds, Compost, Diversity, India, Vermicompost

INTRODUCTION

Aquatic weeds have become a major environmental problem for the lakes across the world and requires immediate remedial measures. During the last century, about 70% of natural wetlands have been lost globally (UNDP). The size of the lakes throughout the world is shrinking, and there is a concerning rate of sediment deposition due to catchment area degradation. The water quality has also deteriorated due to intense pollution caused by various factors. Intense growth of the aquatic weeds results in depletion of dissolved oxygen causing anaerobic digestion in the hypolimnion. It produces huge amount of methane gas whose global warming potential is 34 times more than the carbon dioxide. (Rafiq Kumar, 2018). The aquatic weeds are an indicator of pollution and water bodies. They may cause nutrient overloading leading to eutrophication of the water body (Abbasi, 1997; Khan and Mohammad, 2014; Jain and Kalamdhad, 2018). These aquatic weeds are capable of tolerating eutrophication and nutrient enrichment in the water (Zhou *et al.*, 2017). High nutrient loadings may cause uncontrolled growth of the aquatic weeds (Zhao *et al.*, 2016). Aquatic weeds depend on water and sediments for its nitrogen and potassium requirements (Vindbæk and Nina, 2002). The overgrowth of these aquatic weeds can cause severe problems like blockage of water body resulting in the flooding of the area (Malik, 2007). It severely affects livelihood of the people, as they severely impact fisheries, recreational industries, ship navigation, sedimentation of lake, etc. (Tellez *et al.*, 2008; Chuang *et al.*, 2011). The overgrowth can have considerable ecological and aesthetic changes (Villamagna and Murphy 2010), and cause diseases like malaria, filariasis, dengue etc. (Mailu, 2001).

Depletion of available freshwater resources, falling ground-water levels and deteriorating water quality are all posing a variety of challenges in managing India's water resources (CPCB, 2011). Hence, the present review is undertaken with the aim to understand the nutrition potential of the aquatic weeds and composting as a potential avenue for its control and management in India.

Management of aquatic weeds

Considering the economic and ecological losses of the water bodies, two different approaches can be adopted i.e., preventive measures and control. Management of aquatic weeds can be accomplished by combining a variety of methods as per the requirement. The different methods to control the aquatic weeds include i) preventive measures, ii) manual and mechanical measures, iii) chemical control, iv) biological control, and v) management through utilization. Preventive measures include developing proper design and construction of structures like banks on the edge of water body, construction of channels, ditches and lining of canals. Manual and mechanical measures are one of the oldest methods to control the overgrowth of aquatic weeds and are more effective in controlling free floating weeds using water weed cutter, under water cutters, and harvesters. The weeds are pulled out by hand or cut off by employing human labour. They are cost effective and environment friendly. Chemical control is easiest and time efficient method requiring extensive knowledge of aquatic weed and effective herbicide like 2,4D, endothall, glyphosphate, diquat, paraquat, etc to achieve better results. Biological control, one of the most eco-friendly methods employs plant eating organism like insects, fish, parasites, pathogens like bacteria, fungi, viruses, etc. It requires vigorous monitoring with the possibility that it may harm other economic important plants as well. Management through utilization like by converting them into useful products such as compost, vermicompost, etc as these weeds contain a lot of nutrients.

Aquatic weeds diversity in India

In India also, many water bodies such as rivers, ponds, natural and artificial lakes, are suffering from the spread of aquatic weeds, causing significant damage to the water body. Water bodies in different regions of India, including Northeast India, Goa, Maharashtra, Kerala, and other states have been infested with aquatic weeds like *Eichhornia crassipes*, *Salvinia molesta*, *Nitella*, etc (Varshney *et al.*, 2007). There are more than 160 species of aquatic weeds found across India. Among these, *Eichhornia crissipis*, *Salvinia molesta*, *Ipomoea* spp., *Chara* spp., *Nitella* spp., *Hydrilla verticillata*, *Nymphea stellata*, *Nellumbo nucifera*, *Vallisneria spiralis*, *Typha angustata* are the major problem (Sushilkumar, 2011). *Alternanthera phyloxeroides* has also become a growing menace in India (Sushilkumar, 2005). These weeds growing in wetlands and cultivable land cause serious problems, especially in parts of Assam, Kerala, West Bengal, and Madhya Pradesh (Bhan and Sushilkumar, 1996). About 40% of the whole aquatic body which is utilized for pisciculture is deemed unfit because of uncontrolled invasion of these aquatic weeds (Narayan et. al, 2017). They have invaded lakes and ponds such as Dal Lake, Nigeen and Wular lakes in Jammu & Kashmir, Barwa, Ramgrah and Guiar lake in Uttar Pradesh, Ansupa lake in Odisha, Ootacumund lake in Tamil Nadu, Kallern Lake in Andhra Pradesh, and Loktak Lake in Manipur (Varshney *et al.*, 2007). Common weeds in these lakes and ponds are *N. nucifera*, *Nymphaea* spp., *Trapa natans*, *Lemna gibba*, *L. minor*, *L. trisulca*, *Spirodela polyrhiza*, and *Salnania natans*. The most dominant submerged weeds in the lakes are *Ceratophyllum demersum*, *Potamogeton* spp. etc. *S. natans* is only found around Kashmir region and covers about 2.5-6% of the total water surface there (Varshney *et al.*, 2007). About 60 species of *Ipomoea* are found all over India, but are found mainly in the central, western, southern, and southeastern states (Cook 1987, Kumar, 2018).

It has been estimated that *E. crissipis* (water hyacinth) has infested 20-25% of utilizable water in India and the condition is severe in states like Odisha, West Bengal, and Bihar where infestation was up to 40% of (Gopal and Sharma,1981). The presence of water hyacinth near a water treatment plant has caused problems for the Tapi River in Surat. They can clog reservoirs and restrict the amount of water available for human consumption (Chander *et al*., 2020). Water hyacinth has caused significant siltation in the marshes of India's Kaziranga National Park. This weed has severely plagued Deepor Beel, a freshwater lake generated by the Brahmaputra River (Patel, 2012). India can produce about three million tons of compost from *E. crissipis*.

Aquatic weed as compost

Extensive research is going on in India to find out different ways through which these aquatic weeds can be converted from waste to wealth by converting them into compost (**Table 1**). Dhadse *et al.*, (2021) developed a new vermicompost which was prepared by using 6 species of aquatic weeds namely, *Hydrilla verticilata* (L.f.) Royle, *Ceratophyllum demursum* L., *Nelumbo nucifera* Gaerth., *Ludwigia palustris* L., *Pistia stratioles* L., and *Eicchornia crassipis.* The aquatic sedminent consisting of the above-mentioned weeds along with cowdung and microbes in the ratio of 2:1:1 were stabilized for 45 days in presence of earthworm *Eudrilus eugeniae*. The Vermicompost was found to be rich in NPK and micronutrients. Deka *et al.* (2003) used water hyacinth as the substrate for composting with *Eisenia foetida* and found considerable increase in macro and micro nutrients in the final vermicompost. In another study, Kannadasan *et al.* (2014) prepared vermicompost from *E. crassipes* with *E. eugeniae* and *E. fetida* and found the compost to be rich in macro and micro plant nutrients. Vermicompost of these aquatic weeds have also been tested to be a good conditioner. According to Gajalaxmi and Abbasi (2002) vermicompost of water hyacinth has proven to be a good conditioner. Nutritional composition of vermicompost developed from aquatic weeds has given in Table 1.

Najar and Khan (2013a) studied the waste management and recycling of the macrophytes especially water hyacinth in different combinations using *E. foetida*. Umavathi *et al.* (2015) studied the changes in the nature of vermicompost created using *E. crassipes* and the earthworm *eugeniae* and concluded that the gut enzymatic process which takes place inside the earthworm during the whole process considerably affects the quality of the vermicast improving the nutrient status of the end product. Sannigrahi et. al. (2002), highlighted that the vermicomposting of the the water hyacinth can be a better disposing method having economic benefits too. Ganesh kumar et al. (2014), tried a new method, in which vermicompost was produced from *Salvinia molesta* using the earthworm species *E. fetida* or *E. eugeniae* for 270 days without the use of any cow dung or precomposting. The researcher's assertion was that, the application of cow dung in itself is a costly method, so they established an experiment without precomposting and had considerable results. Mishra et al. (2016), vermicomposted some of the aquatic weeds such as *Azolla microphylla*, *Pistia stratiotes*, *Salvinia cucullate*, and *Salvinia molesta* using earthworm *P. excavates* into a nutrient rich vermicast and concluded it to be a sustainable method to bring out the trapped nutrients from the weeds.

Use of aquatic weed based compost on crop yield

Due to presence of all essential nutrients, it is proven that the vermicompost can stimulate the growth and productivity of plants and are more attractive, economical and environment-friendly option (Datta 2009, Gajalaxmi 2001 a, b, 2002). Numerous studies have established that vermicompost have positive effect on a wide variety of crop plants including cereal and legumes (Souza *et al*., 2013), vegetables (Doan *et al*., 2013; Atiyeh *et al.* 2000a), ornamental and flowering plants (Edward *et al*., 1988; Atiyeh *et al.* 2000b), and field crops (Najar *et al*., 2013; Najar *et al*., 2015; Wu *et al*., 2012; Rajeev *et al*., 2016; Khan *et al*., 2017; Sahoo *et al*., 2017; Roy Chaoudhary *et al*., 2017). Hussain *et al.* (2020) studied the effect of vermicompost made out of *Ipomoea carnea* on the germination, growth, and fruit yield of *Abelmoschus esculentus*. They observed that on increasing the application of compost from 2.5 to 5 tonnes/ha, increase in the germination, growth, and fruit yield was considerable. Other significant observation made was that the application of the vermicompost reduced fungal infections in the *A. esculentus*. In another study, Hussain *et al.* (2018) studied the impact of compost made of *Salvinia molesta* on the germination and seedling growth of *Abelmoschus esculentus*, *Cucumis sativus*, and *Vigna radiata*. They observed that the compost not only improved the germination (up to 98%) and the biochemical content but also improved the morphological growth. Gandhi and Sundari (2012), in their study of vermicomposting of *Azolla* sp. and *Eichhornia* sp. by using earthworm *E. eugeniae* studied the growth and effect of applied vermicompost on eggplant. Chaithra *et al.* (2016)

used compost made out of dried *E. crassipes* leaves and soil (ratio 1:1) and studied its impact on the growth of *Cicer artienium*. They found that the root and shoot length increased. Mahanta et al. (2012) observed that microbial addition to composting matter improves the nitrogen and microbial content of the compost. They found that the vermicompost made out of *Ipomoea carnea* had greater amount of both the nitrogen content and the microbial population.

CONCLUSION

The weeds which are important for balanced aquatic ecosystem can be a nuisance due to their vigorous growth causing many environmental and economic problems. Environmental problems include lake eutrophication leading to adverse effects on the aquatic fauna due to reduced sunlight reaching the lower zones and decreased oxygen. Economic impacts include reduced fishery business, human recreational activities like tourism and boating. Managing these vigourously growing weeds is a complex and cumbersome job. Physical, chemical, and biological methods are the conventional methods being used to control the weeds. But to deal with the huge quantity of aquatic weeds, more efficient methods are being developed recently like making compost from the weed biomass, obtaining biofuels, converting the weeds into compounds to be used as bio-pesticides, etc. These techniques have dual benefit as excessive weed growth can be controlled and obtaining valuable eco-friendly by-products. The literature review revealed that, the *E. crassipes* is the most widely vermicomposted aquatic weed. It is concluded that by using aquatic weed-based vermicompost on a wide scale in agriculture will not only help in controlling the aquatic weeds but also restore and improve the soil organic matter and nutrient content.

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Table 1. Nutrient composition of the vermicompost of some aquatic weeds found in India

Experiment protocol	Nutrients in compost	Reference
Vermicompost was prepared by feeding six different aquatic weeds to earthworm (*Eudrilus eugenie*), namely *Hydrilla verticilata*, *Ceratophyllum demursum*, *Nelumbo nucifera*, *Ludwigia palustris*, *Pistia stratioles*, and *Eicchornia crassipis*. Fresh green plants were collected from the lake and cuted into small pieces. Dry biomass, cow dung, and isolated microbes in the ratio (2:1:1) were put into a 20-liter pots. To these, 10 adult earthworm species *Eudrilus eugenie* were added. Moisture was maintained by frequent sprading of herbal pharmaceutical wastewater.	Total NPK of 3.32%, 2.03%, 0.62% with enriched microbial flora.	Dhadse *et al.* (2021)
Washed fallen leaves of *Ipomoea* were used. They were put into vermireactors (rectangular plastic containers of size 45 x 30 x 15 cm^3) which had a 5 mm thick moist jute cloth at bottom. 50 adult *Eisenia foetida* were used. The moisture was maintained at 65±5%. All reactors were covered with black sheets of low-density poly-ethylene (LDPE). The Vermicompost was ready in 40 days.	Total organic carbon (g/Kg) = 236±15 Total nitrogen (g/Kg) = 23±2 Total phosphorous, (g/Kg) = 5.1±0.4 Calcium, (g/Kg) = 16.1±0.9 Copper, (mg/Kg) = 86 ± 5 Manganese, (mg/Kg) = 291 ± 13 Zinc, (mg/Kg) = 27 ± 3 C:N ratio = 10 C:P ratio = 87	Hussain *et al.* (2020)
Water hyacinth shredding + cattle manure + Saw dust (ratio of 6:3:1) + first 10 days in Rotary drum + final 20 days in vermiculture (*sp Eisenia fetida, Eudrilus eugeniae,* and *Perionyx ceylanensis*). *Eisenia fetida* is the best in culture with respect to lowest CO_2 evolution and Oxygen uptake rate as well as highest nutrient concentration I.e. Nitrogen and Phosphorus in 30 days)	K - 20 g/kg Oxygen uptake rate (mg/g VS/day) - C02 -	Ranjit Chakma *et al.* (2019)
Water hyacinth dried under sunlight and cow dung in the ratio of 1:1 was used. Vermicompost bed was covered with jute bags and water was sprinkled twice or thrice a day to maintain 30-40% moisture. Vermicompost was ready after 60 days.	pH - 8.17 Organic Carbon - 12.5 % Organic matter - 21.55 % Nitrogen - 2.155% Magneshium - 80.16 ppm Zinc - 22.14 ppm	Atul Tiwari *et al.* (2016)
S. Molesta plants of height of 30±5 cm were taken for vermicomposting with earthworm *Eisenia fetida* and put in a rectangular aluminium reactor (area 2.5 m X 1 m; height 0.25 m). Moist 3 mm thich jute cloth was placed at the bottom. Humidity was maintained at 60±10% and vermicompost was taken after 15 or 20 days.	C:N ratio= 14.4±4 Humification index (Q4/6) value = 1.49 ± 0.12	Hussain *et al.* (2016)
Water hyacinth waste was kept to partially decompose for 25 days. It was mixed with cow dung, added toa mud pot and steered to remove methane and other gases. After 4 days, earthworm *Eudrilus eugeniae* was added on the 5th day. Vermicompost was ready after 45 days.	pH - 6.9 Amylase - 25 mg/g Cellulase - 38 mg/g Invertase- 5.3 mg/g Nitrogen - 0.46% Phosphorus - 1 % Pottashium - 1 % Iron- 1.26 % Copper - 1.27 % Protein - 57 % Carbohydrates - 33.5%	Blessy *et al.* (2014)
Water hyacinth waste was kept to partial decomposing for 25 days. Cellulose of water hyacinth was degraded using *Trichoderma reesei*. After degradation, it was mixed with cow dung, added to pot, and water sprinkling every day. On the 5th day *Eudrilus eugeniae* earthworm was added and the vermicompost was ready after 15 days.	pH - 7.2 Amylase - 22 mg/g Cellulase - 23 mg/g Invertase- 7.3 mg/g Nitrogen - 0.56 % Phosphorus - 0.98 % Pottashium - 1.26 % Iron- 2.5 % Copper - 1.97 % Protein - 37 % Carbohydrates - 37 %	Blessy *et al.* (2014)