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Strategies for bioconversion of potential aquatic weed water hyacinth in to commercially important products with special reference to south India- A review

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Abstract
Every product of nature has a significant role to play for maintaining the overall sustainability of the environment and its constituents when maintained in particular limits. Nature often provides competitors or weeds to check the overgrowth of the so called crop plants. Water hyacinth is one such potential aquatic weed that has turned to be hazardous invader in almost all the beautiful water bodies of South India due to their ubiquitous nature and worldwide distribution. The invasion by this potential hydrophyte not only ruins the esthetic beauty of the revers but also affects other aquatic plants and animals by reducing the amount of dissolved oxygen and inhibiting photosynthesis. In spite of their potential damaging effects the plant could be exploited as a very good substrate for the production of commercially important products due it rich nutritive profile. Biotechnology and allied sciences offers more possible solutions to turn this potential weed in to wealth. This research work exploits the possible strategies for biological waste management of water hyacinth with special reference to South Indian states.

Keywords: water hyacinth, bioplastics, bio fuels, eutrophication

Introduction
Water hyacinth (*Eichhornia crassipes)* is a pleustophytic hydatophyte, a cosmopolitan aquatic weed; it is widely recognized as the world's worst aquatic weed. Because of its attractive flowers, the species rapidly established and spread throughout tropical, subtropical and warm temperate regions of the world (Julien *et. al,* 1999) [9]. Water hyacinth was first seen on the White Nile in March 1958At present, it is one of the five-invasive alien plants in the country (Rezene, 2005, Personal communication) [10]. This weed forms dense impenetrable mats across water surface, limiting access by man, animals and machinery. Moreover, navigation and fishing are obstructed, and irrigation as well as drainage systems become blocked. They can tolerate a wide range of environmental conditions such as temperature, illumination, pH, salinity, wind, current and drought. The plant is morphologically very plastic with a rapid mode of vegetative propagation which makes it well adapted to long distance dispersal and successful colonization of diverse ecological niches. It is one of the most prolific aquatic plants which spread at an alarming rate having spikes of large blue flowers and roundish leaves with inflated bladder - like petioles.
The richness of South Indian lakes in case of mineral content followed by the availability of moisture content throughout the year propelled the growth of these potential ubiquitous weeds in the surface of the water bodies as dense green mats. The plant primarily affects the aquatic biome by reducing the amount of dissolved oxygen in the water as the plants consume a large amount of dissolved oxygen for its own respiratory mechanism. Secondly by blocking the sunlight to penetrate in to the deep interiors of the water bodies it reduces the photosynthetic recovery of oxygen by aquatic plants. Water hyacinth will rapidly take over an entire waterway. Under favourable conditions it doubles its mass every 5 days, forming new plants on the ends of stolons. It also grows from seed which can remain viable for 20 years or longer. This enormous reproductive capacity causes annual reinfestation from seed and rapid coverage of previously treated areas, making ongoing control necessary.

Objectives of the study
- To understand the nature, habitat and distribution of water hyacinth with special reference to the South Indian revers.
- To study the mode of destruction offered by the weed to the aquatic biome.
- To evaluate the potential of the weed to be tuned into a valuable natural raw material.
- To highlight the best methods for the possible and ecofriendly utilization to convert the potent weed in to commercially important products.
- To suggest cost effective, sustainable and productive methods for the proper management of water hyacinth in South Indian states.

Environmental impact caused by invasion of water hyacinth
The ubiquitous nature of water hyacinth along with its potential ability to utilize the dissolved nutrients in the water bodies in competition with the other aquatic plants has clearly made it the worst aquatic weed of the world. The plant offers a multiple problems equally to humans, animals and other plants. The common environmental hazards caused by water hyacinth are as enlisted below:
- Clogging of water hyacinth as mats in water bodies blocks proper transport facilities especially in rural and in land water bodies in were the water treatment is rarely done regularly.

- Interruptions caused by water hyacinth carpets for movement of turbines prove a great deal of loss for hydroelectric power generation.
- The densely grown zones of water hyacinth often acts as habitat for the multiplication of important vectors for major infectious diseases like filariasis, malaria, schistosomiasis etc.
- The weed increases the rate of evapotranspiration and there by reduces the amount of water present in sub-tropical zones.
- Reduces the aquatic productivity as the carpets greatly affect the cultivation of commercial fishes and even interrupts proper fishing practices.
- Destruction to natural wet lands and threat to aquatic bio diversity.

Fig 1: Water hyacinth mat

Bioconversion strategies to control pollution by water hyacinth

1) Vermi composting substrate

Vermicomposting involves the use of earthworms to enrich and degrade the nutrient rich organic substrate to yield quality compost for agricultural practice. A mixture of water hyacinth petioles along with cow dung is used as a substrate for preparation of vermicompost. Among various treatments, vermicomposting with E. eugeniae along with enrichment was found to be superior, considering the total N, P, K, Ca and Mg content of the vermicompost. Enrichment with Azospirillum, phosphobacteria and rock phosphate significantly increased the total N, P and Ca content in the vermicompost.

2) Substrate for bioplastic production

Bioplastics are a special type of biomaterial. They are polyesters, produced by a range of microbes, cultured under different nutrient and environmental conditions. These polymers, which are usually lipid in nature, are accumulated as storage materials (in the form of mobile, amorphous, liquid granules), allowing microbial survival under stress conditions. The number and size of the granules, the monomer composition, macromolecular structure and physico-chemical properties vary, depending on the producer organism. They can be observed intracellularly as light-refracting granules or as electronlucent bodies that, in overproducing mutants, cause a striking alteration of the bacterial shape. Due to its high nutritive profiling of water hyacinth including cellulose, lignin and hemicellulose, acid hydrolysis is considered to be the best possible method to convert the polysaccharides in the substrate mixture in to easily fermentable sugars. More research is needed to commercialize the production of bioplastics from water hyacinth effectively using various microorganisms and also using microbial consortium.

3) Fertilizers

All the parts of water hyacinth except the roots can be used as an effective substrate for agricultural fields as they enrich the fertility of the soil. Water hyacinth mixed with cow dung could be employed as an ideal substrate for supplying all essential nutrients to the crop plants. In other methods the plant could be properly ploughed and converted in to green manure to act as fertilizer for the crop plant.

4) Biogas Production

Biogas is a mixture of methane, carbondioxide, with traces of hydrogen sulphide and water. It is formed by the process of anaerobic digestion, in which micro-organisms break down organic material in the absence of oxygen. Due to its inflammable nature it is used as a lightning fuel in home and industries. The whole plant or the mixture of the plant along with cow dung could be used as substrate for the anaerobic

conversion of plant waste in to biogas. Both the commonly used biogas setups like the fixed tank and floating base bioreactors are equally effective in biogas production.

5) Feed stock for bioethanol production

Bioethanol is being considered as a potential liquid fuel due to the limited amount of natural resources. Cellulose biomass is also being investigated as a potential substrate for bioethanol production. The presence of strong linkages between hemicellulose and lignin in water hyacinth hinders the accessibility of carbohydrate polymer. Pretreatment of water hyacinth using acid, alkali, oxidizing agent or a combined process makes feed stock accessible for further enzyme hydrolysis to produce ethanol using these substrates.

Conclusions

Nature truly has blessed India with rich biodiversity in equal manner as its heritage and culture. Unlike all the other agricultural countries whose population initially losses the mind to accept new methods of waste management strategies, India has always welcomed new methods for safe and ecofriendly management of agro waste substrates. The advancements in science and technology can clearly open new windows for converting the invasive water weeds like water hyacinth in to commercially important products. These scientific methods can not only adjust with managing environmental pollution but also proves modern strategies for improved bio based industries that offer ecofriendly products at reduced cost due to the availability of the potential wastes as feed stock for the production of valuablel products. Commercialization of these products requires equal participation from government and common people to tackle the environmental pollution and to maintain the sustainability of the environment to maintain the earth as an 'evergreen planet'.

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