



## Hydrophytes in municipal wastewater treatment and limitation

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OFF-SITE WASTEWATER TREATMENT at low cost is a burning issue in developing countries. Use of water hyacinth and duckweed have been tried world wide and the findings of its efficiency have been found promising. The concept has become old but the work with duckweed is still continuing at different levels. Time has come to arrive at a conclusive policy/decision to the extent this water hyacinth (*Eichhornia crassipes*) or duckweed (*Lemna*) may be utilised. The guidelines in respect of the design parameter and Operation – Maintenance schedule should be available to the community. For the strategy of wide scale success of such system the involvement of NGO's and community participation should be inducted from the initial stage. Different aspects have been discussed in the text to arrive at a conclusion upto what extent and at what level the system of hydrophyte based waste-water treatment will have wider use by the community.

### Materials and Methods

From the reports of different workers & publications the following informations have been gathered and may be taken into account for design.

### Water hyacinth (*Eichhornia crassipes*)

This floating plant is dark green and has broad leaves at distal part. It has a high growth rate, the doubling time is nearly two weeks. Study showed two plants multiplied to 1200 Nos. in 130 days. The standing crop is found microhabitat for mosquito and snails and creates problem by their mobility. Tolerance index (TI) towards heavy metal is comparatively higher. Wilted water hyacinth may be used for anaerobic digestion with cowdung to produce manure. C/N ratio = 20-25. Due to presence of high concentration of other gases, methane produced is not economically viable as fuel. Anaerobic bacteria do not readily degrade the hard biomass of the water hyacinth in between stem of leaf and roots. Phosphate concentration is more in leaves and stems than that present in the root. The plant is cold sensitive, showing 20°C – 35°C range favourable for better growth. It has good nutrient stripping value. For the removal of Cu, Cd, Zn, Fe, Hg, As & Pb from waste water the use of water hyacinth has been tried by the fish farmers making aquaculture in wastewater. In 3-stage aquaculture, the percentage reduction of BOD<sub>5</sub>, NO<sub>3</sub> – N, PO<sub>4</sub>, COD, NH<sub>4</sub>, N, TSS have been reported as 96.90, 81.70, 89.20, 77.90, (70 – 99), (55 – 70), & 95% respectively. Use of water hyacinth in tertiary ponds to treat

effluent from stabilisation ponds upgraded the efficiency of BOD removal. To keep the pond exposed to the growth of algae, the cover of water hyacinth should not exceed 33% of the total area. BOD removal with water hyacinth cover is reported in the range of 300 – 400 kg per hectare per day (kg ha<sup>-1</sup> day<sup>-1</sup>)

### Duckweed (*Lemna*)

Small floating green plant having very small rootlets – known to be the fastest growing aquatic plant. Doubling time is 3-4 days depending upon the richness of the nutrient in the wastewater. Nutrient removal efficiency of water hyacinth > *lemna*. Frond size is 2 – 4 mm across. Zinc absorbing capacity of duckweed is relatively better. Projected growth is reported as 1 t ha<sup>-1</sup> day<sup>-1</sup> and this can be used to produce 130 kg of fish. Although the protein content (dry weight) is 20% – 30% in ideal condition of the growing medium, in poor medium it drops below 20% and the fibre content goes above 5%, roots grow longer, fronds become larger and discoloured. Life span of a frond is short, 4 weeks, during which it produces daughter frond and dies. Regular harvesting is required. Favourable temperature for growth is 20°C – 30°C, above this the growth is affected in the range (30°C – 40°C). High protein content suggests its use in blending fish meal and animal feed. BOD removal efficiency has been found in the range 70% - 80% in municipal sewage. A 0.7 ha sewage lagoon at organic loading of 48 – 60 kg. ha<sup>-1</sup> day<sup>-1</sup> with a duckweed (*S. Polyrrhiza*) cover could remove 90 – 95% & BOD after 20 days Hydrantic Retention Time (HRT). Daily nitrogen and phosphorous up-take (g m<sup>-2</sup> d<sup>-1</sup>) by *lemna* has been reported as 0.50 – 0.59 and 0.14 – 0.30 respectively.

Out of three species of duckweed namely, *spirodella polyrrhiza*, *lemna*, *wolfia arrhiza*, the later two are found to have comparatively better potentials for use in treatment streams and disposal. Fresh *spirodella polyrrhiza* is a good food for the exotic grass carp (*Ctenopharyngodon idella*) where as *lemna* shows favourable position as feed for tilapia fish (*Oreochromis niloticus*) which consumes this weed profusely. The very tiny species *wolffia globosa*, is widely used as fish feed for fry and fingerlings cultivated in rural ponds. Blending of protein enriched duckweed with conventional poultry feed and application of the same has proved improvement both in weight gain of the animals and numbers of eggs by layers, along with the attractive yellowishness of the egg yolk preferred by consumers. A mixture of duckweed with chopped straw and molasses is

being experimented to use as nutritious cattle feed in Bangladesh and its wide application may add a new dimension in fodder management by the community. To produce duckweed for the protein required for 100 dairy cattle, 3.10 hectares will be needed. Use of duckweed to reduce blood loss during menstruation of females, pain relief after burning, healing of coughs, fractures and swellings, as well as treatment of hepatitis have been documented by different workers. The cost of production of ethanol from duckweed is reported to be about 45% less than that of by conventional processes.

Mosquito breeding is remarkably reduced when the water surface is covered with duckweed. *Wolffia arrhiza* is reported to have the potential protein yield of about 2000 kg ha<sup>-1</sup> yr<sup>-1</sup> against 300 and 70 kg ha<sup>-1</sup> yr<sup>-1</sup> for soybean and rice respectively. For human consumption *W. arrhiza* with its lower oxalic acid content is better suited than *lemna*, which again is susceptible to attachment of pathogens. Using fresh duckweed (*lemna*) as fish meal, the feed conversion ratio (FCR) duckweed / fish for tilapia has been recorded as 1.6 to 1.33.

PRISM Bangladesh has demonstrated the ratio in the range between 1.2 and 3.3 in the case of polyculture using *spirodella polyrrhiza* as fish meal. Thus with an average FCR 2.5, for an annual production of 8 tons of fish, nearly 20t (dry matter) ha<sup>-1</sup> yr<sup>-1</sup> of duckweed will be necessary. For fishfeed the PRISM Bangladesh cultivated duckweed in fresh water with the application of chemical fertilizer like urea, tripple superphosphate (TSP), and murate of potash.

Duckweed cover reduces the evaporation loss and is useful to retain pond water for longer, ensuring a larger production of fish. The duckweed compost is useful as manure and fishfeed ingredient. Rural fishermen at Bagnan, India, use *wolffia* as feed for fry and fingerlings. The floating *lemna* is dragged and accumulated in the corner of the fish pond to form a thick mat and is then decomposed by spreading lime and oil cake over it. This product is liked by the fish and used for their growth.

The part of the water hyacinth above the node, containing basal part and leaf, may be used, after drying, as an admixture of fish feed. Mulching for vegetable beds and soil conditioner are other areas for its application. The node (bulb) and root are of no use except land fill. Water hyacinth are mat piled in hydroponics (soil-less cultivation) in wetland and water logged areas to grow vegetables and have been tried by WRDO, a NGO in Bangladesh, successfully. The stocking of fingerlings of Indian major carps are started in April – May. The duckweed appears during this season and remains until the following summer, when intense heat and scorching sunlight inhibits growth and causes death.

The survival of duckweed round the year in wastewater has been observed as different by workers at different locations and photo-periods. In Halisahar, West Bengal (India) the growth of duckweed (*Lemna minor/Lemna perpusilla*) has been found to be seasonal. The appearance of insects, algal bloom and disappearance of duckweed when

heavily infested with algae, was observed. In winter, the treatment pond was found to be devoid of duckweed. In the presence of cold winds, the algal population in the surface diminished, showing clearer water at the tail end compartment of the pond used for tertiary treatment. Cultivation of duckweed (*spirodella & lemna*) in fresh water using chemical fertiliser is being carried out by PRISM – Bangladesh for fishfeed. Growth and survival of this plant throughout the year is not uniform. The number of schemes under co-operative societies for the cultivation of duckweed throughout the year are reported to have been declining due to poor management.

## Results and discussions

If the application of water hyacinth and duckweed in biological treatment of wastewater is carried out scientifically, different obstacles in its management may be overcome considerably. Guidelines are needed. In the tropics, the growth and proliferation of these aquatic plants are seasonal. Thermal and photoperiodic response in the growing of duckweed should be considered for the time span during which this species could be cultivated and used. Duckweed grows vegetatively and each pond may generate 10 – 20 daughter ponds during its life span of 3 to 4 weeks. Use of a nursery pond, the periodical renewal of duckweed in culture ponds and removal of duckweed showing signs and symptoms of irrecoverable distress, are to be included in the operation and maintenance (O & M) schedule. Young fronds are to be used as fish feed. Production of fish will be increased by using duckweed as feed by the community.

Heart ailments in the community consuming fish is considered lower than for red meat and thus the demand of fish-protein will keep increasing. The poor community has greater access to fish food and will add new potential in meeting the protein deficiency among mothers and children of the poor community. To improve mother & child health, on-site sanitation and safe water supply is being promoted by UNICEF, governments and different NGOs, but the use of hydrophytes in selected areas of sanitation and the food chain is considered another aspect to achieve UNICEF's goal. Control of mosquitos and reduction of vector borne diseases by duckweed cover is a health-related aspect which has a bearing on mothers, children and the communities. Scientific work to establish and make wide application of the herbal effects of duckweed is to be explored. Duckweed having high protein, along with trace elements like iron and zinc, may be processed scientifically to make alternative nutrients to take care of blood loss by menstruating women & mothers. Use of fodder with protein-enriched duckweed is considered economical in the production of milk, which is essential for the nutrition of children, women and men of all ages.

Both water hyacinth and duckweed have the potential to remove pollutants from wastewater, but each has its own limitations both in terms of period of survival and type of

wastewater quality. For the removal of heavy metals, oil and grease, the use of water hyacinth in primary and tertiary treatment is considered a better option over duckweed. Care should be taken to control mosquito breeding and other problems from the water hyacinth. Disposal problems of water hyacinth is more acute than that of duckweed. For promotion of an integrated approach of wastewater treatment and pisciculture, tailored with the production of fishmeal and animal feed, the possibilities of duckweed need to be considered by the community. Design of the treatment system with water hyacinth and duckweed is condition specific and needs to be dealt with according to the locations and variables as applicable. The efficiency in removal of pollutants is not uniform in this system. So the period of survival and disappearance of each plant in the area of operation should be taken care of in making the operational schedule.

Duckweed (*wolffia arrhiza*) can also be taken raw as vegetable salad, when produced in fresh water.

Dry water hyacinth (basal and distal part) is a cheap fuel in the kitchen. It does not produce much smoke and can be burnt easily.

## Conclusion

Use of water hyacinth and duckweed may be done in restricted use. In this biological process, land requirement

is comparatively more, which suggests its limitation. The collection of inoculum of duckweed, renewal, harvesting and the disposal of the same is to be done meticulously for success.

Due to environmental problems like mosquito and insect infestation, the disposal system is comparatively more labour intensive. The hard bulb of biomass is not very responsive to anaerobic bio-degradation, so the popularisation of the use of water hyacinth in wastewater treatment has not yet been widely established for commercial use. Use of water hyacinth in growing vegetables on hydroponics, filling derelict land and the generation of cultivation beds are other aspects of productivity. Aquatic plant engineered “**wastewater purification system design**” needs to be evolved, with multiple choice to harness their efficiency for use as a wastewater purifying engine, energized from nature and exploring economic benefits. Some guidelines for the effective use of hydrophytes like water hyacinth and duckweed have been highlighted in the discussions.

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