PRACTICAL ACTION
Technology challenging poverty

WATER HYACINTH CONTROL AND POSSIBLE USES

technical brief

Introduction

Water hyacinth (Eichhornia Crassipes)

Water hyacinth is an aquatic plant which can live and reproduce floating freely on the surface of fresh waters or can be anchored in mud. Plant size ranges from a few inches to a metre in height. Its rate of proliferation under certain circumstances is extremely rapid and it can spread to cause infestations over large areas of water causing a variety of problems. It grows in mats up to 2 metres thick which can reduce light and oxygen, change water chemistry, affect flora and fauna and cause significant increase in water loss due to evapotranspiration. It also causes practical problems for marine transportation, fishing and at intakes for hydro power and irrigation schemes. It is now considered a serious threat to biodiversity.

The plant originated in the Amazon Basin and was introduced into many parts of the world as an ornamental garden pond plant due to its beauty. It has proliferated in many areas and can now be found on all continents apart from Europe. It is particularly suited to tropical and sub-tropical climates and has become a problem plant in areas of the southern USA, South America, East, West and Southern Africa, South and South East Asia and Australia. Its spread throughout the world has taken place over the last 100 years or so, although the actual course of its spread is poorly documented. In the last 10 years the rapid spread of the plant in many parts of Africa has led to great concern.

Figure 1: Water Hyacinth
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The plant is a perennial aquatic herb (*Eichhornia crassipes)* which belongs to the family Pontedericeae, closely related to the Liliaceae (lily family). The mature plant consists of long, pendant roots, rhizomes, stolons, leaves, inflorescences and fruit clusters. The plants are up to 1 metre high although 40cm is the more usual height. The inflorescence bears 6 - 10 lily-like flowers, each 4 - 7cm in diameter. The stems and leaves contain air-filled tissue which give the plant its considerable buoyancy. The vegetation reproduction is asexual and takes place at a rapid rate under preferential conditions. (Herfjord, Osthagen and Saelthun 1994).

The problem

Water hyacinth can cause a variety of problems when its rapid mat-like proliferation covers areas of fresh water. Some of the common problems are listed below:

- *Hindrance to water transport*. Access to harbours and docking areas can be seriously hindered by mats of water hyacinth. Canals and freshwater rivers can become impassable as they clog up with densely intertwined carpets of the weed. It is also becoming a serious hazard to lake transport on Lake Victoria as large floating islands of water hyacinth form, while many of the inland waterways of south east Asia have been

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all but abandoned.

Figure 2: Water Hyacinth causes problems in many regions ©Paul Calvert/Practical Action

- *Clogging of intakes of irrigation, hydropower and water supply systems*. Many large hydropower schemes are suffering from the effects of water hyacinth. The Owen Falls hydropower scheme at Jinja on Lake Victoria is a victim of the weeds rapid reproduction rates and an increasing amount of time and money is having to be invested in clearing the weed to prevent it entering the turbine and causing damage and power interruptions. Water hyacinth is now a major problem in some of the world's major dams - the Kariba dam which straddles the Zambia-Zimbabwe border on the Zambezi River and feeds Harare has pronounced infestations of the weed.

- *Blockage of canals and rivers causing flooding*. Water hyacinth can grow so densely that a human being can walk on it. When it takes hold in rivers and canals it can become so dense that it forms a herbivorous barrage and can cause damaging and dangerous flooding.

- *Micro-habitat for a variety of disease vectors*. The diseases associated with the presence of aquatic weeds in tropical developing countries are among those that cause the major public health problems: malaria, schistosomiasis and lymphatic filariasis. Some species of mosquito larvae thrive on the environment created by the presence of aquatic weeds, while the link between schistosomiasis (bilharzia) and aquatic weed presence is well known. Although the statistical link is not well defined between the presence of aquatic weeds and malaria and schistosomiasis, it can be shown that the brughian type of filariasis (which is responsible for a minor share of lymphatic filariasis in South Asia) is entirely linked to the presence of aquatic weeds (Bos, 1996).

- *Increased evapotranspiration*. Various studies have been carried out to ascertain the relationship between aquatic plants and the rate of evapotranspiration compared with evaporation from an open-surfaced water body. Saelthun (1994) suggests that the rate of water loss due to evapotranspiration can be as much as 1.8 times that of evaporation from the same surface but free of plants. This has great implications where water is already scarce. It is estimated that the flow of water in the Nile could be reduced by up to one tenth due to increased losses in Lake Victoria from water hyacinth.

- *Problems related to fishing*. Water hyacinth can present many problems for the fisherman. Access to sites becomes difficult when weed infestation is present, loss of fishing equipment often results when nets or lines become tangled in the root systems of the weed and the result of these problems is more often than not a reduction in catch and subsequent loss of livelihood. In areas where fishermen eke a meagre living from their trade, this can present serious socio-economic problems. Fishermen on lake Victoria have also noted that, in areas where there is much water hyacinth infestation, the water is 'still and warm and the fish disappear'. They also complain that crocodiles and snakes have become more prevalent.

- *Reduction of biodiversity*. Where water hyacinth is prolific, other aquatic plants have difficulty in surviving. This causes an imbalance in the aquatic micro-ecosystem and often means that a range of fauna that relies on a diversity of plant life for its existence, will become extinct. Diversity of fish stocks is often effected with some benefiting and others suffering from the proliferation of water hyacinth. People often complain of localised water quality deterioration. This is of considerable concern where people come to collect water and to wash.

Quantification of the problem is often extremely difficult. The real effect on fish stocks and flora is unknown. It is hard to calculate the effect on fishing communities. Even quantifying the coverage of the weed is difficult on bodies of water which are as large and geographically complex as Lake Victoria. Satellite methods are the only accurate way of determining the spread of the weed. Success is hard to measure when the exact scale of the problem is not clearly defined and is anyway growing rapidly.

In many areas of the world few studies have been carried out to quantify the basic effects of the growth of the weed on the surrounding communities and environment. This causes problems when trying to evaluate the scale of the problem, possible ways of combating its proliferation and the impact that any control or management programme may have.

Figure 3: The scale of the problem is considerable
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Solutions

Control of water hyacinth

There are several popular control mechanisms for preventing the spread of, or eradication of, water hyacinth. The 3 main mechanisms used are biological, chemical and physical control. Each has its benefits and drawbacks. Chemical control is the least favoured due the unknown long-term effects on the environment and the communities with which it comes into contact. Physical control, using mechanical mowers, dredgers or manual extraction methods, is used widely but is costly and cannot deal with very large infestations. It is not suitable for large infestations and is generally regarded as a short-term solution. Biological control is the most widely favoured long-term control method, being relatively easy to use, and arguably providing the only economic and sustainable control. Below we will briefly discuss each of these methods.

Biological control

Biological control is the use of host specific natural enemies to reduce the population density of a pest. Several insects and fungi have been identified as control agents for water hyacinth. These include a variety of weevils, moth and fungi. Biological control of water hyacinth is said to be environmentally benign as the control agents tend to be self-regulating. Control programmes are usually inexpensive due to the fact that the control agents are known and only a small numbers of staff are required to run such programmes. One major drawback is that it can take a long time to initiate such projects because it can take several years for the insect population to reach a

population density sufficient to tackle the pest problem.

In Kenya work is being carried out on the development of a biological herbicide from a locally found fungal pathogen.

Chemical control

The application of herbicides for controlling water hyacinth has been carried out for many years. The common herbicides are 2,4-d, Diquat and Glysophate. It has been found that there is a good success rate when dealing with small infestations but less success with larger areas. Application can be from the ground or from the air and requires skilled operators. As mentioned earlier the main concern when using herbicides is the environmental and health related effects, especially where people collect water for drinking and washing.

Physical control

Mechanical removal of water hyacinth is seen as the best short-term solution to the proliferation of the plant. It is however costly, using either land-based 'clamshell' bucket cranes, draglines or booms or, alternatively, water based machinery such as mowers, dredges, barges or specially designed aquatic weed harvesters. Such methods are suitable for only relatively small areas. Many of these techniques require the support of a fleet of water and land-based vehicles for transporting the large quantities of water hyacinth which is removed. Mats of water hyacinth can be enormous and can have a density of up to 200 tonnes per acre (Harley, Julien and Wright, 1997).

Manual removal of water hyacinth is suitable only for extremely small areas. It is difficult, labour intensive work and in some areas there are serious health risks associated with the work (crocodiles, hippopotamus and bilharzia in Lake Victoria for example).

Transportation of the harvested weed is also costly, because it has such a high water content. Chopping can reduce the volume and the water content.

Besides these three mainstream forms of control Harley, Julien and Wright suggest another method, namely the reduction of nutrient inputs to the water. Although strictly speaking this is a preventative method, it can be argued that a reduction in nutrients in the water body will result in a reduction in the proliferation of water hyacinth. In recent decades there has been a significant increase in the level of nutrients dumped into waterways from industrial and domestic sources as well as from land where fertilisers are used or where clearance has caused an increase in run-off.

Possible practical applications of water hyacinth

Although water hyacinth is seen in many countries as a weed and is responsible for many of the problems outlined earlier in this fact sheet, many individuals, groups and institutions have been able to turn the problem around and find useful applications for the plant. The plant itself, although more than 95% water, has a fibrous tissue and a high energy and protein content, and can be used for a variety of useful applications. Below we will consider a number of possible uses for the plant, some which have been developed and others which are still in their infancy or remain as ideas only.

- *Paper*. The Mennonite Central Committee of Bangladesh has been experimenting with paper production from water hyacinth for some years. They have established two projects that make paper from water hyacinth stems. The water hyacinth fibre alone does not make a particularly good paper but when the fibre is blended with waste paper or jute the result is good. The pulp is dosed with bleaching powder, calcium carbonate and sodium carbonate before being heated.

  The first project is quite large with 120 producers involved in paper manufacture. The equipment for pulping is relatively sophisticated and the end product is of reasonable quality. The second project involves 25 - 30 people and uses a modified rice mill to produce pulp. The quality of the paper is low and is used for making folders, boxes, etc.

  Similar small-scale cottage industry papermaking projects have been successful in a number of countries, including the Philippines, Indonesia, and India.

- *Fibre board*. Another application of water hyacinth is the production of fibreboards for a variety of end uses. The House and Building Research Institute in Dhaka has carried out experimental work on the production of fibre boards from water hyacinth fibre and other indigenous materials. They have developed a locally manufactured production plant for producing fibreboard for general-purpose use and also a bituminised board for use as a low cost roofing material.

  The chopped water hyacinth stalks are reduced by boiling and then washed and beaten. The pulp is bleached and mixed with waste paper pulp and a filter agent such as china clay and the pH is balanced. The boards are floated in a vat on water and then finished in a hand press and hung to dry. The physical properties of the board are sufficiently good for use on indoor partition walls and ceilings. Investigations into the use of bitumen coated boards for roofing are underway.

- *Yarn and rope*. The fibre from the stems of the water hyacinth plant can be used to make rope. The stalk from the plant is shredded lengthways to expose the fibres and then left to dry for several days. The rope making process is similar to that of jute rope. The finished rope is treated with sodium metabisulphite to prevent it from rotting. In Bangladesh, the rope is used by a local furniture manufacturer who winds the rope around a cane frame to produce an elegant finished product.

- *Basket work*. In the Philippines water hyacinth is dried and used to make baskets and matting for domestic use. The key to a good product is to ensure that the stalks are properly dried before being used. If the stalks still contain moisture then this can cause the product to rot quite quickly. In India, water hyacinth is also used to produce similar goods for the tourist industry. Traditional basket making and weaving skills are used.

- *Charcoal briquetting*. This is an idea which has been proposed in Kenya to deal with the rapidly expanding carpets of water hyacinth which are evident on many parts of Lake Victoria. The proposal is to develop a suitable technology for the briquetting of charcoal dust from the pyrolysis of water hyacinth. The project is still very much at the idea stage and both a technical and a socio-economic study are planned to evaluate the prospects for such a project. It is suggested that a small-scale water hyacinth charcoal briquetting industry could have several beneficial aspects for the lakeside communities:

  - providing an alternative income
  - providing an alternative source of biomass
  - improvement of the lake shore environment through the removal of water hyacinth
  - improved access to the lake and less risk to maritime transport
  - reduced health risk associated with the presence of water hyacinth
  - alleviation of pressure on other biomass fuel sources, such as wood, thereby ` reducing deforestation and associated soil erosion

  The technical aspects are yet to be fully developed and tested but 7 main stages have been identified in the process of converting the plant into charcoal briquettes:

  - harvesting and collection of the plant
  - drying
  - collection and transport to the kiln
  - pyrolysis
  - mixing of the resultant dust with a binder
  - pressing into briquettes
  - marketing of briquettes

  Eden (1994) considers the requirements for large-scale production of charcoal briquettes from water hyacinth. He states that with an energy density of 8.3 GJ/m^3 this would be comparable with the energy density of charcoal at 9.6 GJ/m^3.

However, for a plant to produce 40 tonnes per day of briquettes an area of 12 hectares would be required for drying the water hyacinth, 1,300 tonnes of wet hyacinth would be required daily and the climate would need to be one of low humidity and relatively high temperature.

- *Biogas production*. The possibility of converting water hyacinth to biogas has been an area of major interest for many years. Conversion of other organic matter, usually animal or human waste, is a well established small and medium scale technology in a number of developing countries, notably in China and India. The process is one of anaerobic digestion which takes place in a reactor or digester (an air tight container usually sited below ground) and the usable product is methane gas which can be used as a fuel for cooking, lighting or for powering an engine to provide shaft power. The residue from the digestion process provides a fertiliser rich in nutrients.

  The use of water hyacinth for digestion in a traditional digester presents some problems. Water hyacinth has a very high water content and therefore harvesting effort yields a low reward in terms of organic matter for conversion to biogas. The digester size has to be large compared with that of a traditional type due to the low gas production to plant volume ratio and this can in turn present problems for obtaining an airtight seal. Water hyacinth has to be pre-treated before entering the digester (macerated, chopped or beaten) to promote digestion and to remove air entrapped in the tissue of the plant which would cause it to float.

  To reduce the need for large volume digesters high rate digestion techniques have been employed. One such design has been tested in Bangladesh by a team from Warwick University, UK and the Housing and Building Research Institute, Dhaka, Bangladesh. The design was for a small (8.3 cubic metre) baffled reactor which was fed with juiced water hyacinth. The throughflow of the reactor was 1.2 cubic metres per day. Some cow dung and rumen (taken from a cow's stomach) was added to the water hyacinth juice to promote digestion. Gas was produced in reasonable quantities but some problems were experienced with throughflow and further development is still required.

Other studies have been carried out, primarily in India with quantities of up to 4000 litres of gas per tonne of semi dried water hyacinth being produced with a methane content of up to 64% (Gopal 1987). Most of the experiments have used a mixture of animal waste and water hyacinth. There is still no firm consensus on the design of an appropriate water hyacinth biogas digester.

- *Water purification*. Water hyacinth can be used to aid the process of water purification either for drinking water or for liquid effluent from sewage systems. In a drinking water treatment plant water hyacinth have been used as part of the pretreatment purification step. Clean, healthy plants have been incorporated into water clarifiers and help with the removal of small flocs that remain after initial coagulation and floc removal or settling. (Haider 1989). The result is a significant decrease in turbidity due to the removal of flocs and also slight reduction in organic matter in the water.

In sewage systems, the root structures of water hyacinth (and other aquatic plants) provide a suitable environment for aerobic bacteria to function. Aerobic bacteria feed on nutrients and produce inorganic compounds which in turn provide food for the plants. The plants grow quickly and can be harvested to provide rich and valuable compost. Water hyacinth has also been used for the removal or reduction of nutrients, heavy metals, organic compounds and pathogens from water (Gopal 1987).

Figure 4: Sewage system using water hyacinth
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- *Animal fodder*. Studies have shown that the nutrients in water hyacinth are available to ruminants. In Southeast Asia some nonruminant animals are fed rations containing water hyacinth. In China pig farmers boil chopped water hyacinth with vegetable waste,

rice bran, copra cake and salt to make a suitable feed. In Malaysia fresh water hyacinth is cooked with rice bran and fishmeal and mixed with copra meal as feed for pigs, ducks and pond fish. Similar practices are much used in Indonesia, the Philippines and Thailand (National Academy of Sciences, 1976). The high water and mineral content mean that it is not suited to all animals.

The use of water hyacinth for animal feed in developing countries could help solve some of the nutritional problems that exist in these countries. Animal feed is often in short supply and although humans cannot eat water hyacinth directly, they can feed it to cattle and other animals which can convert the nutrient into useful food products for human consumption.

- *Fertilisers*. Water hyacinth can be used on the land either as a green manure or as compost. As a green manure it can be either ploughed into the ground or used as a mulch. The plant is ideal for composting. After removing the plant from the water it can be left to dry for a few days before being mixed with ash, soil and some animal manure. Microbial decomposition breaks down the fats, lipids, proteins, sugars and starches. The mixture can be left in piles to compost, the warmer climate of tropical countries accelerating the process and producing a rich pathogen free compost which can be applied directly to the soil. The compost increases soil fertility and crop yield and generally improves the quality of the soil.

  Compost can be made on a large or small scale and is well suited to labour intensive, low capital production. In developing countries where mineral fertiliser is expensive, it is an elegant solution to the problem of water hyacinth proliferation and also poor soil quality. In Sri Lanka water hyacinth is mixed with organic municipal waste, ash and soil, composted and sold to local farmers and market gardeners.

- *Fish feed*. The Chinese grass carp is a fast growing fish which eats aquatic plants. It grows at a tremendous rate and reach sizes of up to 32kg (National Academy of Sciences, 1979). It is an edible fish with a tasty white meat. It will eat submerged or floating plants and also bank grasses. The fish can be used for weed control and will eat up to 18 - 40% of its own body weight in a single day (Gopal 1987).

  Other fish such as the tilapia, silver carp and the silver dollar fish are all aquatic and can be used to control aquatic weeds. The manatee or sea cow has also been suggested as another herbivore which could be used for aquatic weed control.

  Water hyacinth has also been used indirectly to feed fish. Dehydrated water hyacinth has been added to the diet of channel catfish fingerlings to increase their growth (Gopal 1987). It has also been noted that decay of water hyacinth after chemical control releases nutrients which promote the growth of phytoplankton with subsequent increases in fish yield (Gopal 1987)

References, resources and organisations of interest

References

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8. Hill, G., Waage, J. and Phiri, G., *The Water hyacinth Problem in Tropical Africa*,

Proceedings of the first meeting of the International Water Hyacinth Consortium, World Bank, 18-19 March 1997.

Useful addresses

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This organisation has carried out research on the use of water hyacinth for various applications.

2. Centre for Aquatic Plants
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   Gainesville, FL 32606, USA
   (904) 392 - 1799

Administer the 'Aquatic Plants Information Retrieval System' (APIRS) which is an accessible resource of information relating to all kinds of aquatic plant.

Companies dealing in aquatic weed harvesters, herbicides, fish stocking, etc.

- Aquatic Unlimited
  2150 Franklin Canyon Road
  Martinez, CA 94553, USA
- Resource Management, Inc.
  2900B 29th Ave. S.W.
  Tumwater, WA 98512, USA
  (360) 754-3460
- Allied Aquatics
  4426 Bush Mountain Dr. SW
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Useful Internet addresses

- http://pest.cabweb.org/index.htm
  CAB International
  Organisation dealing with weed science and pest management

- http://www.sidney.ars.usda.gov/scientists/neal/water_h/consortium.htm
  Proceedings of the International Water Hyacinth Consortium, World Bank, Washington, 18-19 March 1997

- http://solstice.crest.org/common/crestinfo.shtml
  Website for the Centre for Renewable Energy and Sustainable Technology. Information on digestion of water hyacinth

- http://veghome.ucdavis.edu/AquaticWeed/About.htm
  The Aquatic Weed Control Research Laboratory, California, USA.

In March 1997, a meeting was held of the newly formed International Water Hyacinth Consortium at the World Bank in Washington. The following is a list of organisations that took part (with contact name given).

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