Research article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

Assessment and Utilization of Water Hyacinth in the Water Bodies of Tamil Nadu

N. Cherly Anto Frezina

M. Tech. Scholar, Department of Biotechnology and Genetic Engineering, Bharathidasan University, Tiruchirapalli-24.

ABSTRACT

This paper tries to highlight the extent of trouble caused by Water Hyacinth in Tamil Nadu and suggest methods to curb its menace. Various alternate methods to put this weed to good use have also been discussed below.

The origin of Water hyacinth is believed to be Amazonia, Brazil, with natural spread throughout Brazil and to other Central and South American countries. It infests rivers, dams, lakes and irrigation channels on every continent except Antarctica. It devastates aquatic environments and costs billions of dollars every year in control costs and economic losses. It is perennial, herbaceous, aquatic plant of the family Pontederiaceae. The genus Eichhornia contains number of other species all of which are aquatic, but only Eichhornia crassipes has become a serious weed. The leaves of water hyacinth are compressed of a smooth, glossy, circular to kidney shaped lamina and a swollen spongy petiole. It has been reported as a weed in 56 countries.

Water hyacinth possesses specialized growth habits physiological characteristics and reproductive strategies that allow for rapid growth and expansion in freshwater environments and has spread rapidly throughout the tropics and subtropics. Eichnoria crassipes forms large free floating, mono-specific mats that complete with other aquatic species for light nutrient and oxygen. As biomass from mats decomposes, organic input to sediments increases dramatically. Eichornia crassipes grows in shallow temporary ponds, wetlands and marshes, sluggish flowing waters and large lakes reservoirs and rivers plants can tolerate extreme of water level fluctuation and seasonal variations in flow velocity and extreme of nutrient availability, pH, temperature and toxic substances. It was introduced into many countries during late 19th and 20th centuries, where it spread and degraded aquatic ecosystems.
Eichhornia crassipes remains the world’s most problematic water weed despite wide spreads and various approaches for its control.

Corresponding Author:-

N. Cherly Anto Frezina

M. Tech. Scholar, Department of Biotechnology and Genetic Engineering, Bharathidasan University, Tiruchirapalli-24

INTRODUCTION

Distribution:

Water hyacinth has been widely introduced in North America, Asia, Australia, Africa and New Zealand. They can be found in large water areas such as Louisiana, or in the Kerala Backwaters in India. First introduced to North America in 1884, an estimated 50 kilograms per square metre of hyacinth once choked Florida's waterways, although the problem there has since been mitigated. Directly blamed for starving subsistence farmers in Papua New Guinea, water hyacinth remains a major problem where effective control programs are not in place. Eichhornia crassipes, the Common water hyacinth, has become an invasive plant species on Lake Victoria in Africa after it was introduced into the area in the 1980s. Despite management and control efforts since then, a significant seed bank still remains across the region.

It is particularly suited to tropical and subtropical 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.

Habitat:

Water hyacinth grows in still or slow-flowing fresh water in tropical and temperate climates. Optimum growth occurs at temperatures of between 28°C and 30°C, and requires abundant nitrogen, phosphorus and potassium. Although this plant will tolerate a wide range of growth conditions and climatic extremes including frost, it is rapidly killed by sea strength salinity and will not grow in brackish water. Where water levels have receded, plants can survive on damp soil for several months.

Impact:

Water hyacinth is justifiably called the world's worst aquatic weed due to its ability to rapidly cover whole waterways. When not controlled, water hyacinth will cover lakes and ponds entirely; this dramatically impacts water flow, blocks sunlight from reaching native aquatic plants, and starves the water of oxygen, often killing fish. The plants also create a prime habitat for mosquitos, the classic vectors of disease, and a species of snail known to host a parasitic flatworm which causes schistosomiasis (snail fever). Water hyacinth is often problematic in man-made ponds if uncontrolled.

Water hyacinth invades bodies of water that have been impacted by human activities. For example, these plants can unbalance natural lifecycles in artificial reservoirs or in eutrophied lakes that receive large amounts of nutrients[1]. Some of the problems associated with Water Hyacinth are elaborated 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 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 has to be invested in clearing the weed to prevent it entering the turbine and causing damage and power interruptions[2].

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[3]. 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 [4].

• ***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'[5]. They also complain that crocodiles and snakes have become more prevalent.

In addition to all this they also

- block irrigation channels and rivers
- restrict livestock access to water
- destroy natural wetlands
- eliminate native aquatic plants
- reduce infiltration of sunlight
- change the temperature, pH and oxygen levels of water
- reduce gas exchange at the water surface
- increase water loss through transpiration (greater than evaporation from an open water body)
- alter the habitats of aquatic organisms
- restrict recreational use of waterways
- a serious threat to biodiversity
- reduce aesthetic values of waterways
- reduce water quality from decomposing plants
- destroy fences, roads and other infrastructure when large floating rafts become mobile during flood events, and
- destroy pastures and crops when large floating rafts settle over paddocks after flood events.

Water hyacinth will rapidly take over an entire waterway. Under favourable conditions it can double 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.

With these characteristics, the water hyacinth has become a major ecological and economic problem in this century in the tropics and subtropics.

METHODS OF SPREAD

Water hyacinth infestations increase most rapidly by the production of new daughter plants. During high water flows and flooding, infestations can break up and be moved to new locations. Most spread can be attributed to human activity such as the deliberate planting of water hyacinth in ornamental ponds or dams. Unwanted aquarium plants that are discarded into waterways are a major form of spread[6]. Water hyacinth can also be spread by contaminated boating equipment. Seeds are the main source of new infestations and are carried in water, mud (e.g. on machinery or boots) and by birds.

Control Measures in Use

Water hyacinth is difficult to control in all freshwater aquatic environments. When access is limited by the presence of the weed itself, control becomes more difficult. Early detection and rapid response offer the greatest likelihood of successful control and the opportunity for eradication. It is essential that any new infestations are controlled as soon as possible. If allowed to become established, the seed bank rapidly expands, increasing costs and massively increasing the duration of the control program.

Some of the control methods employed till date have been listed below:

Physical removal

Early control attempts concentrated on removing plants from the water with pitchforks, dumping the accumulated mass on land to die. Manually removing plants from small areas of water such as farm dams and drains is an effective form of controlling water hyacinth, but only when the rate of removal is faster than the rate of regrowth. On a larger scale, manual removal is less likely to achieve control of water hyacinth[7].

There are instances where mechanical harvesting of large infestations has been effective, although costly. As a guide, it takes between 600 and 900 hours to harvest one hectare of dense water hyacinth – which should be undertaken prior to flowering and seed set. Fifty million tonnes of water hyacinth are removed from the White Nile annually, and the Panama Canal is kept clear of the weed by mechanical harvesting.

Chemical control

The most commonly used technique for applying herbicides to water hyacinth is high volume spraying with hose and handgun power sprays either from a boat or from the banks. In some situations large infestations have been aerially sprayed.

Various kinds of herbicides such as 24-D, Dalapon, Diquat, and others have been used in some places. The ecological problems created by these herbicides were obvious. The water could not be used for irrigation or human consumption for long periods of time, and the fauna in the eco-system were seriously affected.

Spraying an entire heavy infestation can cause the weed mat to sink and rot resulting in de-oxygenation of the water, potentially killing fish. This can be avoided by spraying one third of the infestation at a time, or by physically removing as much of the weed as possible prior to spraying.

Biological control

Four insects from South America have been released by CSIRO since 1975 and are well established across the world. There are two weevil species, Neochetina eichhorniae and Neochetina bruchi, and two moth species, Niphograpta albiguttalis and Xubida infusellus.

Biological control of the hyacinth was studied with several kinds of animal viruses, bacteria, and fungi, as well as with manatees, insects, herbivorous fish such as grass carp and tilapia, ducks, geese, turtles, snails, and other animals. However, the results were disappointing, perhaps because of defence mechanisms in the plants[8]. For example, the larger plants form 2.5 or more leaves for each one destroyed by pathogen attack.

The Neochetina eichhorniae weevil has been successful in destroying large water hyacinth infestations in tropical northern areas of Australia. The adult is black, 5 mm long, and feeds on leaves, making small scars. Eggs are laid in the bulbous leaf stalks and the larvae tunnel through the plant tissue, which is then attacked by bacteria and fungi. This causes the plant to become waterlogged and death can occur under heavy attack. These weevils are inactive during winter.

In Australia, the Neochetina bruchi weevil is more active through the winter and is now well established from northern Queensland to Sydney, although both weevils are much less effective in subtropical and cooler areas. The moth Niphograpta albiguttalis is well established in northern NSW and Queensland. Its larvae tunnel into the leaf stalks and buds, as do the larvae of Xubida infusellus. Both species are very damaging to young plants and luxuriant weed growth but their impact is often temporary and patchy.

Unfortunately biological control cannot be solely relied upon for effective control of water hyacinth. It will provide some reduction in flowering and growth rates of the plant and occasionally mat sinkage has occurred as a result of insect damage[9].

Control programs should view biocontrol as a useful addition to the other available control techniques. It is possible that some infestations exist which do not have biological control agents present.

Cultural control

As part of a control program, nutrient run-off into infested waterways should be minimised. Drainage or reduction of water levels can also reduce the area of water hyacinth plants, but it is important to note that seeds will remain viable in the soil and will germinate when the area refills with water. In some situations salty water is able to be retained or naturally introduced to infested waterways.

Managing flood-stranded infestations

Vast areas of land can become covered in stranded water hyacinth when floating mats become mobile during flood events. This creates major problems if the weed settles over roads, crops or pastures.

Earthmoving equipment can be used to remove hyacinth from roads and verges. While crops will be damaged by the weed mass, pasture recovery can be enhanced by the use of windrowing or mulching as the plant mass can take up to 12 months to break down naturally[10].

SITUATION IN TAMIL NADU

Most rivers in Tamil Nadu have been covered by the green carpet of Water Hyacinth because of the pollutants dumped by the industries on their banks. Many textile processing units in Tamilnadu use a number of unclassified chemicals that are likely to be from the Red List Group which is said to be harmful and unhealthy.

The Public Works Department (Water Resources Organisation) launched a massive campaign in April 2012 along a stretch of 400 m near the mouth of Mannarai anicut to weed out water hyacinth along River Noyyal course as the plant is blocking free flow of water into the supply channels that feed irrigation tanks.

Following directions from the Coimbatore Mayor R. Venkatachalam and Corporation Commissioner, P. Muthuveeran, the officials have deployed three earthmovers to clear Singanallur tank from three different angles and using a motorised instrument, a net is being spread over the water hyacinth in the water spread area and using a motor the plants are being removed. Corporation sources show that the work estimated to cost close to Rs. 5 lakh would take nearly a month.

In Namakkal district, increased complaints are received from the farmers stating the Water Hyacinth menace due to the sewage from Kumarapalayam and Pallipalayam municipalities and untreated effluents from dyeing units, let into the Cauvery[11].

In February 2013, a major effort to clean up water Hyacinth clogging up the lakes in the Coimbatore district was given up. After spending Rs 8.10 lakh to remove water hyacinths from the Valankulam Lake, the city corporation claimed that the project was a success. They even replicated the work at Ukkadam Main Tank. But the euphoria was short-lived and the deadly weed is back in both water bodies choking aquatic flora and fauna. Expectedly, the return of water hyacinths in Valankulam has made the authorities wary of cleaning up the other major lakes in the city. Six months earlier the state government had allocated Rs 39.9 lakh to the corporation to clear water hyacinth from eight major water bodies in the city. Valankulam, one of the biggest water bodies within corporation limits, got the maximum allotment. "We have decided to put the entire operation on hold because of the negative results in Valankulam and Ukkadam. Manual removing the plant species is not a permanent solution. We are probing other options which can offer lasting solutions," said a senior officer of the corporation.

About Four Lakh rupees were spent to clear up one acre of wetland. And each wetland area in the city spreads over 200 acres.

The weed, which grows into a thick bed of waxy leaves and multiplies with astounding rapidity, has turned out to be a major problem for the farming community and the power generation barrages of Tamil Nadu Generation and Distribution Corporation (TANGEDCO).

The leaves clog bridges in the rivers. When water is released from the reservoirs, the leaves also enter into the irrigation canals and clog the regulation structures. The leaves also choke the power generation barrages of the TANGEDCO, affecting the generation activities. The Corporation employs fishermen to remove the water hyacinth near its barrages. The weed, according to officials in the Public Works Department, grows rapidly in places where sewage is discharged into the water courses[12].

In the city of Chennai, Velachery Lake, the boundary of pallikarani drainage swamp, a portion of Adyar river, Buckingham canal and Otterinullah have turned eutrophic due to *Eichhornia crassipes*. This is also the case with water bodies around Trichy, Madurai, Tirunelveli, Coimbatore, Salem and other districts. *Eichhornia crassipes* is the first order among water weeds causing menace only second to *Ipomoea aquatica*. In Tamilnadu almost 80% of 39000 tanks are already infested with this weed. Even very big lakes like Chembarakkam lake, Dusi- Mamandur lake, Kavaripakkam lake, Veeranam lake, etc are affected by Water Hyacinth [13].

A programme for spraying Chemicals to prevent the Water Hyacinth, on a trial basis got under way in Velachery Lake, Chennai from May 19, 2012. The chemical was sprayed in the presence Mayor Saidai S.Duraisamy. The agency in charge of the programme claimed that the chemical would prevent the growth of the weed for a period of five years after spraying. The chemical would not affect any other forms of life in the water body, an official has said.

INITIATIVES IN NEIGHBOURING STATES

Andhra Pradesh

Kondala Ruthala, a non-resident Indian from Andhra Pradesh has proposed the use of biogas produced from water hyacinth to be used for generating electricity, heating and industrial purposes.

The aim is to provide efficient energy solution that is reliable, scalable and cost effective. Chairman of Bengaluru-based Benaka Biotechnologies Pvt. Ltd., Mr. Ruthala has submitted the proposal to Krishna district Collector seeking permission to set up a biogas plant at Nandigamalanka in the district.

A citizen of USA and equipped with 17 years of experience in crude oil/gas exploration, high-tech electronics, medical and silk industries in the US and in India, he proposes to use indigenous technology developed by Village Vision Biotechnologies, IIT/GBES and National Environmental Engineering Research Institute (NEERI) to set up the gas plant.

The Collector has entrusted the task of looking into the proposal to the RDO and has directed District Manager NREDCAP (Non-conventional Renewable Energy Development Corporation of Andhra Pradesh) Limited G. Satyanarayana to offer his comments.

Besides the fact that farmers will benefit from the project, the Irrigation Department which spends between Rs.10 lakh and Rs.15 lakh every year on removal of water hyacinth, will have a reason to rejoice.

Listing out the many benefits of the project, Mr. Ruthala's proposes to produce 10,000 cubic metres of raw gas and 50 tonnes of manure every day, besides reducing green house gas effects, odours and pathogens and zero discharge and carbon negative. The other benefits, he says, include availability of road access from Gudivada, Kaikaluru and Eluru to the proposed site, availability of electricity next to the site and adequate water hyacinth in canals around the year. The proposed site is only 100 metres away from Chandrayya and Budameru canals and accessible to manpower. Mr. Ruthala has proposed to develop the plant in a phased manner[14].

Kerala

The Kottapuram Integrated Development Society (KIDS), a non-governmental organisation, in collaboration with the India-Canada Environmental Facility, is utilising water hyacinth for producing biogas. The project has been running successfully, according to Sunny George, a scientist who is associated with the project.

Water hyacinth has more than 85 per cent water. It is homogenised using a special machine. Special mechanisms are provided for maintaining constant temperature and pressure in a digester. Variations in the temperature are avoided by heating the inside of the digester through a hot water circulating system.

Biogas is collected in a conventional biogas plant. The slurry is ejected out of the digester once every fortnight.

A tank that is fed with 700 litres of homogenised water hyacinth yields 3,600 litres of biogas (i.e. 150 litres an hour). The entire requirement of cooking in the college canteen of KIDS is met by biogas from the water hyacinth project, according to Mr. George. The slurry generated from this processes is extensively used for organic farming among the self-help groups, according to P. Johnson, Director of KIDS[15].

Another project of KIDS involves production of vermi-compost from water hyacinth. The process involves several steps. The water hyacinth is chopped manually. Cow dung is used to absorb excess water from water hyacinth. A layer of coconut husk is prepared at the bottom of the vermi-compost tank followed by a layer of cow dung. Then, the chopped water hyacinth is spread over it, after which worms are put into the tank.

Each worm is expected to eat one gm of water hyacinth per day and excretes one gm. About 2 kg of worms are introduced into each tank.

PROPOSED SOLUTION

Mere clearing of the weed has always led to negative results due to the fast regrowth of the Water Hyacinth. Hence, the best way to solve this problem is to make the best out of it and find apt ways to use Water Hyacinth for Social Wellbeing. Some ways in which this plant can be used have been given below. But the choice of the solution lies in the size of the water body, area of Water Hyacinth growth, lifestyle of people living around it, need for employment, etc.

Fertilizers:

Water hyacinth can be converted into compost and used on the land with proper management & technology. Water hyacinth is a well known cleaner of polluted water & different pollutants (like heavy metals) are deposited in its root. So roots are generally removed in case where water hyacinth is collected from polluted water. As a green manure it can be either ploughed into the ground or used as mulch.

Water Hyacinth and Cow dung in 8:1 ratio has been shown to greatly increase the agricultural production by many folds. Only the leaves and stalk portion of the Water Hyacinth has to be used. Straw can be added as an extra source of Carbon. Mud plastering at the outside of the heap is essential in all models for restoring moisture & temperature during composting[16].

Vermi Composting

Fresh water hyacinth is mixed thoroughly with cow dung (25%).After partial decomposing for 40 days, the earthworms are introduced and again composting is done for the next 40 days. The size of the heap: 5’ X 5’ X 5’ (Approx.).

A study was conducted in Tamil Nadu Agricultural University, Coimbatore to explore the possibility of conversion of water hyacinth into nutrient rich 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.

This kind of manure production can be done by any farmer with access to a small pond with Water Hyacinth. No investment or instruments is required, only labour and time.

Bio Plastics

Researchers at Manonmaniam Sundaranar University in Tirunelveli, Tamil Nadu, have found that water hyacinth-derived sugar molecules like lignin, cellulose and hemicellulose can be converted into polyhydroxybutyrate (PHB), a polymer that is a raw material for making biodegradable plastic. Plastics developed using PHB are compostable. Also, making PHB from natural resources can reduce cost and harmful gas emissions.

To make PHB, researchers dried and crushed water hyacinth into a fine powder and subjected it to acid and enzyme treatment in the presence of water. The end product was used to grow Cupriavidus necator, a bacterium known to produce PHB, in the presence of organic and inorganic nitrogen sources. As the bacteria grew, PHB was found to accumulate inside them. Researchers ruptured the bacterial cells using an alkaline solution and extracted the PHB[17].

Maximum PHB, 4.3 grams per litre, was obtained from the bacteria cultured using the products of enzymatic breakdown of water hyacinth powder. The quality of PHB derived from hyacinth will be similar to PHB from other sources. The advantage with using water hyacinth as raw material is that it is available free of cost throughout the year. The study is set to appear in the October issue of Bioresource Technology journal.

More research is needed to commercialise the Bioplastics production from the Water Hyacinth.

Biogas

There is world-wide interest in biogas production, and research is undertaken and equipment manufactured in very many tropical countries. Biogas is a combustible mixture of methane (50 - 70%) and carbon dioxide, with traces of hydrogen sulphide and water. This gaseous mixture is formed naturally. It is produced spontaneously in the rumens of cows, which each day produce about 200 litres of methane gas. It is also given off from the bottom of some marshes and lakes, and from rubbish dumps. It is formed by the process of anaerobic digestion, in which micro-organisms break down organic material in the absence of oxygen. This process has been used to treat sewage waste for over 100 years. The energy crises of the 1970s stimulated the construction of digesters, particularly in India and China, where there was already a committed interest in the process[18, 19].

Since the late 80s, a great interest has developed in many countries, partly because of the fuel wood crisis and partly because of the improved technology available. It has been estimated that each year one hectare can yield about 100 tonnes of dry water hyacinth, that this, in turn, can produce 30,000 m^3 of gas, and that this could satisfy the cooking needs of 40 or 50 rural families.

There are many advantages in producing biogas:

- The gas can be used for cooking, lighting, heating and running refrigerators, incubators and engines. Small tractors have been run from biogas, though the gas cylinder must be transported by the tractor on a trailer.
- It is produced from waste materials, including water hyacinth.
- The effluent from the process makes an excellent fertiliser. The nitrogen, potassium and phosphorus present in the feed are made into a form more easily absorbed by the plants, and the fibrous nature of the slurry provided by the water hyacinth makes it a good soil conditioner.
- If human faeces are used, it may lead to an improvement in sanitation, and therefore health.
- It leads to less deforestation, if biogas is used in place of fuel wood.
- An anaerobic digester uses relatively simple technology; there are no moving parts.
- Small digesters can be made from locally available materials using locally available skills.

In order to promote the construction and use of digesters at the household or village level, therefore, it is important that there exists:

- At least one national supplier of equipment suitable for running on biogas - lighting, heating, refrigerators, incubators etc.
- The availability of credit facilities, on good terms. This usually requires government backing.

Raw material for the biogas plant

The whole of the water hyacinth plant can be used. It must be chopped into small pieces. The process is improved if water hyacinth pieces are mixed with cow slurry, which is rich in the micro-organisms needed for digestion. The ratio of water hyacinth to cattle dung depends upon the availability of cattle dung and the size of the digester, but amounts as small as 2% cattle dung are effective. A lot will depend on the particular experience in a location.

Solid waste must be mixed with water before being put into the digester, possibly as much as 10 parts water to 1 of solids.

Digester design

There are three widely used basic designs, each of which can be modified in the light of local conditions and experience. They are:

- the floating drum digester, from India
- the fixed dome digester, from China
- the flexible bag digester, from Taiwan.

These digesters are essentially cylindrical or partially spherical in design. Such shapes are stronger, and can be more easily sealed and made water and gas tight than can a shape with corners. Concrete and brick are the best materials for construction.

The Floating Drum Digester Design (also known as the Gobar Gas Plant, from India)

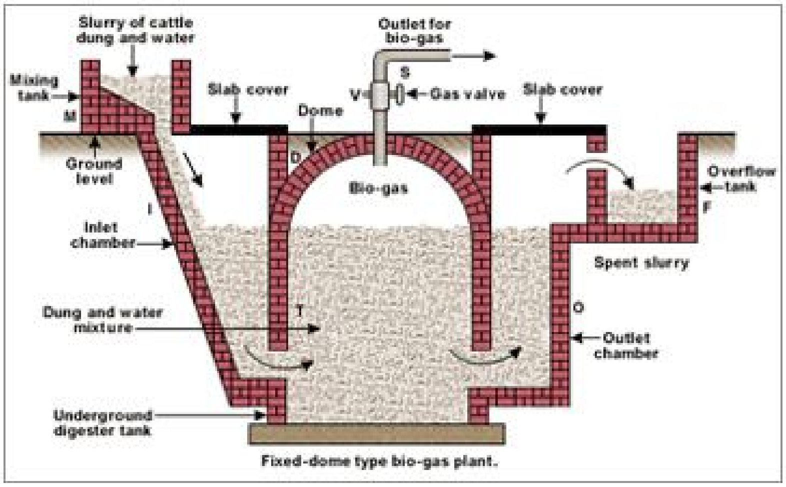


Figure 1: The Floating Drum Digester Design

The slurry is kept in a cylindrical pit in the ground. The pit is usually lined with bricks, similar to dug water well. The soil around the pit supports the brick walls.

The gas is collected in a cylindrical steel drum that floats inverted in the slurry. As the quantity of gas builds up, the drum floats higher in the liquid. As gas is used, the drum sinks back down. If the drum becomes full the gas bubbles out around the sides and is lost to the air. The drum is usually made from mild steel sheet, welded around a light frame made of welded steel angle bars. These bars serve a second function - the drum is rotated by hand and the bars stir up the surface of the slurry, preventing the formation of a solid layer, or crust, of indigestible matter. If this layer were allowed to form, then there would be a serious pressure build-up of gas beneath it[16, 20, 24].

The drum is held in place by a central guide rod, which ensures that the drum is free to rotate and does not jam against the walls of the digester while moving up and down.

The major criticism of this design has been of its cost (up to 35% of total expenditure) and the durability of the steel drum, the biogas slurry is corrosive to the steel. However, if the drum is conditioned properly initially and painted annually, it should last a long time. Some drums have been reported to have lifetimes greater than 30 years, while those that are poorly maintained will not last more than five.

The Fixed Dome Design (also called the drumless digester, from China)

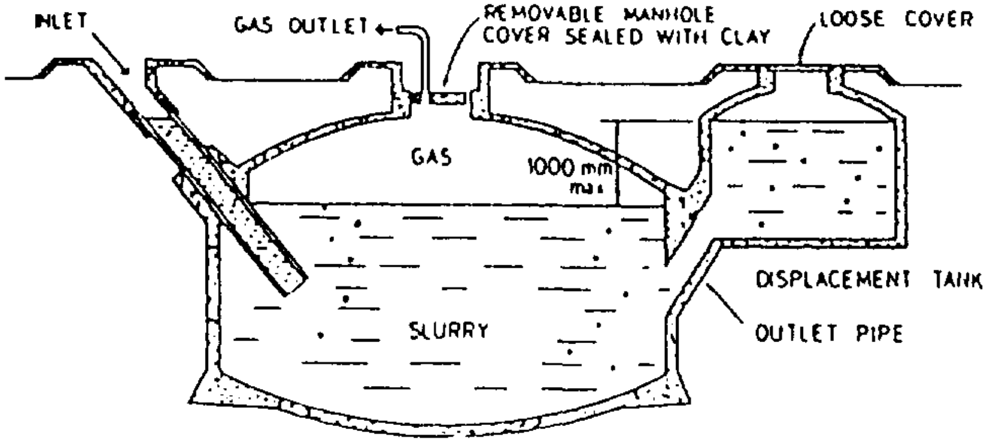


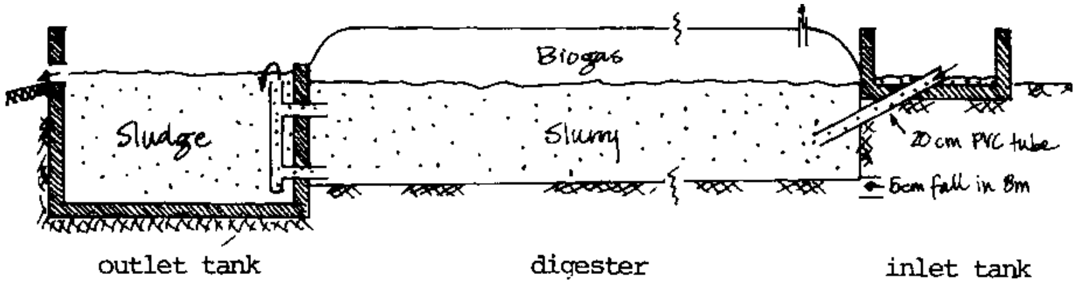
Figure 2: The fixed dome design

This type consists of an underground pit lined with brick or concrete with a dome shaped cover, also made from brick or concrete. The cover is fixed and held in place by earth (about $1m^3$) piled over the top to resist the pressure of the gas inside. A second pit, the slurry reservoir, is built above and to the side of the digester. As gas is given off it collects in the dome and displaces some of the slurry into the reservoir. As gas is used the slurry flows back into the digester to replace it.

The reservoir is built from brick or stone masonry. The gas is taken out form the centre of the dome, via a pipe which is supported by a small masonry turret. Access to the digester pit during building, and also if the pit needs cleaning, is through the slurry reservoir and outlet. The gas pressure inside a typical dome plant can be as high as 1000 mm of water and can exert a force of several tonnes upward from under the dome.

The main problem with the dome design is that concrete and brick masonry are porous to biogas unless they are carefully sealed. In China, a cement and lime plaster is used inside the dome, although it is possible to use polymer based paints such as vinyl emulsion. However, epoxy and polyurethane paints cannot be applied in a confined space since the fumes are toxic to painters as well as to micro-organisms[23].

The flexible bag design (from Taiwan)



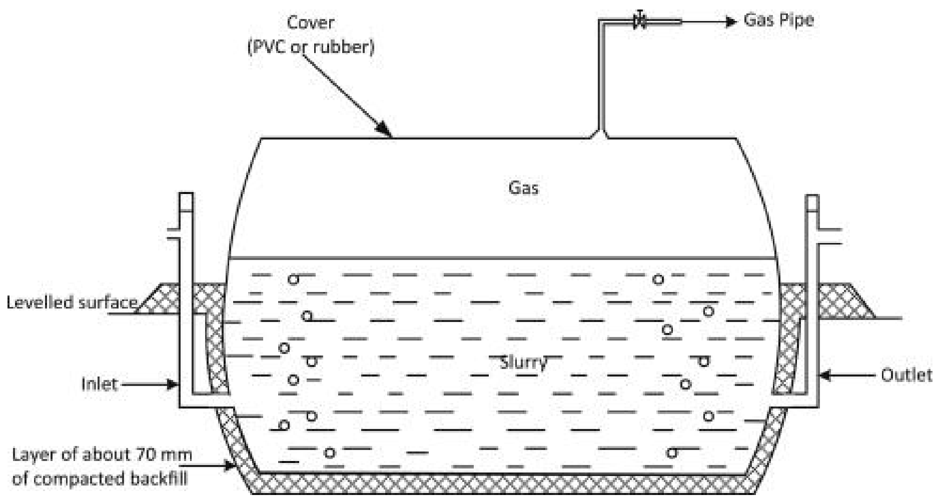


Figure 3: The Flexible Bag Design

This design uses a long cylindrical bag made of plastic supported in a trench lined with masonry, concrete or compacted sand or mud. The slurry fills the lower two-thirds of the bag and the gas collects above it. As the biogas is used, the bag collapses. The original rubber material used to make the bag was not very durable. However, the introduction of a new material known as red mud plastic (RMP) has proved to be much stronger and resistant to sunlight. Red mud plastic is made from PVC and a filler material which is a by-product of aluminium lining. Ten year lifetimes are claimed.

The major problem is the removal of the gas. A flexible PVC pipe coupling is welded to the top of the bag but it must be capable of moving when the bag inflates and deflates. There are reports of gas leakages at this point.

One of the attractions of this design is that its weight and compressibility mean that it can be more easily transported to more remote locations. However, the plastic is rather vulnerable to attack by children, goats, birds and so on. Although it can be repaired, the necessary facilities may not always be available locally.

Size of the Digester

A typical size for a household is between 5 and 10 cubic metres. The following data might help in the decision about size.

Approximate gas consumption:

Cooking 250 litres per person per day

Lighting 120 to 150 litres per hour per lamp

Engine fuel 750 litres per kWh power

Reports from different projects indicate that, on average, between 390 and 550 litres of biogas is given per kilogram of dried water hyacinth - so perhaps between 2 and 4 kg dried water hyacinth would be enough to meet the energy needs of one family each day.

Fermentation time:

- In hot, tropical countries 30-40 days
- In hot regions which only cool slightly in winter 40-60 days
- In more temperate climates, with significantly cooler winters 60-90 days

Since, Tamil Nadu comes in the first category; an average of 35 days is enough for the production of biogas.

Operating the Digester

Household scale digesters are usually run on a batch system. This requires two digesters. The first is filled, and gas output increases, peaks and then, as it begins to decline, the second is filled and brought on-line. The alternative is to feed a larger digester once a day, with a corresponding quantity being withdrawn.

The optimum temperature of operation is between 30 and 35 degrees centigrade. Some people say that 38 is optimum. If the temperature drops significantly, digestion will slow down, or even stop altogether. The digestion process can also be stopped altogether if the microorganisms are killed by certain chemicals such as antibiotics, disinfectants, detergents and pesticides.

The plant has a floating drum, and is made of steel. It runs continuously. For every 300kg fresh water hyacinth, 25kg cattle dung is used.

CONCLUSION:

Tamil Nadu has many rivers, lakes and many other water bodies including ponds, canals and irrigation ways. More than 70 % of these water bodies are infested by Water Hyacinth. If these plants can be put to good use, a lot of profitable products can be obtained from these so called weeds.

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