Experimental Investigation on Production of Biogas Water Hyacinth Plant with Cow Dung

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Abstract- **Biogas produced is a green replacement of unprocessed fuels like fuel wood, dung, crop residues. It is a cost effective replacement of conventional domestic fuels like LPG or kerosene. Biogas technology has the potential to meet the energy requirements in India Cleaning and removal of water hyacinth from lakes and various historical places government spends lacks of rupees per year. High rate of propagation and easy availability, water hyacinth could be used as a renewable source for fuel production. Water hyacinth an invasive water weed thrives in fresh water bodies causing serious environmental problems. The River Thirumanimutharu runs in the heart of Salem city. The weed has invaded Thirumanimutharu River and poses great socioeconomic and environmental challenges. Currently the weed is harvested from the Thirumanimutharu and left in the open to rot and decay leading to loss of aesthetics, land and air pollution. There is therefore need for development of value addition and economic exploitation strategies. The aim of the study is to assess the potential for utilization of the weed as a renewable energy resource for biogas production. Samples were collected from Thirumanimutharu River, pulped and blend with cow dung with different ratios. This study thus forms an attempt in a lab scale level to use the unwanted weeds as substrates for methane production.**

1. INTRODUCTION

The ThirumanimutharuRiver is the most polluted river of tamilnadu which origin from manjavadi in Shevaroy Mountain and through salem and namakkal and joins cauvey at nanjaiedayar place in namakkal.Length of the river about 120km.Nearlymore than 50,000 farmers using for the cultivation purpose and also domestic and Pavalathanoor lake has also been most solid waste placed at Pavalathanooor village, Tharamangalam. Catchment area about 7 acres and also surrounded population 19,234 and also there has been huge accumulation of solid waste. It has become a persistent and expensive aquatic problem damaging the environment, causes ecological and economic problems by impeding navigation and fishing activities, clogging irrigation systems and by creating a chronic shortage of dissolved oxygen harmful to the fauna and the flora

1.2 EICHHORNIA CRASSIPES

Commonly known as water hyacinth, is an aquatic plant native to the Amazon basin, and is often considered a highly problematic invasive species outside its native range. The beautiful, large purple and violet flowers of the South American water hyacinth (Eichhorniacrassipes) make it a very popular ornamental plant for ponds. However water hyacinth has also been labeled as the world's worst water weed and has garnered increasing international attention as an invasive species Water hyacinth is a free-floating perennial plant that can grow to a height of 3 feet. It is one of the fastest growing plants that reproduces primarily by way of runners or stolon's, which eventually form daughter plants.Each plant can produce thousands of seeds each year, and these seeds can remain viable for more than 28 years. These are vigorous growers known to double their population in two weeks. Eichhorniacrassipes is an excellent source of biomass. One hectare of standing crop thus produces more than 70,000 m3 of biogas.

Fig 1.1 Water Hyacinth

1.3 GEOGRAPHICAL DISTRIBUTION OF WATER HYACINTH

Water hyacinth is found across the tropical and subtropical regions originally from the Amazon Basin, its entry into Africa, Asia, Australia, and North America was facilitated by human activities. In Asia, water hyacinth is widespread on freshwater wetlands of the Mekong Delta, especially in standing water. It has been detected in the Sundarbans mangrove forest of Bangladesh and has caused heavy siltation in the wetlands of the Kaziranga National Park, India. DeeporBeel, a freshwater lake formed by the Brahmaputra River is heavily infested with this weed. The lake is considered one of the large and important riverine wetlands in the Brahmaputra valley of lower Assam, India. As in many other countries, water hyacinth has caused many economic, social and environmental problems in India

1.4 THREATS POSED BY WATER HYACINTH

1.4.1 Destruction of Biodiversity

Water hyacinth is challenging the ecological stability of freshwater water bodies out-competing all other species growing in the vicinity, posing a threat to aquatic biodiversity. Besides suppressing the growth of native plants and negatively affecting microbes, water hyacinth prevents the growth and abundance of phytoplankton under large mats, ultimately affecting fisheries.

1.4.2 Oxygen Depletion and Reduced Water Quality

Large water hyacinth mats prevent the transfer of oxygen from the air to the water surface, or decrease oxygen production by other plants and algae. When the plant dies and sinks to the bottom the decomposing biomass depletes oxygen content in the water body. Dissolved oxygen levels can reach dangerously low concentrations for fish that are sensitive to such changes. Death and decay of water hyacinth vegetation in large masses deteriorates water quality and the quantity of potable water, and increases treatment costs for drinking water.

1.4.3 Blockage of waterways

Water hyacinth often clogs waterways due to its rapid reproduction and propagation rate. The dense mats disrupt socioeconomic and subsistence activities (ship and boat navigation, restricted access to water for recreation, fisheries, and tourism) if waterways are blocked or water pipes clogged. The floating mats may limit access to breeding, nursery and feeding grounds for some economically important fish species.

1.5 ENERGY DEMAND IN INDIA

The demand for power is growing exponentially and the scope of growth of this sector is immense. India's power supply-demand gap has averaged between 8 and 10 per cent over the last decade where electricity access exists. By 2012,

India’s energy requirement to touch 975,222 MU (and peak demand 1,571,070 MU) an increase of 31.9% and 44.3% respectively from the current demand. India's grid-connected power generation capacity will need to scale from 148GW currently to 460GW by 2030 while the country's primary energy demand is expected to grow from 400 million tons of oil equivalent to well over 1,200 million by 2030. It is feared that by 2030, the country will import 94% of its petroleum requirement. Undoubtedly, renewable energy appears to be the most plausible option for the country to rely on.

1.5.1 Biomass Energy in India

Globally, India is in the fourth position in generating power through biomass and with a huge potential, is poised to become a world leader in the utilization of biomass. Biomass power projects with an aggregate capacity of 773.3 MW through over 100 projects have been installed in the country. For the last 15 years, biomass power has become an industry attracting annual investment of over Rs. 1,000 billion, generating more than 09 billion unit of electricity per year. More than 540 million tons of crop and plantation residues are produced every year in India and a large portion is either wasted, or used inefficiently. By using these surplus agricultural residues, by conservative estimates more than 16,000 MW of grid quality power could be generated through Biomass.

1.5.2 Estimated Renewable Energy potential

Table below demonstrates the renewable energy achievements in India as on 31.12.2009.

No.	Sources / Systems	Estimated Potential	Cumulative Achievements
1	Biomass Power (Agro residues)	16,881 MW	834.50 MW
2	Wind Power	48,500 MW	10925.00 MW
3	Small Hydro Power	15,000 MW	2558.92 MW

4	Cogenerationbagasse	5,000 MW	1302.00 MW
5	Waste to Energy	2,700 MW	65.01 MW
6	Solar Power	50 MW/sq.km.	6.00 MW
	Sub Total (A)	88,081 MW	15691.43 MW

Table 1.1 Estimated Renewable Energy potential

1.6 USAGE OF WATER HYACINTH

- Water Hyacinth is an excellent source of biomass.
- One hectare of standing crop thus produces more than 70,000 m3 of biogas.
- One kg of dry matter can yield 370 liters of biogas.
- Water Hyacinth is used to make furniture, handbags and rope.
- Water Hyacinth being used for paper production on a small scale.

LOCATIONS:
SITES AT THIRUMANIMUTHAR RIVER (MINNAKKAL)

PAVALATHANOOR LAKE

2. BIOMETHANATION PROCESS

2.1 Biogas Production in Batch and Semi continuous Digesters Using Water
Hyacinth

Digestion experiments at ambient temperature of 29& 2°Cconducted in a batch digester using chopped and groundwater hyacinth showed higher methane production rate; lower digester residence time are obtained with groundwater hyacinth. The biogas produced from groundwater hyacinth had higher methane content, 77%. Semi continuous digestion experiments at ambient temperature conducted in a pilot size mixed digester using groundwater hyacinth showed that maximum specific methane production rate was obtained at the highest volatile solids loading rate and lowest hydraulic detention time. Specific methane production rate is correlated with volatile solids loading rate; this correlation offers a simple tool to design semi continuous biogas digesters for commercial plants using water hyacinth.Digestion experiments at ambient temperature of 29 &2°C conducted in a batch digester using chopped and groundwater hyacinth showed higher methane production rate; lower digester residence time are obtained with groundwater hyacinth. The biogas produced from groundwater hyacinth had higher methane content, 77%. Semi continuous digestion experiments at ambient temperature conducted in a pilot size mixed digester using groundwater hyacinth showed that maximum specific methane production rate was obtained at the highest volatile solids loading rate and lowest hydraulic detention time. Specific methane production rate is correlated with volatile solids loading rate; this correlation offers a simple tool to design semi continuous.

2.2 CHARACTERISTICS OF BIOMETHANE AND THE TEST CONDUCTED

2.2.1 Methane generation potential and biodegradability of MSW components.

E.J.Jeon, et al. (2007) as important parameters for estimation of methane generation from landfills, we analyzed properties and ultimate biodegradability of each waste component was calculated. The results obtained in this study could be used as fundamental data for estimating methane generation potential of wet bulk waste in landfills.it was also possible to calculate the fraction of the degradable organic carbon that can decompose under anaerobic condition (DOCf) of wet bulk waste by using the data measured for various waste components. Methane is considered as an alternative energy due to its heat value. Thus, the estimation of methane emission from MSW landfill is important in terms of not only prevention of climate change but also recovery of energy.

2.2.2 Bio methane potential tests to measure the biogas production from the digestion and co-digestion of complex organic substrates.

Giovanni Esposito et al. (2012) This paper shows that BMP (bio methane potential) tests are extremely helpful to determine the amount of bio-methane obtainable from different organic solids and under different operational conditions as well as the biodegradability of the investigated substrate, the relative specific rate of bio-methanation and the synergic effect of multiple co-digested substrates. Furthermore BMP tests represent an interesting tool for the technical and economical optimization of bio-methane producing plants. Anaerobic digestion is easily performed in a biological reactor where mixers and heater exchangers could be the only technological and power consuming equipment needed.

3.1 MATERIALCOLLECTION
- Cow dung sample were collected from Uthukkottai, Thiruvallur.
- Water hyacinth (WH) was collected from Koovam River near Maduravoyal, Chennai.

3.2 MATERIAL PROCESSING
- Water hyacinth was chopped separately to about 20mm pieces later it was grinded
- Cow dung was diluted with water and mixed with water hyacinth with different ratios (100% cow dung sample followed by 50% WH + 50% CD and 75% WH+25% CD combination).

3.3 ANAEROBIC DIGESTION
- Anaerobic digestion is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. One of the end products is biogas, which is combusted to generate electricity and heat, or can be processed into renewable natural gas and transportation fuels.

3.4 PRINCIPLE OF ANAEROBIC DIGESTION
- The four key stages of anaerobic digestion involve hydrolysis, acidogenesis, acetogenesis* and methanogens. The overall process can be described by the chemical reaction, where organic material such as glucose is biochemically digested into carbon dioxide (CO2) and methane (CH4) by the anaerobic microorganisms.
- $C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$

3.4.1 Hydrolysis
- Through hydrolysis*the complex organic molecules are broken down into simple sugars, amino acids, and fatty acids.

3.4.2 Methanogenesis
- Flowchart below shows the process of methanogenesis

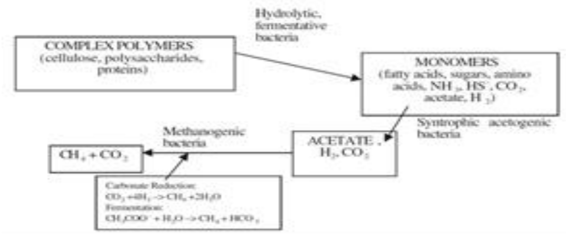

Fig 3.3 Systematic Overview of Anaerobic Digestion System

3.5 ENVIRONMENTAL FACTORS AFFECTING ANAEROBIC DIGESTION
3.5.1 Temperature
The effects of temperature on anaerobic digestion are well recognized. Mesophilic (25-450 C) and thermophilic (45-650 C) anaerobic digestion are commonly applied in the field.

3.5.2 pH Control in Anaerobic Digestion
pH is an important factor for keeping functional anaerobic digestion. A typical pH is in the range of 6.5 - 7.6. The accumulation of intermediate acids leads to pH drop during fermentation. In order to maintain stable operation, it is necessary to add bicarbonate or carbonate as an alkalinity buffer to neutralize volatile fatty acids and carbon dioxide.

4.1 FABRICATION OF ANAEROBIC DIGESTER

It consists of a plastic can that acts as an anaerobic digester is connected to a Borosilicate gas collector by means of a connecting tube. Biogas evolved is collected by downward water displacement method water is displaced into graduated transparent measuring jar.

Fig 4.1 Biomethanation unit

4.2 SOLIDS AND pH ANALYSIS
Total solids analysis and pH are important for assessing anaerobic digester efficiencies. TS

S. N	RATIO BETWEEN	TOTAL SOLIDS	TOTAL FIXED	TOTAL VOLATILE	pH Values

O	WH & CD	(10^3mg/L)	SOLIDS (10^3mg/L)	SOLIDS (10^3mg/L)	
1	50% W.H + 50 % C.D	862.8	36.8	826	6.9
2	75% W.H + 25% C.D	892	30.2	862.5	6.9
3	100% C.D	900	34.6	865.4	6.4

analysis was done using standard methods while pH was measured using pH meter.

4.2.1 pH Variations

During the digestion process pH varies between pH 6.6 and 7.6

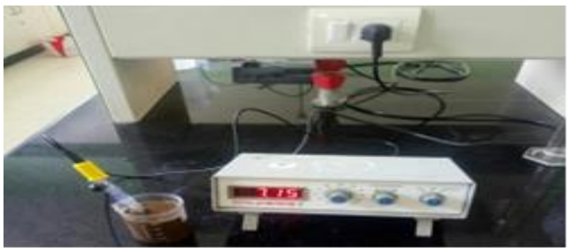

Fig 4.2 Digital pH meter

4.2.2 Solids Analysis

Total solid (TS), Total fixed solids (TFS) and volatile solid (VS) were analyzed for water hyacinth & cow dung according to standard methods.

5. RESULTS AND DISCUSSIONS

5.1 THEORETICAL BIOGAS PRODUCTION

The waste must be ensuring that no inorganic material is mixed up with the organic waste. The parameters of the waste such as pH, moisture content, total solids, volatile solids, carbon content, etc.

The total solid was found to be 860-900 mg/l in all the combination. A considerable number of studies have been conducted to investigate anaerobic digestion of water hyacinth. For increased gas yield, a pH between 7.0 and 7.2 is optimum, though the gas production was satisfactory between pH 6.6 and 7.6 as well. The pH of the digester is a function of the concentration of volatile fatty acids produced, bicarbonate alkalinity of the system, and the amount of carbon dioxide produced.

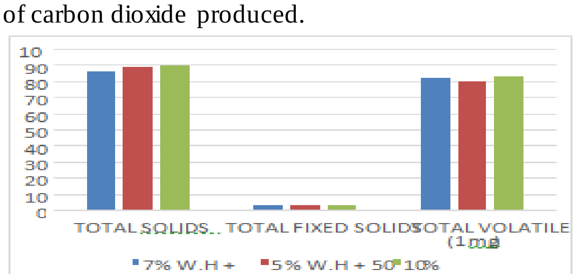

Fig 6.1 Relationship between TS, TFS&TVS

5.2 TEMPERATURE VARIATION WITHIN THE BIOGAS DIGESTER

Temperature varies widely during the biogas production period. The temperature varied between 23˚C - 38˚C, the fermentation process is an exothermic process and the variations could be attributed to the microbial action at various stages of decomposition.

5.3 BIOGAS PRODUCTION WITH TIME

The study shows a greater yield of biogas from the hyacinth/cow dung mixture compared to cow dung

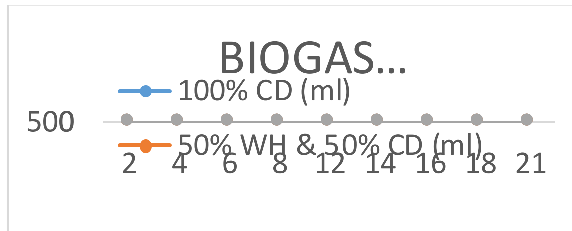

Fig 6.2 Amount of biogas produced

6. CONCLUSION

- The study revealed that it is possible to produce biogas from a mixture of water hyacinth and cow dung.
- Water hyacinth is a very good biogas producer needs minimal pre-treatment.
- This study forms an attempt to use the unwanted weeds as substrates for methane production.
- The different combination using cow dung and water hyacinth were tried and encouraging results were obtained when 50% Water hyacinth and 50% cow dung combination.
- Further studies are needed for the enhancement of methane generation from the different substrates for their further use in such systems.
- The use of pretreated water hyacinth for biogas generation therefore, will be a good energy source for those residing in the coastal areas, which face the menace of clogging of waterways by the weed.

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