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RESEARCH ARTICLE

# AGRO INDUSTRIAL WASTES AND AQUATIC WEED ECHHORNIA AS A SUPLEMENTORY SUBSTRATE FOR BIOGAS PRODUCTION

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ABSTRACT

Dependence of different countries on fossil fuels, leads to increasing the cost of oil in world market. To overcomes this problem the countries have to give extra emphasis on indigenous and renewable energy sources. The present paper deals with the study of bio energy production mainly biogas by using Aquatic weed Echhornia and wastes from Agro- based industries like Distillery, Sugar industry, Dairy and Farm house waste. The pretreated and untreated Echhornia biomass alone and in combination with waste was used, there was marked increase in biogas production in weed and waste combination. Experiments were carried out in 1-L digester flasks; measurement of biogas was done by water displacement method. The biogas production was recorded up to 30 days. In general Distillery waste and pretreated Echhornia showed highest 616.33 mL/day biogas production. The use of Echhornia and Distillery waste can be made to supplement the conventional substrate like dung in urban and rural areas to augment the biogas production.



## INTRODUCTION

The majority of world population lives in villages, Where the plant and animal biomass in the form of cattle dung, dry leaves, agricultural residues and plant weeds is available in plenty, which can be easily converted into biogas. To meet the daily biogas needs of family of four persons on an average, twenty five kg/day of dung will be required and hence the technology even today by and large caters to the need of rich farmers only In order to replace dung other resources commonly present in rural areas, has to be made to supplement the biogas production (Bose et al, 1983). Biogas is a mixture of methane (65-75%) and $CO_2$ (30-35%) together with other gases like $NH_3$, $H_2S$, $H_2$ and $N_2$, etc. in trace quantities, produced from organic matter by microbial decay under anaerobic condition. The biogas is highly combustible and can be used for generation of heat, electricity and mechanical energy. In order to augment the resource for biogas generation tapping of other resources has become necessity to supplement gas production (Annonymous 1981) in the light of this a series of publications have appeared in the last two to three decades to test the potentiality of other forms of biomass. Methane produced by anaerobic digestion of animal excreta like camel, horse, pig, poultry has been compared with that of cow dung (Biswas 1997; Malik et al, 1990). Agricultural wastes like rice straw, Tomato plants and Potato stems have been tested. In most of the cases pretreatment in the form of soaking in water, acid or alkali was found to increase the biogas content on digestion mixed with cow dung or any other animal waste the yield was higher. Several researchers have suggested an integrated approach to Biomethanogenesis Brahma (2001) used petrochemical waste for biogas production, the waste from distillery sugar factory, cellulose pulp, fishery waste used in India for biogas production. This type of production is quite cost effective. The literature survey thus reveals that majority cases investigated have yielded positive information and a vast plant biomass and agricultural industry wastes still awaits screening. *Eichhornia crassipes* (Mart) Solms It is one of the most prominent, persistent and troublesome aquatic weeds. Water hyacinth is a commonly present in ponds, lakes and tanks in most of the villages, towns and cities. The plants have blue flowers and buoyed by bladder like inflated leaf petioles. It reproduces by means of slender horizontal runners called stolons and seeds, which can remain viable for 15 years in the bottom of soil. Single plant is capable of infesting an area of one acre in a year. It produces greater dry matter content and converts solar energy more efficiently than any other plant. The plants cause enormous losses of water through evapotranspiration, damage to irrigation canals and waterways, pollute drinking water, killing of fishes, and clogging of slow moving streams. The present work is an attempt to use weed and waste for biogas production.

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## MATERIALS

**1) Agro-industrial wastes**;
**2) *Eichhornia crassipes* (**Mart) Solms entire plant material was used collected from Satara region

**3) Slurry of cattle dung based biogas plant** - Cattle dung based biogas plant slurry was collected from a biogas plant situated at Degaon, M.I.D.C. region Satara,

**3) Biogas digesters** - Preliminary screening studies regarding biomethanation potential of weed biomass was carried out by using 1-L capacity glass flasks and plastic carboys.

**Table 1. Wastes used for study**

| S. No. | Industry | Remarks |
|---|---|---|
| 1) | Distillery of Ajinkyatara Sahakari Sakhar Karkhana, Satara (distillery waste) | Rich in organic material, deep brown, Jaggary smell, acidic in nature. |
| 2) | Ajinkyatara Sahakari Sakhar Karkhana, Satara (Sugar plant waste) | Organic in nature, putrefaction leads to odor nuisance. |
| 3) | Government Dairy, M.I.D.C., Satara. | Organic in nature, slightly alkaline, anaerobic condition leads to odorous black sludge. |
| 4) | Local ongoing gobar gas plant, Degaon, Satara. | Plant based on animal excreta and human waste. Rich in organic matter. |

## METHODS

**1) Collection, preparation and storage of weed material**.

The entire Eichhornia material free of soil, were collected from selected sites in sterile plastic bags using sterile hand gloves and a knife. This plant material was then processed in laboratory, where it was chopped and cut into pieces of about 2 cm sizes. The pieces were powdered in a mixer, dried at room temperature ($30^0$C – $35^0$C) for 96 hrs, and then stored at refrigeration for further use. The dried biomass was soaked in water (for studies on untreated biomass) or dilute alkali (for studies on pretreated biomass) to form a slurry at the time of further use.

**2) Pretreatment of weed biomass- Alkali treatment**.

The 25-g of the air dried weed sample was treated with 1% NaOH solution for 8 days, using 10 parts of alkali solution to one part of the substrate i.e., 25-g of weed sample in 250 mL 1% NaOH solution at room temperature. Untreated and pretreated grass material was stored at refrigeration and used for further studies as and when required.

**3) Collection and storage of wastes**.

The distillery, sugar industry, Dairy and Farm house wastes were collected as fresh composite samples in disinfected plastic carboys of 5-L capacity and stored at refrigeration till further use.

**4) Chemical analysis of weed biomass and agro based industrial wastes**

Chemical reagents, apparatus and methods used for chemical analyses of weed material and agro based industrial wastes were as per APHA (1985), Trivedy and Goel (1984) and AOAC (1990).

**5) Biomethanation study**

a) Control set**-** Using only cattle dung slurry as substrate
The 600 mL of the ongoing cattle dung based biogas plant slurry was added to 1-L capacity digester as initial inoculums. The digester was then added with daily loading of 20g dung slurry at 30 days retention time and amount of biogas produced was measured daily. The combustibility of biogas was tested daily by burning test.

b) Test sets - Using Un treated and pre treated Echhornia biomass material.

The biogas digesters (1-L capacity) were loaded with 600 mL slurry from ongoing dung based gas plant as initial seeding material. The gradual stepwise removal of dung slurry from these plants and replacement with weed biomass slurry was done by gradually decreasing dung slurry and increasing weed biomass slurry in the daily loading of 20 g (30-day retention time). The details of daily loading are given in Table-2.

c) Test sets using Echhornia biomasses admixed with agro wastes**.**

Biogas digesters (1-L capacity) were initially filled with 600 mL slurry of ongoing cattle dung based biogas plants as initial seeding material. The untreated and pretreated Echhornia biomass of and four agro based wastes under study were admixed in proportion to adjust 35% total solids of admixture by taking into account total solids of individual agro based wastes. The cattle dung slurry was gradually and stepwise replaced in daily loading volumes of 20 mL (30 days retention time) by gradually decreasing cattle dung slurry and increasing the amount of admixture of weed and wastes prepared as shown in Table 3. The biogas volumes were measured daily and combustibility was tested by burning test.

**6) Measurement of gas.**

Biogas which produced in digesters proportionately displaced water level for which saline bottle was provided an outlet. After complete displacement of water from bottle, it was tested for the combustibility test and reported as biogas. The new saline bottle was filled with water and connected to digester for further collection of gas.

**7) Combustibility Testing.**

The needle of the gas displacer was first pierced though rubber cork of the saline bottle filled with gas. The tap water was then injected into the bottle through syringe. The gas got displaced from the saline bottle and moved through the displacer which was placed in the vicinity of the burner. The production of flame indicates combustibility of the gas.

**8) Storage of gas,**

The corks of the saline bottles filled with biogas were sealed with bees wax and were labeled species wise. They were then stored in cupboard at room temperature.

**Table 2. Screening of pretreated or untreated Echhornia biomass for Biomethanation potential and its admixture pattern with cattle dung slurry in 1-L biogas digesters, working volume 600 mL, pH of digester material 7.0 Ambient temperature (28-30$^0$C) and Retention time 30 days**

| Sr. No. | Amount of daily loading (g) | Proportion of dung slurry admixed with pretreated / untreated biomass slurry at various stages of experiment (g) | | | |
|---|---|---|---|---|---|
| | | Stage I 1-10 days : 25% weed material + 75% Dung slurry | Stage II 11-20 days : 50% weed material + 50% dung slurry | Stage III 21-30 day : 75% weed material + 25% dung slurry | Stage IV 31-40 days: 100% weed material |
| 1 | 20 | 5 + 15 | 10 + 10 | 15 + 5 | 20 + 0 |

**Table 3. Screening of pretreated/untreated Echhornia biomasses admixed with agro wastes for Biomethanation potential and its admixture pattern with cattle dung slurry in biogas digester. Capacity of digester – 1-L, Working volume – 600 mL .pH of digester**

| Sr. No. | Volume of daily loading (g) | Proportion of dung slurry admixed with pretreated / untreated weed biomass in combination with agro-based industrial wastes at various stages of experiment (g) | | | |
|---|---|---|---|---|---|
| | | Stage I 1-10 days : 25% (weed + waste)+ 75% Dung slurry | Stage II 11-20 days : 50% (weed + waste) + 50% dung slurry | Stage III 21-30 day : 75% (weed + waste) + 25% dung slurry | Stage IV 31-40 days: 100% weed + waste |
| 1 | 20 | 5 + 15 | 10 + 10 | 15 + 5 | 20 + 0 |

## RESULTS AND DISCUSSION

**1) Chemical nature of Echhornia-** Chemical nature was studied by using standard procedures and it was as shown in Table-4

**Table 4. Echhornia Chemical nature**

| Sr.No | Character | Amount |
|---|---|---|
| 1 | Organic matter | 60.40 mg/kg |
| 2 | Carbon, | 44.50 mg/kg |
| 3 | Nitrogen, | 31.10 mg/kg |
| 4 | C : N ratio | 14.30 |
| 5 | BOD, | 37,500 mg/kg |
| 6 | Phosphorus, | 130 mg/kg |
| 7 | Potassium, | 1900 mg/kg |
| 8 | Calcium, | 2570 mg/kg |
| 9 | Magnesium, | 2050 mg/kg |
| 10 | Iron, | 420 ppm |
| 11 | Manganese, | 20 ppm |
| 12 | Zinc, | 71 ppm |
| 13 | Copper, | 5 ppm |
| 14 | BOD : N : P ratio | 120:9.5 :0.42 |

**2) Physicochemical characteristics of wastes;** Characters of different wastes were studied by using standard procedures and it was as reported in Table-5.

**Table 6. Biogas productions from admixture of *Echhornia crassipes* and Agro industrial wastes. (UT- untreated, PT-pretreated) Echhornia biomass**

| Sr.No | Type of plant and Agro waste | Nature of waste | Range of gas mL | Average gas Production mL |
|---|---|---|---|---|
| 1) | Control (cow dung) | - | 60-90 | 85.00 |
| 2) | *Echhornia crassipes (EC)* | UT | 70-120 | 102.17 |
| | (EC) | PT | 125-200 | 167.83 |
| 3) | Distillery waste (DW) | UT | 300-620 | 424.33 |
| | (DW) | PT | 390-600 | 616.33 |
| 4) | Sugar industry ( SI) | UT | 150-320 | 185.03 |
| | (SI) | PT | 180-270 | 222.00 |
| 5) | Dairy industry(DI) | UT | 140-210 | 168.70 |
| | (DI) | PT | 170-240 | 322.03 |
| 6) | Farm house (FH) | UT | 210-420 | 313.33 |
| | (FH) | PT | 290-680 | 437.00 |

### 3) Biomethanation study -

It was thought that Biomethanation of Echhornia biomass could be improved by admixing with easily amenable organic materials like distillery, sugar, dairy industry and farmhouse wastes. These wastes would add to organics of admixture, and hence, cause improvement in C: N and BOD: N: P ratios

**Table 5. Characteristics of wastes**

| Sr. No. | Parameter | Distillery waste Value/Obs. | Sugar Industry Value/ Obs. | Dairy Value/ Obs. | Farmhouse waste Value/ Obs. |
|---|---|---|---|---|---|
| 1) | Colour | Dark brown | Yellowish brown | Dirty white | Brown yellowish |
| 2) | Odour | Alcoholic noxious | Unpleasant | Unpleasant | Pungent |
| 3) | pH | 4.2 – 4.5 | 6.2 – 6.4 | 6.3 – 6.6 | 5.8 – 6.0 |
| 4) | BOD mg/kg | 41290 | 1150 | 1350 | 16500 |
| 5) | COD mg/kg | 112000 | 1830 | 2100 | 33500 |
| 6) | Total solids mg/kg | 95000 | 2200 | 1320 | 32000 |
| 7) | TVS mg/kg | 64000 | 1950 | 1200 | 28400 |
| 8) | TOC(Carbon) mg/kg | 29700 | 690 | 810 | 9900 |
| 9) | Nitrogen mg/kg | 1550 | 28 | 39.5 | 443.9 |
| 10) | Phosphorus mg/kg | 950 | 3 | 4.6 | 113.4 |
| 11) | Potassium mg/kg | 11200 | 4.5 | 1.8 | 6.2 |
| 12) | Calcium mg/kg | 720 | 4.0 | 2.1 | 31.8 |
| 13) | Magnesium mg/kg | 290 | 3.0 | 1.1 | 19.3 |
| 14) | Iron mg/kg | 195 | 0.5 | 0.5 | 2.46 |
| 15) | Mangenese mg/kg | 0.5 | 0.1 | 0.15 | 15 |
| 16) | Zinc mg/kg | 0.4 | BDL | BDL | 2.46 |
| 17) | Copper mg/kg | 0.2 | BDL | BDL | BDL |
| 18) | C : N ratio | 19.16 | 24.64 | 20.50 | 22.30 |
| 19) | BOD : N : P ratio | 120 : 4.5: 2.77 | 120 : 2.9 : 0.31 | 120 : 3.5 : 0.4 | 120 : 3.2 : 0.82 |

## DISCUSSION

Industrial and agro based wastes like distillery, sugar; dairy and farmhouse were available in large quantities in the Satara region. The hundreds of cubic meters of wastes were produced daily in these industries. Farmhouse waste was produced in comparatively low quantities of 1–2 $m^3$/day. All of them possess huge pollution potential with respect to their volumes and organic content. These wastes, if disposed into water bodies and land or soil environments without prior treatment, can cause severe environmental problems. The organic content of these wastes hinted at their utilization to the processes like Biomethanation along with weed biomass to generate energy in the form of biogas, and sludge and effluents as supplement to manure and fertilizer. Further, the process will cause reduction in environmental pollution. It was found that Echhornia biomass material after admixing with distillery waste, when fed to 1-L biogas digesters, showed expected increase in the biogas volume. The distillery waste is a well known substrate for Biomethanation, which is proved in the present studies as well as by many other workers earlier (Gadre, 1982). The chemical characteristics of distillery waste in the present studies showed that it possess high level of TVS at 64,000 mg/kg and more organic carbon as compared to N and P, and hence, if it is admixed with substrates containing higher levels of N and P, the Biomethanation can be improved. It has been observed in the present studies that amount of biogas increases when Echhornia biomass was admixed with distillery waste for use as substrate for Biomethanation.

In Sugar industry waste It was observed that admixing of untreated and pretreated weed biomasses with sugar industry waste caused increase in the volume of biogas produced as compared to the untreated and pretreated weed biomass alone. The dairy industry waste contained more BOD and TVS but comparatively low N and P, hence alone it was not much suitable for Biomethanation. When untreated or pretreated weed biomass was admixed with dairy waste it improved the Biomethanation efficiency. The farmhouse waste consisted of large amount of bioamenable organics and TVS but insufficient of N and P contents. When this waste was admixed with weed biomasses, the Biomethanation efficiency was increased as compared to weed biomasses alone it was observed that more biogas production was obtained in pretreated Echhornia alone as compared to untreated one, and in the admixture of pretreated Echhornia biomass and other wastes as compared to untreated Echhornia biomass and among the four wastes studied the Distillery waste was the best substrate for Biomethanation.

### Summary and conclusion

1) The biomethanation process was studied up to 30 days at ambient temperature (37–38$^0$C)
2) Untreated Echhornia biomass was proved comparatively a poor substrate for Biomethanation than pretreated (dilute alkali) biomass.
3) Cow dung alone was not found to be good substrate for biomethanation but when admixed with Echhornia biomass and Agro-based industrial waste gives Good potential.
4) Chemical analysis of Echhornia and distillery waste show C:N and C:N:P ratio was in desirable range for biogas production.
5) In the present studies pretreated Echhornia biomass and distillery waste admixture proved to be the best substrate produce 616.33 mL of biogas.
6) The large volume of biogas production from pretreated Echhornia and Distillery waste was
7) The project could help to remove Echhornia and agro industrial wastes from the area and could be eco-friendly that can achieve the goal of the zero pollution.
8) In the present study some Agro-based industrial wastes and Echhornia Sample proved to be the best substrate for biomethanation. However some other additional plant biomasses and organic wastes available should also be tried and studied for their disposal through biomethanation process, which could be economical, acceptable one and fulfils energy need of rural area.

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