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# Employability of Biogas & Bio-Slurry with algae and cow dung as substrates for Continuous Advancement

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**Abstract**

In present experimental study algae, an organic waste obtained was mixed with cow dung (CD) in three different proportions, viz., 80:20, 40:60 and 20:80 percentages on a mass basis, and the mixtures were denoted as sample S1, S2 and S3 respectively. Important parameters, such as the pH, temperature, hydraulic retention time (HRT), and carbon/nitrogen ratio (C/N) were evaluated and analyzed. The results indicated that sample S2 gave best result, in comparison with the other samples, and the methane (CH4) and carbon dioxide (CO2) content in the biogas was found to be best for production. These readings are also compared with readings of algae and CD alone and Sample S2 is better than algae.

**Keywords:** Anaerobic reactor, Biomass, Biogas.

## 1. Introduction

The demand of energy is increasing every year due to the very high growth rate of the population of the world. To fulfil energy requirement, fossil fuels are burnt in a very large quantity and which are also present in finite quantity. There are some cities in the world in which we can't even breathe properly. And due to the regular emission of GHG, temperature of the environment is increasing day by day. To reduce all these problems, renewable energy can be used as source to fulfil our energy needs. There are many forms of renewable energy. Most of these renewable energies depend in one way or another on sunlight. Wind and hydroelectric power are the direct result of differentials heating of earth's surface which leads to air moving about and precipitation forming as the air is lifted. Solar energy is direct conversion of sunlight using panels and collectors. Biomass energy is stored sunlight contained in plants. Other renewable energies that do not depend on sunlight are geothermal energy, which is a radioactive decay in the crust combined with the original heat of accreting the earth, and tidal energy which is a conversion of gravitational energy. And biogas is one of the renewable sources to fulfil these needs.

Production of biogas is a fully biochemical process in which degradable organic matters are digested in a closed container called digester in the absence of oxygen with micro bacteria. Biogas is a clean and renewable form of energy and it can easily replace the other forms of energy like fossil fuels, oils etc and mainly in the rural sector. Raw materials are available for biogas production in abundant form. It was estimated that there are over 240 million cattle present in India. If one third of their dung produced annually is available for biogas then 12 million biogas plants can be installed. In recent years biogas technology has been upgrading tremendously and, now we can use this gas as vehicle fuel, power generations, heating etc. In this process digestion of cellulosic organic matter into biogas is done by syndication of microorganisms through a series of metabolic stages such as hydrolysis, acidogenesis, methanogenesis. In first, transformation of insoluble inorganic material and higher molecular mass compound such as lipids, polysaccharides proteins, fats etc are done into soluble inorganic compounds like monosacharides, aminoacid by bacteria like bactericides, clostridia, streptococci etc. In acidogenesis break down of products into acetic acid, hydrogen, CO2 , and low weight acid such as propionic acid , butyric acid with the help of acidogens bacteria. In methanogenesis these acetic acids, H, CO2 are converted into a mixture of methane and CO2 with the help of methanosacrcina, methanothrix, methanobacterium, methanococcus etc [1-2].

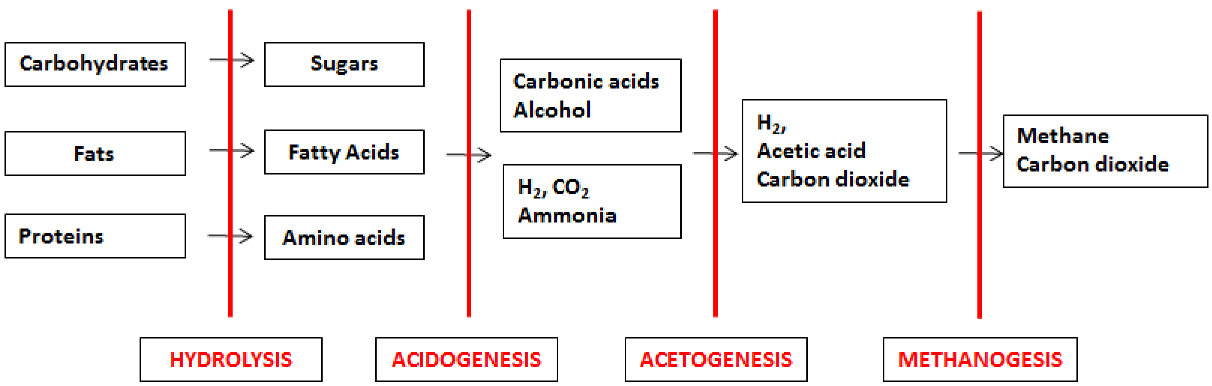


**Figure 1 Process in AD**

A wide range of organic wastes are available everywhere for anaerobic digestion. In addition to municipal sewage waste in both solid and liquid forms, waste is also generated by the industrial sector like sugar mills, agro processing, food processing, leather, pharmaceuticals and paper and pulp industries. Poultry waste has the highest biogas potential per ton of waste however livestock wastes have the greatest potential for energy generation in the agricultural sector.

An alga is organic degradable substance and contains cellulosic compounds and also contains large amount of nutrition. There are some locations on earth where we can find out a large amount of algae as compared to other raw sources of biogas like cow dung, poultry waste, sewage waste etc. Algal biomass can be cultured or acquired from natural, eutrophicated and degraded water bodies. Algae grows in the coastal regions water bodies where large amount of N, P, $CO_2$, and insufficient amount of $O_2$ present. Algae have some problems while using in anaerobic digestion like its strong cellular wall which makes resistance in the degradation. Hence algae have to be dried before using for anaerobic digestion in the sunlight for a period of 2 to 3 days. Anaerobic digestion of microalgae as a necessary way to make algae as a good fuel source and describe the theoretical yields of methane from lipids, carbohydrates and proteins. Lipids show the largest value of 1.014 L $CH_4$ /g VS (Volatile Solids), when compared with proteins (0.851 L $CH_4$ /g VS) and carbohydrates (0.415 L $CH_4$ /g VS). It has been identified that microalgae present large lipids content, between range of 4–19% dry weight. Microalgae as a source of protein with as high as of 90% dry weight under certain growth conditions. For this reason, microalgae can be regarded as a valid feed stock for AD purposes. Lipids level in macro algae has been found to be very low, i.e. between 0.4% and 3.5% dry weight, but exhibit higher values of carbohydrates. Carbohydrate content ranges between 3% and 40% dry weight, depending on genera and season. Algae do not require as much attention as crops for cultivation and digestion. They do not need any arable land for production. This opens a new alternative way to solve the food-energy competition problem.

**Table 1 Different types of raw feed for anaerobic digestion**

| ***Agricultural Feedstock*** | ***Community-Based Feedstock*** | ***Industrial Feedstock*** |
|---|---|---|
| Animal manure | Organic fraction of MSW | Food/beverage processing |
| Energy crops | Sewage sludge | Dairy |
| Algal biomass | Grass clippings/garden waste | Starch industry |
| | Food residuals | Sugar industry |
| | Institutional wastes etc. | Pharmaceutical industry |
| | | Cosmetic industry |
| | | Biochemical industry |
| | | Pulp and paper |

Algal bloom is very helpful in AD. An algal bloom is a rapid increase or accumulation in the population of algae in a water system. Two days are enough to increase mass of algae double of itself because of its high productivity rate [3]. Algae can be used effectively by drying in the sunlight so that its cellular wall can be broken down and its capability of photosynthesis will be reduced and hence can be easily digested.

## 2. Materials and Methods

### 2.1 Source of raw feed

Algae have been collected from a pond near NIT KURUKSHETRA in HARYANA which is approx 1 hectare in size and there is no use of this in anything else. And cow dung was taken from village DYALPUR near NIT KURUKSHETRA College. Algae was taken out and dried under the heat of sunlight continuously for three days. Particle size of algae is reduced by use of a mechanical stirrer which is run by a small motor operated by the electricity. Cow dung is also mixed with water in the stirrer and fine paste of it was prepared. About 50 gm of powdered dry rice straw with a particle size 0.12–2.2 mm was mixed with the substrate samples, for maintaining the proper C/N ratio. Rice straw was collected from the local farmer and washed with water. Then, the washed rice straw was dried in sunlight.

### 2.2 Processing

Names were given to digesters as D1, D2, D3 in which different ratios of both cow dung and algae were mixed. A small amount of Rice straw was also added in each digesters because of the low C:N ratio of the algae. Rice straw is available everywhere in sufficient quantity. (from news papers) Each individual digester has a volume of 5 litters and connects with two pipes, one is for gas outlet and another is for slurry outlet. Slurry is pouring from the top of the containers after regular intervals.

**Table 2 Proximate analysis of the CD, Algae and Rice straw**

| Feed material | Wt % dry basis | | | |
|---|---|---|---|---|
| | Moisture content | Total solid | Volatile matter | Non volatile solid |
| CD (a) | 78.02 | 19.80 | 19.90 | 19.60 |
| Algae (b) | 49.20 | 66.70 | 34.00 | 23.02 |
| Rice straw (c) | 12.20 | 80.30 | 79.02 | 4.60 |

Algae has low C:N ratio and due to this it cannot be used alone in the digester. A high amount of nitrogen and other nutrients present in the algae make final biogas and biogas slurry corrosive in nature due to the formation of ammonia ions. Hence to increase amount of carbon with respect to nitrogen, we add some rice straw which has high C:N ratio about 74:1 and also found in large quantity as the rice is produced in most of the area of the world. All maximum functional groups are identified by spectroscopy method. All samples are measured regularly. U-shaped glass tubes are used to measure daily biogas production with water displacement (outer diameter 20 mm, length 2000 mm and 2.5 mm thickness). From the test it was observed that N-H , C-O , N-O , C-C , C-N groups are present in the samples.

In terms of percentage of first two substrates (a) and (b), we are making ratios in the digester and depend upon these we are making entire analysis as

## 3. Experimental results and analysis

### 3.1 PH

Anaerobes can be divided into two groups: acidogens and methanogens. The optimum pH is 5.5 - 6.5 for acidogens and 7.8 - 8.2 for methanogens. If we combine the cultures, it can be said that the optimum pH ranges from 6.8 to 7.4. The average pH of the input substrate for the algae and CD was found to be about 7.0, 6.5 and 6.0 for samples s1, s2, and s3. For the samples S2 and S3, the initial pH was decreased, due to the production of volatile acids, and later 10–15 days of HRT the pH increased, and hence production of alkaline increased. But for samples S1 the initial pH was 6.0 which was about 10% less than that of the 100% CD sample, because in the 5 to 8 days of HRT the hydrolytic and acetogenic bacteria are predominant, forming acetic acid. During anaerobic digestion, the average pH was found to be about 6.5 for S1 with 30 days of HRT, 6.2 for S2 with 28 days of HRT, 6.0 for S3 with 27 days of HRT.

### 3.2 Temperature

All the three samples were analysed in the same temperature conditions. The biogas digestion process depends directly on temperature. Mesophilic methane forming bacteria are active in 30 - 35 °C and thermophilic methane forming bacteria are active in 50 – 60 °C. Between 40 - 50 °C, bacteria are inhibited. Biogas production can occur better at 35°C. The average temperature of 30 days of anaerobic process was calculated as 37°C. Samples were kept in the closed room and regular observations were made of temperature there.

### 3.3 C:N ratio effect

The ratio of carbon to nitrogen present in organic materials is expressed in terms of the carbon/nitrogen ratio (C/N). A C/N ratio ranging from 20 to 30 is considered optimal for anaerobic digestion. If the C/N ratio is very high, methanogens consume nitrogen at fast rate for meeting their protein requirements and will no longer react on left over carbon content of the material. As a result, gas production will be low. On the other hand, if the C/N ratio is small enough, nitrogen will be liberated and accumulated in the form of ammonia accumulation will be happened due to the liberation of nitrogen. Sample s2 can be calculated as the best sample in terms of carbon to nitrogen ratio of three different samples. C:N ratio of three different samples is 19,21, and 16. Sample s2 has 50 percent ratio in between cow dung and algae and this sample has 17% rice straw of total quantity.

### 3.4 Gas comparison

It was observed from the samples S2 and S3 that, the biogas production rate became stable after a HRT of 10 days, and started falling after 26 days of HRT, because of the scarcity of feed materials in the batch reactor for the growth of microorganisms. The initial days (1–9 days) biogas production was found to be low, compared to the later days of the HRT. In this analysis it is observed that sample s2 gives best reading among all three other samples. Sample s2 has fifty percentage of cow dung with algae and has 100 grams of rice straw. This sample has also minimum amount of $H_2S$ present and has lesser amount of $CO_2$ present in comparison with other two samples s1 and s3. Amount of methane in Sample s2 has 20% and 14% more than samples s1 and s3 respectively. Also sample s2 has 20% more methane production as compared to algae and 8% less than cow dung.

Readings of samples s1, s2, and s3 are not better than cow dung alone but these are too much better than the readings obtained by AD of alone algae.

**Table 3 Content comparison of various gases**

| Properties | S1 | S2 | S3 | reference | Algae |
|---|---|---|---|---|---|
| PH | 6.5 | 6.2 | 6.0 | 7.0 | 6.7 |
| $CO_2$ % | 30-40 | 20-30 | 25-35 | 20-30 | 31.9 |
| $O_2$ % | ≤3 | ≤1 | ≤0.5 | 0-3 | - |
| CO mg/m3 | 15 | 19 | 22 | - | - |
| $N_2$ | 5-15 | 10-20 | 15-20 | 0-1 | 6.2 |
| $CH_4$ % | 45-55 | 55-65 | 48-58 | 60-68 | 50.9 |
| NO mg/m3 | 18 | 25 | 29 | 1-15 | - |
| $H_2S$ ppm | <150 | <100 | <200 | 0-2 | 1.0 |
| Temperature(°C) | 27 | 27 | 27 | 29 | 28 |

**Table 4 Fertilizer value of four different slurry mixers**

| Samples | Nitrogen % | Phosphorous (ppm) | Potassium (ppm) |
|---|---|---|---|
| S1 | 0.800±0.019 | 22.67±3.060 | 135.0±30.0 |
| S2 | 0.823±0.024 | 39.33±3.060 | 150.0±20.0 |
| S3 | 0.775±0.025 | 28.14±2.080 | 108.7±20.5 |
| Cow dung slurry | 0.931±0.0259 | 28.55±4.11 | 153.2±25.3 |

### 3.4 Slurry analysis

All the analysis of slurry was done at SIGMA TEST CENTER at delhi. Three different samples sent to the lab in three different bottles of 1 litre each. Nitrogen content was determined by kjeldahl nitrogen assembly apparatus and spectrophotometer and flame photometere determines the contents of phosphorous and potassium respectively. Nutrients in slurry of sample 1 can be considered as the best one in comparison with other three samples s1 s2 and s3. Percentage of nitrogen is maximum in sample 1 in which value of cow dung is maximum about 75 % of the weight. Value of phosphorous is maximum in not digested cow dung and if observations will be carried out in three different samples than s1 contains the maximum amount of P. Value of potassium is maximum in second samples which contains fifty fifty ratio of CD and algae. From the overall observations we can say that sample one has the best slurry nutrients in comparison with samples 2 and 3. it can be observed that after digestion, the nitrogen, phosphorus and potassium value of the slurry was increased, which is good for the growth of plants. Also, the digested slurry became nontoxic due to the action of anaerobic microorganisms. It is suggested that the digested slurry can be used as an organic fertilizer in the agricultural sector.

## 4. Conclusions

Algae can be easily use with other organic digestible substances for the production of biogas and bio slurry. Rice straw can be used to improve the c:n ratio of gas produced and hence increase the yield of the both gas and slurry. The algae have the potential for biogas production and up to 65% methane can be obtained after mixing in the above ratio. Best sample among the above samples is s2 in case of gas production and s1 in case of slurry nutrients. C:N ratio of the algae is very low which is not good for us while using it in AD process but we can use it while mixing with others substrates having large value of the carbon to nitrogen like that of rice straw and cow dung. The best value of C:N for these samples is 21:1 which is very good for results. This type of value can't be gotten if alone algae was used as the substrate. Algae has the C:N of 10:1. Algae have the good nutritional values and hence slurry produced from the sample s2 has the best nutritional values among the all others. Sample s2 has the highest value of all three N, P, and K values.

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