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Improvement of Biogas Production by Co-digestion of Microalgae

Himanshu Joshi[1], Archana Paranjpe[2]
[1]M.Tech Scholar, [2]Prof dept. of EX, Takshshila Institute of Engg. & Tech., Jabalpur, India

Abstract: This paper presents microalgae as the third generation bio energy feedstock. Whether it has possibility and feasibility to replace the fossil fuel in future was discussed. Microalgae can convert to biogas, bio oil, and bio diesel and bio ethanol. Through the description of the microalgae characteristics and compilation with other biomass feedstock, Microalgae has high lipid contents, fast growing and less land use superiorities. Microalgae have potential benefits to become a renewable energy from biological properties point of view. Microalgae as renewable energy resource, the sustainability of microalgae must to be estimated. However, some challenges are still limiting the development of microalgae. In conclusion, microalgae have most possibility to replace fossil fuel in the near future.

Keywords: Biomass, Microalgae, Co-Digestion, Renewable Energy , Biogas

I. INTRODUCTION

Biomass energy, as one of the representatives of renewable energy, has been developing rapidly in form of agriculture and aquaculture. Biomass energy is usually produced by terrestrial crops and marine algae for conversion into bio fuel and biogases. Since the 1970s, the United States and Brazil have begun to develop bio fuel by using corn to produce bio-ethanol, and achieved significant results. Biomass energy cannot only reduce the energy shortage problem, but is also much better for the environment than fossil fuel. However, terrestrial crops - the first and second generation bio fuel feed stocks pose new challenges such as the occupation of arable land which end in food crisis. Thus one of the most serious concerns regarding sustainability aspects today is the need of land to produce food to an increasing population. There is average of 25 000 people that die of hunger every day in the world. In another words, there is one person die of hunger every 3.4 seconds [1].

Biomass energy sources have three generations development steps. The first generation bio fuel feed stocks derived from food crops, such as sugarcane, corn and wheat. Rice straw and switch grass as sorts of non-food raw materials become the second generation bio fuel feed stocks. The third generation bio fuel feedstock is algae (especially microalgae). Algae will probably play an increasing role in the sustainable energy use field in the near future [2]. Algae are the oldest plant living in the freshwater, saline and even sewage. There are around 2100 general, 27000 species of algae living in the world. The lipid and protein which are contained within the algae cells are higher than other terrestrial plants. It can produce biomass energy only by using sunlight, water and CO_2. Algae have short growth period (2-6 days breeding one generation), high efficiency photosynthesis, and it does not occupy land. Algae can be simply divided into macro algae and microalgae. Macro algae include brown algae, red algae and green seaweed. Chlorella, spirulina, and green algae belong to the Microalgae.

There are more than 20,000 kinds of microalgae found in the marine and fresh water environment. However, only few kind of microalgae have been found for bio energy conversion so far .Compared with macro algae, microalgae have greater advantages such as simple structures, fast growth rate and high oil content and so on. Therefore most of the industrial companies prefer to use microalgae as the feed stocks to produce biomass energy [1].

1.1 Uses of Algae as Energy source

Humans use algae as food, for production of useful compounds, as biofilters to remove nutrients and other pollutants from wastewaters, to assay water quality, as indicators of environmental change, in space technology, and as laboratory research systems. Algae are commercially cultivated for Pharmaceuticals, Nutraceuticals, Cosmetics and Aquaculture purpose.

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1. Algae can be used to make Biodiesel (see algaculture), Bioethanol and biobutanol and by some estimates can produce vastly superior amounts of vegetable oil, compared to terrestrial crops grown for the same purpose.
2. Algae can be grown to produce hydrogen. In 1939 a German researcher named Hans Gaffron, while working at the University of Chicago, observed that the algae he was studying,*Chlamydomonas reinhardtii* (a green-algae), would sometimes switch from the production of oxygen to the production of hydrogen.
3. Algae can be grown to produce biogas, which can be burned to produce heat and electricity.

1.2 Biogas Production by Anaerobic Digestion

Anaerobic digestion takes place when bacteria convert a biomass feedstock into various other organic compounds, ultimately ending in a mixture of carbon dioxide and Biogas called biogas. This biogas is a mixture approximately made of 60% Biogas and 40% carbon dioxide, with other trace gases found.

While anthropogenic carbon dioxide is a concern with greenhouse gas emission, the carbon dioxide released in this reaction is considered carbon neutral. The Biogas can be purified and used for purposes of generating heat or electricity. The energy provided from anaerobic digestion not only is considered a net positive resource, but also a useful carbon reduction method [14]. Anaerobic digestion serves a dual purpose in both providing the Biogas and reduction in volatile solids, lowering the risk of possible pollution when the slurry is disposed. The solids can also be used for various agricultural purposes such as fertilization.

II. Materials And Methods

This research explores the potential of algal Biogas gas via anaerobic digestion (AD) as a carbon-neutral energy source. In particular, the research investigates Biogas production from the anaerobic co-digestion of the microalgae, Chlorella vulgaris (C. vulgaris), with wastewater sludge.

2.1 Algae substrate for anaerobic Digestion

Algae cultivation Fresh water was collected from gwarighat in March (early spring/late winter). The water was used immediately in the experiment, without any preservation or storage. A batch experiment was set up with two 10 litres airtight container each containing about 7 litres algae waste and other mix waste. The containers were placed in a climate chamber with consistent light at 30-40^{o}C

2.2 Cow Manure substrate for anaerobic Digestion

Fresh cow manure was collected from research from the dairy form. The 4 litres (with water) manure was collected in container and used the same day as collection to maintain freshness. Care was taken that samples were as fresh as possible to maximize Biogas production potential. Manure was dried and analyzed for solids content and moisture, as well as carbon and nitrogen content.

2.3 Inoculums Sludge and Carbon Input

Anaerobic digester inoculums sludge was gathered from pariyat Biogas plant Jabalpur. Similar to the cattle manure, 1-litre container were used to contain the digested sludge. The sludge was collected directly from the recycle stream of the anaerobic digesters, and as such contained high moisture content, yet also high amounts of activated microbes for Biogas production.

The inoculums sludge was used the same day to maintain microbial activity. It was noted that extended residence time caused settling of the sludge and separation of components into layers. Proper mixing and quick use prevented this becoming an issue in the digesters. Samples were dewatered to measure solids content, density, and pH, as well as carbon and nitrogen content.

III. Experimental setup

The experimental setup consisted of 2 reactors, each with approximate working volumes of 10 litres. The digesters were constructed of clear airtight Plastic container with 0.5 inch plastic tube for carry the biogas and 2 litres plastic bottle for gas collection. A threaded PVC fitting was used on the top of each reactor, with a threaded PVC plug sealing the reactor. M. seal was used to seal all fitting on the reactor, not including the top threading, allowing for opening. Sealing compound putty was used in the threaded connection to prevent gas leaks from the pressure inside the reactors.

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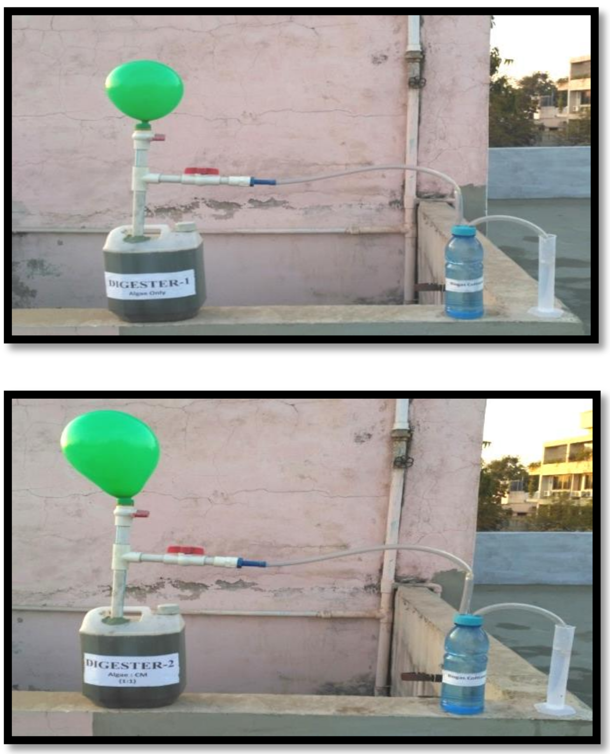
Experimental setup developed 2 air tide 10 litres digesters installed at mesophilic temperature (35-40^{o}C) for experimental work for 35 days in month of April- May.

Table 1
Experimental setup for co-digestion experiments with algae and cow manure.

S.NO.	Algae (liters) with water	Cow manure (liters) with water	inoculums sludge (liters)
1	7 liters	0	1 liter
2	3.5 liters	3.5 liters	1 liter



Picture 1: Experimental Setup

Both experimental setup installed and daily biogas generation measured by water displacement method and temperature, pH value also measured by digital Thermometer and Digital pH-electrode meter

IV. Results And Discussion

Initial analysis shows high volatile solids content in algae, and manure demonstrating the spent microbial activity from the original process. Algae and anaerobic sludge showed fairly similar moisture contents. For the proper functioning of anaerobic digesters, the physical and chemical characteristics like Total solid, pH value, Temperature of the substrate are important as they affect the biogas production and the stability of the process.

4.1 Daily biogas production rate

The main components of biogas are Biogas and carbon dioxide. Figure shows the proportion and yield of the biologically produced Biogas after 35 days of fermentation. The proportion of Biogas was highest for 50% of algae and 50% cow manure, whereas the yield, measured as ml g-1 VS, was highest for 15% followed by 50 % of algae. Altogether, the increased production of biogas as well as the increased proportion of Biogas indicates the potential of algal substrates as a complement to the traditionally used cow manure based on higher plants. In addition, if properly managed, algae cultivation can also be considered as more sustainable than plant cultivation because uncultivable land can be used, significantly less water is needed, and the risks of nutrient run off and biodiversity loss can be controlled. However, specific energy requirements must be taken into account, such as continuous mixing, CO_2 supply and costs for harvesting of the biomass.

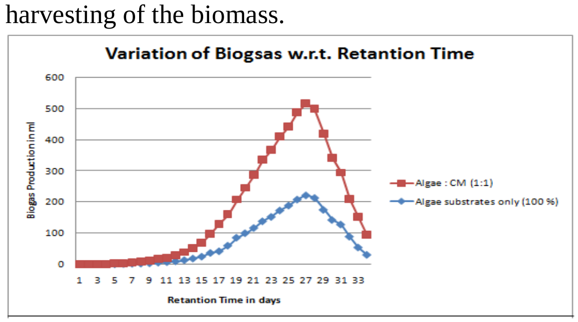


Fig. 1 Daily biogas production rate from batch reactor (ml/day)

V. Conclusion

This study investigated the feasibility of biogas production from the co digestion of algae with cow manure. The results from the co digestion experiment of algae with cow Manure is maximum biogas generation is 100.5 ml/day and cumulative biogas production is 3518 ml/kg means 0.50 m^3/kg compare to single subtract digestion biogas generation is 70.2 ml/day and cumulative biogas production is 2457.6 ml/kg means 0.35 m^3/kg

This work is yet to investigate the seasonal availability of algae based on which together with the findings so far, the choice of the type of algae for co-digestion with cattle manure can be determine. At the conclusion of the experiment, it was found that biogas production increased when algae with co digestion cow manure was added to the digester. This shows that the presence of cow manure with algae increases the overall Biogas production. The effects of carbon balancing for the carbon-to-nitrogen ratio also showed that overall, mixtures balanced at 25:1 carbon-to-nitrogen yielded more biogas. The exception is the normal algae mixture, in which the optimal ratio was 20:1. In conclusion, the anaerobic co-digestion of cattle manure with algae, when balanced for carbon and nitrogen, can severely increase Biogas production rates.

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