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Research Article

Effectiveness of Biodiesel Fuel Produced from Urban Algal Bloom

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ABSTRACT

Excessive use of petroleum and conventional crude oil led to its depletion from the natural ecosystem. To replace the use of conventional fuels, an alternative way of production of crude oil is required. The synthesised fuel should be energy efficient, vehicle friendly, cost effective and release minimal amounts of CO_2 and toxic oxides. Use of such a type of fuel will effectively help in reducing global warming. Thus, biofuels can be a great substitute to conventional fuels like petroleum and diesel. In the biofuel production industry, algae are one of the efficient and easily growing protists. Algae can be grown in labs by culturing it in nutrient rich media and algal oil can be used to synthesise biodiesel. As growing algae in labs involves lots of infrastructure development and cost, algal blooming species growing in natural water sources can be used for biofuel production. In this research paper we will study the efficiency of algal blooming species found in urban water bodies. The comparison of market biodiesel with the biodiesel synthesis from algae will also be done. In this paper we will investigate the biodiesel production efficiency of species like *Cosmarium*, *Eudorina* and *Navicula* which constitutes the major portion of the collected algal biomass. The results have shown presence of triglycerides in the sample oil and GCMS results also show similarity of sample oil with biodiesel available in the market. This infers that the algal bloom found in urban areas can also be used as a substitute of biodiesel with further modifications.

Keywords: Biofuel, algal biomass, less toxic, environment friendly, energy efficient, cost effective, biodiesel.

INTRODUCTION

Fuel has become an inseparable part throughout the world and the excessive use of fuels like petrol, diesel leads to their depletion as they are non-renewable resources. Due to this an alternative route of fuel production is required, biofuels like bioethanol, biodiesel and biobutanol are biodegradable, non-toxic, carbon neutral, possess minimal greenhouse gases emission and are cheap as compared to conventional fuels. Biofuel is generally obtained from plant biomass or animal waste [1]. It is a renewable source of energy unlike conventional fuels like petroleum, diesel, coal and natural gas. Biofuel can also be obtained from various species of algae. Algae is a eukaryotic, photosynthetic and cosmopolitan organism. Generation of biodiesel from algae is a great alternative to non-renewable fuels. Algae convert solar energy into chemical energy and produce hydrogen gas. Algae do not impact the food chain, and can be grown in aqueous medium, needs less water, possess O_2 generating system, CO_2 declination by photosynthesis and are available throughout the year [2-7]. Its biomass can be burned as wood and on providing anaerobic conditions it aids in production of methane biogas to generate heat and electricity. The crude bio-oil is extracted from algae by pyrolysis and is used in many cosmetics and beauty products.

Algae can be seen in many forms in nature as they are tolerable to different intensities of light, wide range of pH values and can grow alone as well as in symbiosis [8-10]. In our research work we will use algal bloom for synthesis of biodiesel. Algal bloom is a large population of microalgae aggregated together growing continuously over the surface of water bodies, they are also a rich source of carbon compounds [11]. Nutrients like nitrogen, iron, amino acids, vitamins or phosphorus runoff into water bodies cause accumulation of algae [12-14]. Algae are generally considered harmful for aquatic life as they reduce water transparency, lower BOD (Biological Oxygen Demand), extracts nutrients from the water bodies which ultimately leads to death of aquatic organisms [15-17]. In some extreme cases they also release harmful toxins and lead to scarcity of many aquatic species. Production of around 5,000 - 15,000 gal of biodiesel from biomass of algae per acre per year reflects its potentiality [18].

Species of algae like *Botyrococcus braunii*, *Chlorella sp.*, *Crypthecodinium sp.* are generally grown in a lab for biofuel production. The need of these species has increased drastically over the last few decades. Large cultures of microalgal species are set up for extracting algal oil and further processing of these oils lead to biofuel production. In the present work algal bloom forming species from urban water bodies were used for biofuel production. This idea of replacing lab grown algae from algal bloom forming species is not yet in practice at a large scale, but many works have been done in characterising the feasibility of algal blooming species to produce biofuel. The replacement of lab grown species of algae with bloom forming algae species will efficiently reduce the cost of managing algal cultures. This will also lead to removal of algal blooms from water bodies which will aid in cleansing and upgrading the aquatic ecosystem, hence it will reduce both air and water pollution[19-21].

In the present research work we will synthesise biodiesel from common algal species blooms found in urban localities. We will also compare the efficiency of synthesised biodiesel with the biodiesel available in the market. The synthesised biodiesel can be used as a substitute to the commercial biodiesel.

MATERIALS AND METHODS

Chemicals Used: NaOH, Methanol, Hexane, Ether were used as such obtained from Merck Chemicals, India.

Sample Collection : 30 g of algal bloom having different species of algae was collected from the water bodies near India Gate.

Algal species like *Cosmorium, Eudorina* and *Navicula* were found in the collected algal blooms, and the species were detected using a compound microscope.

Techniques like centrifugation, flocculation, floatation, sedimentation and filtration were used for harvesting and concentrating the algal biomass [22].

Oil extraction: The algae were filtered using a normal filter cone and then smashed finely with the use of mortar and pestle. After this the algae were left for sun drying for a day to release moisture. For the extraction of algal oil, solution of hexane and ether (30 mL each) were added to the dried algae and left for mixing and settling for 18 h.

Collection of algal oil: The algal mass was collected after filtration and the filtrate was centrifuged for removal of hexane and ether solution. The algal oil was separated using centrifugation technique.

Mixture of 0.35 g of NaOH and 34 mL of methanol was then added to the above extracted algal oil with continuous stirring for almost 30 min. Centrifugation was again done at 500 rpm for 2 h for carrying out transesterification.

Biodiesel separation: After centrifugation the solution was left for 24 h for settling of biodiesel and other sediment layers. By the process of sedimentation, the biodiesel was extracted from the mixture (Fig 1).

Washing and Drying: Washing of biodiesel was done by using distilled water multiple times to get a clean solution. After washing biodiesel was left for 18 h for drying.

Characterization: Above extracted biodiesel was analysed by using GC-MS process, analysis of physical properties and estimation of boiling point were also done.

RESULT AND DISCUSSION

GC-MS (Gas Chromatography Mass Spectrometry) confirmed the presence of various biofuel yielding compounds (Table 1). The algal biomass was majorly occupied by unicellular green algae species like *Cosmorium, Eudorina* and *Navicula.* Fuel has a characteristic ignition value, which should neither be too high nor too low. The obtained biodiesel had a moderate ignition value.

Figure 1: Two layers obtained after extraction of biodiesel from algal bloom: Upper layer is of biodiesel and lower layer is of glycerine.

Table 1: GC MS Parameter of extracted Biodiesel

Parameter	Setting
Column temperature program	Initial temp 60^{O} C for 2 min, raise to 150^{O} C by 10^{O} C/min, hold 5 min, raise to 280^{O}C by 10^{O}C /min, hold for 5 min
Injector temperature	300^{O}C
Injector Volume	0 µL
Carrier gas	He
Split	20:1
Solvent Delay	3.00 min
Transfer Temperature	50^{O}C
Source Temperature	50^{O}C
Scan	30 to 400 Da
Column	30.0m x 250µm

Figure 2: *Cosmarium* (Member of Chlorophyceae)

Figure 3: *Eudorina* (Member of Chlorophyceae)

The algae found in the collected algal bloom contained two Chlorophyceae species i.e *Cosmarium* and *Eudorina* in abundance (Fig 2 and 3). Compounds such as hexadecanoic acid methyl ester, dodecanoic acid methyl ester and tetra decanoic acid methyl ester were found in the extracted biofuel after GCMS analysis (Fig 4).

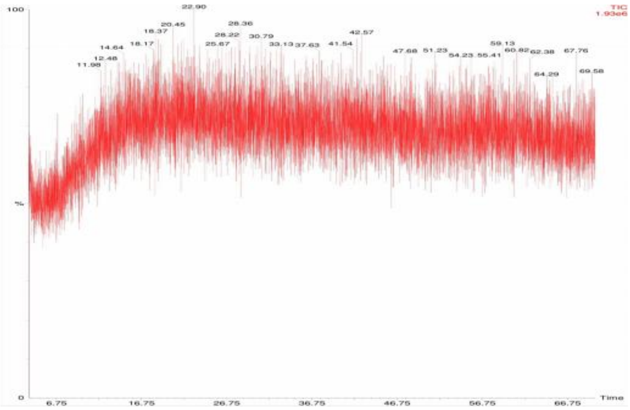

Figure 4: Presence of diesel components shown by GCMS

These compounds are also present in common biofuels available in the market. Traces of fucoxanthin were also found in the sample indicating the presence of freshwater brown algae in algal biomass. The color and odour of the obtained biofuel is similar to commercially available biofuels (Fig 5). Gasification of dry biomass, BtL (Biomass to Liquid) technology, and HTL (hydrothermal liquefaction) of vegetable oils are the main processes involved in gasification, even though researchers are employing sources other than algae to produce biofuel through fermentation of saccharides. The lighter fuel biohydrogen is produced by gasifying dried biomass. Ethanol, butanol and methanol are produced by fermenting cellulose and syngas, and C5-C18 hydrocarbon fuels are produced by FT synthesis followed by BtL. According to EU-RED (EU Renewable Energy Directive), these fuels are environmentally friendly, clean burning, and non-corrosive because of their less toxicity [23-26]. However, there is still a need to provide a more affordable and effective fuel. Therefore, the use of algal bloom in biodiesel production will result as a boon in the fuel industry. In this work it is represented that the algal bloom species found in polluted urban locality are not that efficient in biodiesel production, due to presence of impurities in them. Hence, a more detailed and mechanical approach towards production of biofuel from algal bloom can be done.

Figure 5: Extracted Biodiesel from algal bloom

Presence of various fatty esters determines overall fuel properties. In several researches diatoms and green algae are said to be the most promising aspect of biodiesel production from algae. Algal cells possess 30% of lipid content which is larger than other sources such as soybeans and palm oils [27-29].

CONCLUSION

Algal fuel is an alternative to liquid fossil fuels which aim to replace the current non-renewable fuels like petrol, diesel etc. Algal fuel is rapidly growing, high yielding, biodegradable, emits less carbon and has a higher portion conversion efficiency, but its commercialisation is hindered by its high maintenance and pH imbalance. The idea of discovering the potential of local algal species has led to the inference that they are less efficient than the commercially grown but further processing of these blooming algal species at industrial level may make them a part of commercialised biodiesel.

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