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BIODIESEL PRODUCTION FROM ALGAE

G. KHOLA AND B. GHAZALA*

Department of Botany, Govt. College University, Katchery Road, Lahore-54000, Pakistan
**Corresponding author: dr.ghazalayasmeen@gcu.edu.pk*

Abstract

Algae appear to be an emerging source of biomass for biodiesel that has the potential to completely displace fossil fuel. Two thirds of earth's surface is covered with water, thus algae would truly be renewable option of great potential for global energy needs. This study discusses specific and comparative biodiesel quantitative potential of *Cladophora* sp., also highlighting its biomass (after oil extraction), pH and sediments (glycerine, water and pigments) quantitative properties. Comparison of *Cladophora* sp., with *Oedogonium* sp., and *Spirogyra* sp., (Hossain *et al*., 2008) shows that *Cladophora* sp., produce higher quantity of biodiesel than *Spirogyra* sp., whereas biomass and sediments were higher than the both algal specimens in comparison to the results obtained by earlier workers. No prominent difference in pH of biodiesel was found. In Pakistan this is a first step towards biodiesel production from algae. Results indicate that *Cladophora* sp., provide a reasonable quantity of biodiesel, its greater biomass after oil extraction and sediments make it a better option for biodiesel production than the comparing species.

Introduction

Biodiesel has attracted attention during the past few years as a renewable and environmentally friendly fuel because of diminishing petroleum reserves and the deleterious environmental consequences of exhaust gases from petroleum diesel (Vasudevan & Briggs, 2008). Biodiesel (fatty acid alkyl esters) is an alternative diesel fuel derived from the reaction of vegetable oils or lipids and alcohol with or without the presence of a catalyst (Janaun & Naoko, 2010). The chemical conversion of the oil to its corresponding fatty ester (biodiesel) is called transesterification (Demirbas, 2009).

Biodiesel is non toxic and biodegradable alternative fuel that is obtained from renewable sources (Hossain *et al.,* 2008). In many countries, biodiesel is produced mainly from soybeans. Other sources of commercial biodiesel include canola oil, animal fat, palm oil, corn oil and waste cooking oil (Kulkarni & Dalai, 2006; Bansal & Sharma, 2005; Melting, 1996).But the recent research has proven that oil production from algae is clearly superior to that of terrestrial plants such as palm, rapeseed, soybeans or jatropha and has the potential to completely displace fossil fuel (Spolaore *et al*., 2006; Chisti, 2007).

Algae can have anywhere between 20-80% of oil by weight of dry mass (Bajhaiya *et al*., 2010). Algae have much faster growth-rates than terrestrial crops. The per unit area yield of oil from algae is estimated to be from 20,000 to 80,000 L per acre, per year; this is 7–31 times greater than the next best crop, palm oil (Demirbas & Demirbas, 2011). The calculations made by Chisti (2008) clearly demonstrated the strong scenario for algal biofuels. The use of algae as energy crops has potential, due to their easy adaptability to growth conditions, the possibility of growing either in fresh or marine waters and avoiding the use of land. Furthermore, two thirds of earth's surface is covered with water, thus algae would truly be renewable option of great potential for global energy needs (Patil *et al.,* 2008). Demirbas & Demirbas (2011) investigated the importance of algae oil as a source of biodiesel. They found that different species of algae are better suited for different types of biofuels. Schenk *et al*., (2008) studied that algal biofuels appear to be the only current renewable source that could meet the global demand for transport fuels. Hossain *et al.,* (2008) investigated that algae have emerged as one of the most promising sources for biodiesel production and studied proper transesterification, amount of biodiesel produced (ester) and physical properties of biodiesel.

Materials and Methods

The experiment was conducted in the Phycological Laboratory at Dept. of Botany, Govt. College University Lahore. Alga (*Cladophora* sp.) was collected from the aquatic ponds of GC University Botanic Garden. It was ground with grinding machine, and dried for 20 min. at 80^{o}C in an incubator for releasing water. Oils were obtained by extracting the algae with hexane in a Soxhlet extractor for 18 h (Demirbas, 2009). Biomass obtained after filtration. Solvent from extracted oils was separated using rotary evaporator. For transesterification reaction methanol was mixed with a catalyst (NaOH) and stirred properly for 20 mins. The mixture of catalyst and methanol was poured into the algal oil in a conical flask. Alkali- catalyzed transesterification carried out at approximately 60^{o}C under atmospheric pressure, as methanol boil off at 65^{o}C at atmospheric pressure and reaction required 90 mins to complete (Bajhaiya *et al*., 2010). The solution was kept for 16 h to settle the biodiesel and sediment layers clearly. The biodiesel was separated from sediments by flask separator carefully. Quantity of sediments (glycerine, pigments, etc.) was measured. Biodiesel was washed by 5% water until it become clean and dried by using dryer and finally kept under the running fan for 12 h (Hossain *et al.,* 2008). Biodiesel produced was measured by using measuring cylinder, pH was measured and stored for further analysis.

Results

Comparison of *Cladophora* sp. with Hossain *et al*., (2008) work on *Oedogonium* sp. and *Spirogyra* sp. shows that *Cladophora* sp. produce higher quantity of biodiesel than *Spirogyra* sp. (Fig. 1) and extracted oil in *Cladophora* sp. was also higher than the *Spirogyra* sp., (Table 1).

Biomass (after oil extraction) of *Cladophora* sp., was higher than the comparing species (Table 1) whereas sediment quantity was greater in *Cladophora* sp., (Fig. 2). No prominent difference of biodiesel pH was found between the algal specimens such as *Cladophora* sp., *Spirogyra* sp. and *Oedogonium* sp. (Fig. 3).

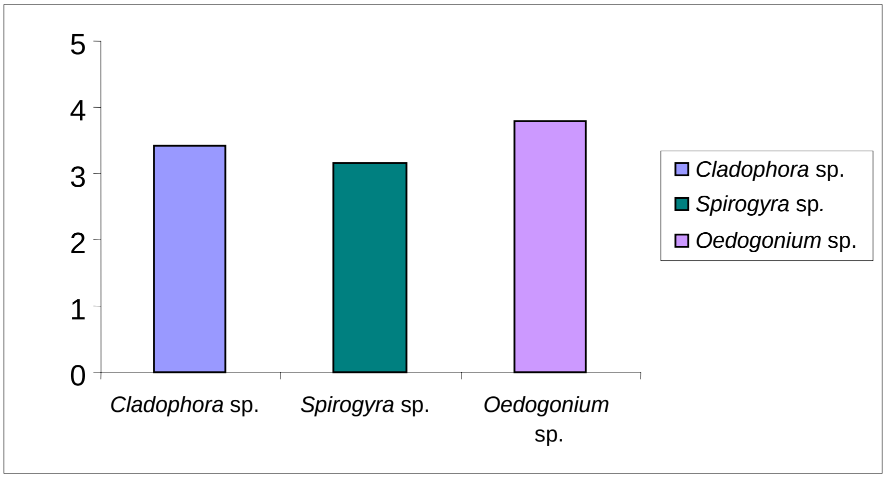

Fig. 1. Biodiesel production from *Cladophora* sp., *Spirogyra* sp. and *Oedogonium* sp.

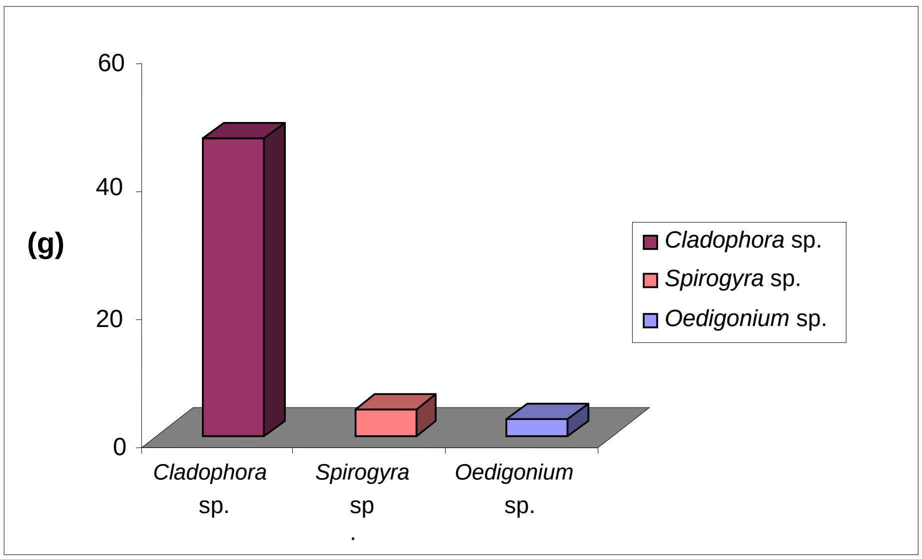

Fig. 2. Sediments after algal biodiesel extraction in *Cladophora* sp., *Spirogyra* sp., and *Oedogonium* sp.

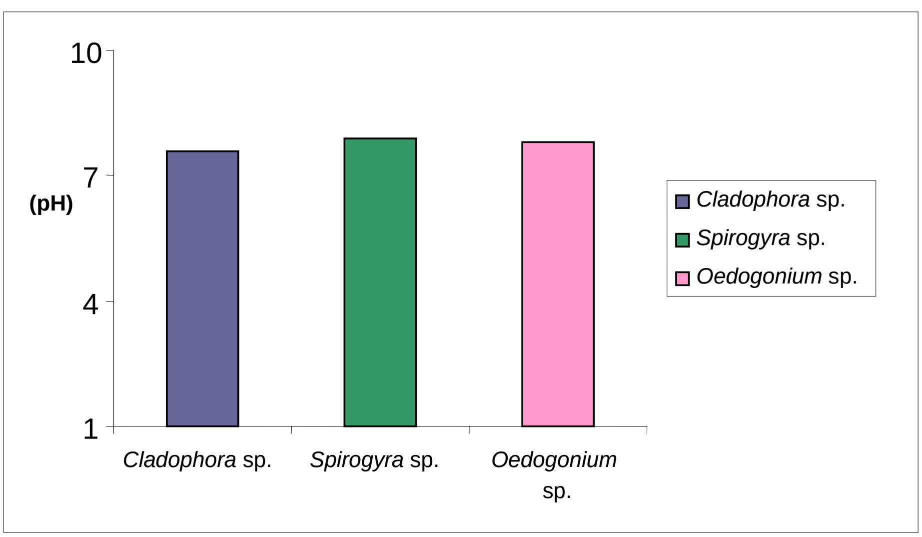

Fig. 3. pH of biodiesel obtained from different taxa of algae.

Table 1. Quantity of Extracted oils and Biomass (after oil extraction) of algae.

Algal specimens	Dry weight (g)	Extracted oil (g)	Biomass (after oil extraction) (g)
Cladophora sp.	15	3.58	11.14
Spirogyra sp.	15	3.33	6.48
Oedogonium sp.	15	3.98	5.04

Discussion

Production of alternative fuel has attracted wide attention during the past few years, due to the diminishing petroleum reserves and environmental consequences of exhaust gases from fossil diesel. In this context, biodiesel which is characterized as a renewable, biodegradable, and environment-friendly fuel is becoming a blooming area of high concern. Biodiesel can be produced from macroalgae because it contain considerable amount of lipid contents (Hossain *et al.*, 2008). In addition in heterotrophic condition lipid content can be more in algae (Renaud & Luong-Van, 2006). Pohl & Zurheide (1979) investigated that lipids of some macroalgae (seaweeds) was reported to be very high, up to 51% of total fatty acids.

The majority of biodiesel today is produced by alkali-catalyzed (e.g., NaOH, KOH) transesterification with methanol, which results in a relatively short reaction time (Freedman *et al*., 1984). Vasudevan & Briggs (2008), examined different biodiesel sources (edible and nonedible), virgin oil versus waste oil, algae-based biodiesel that is gaining increasing importance, role of different catalysts including enzyme catalysts, and the current state-of-the-art in biodiesel production. The biodiesel esters were characterized for their physical and fuel properties including density, viscosity, iodine value, acid value, cloud value, pure point, gross heat of combustion and volatility and fuel produces slightly lower power and torque, and higher fuel consumption than No. 2 diesel fuel (Demirbas, 2008).

Biodiesel is better than diesel fuel in terms of sulfur content, flash point, aromatic content and biodegradability (Bala, 2006).

Conclusion

- Algae are an economical choice for biodiesel production, because of its availability and environmental friendly properties.
- Considerable amount of biodiesel can be produced from macroalgae.
- Due to greater biomass and sediments *Cladophora* sp. proves, a better choice for biodiesel production than *Oedogonium* sp. and *Spirogyra* sp.
- Biomass after oil extraction may be used for livestock, ethanol production and also in paper making.

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