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Algal Oil Potential as a Bio Fuel and Food Supplement

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Abstract

A total of four naturally existing alga samples were gathered from Satna –Kothi region satna (M.P.).Samples were washed with water and identified in botany lab MGCGV Satna as Spirogyra, Hydrodictyon, Oedogonium, and Pithophora. Oil was separated from the algal powdered samples. Physical parameters of algal oils for instance viscosity, density, algal oil content, pH were estimated. Total Carbohydrate concentration, Total Protein concentration, Fatty matter, Saponification no, Iodine value of algal sample were also determined. Physical parameters of algal oil fulfil all the properties mentioned in ASTM D6751, ISO 15607and EN14214- Europe. All four algal samples, Oedogonium contains maximum percentage of algal oil while Pithophora revealed minimum oil percentage. This analysis suggested that alga Oedogonium is suitable for algal biodiesel production. Total carbohydrate content of all four alga was determined by Anthrone's method and the result shows that green alga Oedogonium has maximum amount of carbohydrate while alga spirogyra has minimum amount of carbohydrate. Total protein contents of all four alga was determined by Folins Lowry method and the result shows that green alga Oedogonium has maximum amount of protein while Hydrodictyon revealed minimum amount of protein. All four algae, Oedogonium shows lowest value of Saponification number while Hydrodictyon shows maximum saponification number. Oedogonium has maximum iodine value while Hydrodictyon has minimum iodine value. All four algal species Oedogonium shows maximum flash point reading while Hydrodictyon species shows minimum flash point of algal oil. Estimation of fatty matter shows that Oedogonium has maximum percentage of free fatty matter while Hydrodictyon has minimum percentage of free fatty matter.

Keywords: Algae, Carbohydrate, Protein, Bio fuel.

Introduction

The increasing demand of fuel has necessitated the search for an alternative to diesel fuel[1,2]. Searching alternative and eco-friendly energy resources is a pressing mission for many countries which are suffering conventional energy resources[3,4].

Recently, algae as alternative sources have gained a lot of attention. Some of the special features that distinguish algae from other biomass sources are high biomass yield per unit area, have a high oil, do not need farm land, nor fresh water is essential, and nutrients can be supplied through waste water and CO_2 released from combustion of gas. Algae cultivation less than 3 % of India's whole land can fulfil the requirements of liquid fuel[5-8]. Estimated algal production is 30 times greater than Jatropha in 4046.86 square m of wasteland, along with this algae also a good source of carbohydrate, Protein, and lipids.

The key benefits of algal based bio fuels can be notable because: i. It can be grown using land and water unsuitable for farming[9]. ii. Selected species of algae are capable to produce bio oils through photo- synthesis requiring sunlight, H_2O and CO_2, supplemented with Nutrients. iii. Growing algae consume CO_2; thus reduces greenhouse gas concentration. iv. Algae has ability to gather lipids without need for accurate control of nitrogen levels[9,10]. v. The bio fuel production of algae per acre is highest than any other crop based bio fuel source[4,7,11]. vi. The environmental benefits of algal derived bio fuels are that their cultivations can not only absorb pollutants of nutrient-rich waste- water and capture anthropogenic carbon di oxide, but also do not require herbicides or pesticides[12-14].

Table-1
Showing biofuel production of different crops and that of microalgae[5]

Crop	oil yield l/ acre
Corn	68.13
Soyabean	181.68
Sunflower	386.07
Rapseed	480.69
Canola	495.83
Jatropha	788.33
Oil palm	2403.47
Microalgae	19,000-57,000

Materials and Methods

Four algae biomass samples were collected from Satna - Chitrakoot regions and were brought to the botany lab MGCGV Satna, air dried for 2 days, later on dried 2-3 days at 40°C in an oven till the dry weight was constant. They were identified as *Spirogyra,* Hydrodictyon, Oedogonium, and Pithophora.

Solvent Oil extraction method: Oil extraction was done by using Soxhlet apparatus. 5g of dried algal biomass was weighed into single cellulose thimble. A total 100 ml of $CHCl_3$ –CH_3OH (2:1 v/v) was reflexed over thimble for 4 hours. After extraction, the contents were cooled and centrifuged to isolate the algal mass and washed the biomass with 25 ml of $CHCl_3$ twice to separate the residuals lipids present in the biomass. The extract was transferred to a separating funnel and washed with 1% aqueous NaCl solutions (50 ml) twice. The solvent layer was passed through anhydrous Na_2SO_4 and removed the solvent using rota-evaporator under vacuum to get the algal oil. To determine the oil content in biomass the weight of algal oil was taken. Algal oil properties were compared with bio fuel standards mentioned in EN14214 and ISO15607[15].

Total carbohydrate estimation was done by Anthrone's method: Carbohydrates are first hydrolysed into simple sugars using dilute HCl. In hot acidic medium glucose is dehydrated to hydroxyl methyl furfural. This compound with anthrone forms a green coloured product with an absorption maximum at 630 nm[16].

Total protein determination was done Folin's Lowry method: The phenolic group of tyrosine and trytophan residues (amino acid) in a protein will produce a blue purple colour complex, with maximum absorption in the region of 660 nm wavelength, with Folin- Ciocalteau reagent which consists of sodium tungstate molybdate and phosphate[17].

Iodine value: Iodine value (IV) is a determination of the extent of unsaturation in oil. This is constant for particular oil or fat EN 14214 has a maximum IV specification of 120 mg I2/100 g FAME[18].

Saponification Value: Saponification number is defined as the number of miligrams of KOH needed to saponify the fatty material present in one gram of the oil[19].

Estimation of oil in Algae: Oil was extracted with petroleum ether solvent from algal sample. It is then distilled off, completely dried the oil weight & the % oil are calculated.

Flash point: Flash point of the oil is the minimum temperature at which the oil discharge sufficient vapours that set fire to a moment, when a tiny flame is brought near it. It was detrmined by Pensky Martin apparatus.

Results and Discussion

The findings of the carried out work is tabulated in the Tables 2 to 5 and in the Figures 1 and 2.

Table-2
Algal oil percentage w/w and physical parameters of Pithophora, Spirogyra, Hydrodictyon, Oedogonium

Samples	Oil percentage (w/w)	pH	Density g/cm^3	Viscosity at 40^{o}C(mm^2/sec)
Pithophora	10.35	7	0.872	4.2
Spirogyra	14.82	7	0.883	4.4
Hydrodictyon	13.50	7	0.866	3.8
Oedogonium	15.60	7	0.886	4.3

Table-3
Comparative table showing total carbohydrate concentration in all the four algae Pithophora, Spirogyra, Hydrodictyon, Oedogonium

Algae	Carbohydrate concentration in mg/l	WL-630 nm Absorbance
Pithophora	0.458	0.666
Spirogyra	0.204	0.346
Hydrodictyon	0.331	0.366
Oedogonium	0.661	0.859

Table-4
Comparative table showing total protein concentration in all the four algae (Pithophora, Spirogyra, Hydrodictyon, Oedogonium in mg/l by Lowry's method)

Algae	Protein concentration in 0.5 ml sample in mg/l	WL-630 nm
Pithophora	1.601	1.099
Spirogyra	2.058	1.398
Hydrodictyon	1.307	0.907
Oedogonium	2.505	1.677

Algal species which contain maximum oil content are suitable for algal biodiesel production. The algal oil contents of four algal species were given in Table-2 which is generally found in Satna region. Above analysis showed that *Oedogonium* contains maximum percentage of algal oil while *Pithophora* revealed minimum oil percentage. This analysis suggested that alga *Oedogonium* is suitable for algal biodiesel production but much of research needed to get optimum percentage of oil. Economics of producing algal biodiesel from algal oil is need to improve substantially to make it competitive with petro diesel, but the level of improvement necessary appears to be attainable.

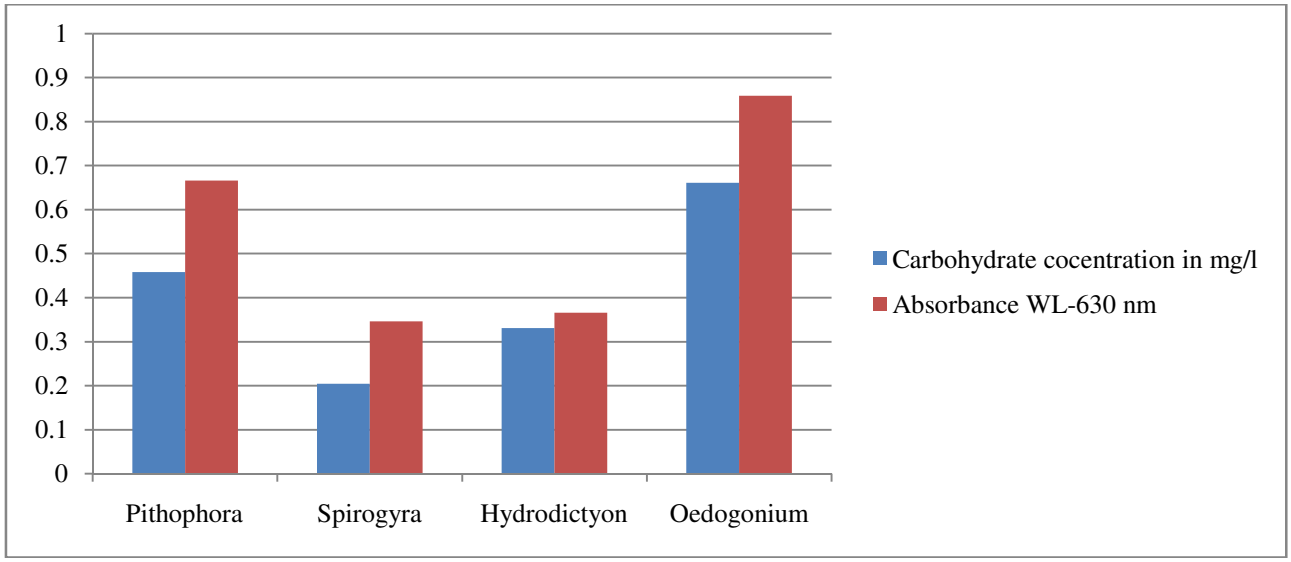

Figure-1
Comparative Plot of Absorbance Vs total carbohydrate concentration for all the four algae *Pithohora*, *Spirogyra*, *Hydrodictyon* and *Oedogonium*

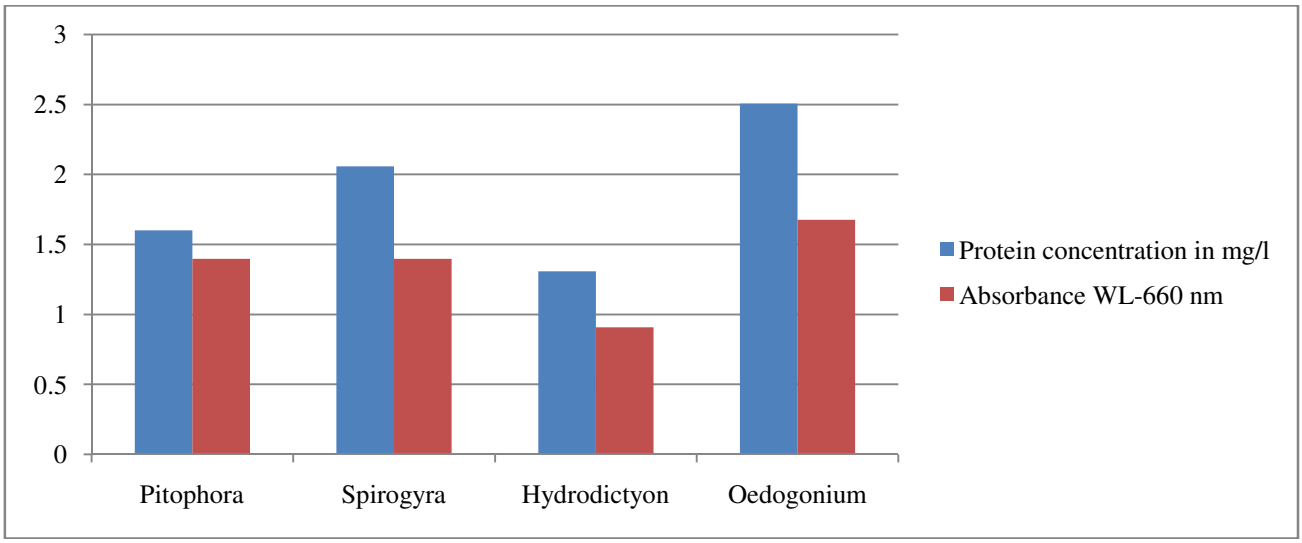

Figure-2
Comparative plot of Total Protein concentration Vs Absorbance for all the four algae Pithophora, Spirogyra, Hydrodictyon and Oedogonium

Table-5
Showed saponification value, iodine value, fatty matter and flash point of algal sample

Samples	Sapnification value mg KOH g^{-1}	Iodine value g I2/100g	Oil in ground sample %	Flash point
Pithophora	122	118	3.2689	112
Spirogyra	121	118.5	3.6880	115
Hydrodictyon	123	117	3.0678	110
Oedogonium	120	119	4.067	116

Density of all four algal oils matches with the density limits of a biofuels mentioned in EN 14214 and ISO 15607 (0.86-0.90g/cm), The viscosity limit mentioned in EN 14214 and ISO 15607 is 3.5- 5.0 mm /s [15]. Our outcomes were well matched with these standard parameters. Total carbohydrate content of all four alga was determined by Anthrone's method and the result depicted in table-3 shows that green alga *Oedogonium* has maximum amount of carbohydrate while alga *spirogyra* has minimum amount of carbohydrate. This result indicates that *Oedogonium* is a richest source of carbohydrate among all four alga. Total protein content of all four alga was determined by Folins Lowry method and the result depicted in table -4 shows that green alga *Oedogonium* has maximum amount of protein while *Hydrodictyon* revealed minimum amount of protein. Table-5 depicted Saponification value, Iodine Value, Flash point and oil content.

Saponification value of oil shows the quantity of fatty oil in compound oil. All four algae, *Oedogonium* shows minimum value of Saponification number while *Hydrodictyon* shows maximum Saponification number. Iodine value provides an idea of the extent of unsaturation. All four algae *Oedogonium* have maximum iodine value while *Hydrodictyon* has minimum iodine value.

Flash point of the oil is the minimum temperature at which the oil discharge sufficient vapours that set fire to a moment, when a tiny flame is brought near it. Good oil should have flash point at least above the operating temperature. All four algal species *Oedogonium* shows maximum flash point reading while *Hydrodictyon* species shows minimum flash point of algal oil. Estimation of fatty matter shows that *Oedogonium* has maximum percentage of free fatty matter while *Hydrodictyon* has minimum percentage of free fatty matter.

Conclusion

The entire research was focused on algae as a potential source of bio energy for the production of algal biodiesel and algae as a food source. This research provides a valuable information regarding most commonly alga found in Satna region and their potential as oil and as a protein and carbohydrate value. This research is a clear indication of future prospects of algae as a source of energy. Producing oil from algae is more advantageous than crop based biomass on various aspects. Despite all of the features that make microalgae bio fuels a subject of much research and speculation. Different technical obstacles must be solved in sequence to make production economically[20].

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