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VIABILITIES OF ALGAE TO OIL TECHNOLOGY

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ABSTRACT - As per the increasing energy demand, climate change, increasing price of petroleum and most importantly the fossil fuel resources will be diminished rapidly. Presently it is very crucial to replace the conventional fuels by bio fuel from renewable sources. Slow growth rate, low biomass, low productivity and requirement for agricultural land for cultivation restricts to use soybean, sunflower, coconut, jatropha, used fried oils and various animal fats as bio fuel. Right now Microalgae appears to be the only source of renewable bio fuel that is capable to meet the global energy demands economically. This paper provides the best culture method, best harvesting method and optimum oil extraction method. The finding of this paper shows the present status of work done in the area of algal oil development.

Keywords- Microalgae, Biodiesel

I. INTRODUCTION

In this present era due to the depletion of conventional fossil fuel reserves, it has triggered an increase in both the demand and price of fuel. It is the main reason why the researchers are trying to find an alternate source of energy, which can supplement or replace fossil fuels. Hence, biodiesel / oil from algae have emerged as one of such sources reliably.

Algae fuel or algal oil is an alternative to liquid fossil fuels that uses algae as its source of energy-rich oils. Also, algae fuels are an alternative to common known biofuel sources. Currently, biodiesel is being produced from different crops like, soybean, sunflower, coconut, palm, jatropha, rapeseed, karanja, used fried oils and various animal fats [1, 2]. But As these sources are having some limitations in their use as alternate fuels because of their food demand, life span, lower yield, higher land uses etc.[3]. Microalgae are being considered as a more viable feedstock among the other biomass sources [4, 3] because of the main selective criteria of these are aquatic, non-edible, highly genetically modifiable and fast growing with productivity 3–35 times higher than terrestrial plants in terms of energy content, [5].Also, cultivation of microalgae is less water intensive than terrestrial plants [6].

According to the report by Shay[7] (1993), algae are one of the best sources of biodiesel. Indeed algae are the highest yielding feedstock for biodiesel. This yields 250 times more than the amount of oil per acre as soybeans. In fact biodiesel from algae may be the only way to produce enough automobile fuels to replace current gasoline usage (8). Algae are having the potential to produce 7 to 31 time greater oil than palm oil [9]. The best algae for biodiesel would be microalgae [10]. Microalgae have much more oil than macroalgae and it is much faster and easier to grow and harvest [7].

Table 1: Comparison of some sources of biodiesel [11]

Crop	Oil yield (L/ha)	Land area needed (M ha) [a]
Corn	**172**	**1540**
Soybean	**446**	**594**
Canola	**1190**	**223**
Jatropha	**1892**	**140**
Coconut	**2689**	**99**
Oil palm	**5950**	**45**
Microalgae [b]	**136,900**	**2**
Microalgae [c]	**58,700**	**4.5**

a) For meeting 50% of all transport fuel needs of the United States.
b) 70% oil (by wt) in biomass.
c) 30% oil (by wt) in biomass.

II. ALGAL SAMPLES

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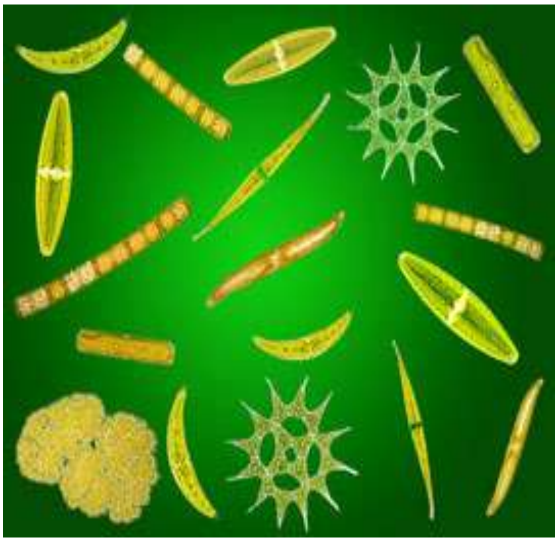
These are prokaryotic or eukaryotic photosynthetic microorganisms. Due to their unicellular or simple multi-cellular structure, naturally they can grow rapidly in fresh or salt water and also they are very efficient converters of solar energy (12). Microalgae have efficient access of water, CO2 and other nutrients because the cells of microalgae grow in aqueous suspension [13]. These are one of the oldest living organisms in our planet. They have more than 300000 species. Many of those species have oil content up to 80% of their dry body weight. Table 2 shows lipid contents of different microalgal species [14, 15].

Table 2. Lipid contents of different microalgal species

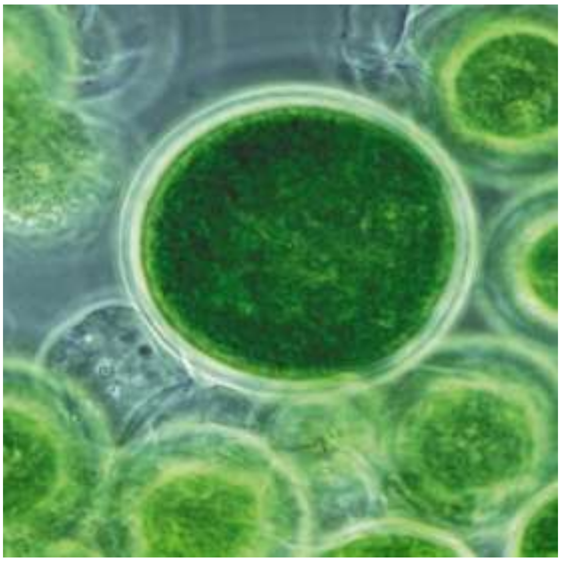
Microalgae species	Lipid content (% dry weight)
Botryococcus braunii	25-75
Chlorella	18-57
Chlorella emersonii	25-63
Chlorella sp.	10-48
Dunaliella sp.	18-67
Dunaliella tertiolecta	18-71
Nannochloris sp.	20-56
Nannochloropsis sp.	12-53
Neochloris oleoabundans	29-65
Phaeodactylum tricornutum	18-57
Scenedesmus obliquus	11-55
Schizochytrium sp.	50-77

(Vandna P. et al.[16]) Three fresh water algae samples were collected by mesh net from Vrindavan Lake, Kothi (India) and immediately after collection; samples were brought to the laboratory, air dried for two days and dried at 40 C in an oven for 2-3 days till the dry weight was constant. Apart fresh algae samples were observed for identification and preserved in 4% formaldehyde and deposited at Phycology.

Algae on a water body



A closer look to algae sample



Microscopic Image of Algae Cell

Fig.1: Algae Sample

The algal samples collected and analyzed were identified as - Spirogyra, Hydrodictyon, Pithophora. Thereafter dried algal biomass (5g) was taken in solvent mixture (100 ml) of chloroform and methanol (2:1, vol. /vol.) and content were refluxed for 4 hrs. After extraction, contents were cooled and filtered (or centrifuged) to separate and washed the biomass with 25 ml of chloroform two times to extract the residual oily organic compounds present in the biomass. The extracts were pooled and gathered in a separating funnel and washed with 1% aqueous sodium chloride solution (50 ml) twice. The solvent layer was treated with anhydrous sodium sulphate (it was taken in a glass funnel with cotton plug) and removed the solvent using Rota-evaporator under vacuum to get the algal oil. The weight of algal oil was taken to examine the oil content in biomass. Algal oil properties were compared with biofuel standards mentioned in ISO15607 and EN14214.

Table 3: Algal oil percentage and physico-chemical properties. (Pankaj K. et al.)

Samples	Oil percentage (w/w)	pH	Density g/cm^3	Viscosity at $40^oC(mm^2/sec)$	Non-saponifi fat (%)
Tolypothrix	12.78	7	0.857	4.1	0.137
Pithophora	10.37	7	0.873	4.2	0.181
Spirogyra	14.82	7	0.884	4.4	0.232
Hydrodictyon	13.58	6	0.868	3.9	0.231
Rhizoclonium	11.64	7	0.889	4.3	0.237
Cladophora	11.76	6	0.892	3.8	0.244

III. DESCRIPTION AND TECHNIQUES:-

The process of biodiesel production from microalgae can include cultivation, harvesting/dewatering, extraction, and final conversion to biodiesel.

1. **Cultivation**: Microalgae can be cultivated via photoautotrophic methods (where algae require light to grow and create new biomass) in open or closed ponds or via heterotrophic methods (where algae are grown without light and are fed an alternative carbon source, such as sugars, to generate a new biomass). The most common cultivation methods include some methods like, Open Pond Culture, Bioreactors (photo bioreactors), Fermentation Methods like Heterotrophic and Mixotrophic etc. (Mukesh Kumar et al.[17])

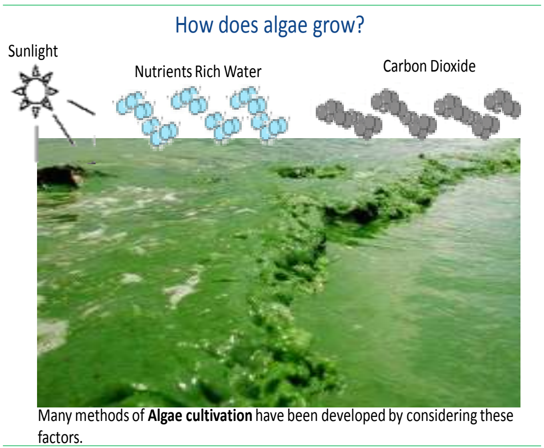


Fig.3: Algae Cultivation

2. **Harvesting/dewatering**: Some processes for the conversion of algae to liquid transportation fuels require pre-processing steps such as harvesting and dewatering. Algal cultures are mainly grown in water and require process steps to concentrate harvested algal biomass prior to extraction and conversion. Algae can be harvested by using Flocculation, Centrifugation, Direct filtration, Ultrasound method, positively charged surface. Due to the microscopic size of the micro algal cells (2-200μm), recovery of micro algal biomass is very difficult [18]. Approximately 20-30% of the total production cost is incurred in the biomass harvesting. Some common harvesting methods include –

Mechanical methods:

The mechanical methods are further classified into -

- Expression/Expeller press
- Ultrasonic-assisted extraction

Chemical methods:

The chemical methods are further classified into:

- Hexane Solvent Method
- Soxhlet extraction
- Supercritical fluid Extraction

Each of these methods has drawbacks:

(I)The mechanical press generally requires drying the algae, which is energy intensive.
(II) The use of chemical solvents present safety and health issues.
(III) Supercritical extraction requires high pressure equipment that is both expensive and energy intensive.

3. Extraction: Three major components can be extracted from algal biomass: lipids (including triglycerides and fatty acids), carbohydrates, and proteins. While lipids and carbohydrates are fuel precursors (e.g., gasoline, biodiesel and jet fuel), proteins can be used for co-products (e.g., animal/fish feeds).

4. Conversion: Conversion technology options include chemical, biochemical, and thermo chemical processes, or a combination of these approaches. The end products vary depending on the conversion technology utilized.

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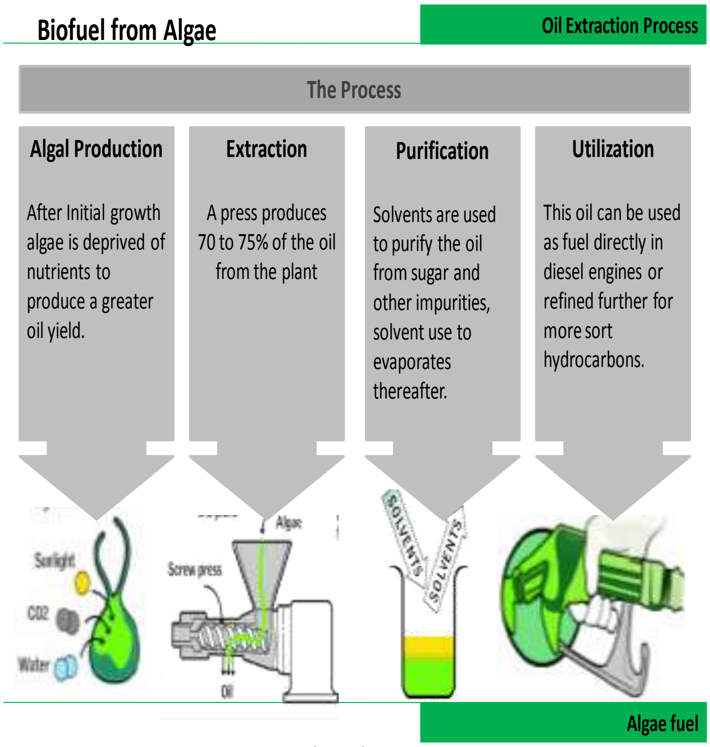

Fig.2: Biofuel from Algae

IV. DISCUSSION AND FUTURE PROSPECTS:

In this paper we have assessed several method regarding the culture of algal oil and also we have gone various harvesting, extraction methods of algal oil to select the right algae species, create the photo biological formula for each species and build a low cost-effective photo bioreactor that can induce a highly efficient microalgae growth. The most suitable method for algae cultivation is photo bioreactor. Out of the methods available, flocculation is reported as the most suitable method for algae harvesting and the supercritical extraction method is most suitable for extraction of algal oil (Mukesh Kumar et al. [17]).

And also algae fuel's carbon footprint is lesser than that of fossil fuels and is renewable, making it more eco-friendly. Additionally, wastewater is a possible nutrient source for algae, making the use of freshwater less necessary and decreasing, rather than increasing, pollution. Compared to other bio fuels, algae have a higher productivity rate, and are non-edible source. Microalgae can harvest energy from the sun into valuable products at very low expense of natural resources like CO2, contributing to global CO2 reduction.

The biomass from algae can also be burned similar to wood or anaerobically digested to produce methane biogas to generate heat and electricity. Algal biomass can also be treated by pyrolysis to generate crude bio-oil[20].

"There is no magic-bullet fuel crop that can solve our energy woes without harming the environment, says virtually every scientist studying the issue. But most say that algae… come closer than any other plant…"

National Geographic October, 2007

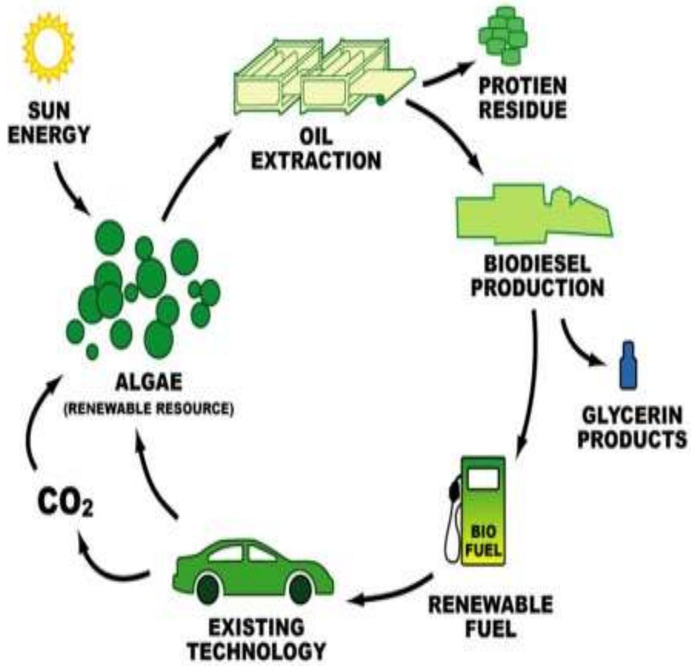

Fig.3: Algae lifecycle

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