A Review on Algae Biodiesel: A Novel Source of Renewable Energy in India

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Abstract— Energy is essential for living and vital for development of all. The global economy thrives on energy. Affordable energy directly contributes to increase productivity, reducing poverty and improving betterment of life. Global population is increasing day by day, which, in a way is leading to the utilization of natural resources and fossil fuels. Fossil fuels cannot be replenished, once it gets depleted, it cannot be produced again and major cause of pollution. Declining fossil fuel production with a rising fuel demand provides the most compelling global reason for alternative fuels. So we have to think for production of such fuels which are not only potential alternatives for fossil fuels, but also are eco-friendly in nature and not get depleted.
This has necessitated the aggressive pursuing of alternative energy sources - solar, tidal, wind, biomass, hydro and many more. Biodiesel derived from oil crops (biomass) is also a potential renewable alternative to petroleum. Present paper discuss about future of biofuel derived from algae in India. It is discussed about replacement of petroleum-derived transport fuel without adversely affecting the supply of food and other crop products, with keeping the environment clean.

Keywords- *fossil fuel, pollution, biomass, algae.*

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I. INTRODUCTION

Energy is essential for living and vital for development of all. The global economy thrives on energy. Power consumption per capita represents the living standard of the people of the country. And hence power consumption per capita represents the growth / development of the said nation. Affordable energy directly contributes to increase productivity, reducing poverty and improving betterment of life. Global population is increasing day by day, which, in a way is leading to the utilization of natural resources and fossil fuels. One of such important necessity to human kind which is in the verge of depletion is the fossil fuel. Since it cannot be replenished, once it gets depleted, it cannot be produced again. Declining fossil fuel production with a rising fuel demand provides the most compelling global reason for alternative fuels. So we have to think for production of such fuels which are not only potential alternatives for fossil fuels, but also are eco-friendly in nature [1].

India meets nearly 33% of its total energy requirements through imports. With the increase in share of hydrocarbons in the energy supply/use, this share of imported energy is expected to increase in future. The challenge, therefore, is to secure adequate energy supplies at the least possible cost without harm in pollution. Currently, India is the sixth largest consumer of energy in the world, and will be the third largest by 2035, with its increased rate of population and hunger of consumption of power. At the same time, the country is heavily dependent on imported fossil fuels of energy for most of its demand. Due to the limited fossil fuel reserves, India meets about 73% of its crude oil and petroleum product requirements through imports, which are expected to expand further in the next coming years. The continued use of fossil fuels is not sustainable, as they are finite resources, limited in amount, non-renewable in nature, and their combustion would lead to increased energy-related emissions of greenhouse gases [1].

This has necessitated the aggressive pursuing of alternative energy sources - solar, tidal, wind, biomass, hydro and many more. Biodiesel derived from oil crops (biomass) is also a potential renewable alternative to petroleum. However due to the various issues (one of them is debate between food v/s fuel), biodiesel from oil crops and animal fats is not a good choice. Moreover it can satisfy only a very small fraction of the existing demand for fuel.

Recent research shows that biodiesel from green algae is the most promising renewable biofuel derived from biomass with the potential to completely displace petroleum-derived fuel without adversely affecting the supply of food and other crop products, with keeping the environment pollution free. An alga grows naturally in entire world. Under optimal conditions, it can be grown in massive, almost limitless in amounts.

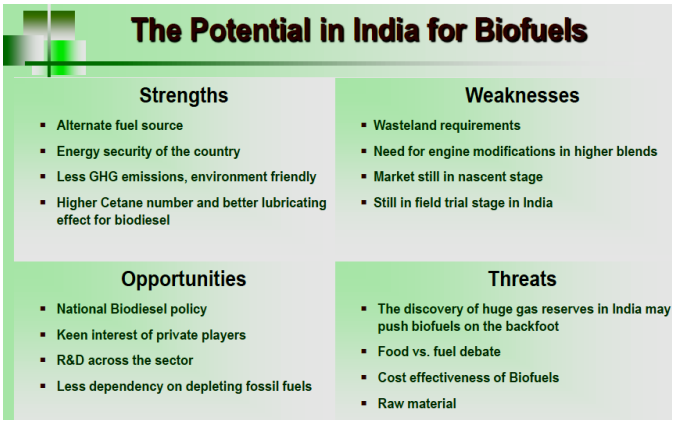

Figure 1: SWOT Analysis [DBT-CII Report 2010] [2]

II. *ABOUT ALGAE*

Literature review indicates biofuel production using various plant sources are Algae , Watermelon, Rape seed beans ,Castor beans (Ricinus communis) , Citrullus colocynthis (Tumba), Jojoba (Simmondsia chinesis), Kokum (Garcinia indica) , Neem (Azadirachta indica) [2].

A. *Evolution of Biofuels*

Alga (or its plural, algae) may be the miracle element, find in the research, more eco-friendly, mass-produced product that can be converted into fuel. Refer Table 1.Algae grows naturally all over the world. Under optimal conditions, it can be grown in massive, almost limitless, amounts. Scientists have been studying this oil for decades to convert it into algae biodiesel -- a fuel that burns cleaner and more efficiently than petroleum and using available CO_2 and sunlight[3].

TABLE1: GENERATION OF BIOFUEL[3]

First generation Biofuels :	Grains and sugar to Ethanol , Vegetable oil to Biodiesel.
Second Generation Biofuels :	Lignocellulose to Alcohols , Lignocellulose to Green Diesel ,Vegetable oils to Green Diesel.
Third generation Biofuels:	Biomass to Hydrogen , Algal Hydrogen , Algal Oil/Biodiesel.
Fourth generation Biofuel :	Biofuel from high solar , efficiency cultivations

Algae range from small, single-celled organisms to multi-cellular organisms, some with fairly complex and differentiated form. Algae are usually found in damp places or bodies of water like sea, lakes, ponds, rivers, canals, places where the water is stored and thus are common in terrestrial as well as aquatic environments. Like plants, algae require primarily three components to grow: sunlight, carbon-dioxide and water. Photosynthesis is an important bio-chemical process in which plants, algae, with some bacteria convert the energy of sunlight to chemical energy. Figure 2 depicts classification of plant.

B. *Algae classification:*

1) According to plant kingdom
Spore Bearing Plants- algae, ferns, mosses
Seed Bearing Plants- flowering plants

2) Based on pigment
Green algae,
Red algae,
Brown algae,
Green- blue algae.

The existing large-scale natural sources are of algae are: bogs, marshes, blackish water and swamps - salt marshes and salt lakes. Algae contain lipids and fatty acids as membrane components, storage products, metabolites and sources of energy. Algae contain anything between 12% and 60% and maximum of 80% of lipids/oils by weight [3-5]. Yield of various plant oils:

TABLE2: COMPARISONS OF DIFFERENT CROPS[5]

Corp	Oil Yield gallons/acre
Corn	19
Cotton	36
Soybean	68
Mustard Seed	65
Sunflower	81
Jatropha	110
Castor	156
Coconut	301
Palm Oil	773
Algae (50gm/m^2/day at 50% TAG) TAG= Triacylglycerols	10657

C. *Advantages of Algae biodiesel*

Producing biodiesel from algae has been touted as the most efficient way to make biodiesel fuel. The main advantages of deriving biodiesel from algae oil are as follows[3-5]:

i. rapid growth rate compare to other crops,
ii. a high yield per-acre (9 to 35 times greater than the next best crop – palm oil),
iii. certain species of algae can be harvested daily,
iv. algae biofuel contains no sulphur (free from SO_X hence no poisonous gases emission),
v. algae biofuel is non-toxic,
vi. algae biofuel is highly bio-degradable , and
vii. algae consume carbon dioxide to grow, so they could be used to reduce level of CO_2 by suing waste gases emitted from power stations and other industrial plant to the surroundings.

III MAPPING PATHWAYS FOR ALGAE TO BIODIESEL PRODUCTION

Algae-to-biofuel production is divided into four stages, a) algae cultivation, b) biomass harvesting, c) algal oil extraction, and d) oil and residue conversion. Refer figure 2[6].

Figure 2: Mapping Framework for Existing and Potential Pathways for Algal Biofuel Production [6]

Each of the first four stages is further broken down into basic, individual, or multiple processes to explain the primary components of algal biofuel production that may have positive or negative environmental externalities.

Algae-to-Biofuel Production is further mapped out in the following composition of processes:

A. *Algae Cultivation Processes*

The purpose of algae cultivation is to grow raw algal biomass for the downstream production of fuel, based on the oil and residual components found in the biomass. In order to flourish, algae need water, carbon dioxide, and essential nutrients (sulphur, potassium, metal etc) which are collectively referred to as the culture medium; algae cultivation facilities need land or other area to occupy; and, in most cases, algae need light to drive photosynthesis [8].

B. *Harvesting Process*

As mentioned by Catie Ryan[6],once an algal culture reaches maturity, the biomass is harvested from the culture medium and dried in preparation for conversion. At this stage, algal biomass from the preceding cultivation system typically carries high water content and, in most cases, is not suited for conversion to biofuel products until it has undergone some degree of dewatering and drying. There are three systemic components of the harvesting process: biomass recovery, dewatering, and drying. The most commonly implemented techniques are flocculation, centrifugation, and decantation[6].

C. Oil Extraction Processes

The actual oil content (20–80 percent), measured in gallons/acre/year, will depend on many parameters. Oil extraction from algal biomass yields algal oil (triglycerides or TAG lipids) and residue (carbohydrates, proteins, nutrients, ash). The percent yield of total available oil from the biomass will depend on the efficiency of the extraction method used [6].

D. Oil and Residue Conversion to Biofuels

Once the biomass is separated into raw algal oil and residue, the energy content of the two components can be thermally or biologically transformed to liquid or gaseous fuels or solid coproducts. Conversion processes are of varying efficiency— depending on reaction temperature, pressure, heating rate, and catalyst type, as well as algal species and quality of biomass—theoretically converting algal biomass (or components of biomass) into several possible biofuels and coproducts[6].

IV Carbon Credits

Algae double up their body, by weight, by transforming carbon dioxide and sunlight into energy (produce TAG) and thereby helps in tackling global warming also produce oil. Hence CO_2 is a necessary input of algae growth.

Although CO_2 is a necessary input of algae growth, some cultivation systems rely on atmospheric CO_2 and others require artificial CO_2 inputs. Where artificial inputs are necessary, CO_2 can be provided by industry exhaust gases, flue gases from power plants, and biogas derived from wastes.

V Conclusion

India has sufficient amount of wastelands including degraded cropland and pasture/grazing land, degraded forest, industrial/mining lands, and sandy/rocky/bare areas etc. it is the large country with variety of seasons, having sufficient amount of blackish/ saline ground water. All the favorable conditions for algae growth such as considerable sunshine, generally warm climate, sources of CO2, and other nutrients, low-quality water, and marginal lands are available in India. But i) Financing, ii) Technology, iii) Competition, iv) Intellectual property are some other obstacles to the realization of Algae oil projects.

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