

BIODIESEL FROM ALGAE: A POTENT ALTERNATE RENEWABLE SOURCE

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Abstract

With the ever increasing demand for energy and progressive depletion of fossil fuel, it has become necessary to find alternatives to conventional fossil fuels. Biodiesel is one such alternative to it and can be defined as a processed fuel which has equivalency with petro-diesel generated from the biological sources. It can be produced from a variety of sources like plant oil, animal fats, cooking oil, used vegetable oil and other similar sources. It is also produced from algae and it has numerous advantages over any other biodiesel production method. A brief overview of utilization of algae as a potent alternate renewable source for biodiesel production is discussed by the authors in the present paper highlighting its advantages and limitations.

Introduction

Energy is the driving force of all the processes in the universe .It can be obtained from renewable and nonrenewable sources. Fossil fuels such as petroleum and its different forms are mostly used for this purpose and also contribute maximum to the increasing pollution. In order to find a solution to the above i.e. limited stock and increasing pollution, some other alternate sources of energy based on primary or native source must be developed. Further there is a urgent need for this as it is been forecasted that the demand is slowly exceeding the supply if the current rate of progress and development continues [1]. A solution is also required for increasing rate of consumption as compared to production or availability and the increasing cost. This has resulted in the emergence of Biodiesel as a solution to all of the above [2].

India is one of the fastest developing countries with a stable economic growth, which multiplies the demand for transportation in many folds.

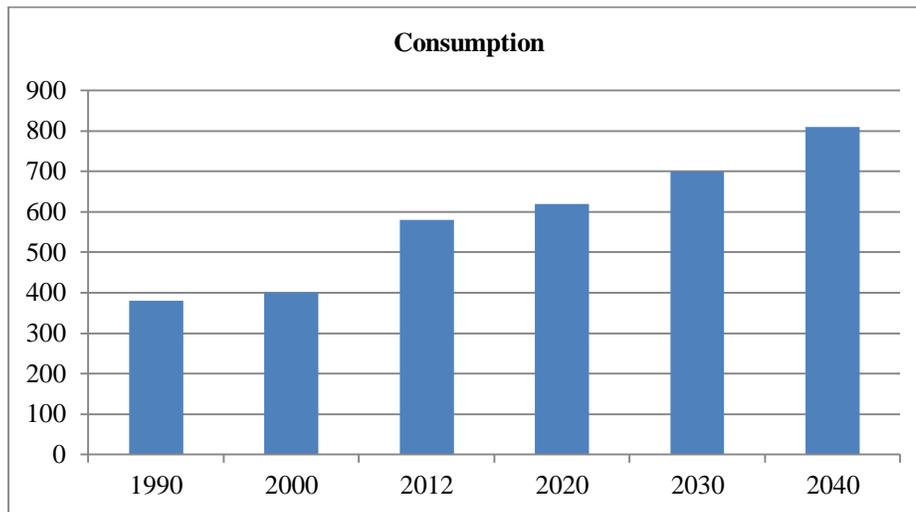


Figure-1 World energy consumption from 1990 up to 2040 in quadrillion Btu [3]

Since 2012-13 to 2017-18 if year wise comparison is done between production and consumption of petroleum products as shown below, it can be clearly seen that the percentage growth in consumption is increasing with an alarming rate as compared to percentage growth in production of petroleum products in India as well as around the world.

Table-1: Year wise Comparison of Production and Consumption of Petroleum Products [4]

Year	Production (MMT)	% Growth in production	Consumption (MMT)	% Growth in Consumption	Difference in %growth of production and consumption
2012-13	217.74	7.15	157.06	6.02	+1.13
2013-14	220.76	1.39	158.41	0.86	+0.53
2014-15	221.14	0.17	165.52	4.49	-3.32
2015-16	231.92	4.88	184.67	11.57	-6.69
2016-17	243.55	5.01	194.60	5.37	-0.36
2017-18	243.58*	0.01	201.90**	3.75	-3.74

*: Target **: Estimated

This is one of the main reasons for selecting Biodiesel as an alternative fuel. There are several reasons behind choosing biodiesel as an alternative fuel. Due to its energy balance ratio (2.5 to 1) and low carbon content it is used as an alternative to heating oil [6]. Like petroleum sources, Biodiesel sources can also make country secure in terms of energy [7].

Table-2: Properties of biodiesel [8-10]

Properties	Values	Unit
Specific gravity	0.87- 0.89	-
Kinematic viscosity	3.7-5.8	@40°C
Cetane number	46-70	-
Higher heating value	16928-17996	Btu/lb
Lower heating value	15700-16735	Btu/lb
Sulphur wt	0.00-0.002	%
Cloud point	(-11) to 16	°C
Pour point	(-15) to 13	°C
Flash point	120-130	°C

Various Biodiesel Sources:

- Biodiesel is produced from both edible and non edible vegetable oils or animal fats and various other bio fuels such as methanol, ethanol etc, is a mono alkyl ester of fatty acids [6] [7]. Direct application of vegetable oil as a fuel in CI-engines has been limited due to its highly viscous nature.

Biodiesel can be obtained from different types of oils which are categorized into:-

2.1 Edible sources:

- Waste cooking oil-** It includes oil left after frying and other cooking purpose. Rapeseed oil, cottonseed oil, peanut oil and sunflower oil are mostly used for this. Other examples include Cottonseed oil, Coconut oil, maize, olive, groundnut, soybean, and sunflower etc [11-12].

2.2 Non edible sources:

- A significant fuel source used in India and Southeast Asia are Jatropha tree (*Jatropha curcas*), Karanja (*Pongamia pinnata*) and Mahua (*M. indica*), neem, castor etc. [13-27].
- Algae are also a source for biodiesel.

Table-3: Amount of oil produced by various feed stocks [28]

Feedstock	Liters/hectare
Castor	1413
Sunflower	952
Palm	5950
Soya Bean	446
Coconut	2689
Algae	100000

Algae: A Source of Biofuel

- Fuels derived from living matter are called Biofuels. They may be derived directly from plants or animals or indirectly from wastes originating due to agricultural, municipal or domestic activities i.e. wastes.
- Biofuels are categorised into three categories:
 - a. First generation: Based on sugars, starch, vegetable oils or animal fats
 - b. Second generation: Based on ligno-cellulosic biomass
 - c. Third generation: Derived from algae.
- Algae is a simple ,non vascular plant (unicellular or multicellular)growing in water, utilises Sunlight, CO₂ and water to convert the light energy to chemical energy by photosynthesis and form a number of substances like sugars, fats, vitamins, proteins and substances of medicinal values too. There is a lot of variation in the relative percentage of these substances in algae depending upon the species and it is also observed that the variation of factors such as nutrients (presence or absence) or certain physical conditions also cause a variation in the relative amount of carbohydrate or lipids in algae.
- Utilisation of algae as a feedstock is advantageous as compared to others as it requires simple raw materials (CO₂, sunlight and water) only and has a high productivity rate as compared to others. They can be easily grown in open pond system or artificially developed bioreactor tubes.

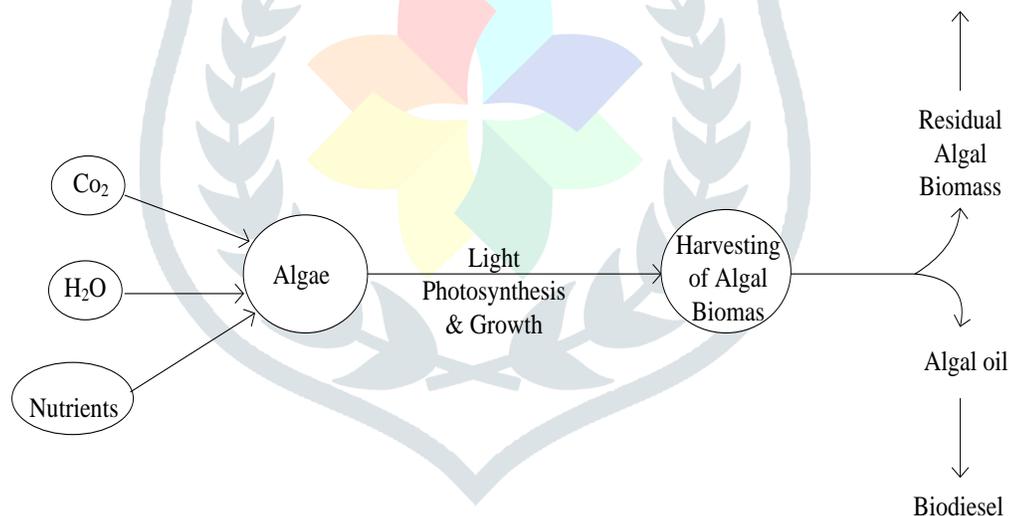


Fig:- Scheme of Biodiesel Production from Algae

- Algae has a very high yield of oil when compared with other feed stocks (Table 3), a very short life span, minimum nutrient requirement and easy to grow. This clearly makes it advantageous when compared with other feed stock for biodiesel production.

Advantages of Algal Fuel over Other Sources

- The yield of Biodiesel produced from algae is very high as compared to its production from other vegetable oils, about 200 times greater, [29].

- **High growth rate:** Both microalgae as well as macroalgae can be used as a source for biodiesel production. Microalgae are preferred as it grows very fast, grows throughout the year, can be used daily also (some species) Due its short life span its growth rate is much higher than normal plants like castor, Jatropha etc [30-35].
- As a result of their high photosynthetic rate, algal cultures grow extremely fast. They commonly double their biomass within 24 h and are capable of doubling times as short as 3.5 h during the exponential growth phase [36].
- Not only do algae grow quickly, but a so large proportion of their biomass is usable as fuel. On an average, lipids constitute approximately 30% of algal biomass (this value can be as high as 80% for some genetically engineered species), compared to 5% of the biomass in the case of palm oil [36].
- **Source of Food:** Algae though is an important source of substances like sugar, fats and oils, proteins, carbohydrates, medicines still it is not used as a primary food source for humans and thus can be used distinctly for fuel [37].
- **Pollution Control and Waste Minimization:** Algae feeds on chemicals like CO_2 , phosphates, nitrates, ammonia etc which are the major water pollutants and thus helps in their mitigation. Further the waste products produced during Biofuel production may be used in the form of animal feed [38-40].

Concluding Remark

Biodiesel can be produced from several different pathways, each with its own set of benefits and problems. Biodiesel produced from algae certainly has its benefits, but there are still some major technical problems that need to be sorted out before it can compete economically within the current energy market. Looking to the numerous advantages of Algae (especially microalgae) over the conventional sources for biodiesel production, it can be considered as the most convenient and suitable feedstock for biodiesel production. There is still a great deal of R&D required to reduce the level of risk and uncertainty associated with the commercialization of the algae-to-Biofuels process.

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