A Review on Cultivation of Green Crude in India

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Abstract: - **Energy demand is increasing day by day because of rapid population explosion and industrialdevelopment which are highly dependent on non-renewable energy sources. Consequently, the continuous use of such resources at the higher rates will cause depletion of these resources in upcoming years. Also, the rates of fuel will going to increase. So, it has become necessary to focus on the alternative energy source. At present, the alternative energy sources available are solar energy, wind energy, geothermal energy and energy from Biomass. From all above sources, here we will only consider energy from biomass. Energy from biomass is obtained from Soybean, Sunflower, Palm, Canola, Jatropha and Algae. The sources mentioned are consider as substitute for petroleum products. This paper is targeting algae for bio fuel production because of its higher growth and oil yield. Especially, it only concentrate on different cultivation methods of algae for biodiesel production. This paper will investigate that open pond cultivation method is more suitable for India.**

Keywords: -Algae, Cultivation, Open Pond system, Biodiesel, fossil fuel.

I. INTRODUCTION

The social, environmental, and economic pressures of human activity require ever increasing energy resources.The rise of developing nations coupled with a predicted expansion of the world population to at least 9 billion by 2050 correlates to a global increase in energyuse from 533 quadrillion (1015) kJ in 2008 to 812 quadrillion kJ by 2035[1]**.** The world need fossil fuel for transportation such as in vehicles, heavy machineries, ships etc. even in mining projects as well as domestic peak power plants. Existing global fossil fuel reserve is rapidly depleting because the world uses billion litres of oils per annum. This oil causes to energy securities and environmental challenges. As the reserve decrease and consumption is increase, prices will continue to rise. Oneof the solution for this problem is to use energy from biomass. Energy from biomass is obtained from Soybean, Sunflower, Palm, Canola, Jatropha and Algae. Algae uses sunlight, CO_2 and nutrients to grow in control environment, algae can multiplies many times in each day. This makes algae one of the most valuable sustainable and renewable fuel resources in the world. In 2008 the annual world primary consumption was estimated 11,295 million tonnes of oil[4]. The use of fossil fuels results in the emission of Greenhouse Gases such as Carbon dioxide (76%), Methane (13%), Nitrous oxide (6%) and Fluorocarbons (5%). Out of these gases Carbon dioxide is the major culprit to cause climate change [2]. The other sources such as nuclear, hydro-electric, solar, wind, etc. are available which are not able to fulfil the current demand of primary energy consumption. Due to increase in rapid population and industrial development the demand of energy is greatly increased and as a result of this price will continues to rise.The world total biodiesel production was estimated to be around 1.8 billion in 2003 [3]. The activity for the production of biodiesel was started from last few years due to rapid demand of fossil fuels. Due to consumption of huge amount of fossil fuels, the releasing of CO_2 in the atmosphere is increased and it has adversely affected the climate change globally. In 2006,CO_2 emissions had been estimated 29 Gallon tones [4]. It has become necessary to develop subsequent techniques and adopt policy for minimising CO_2 emission to reduce environmental pollution and its effects.

II. NEED AND JUSTIFICATION OF ALGAE AS BIOFUEL

Microalgae are the microbes that are extremely small and they are single cell organisms. There are many species of microalgae in world which produces oil. Algae growth is natural occurrence in all types of water bodies. The limited fossil fuels are associated with huge problem so alternative search for biofuel has become necessary. Biofuel has become more significant recently because of its environmental benefits over conventional fossil fuels and also it is renewable source of energy. The use of biodiesel causes reduction in carbon and sulphur content in atmosphere which cut down their amount by 30-20% and it also maintains the CO_2 in the atmosphere[3].Here are the some benefits of using microalgae for biodiesel are as follows.

a) There is no need for fresh water to cultivate algae. It can be grown using either waste water or marine water,
b) Eco-friendly,
c) It can be grown in non-arable land and less land is requiredas compare to other traditional oil seeds.
d) It is utilised in making cosmetics, fertilizers, medicine and animal feed,
e) High oil yield per acre (land),
f) It gets mature within 12-20 hours,
g) Algae biodiesel is non-toxic and highly biodegradable,
h) New design or modification of diesel engine is not required.

Growing of algae takes CO_2 as means of nourishment. These means that, algae forms can be couple with conventional power plant to significantly reduce in emissions from power plant. Similarly, CO_2 that created by algae biofuel combustion is again utilised for its growth.

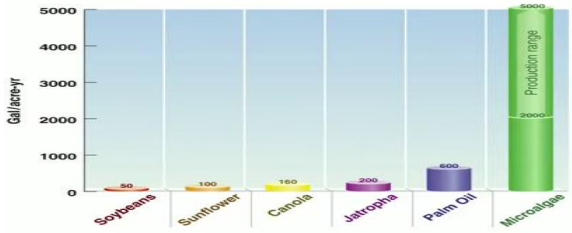

Fig. 1. Oil content from different biodiesel crops &production[5]

The biofuel itself is a carbon neutral.Algae has a potential for making 1000 barrels/acre/year. Another problem associated with the other biodiesel resources is low oil content and productivity as shown in Figure 1. And also food prices tends to rise up. As it is grown on waste land it does not have tendency to compete with food cropping. The number of carbon present in algae fuel is about 14 which is same as number of carbon present in diesel of 14-18 carbons[3]. It is easy to maintain nutrients and pH content. Additionally, the waste from the biodiesel production can be use as fertilizers, animal feed and pharma industries. Natural algae separated for processing into three primary products they are (a) livestock feed supplement, (b) bio-crude and (c) Straight vegetable oil.

The algae is growing through the process of photosynthesis which takes CO_2 from the atmosphere in the presence of sunlight and emits oxygen. That means the algae takes CO_2 from the emissions from industries, automobile, power plant, etc. for its growth so due to this it reduce the greenhouse gases in an area where algae is cultivated.

III. STAGES FOR ALGAE TO BIODIESEL

The different steps for algal biodiesel production can explained as,

Cultivation ⟶ Harvesting ⟶ Oil e

a) After selecting the suitable site for algae cultivation. The next step is to cultivate the algae in presence of sunlight and carbon dioxide and other nutrients through the different methods which are further discussed in this paper.
b) Algae harvesting process comprises of flocculation, centrifugation and microfiltration. In this process, biomass of algae is separated from water through dewatering it. The biomass of algae is further dried in solar dryer.
c) After harvesting algae, oil is extracted from it through mechanical press or liquefaction or by dissolving solvents. The raw algal oil is obtained in this process.In dissolving solvent method, the solvent is mixed with algae so biomass get settled down at the bottom of the container and algal oil will float on its surface.
d) The extracted algal oil is now converted in to bio diesel through biochemical conversion, anaerobic digestion and transesterification.

IV. CULTIVATION METHODS OF MICROALGAE FOR BIODIESEL PRODUCTION

There are several species of algae around 50,000 species, out of which only 30,000 species are studied till now. Algae can be cultivated in any environmental conditions were the retention time of water is long then it start to form in water. There are some algal species which are very rich in oil such as oil produce from chlorella in heterotrophic fermentation [3].

The different methods of cultivating microalgae.

a) Open pond system,
b) Closed loop Photo bioreactor (PBR),
c) Hybrid cultivation of algae,
d) Heterotrophic fermentation and
e) OMEGA (Offshore Membrane Enclosures for Growing Algae).

A. Open Pond System

Algae can be cultivated in open pond in some natural resources available such as lake, ponds, lagoons and artificial ponds [6]. The open pond system is oldest and simplest method to cultivate microalgae. In the cultivation of algae, the sample of algae is being put in the large sources of water. So, by absorbing CO_2 from environment as nutrient, the algae can start to grow.

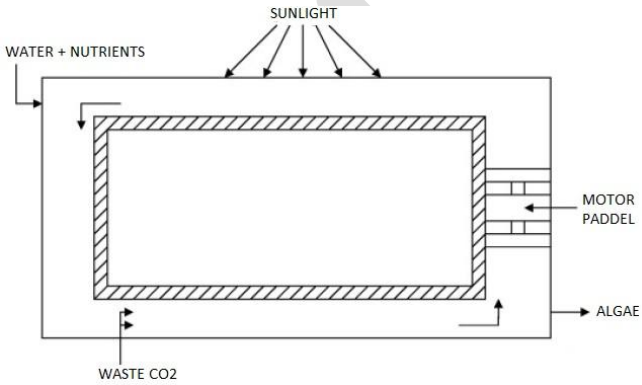

Fig.2: Open Pond cultivation System[7]

Fig. 3. Raceway Ponds [8]

"Raceway ponds" are one of the open pond which provide better circulation of algae, water and nutrients using paddle wheel on regular frequency. It is made of close loop recirculation channel that is typically about 0.3m deep [9]. Open ponds are made of concrete or masonry work which usually coated with plastic. The pH value of water and other physical condition should be controlled to ensure that 90% of CO_2 can be absorbed [7].

It has become an accepted measure that marine plankton have relatively constrained elemental ratios of 106:16:1 (C:N:P)[1]. Although some algae species, primarily cyanobacteria, can fix nitrogen from the air, most microalgae require a soluble form such as urea or ammonia [1]. In raceway ponds, paddlewheels are used to maintain constant mixing of the algae. A single paddlewheel has been shown in Figure 3 to provide sufficient mixing for algae biomass cultivation for arrays of connected ponds covering areas as large as 5 hectare[1].

Following are some environmental benefits of this system which are (a) Simple in construction; (b) Low operating cost

as minimum energy input is required; (c) It is relatively cheaper as compared to other cultivation method; (d) Open pond can be easily cleaned and maintained; (e) It suites to any type of land such as deserts, waste land, non-agricultural land, etc. and (f) Because of its less complexity, maintenance cost is less.

Moreover, it also has some environmental concerns such as (a) Main drawback of system is large area of land is required;(b)Lower strain of algae; (c) There is possibility of microalgae to contaminate with other microbes which are not good for their growth and (d) Paddlewheels are needed for the cultivation of algae, but their main drawbacks come from their operating costs.

B. Closed Loop Photo Bioreactor (PBR)

The second method named close loop photo bioreactors which are commonly used for culturing algae for the purpose of biofuel production. The closed vessel may consists of the steel, plastics, or fibres. Their size may vary according to the production capacity of the plant. The diameter of PBR tubes are small. So, the solar radiation falling on the tubes may cover whole diameter of tubes which allow better growth of algae.

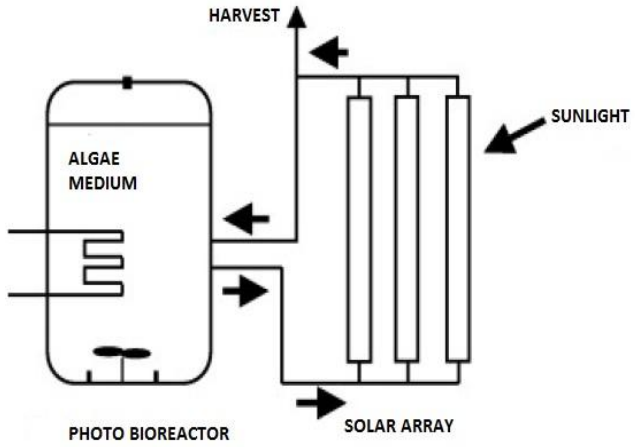

Fig. 4.Tubular photo bioreactor with parallel run horizontal tubes [7]

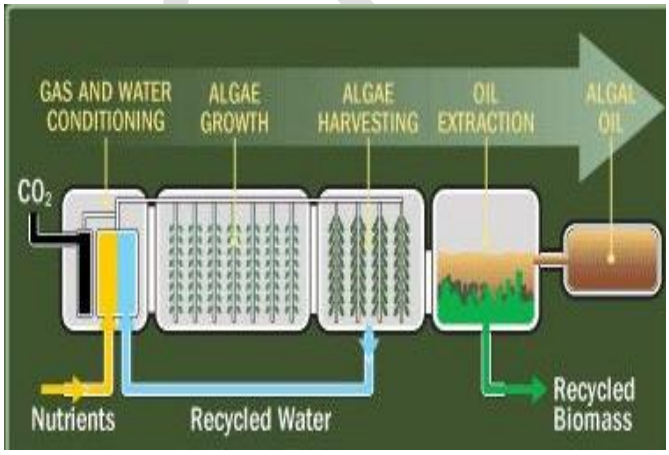

Fig. 5. Biodiesel production with the help of Photo bioreactor system[10]

Tubular algae bio-reactors consist of a vertical or horizontal arrangement of tubes with algae suspended in fluid and circulated throughout the system. The introduction of gas at either the beginning or the end of the system is commonly performed to accelerate algae growth, and generally leaves a lack of gas at the opposite end of the circulatory system therein. A system with even introduction of gas and light would improve the current state of the art [11].

Photobioreactors are closed vessels where algae can be cultured under optimum conditions without the threat of contamination from competitive species or culture collapse from predation (both significant problems in open ponds). Photobioreactors have high capital costs to build, but high rates of productivity, with the potential to yield 5,000-15,000 gallons of microalgal oil per acre per year [12]. By running small air pump with use of solar radiation we can continuously steering the water and algae so the other nutrients and algae can be continuously mixing and better growth take place.

Nutrient starvation consists of a manipulation of algal cells to produce more energy-storing molecules through the alteration of their environments to cause nutrient deprived or stressed conditions [13]. With development through increased experimentation and studies into the building and maintenance of the bioreactors in combination with the strategy of nutrient starvation, the efficiency of cultivation of microalgae could be aided to the point of cancelling out and maybe even overcoming the additional costs of maintaining the more advanced system [13].

The system is advantageousbecause of(a)Higher productivity; (b) It is suitable where availability of land is less; (c) It is easy to sterilize water; (d) Suitable foroutdoor culture and (e) Large illumination surface area.

Also it hassome disadvantages like (a) As compared to open pond system, this method is more expensive; (b) Water data are limited and inconsistent; (c) Very few large scale closed PBR have been implemented so the feasibility is to ascertain; (d) Complexity is more in construction of whole system other than open pond system and (e)It requires external source of energy.

C. Hybrid Cultivation of Algae

Hybrid cultivation system use the advantages of both the system as closed photobioreator and open pond system.

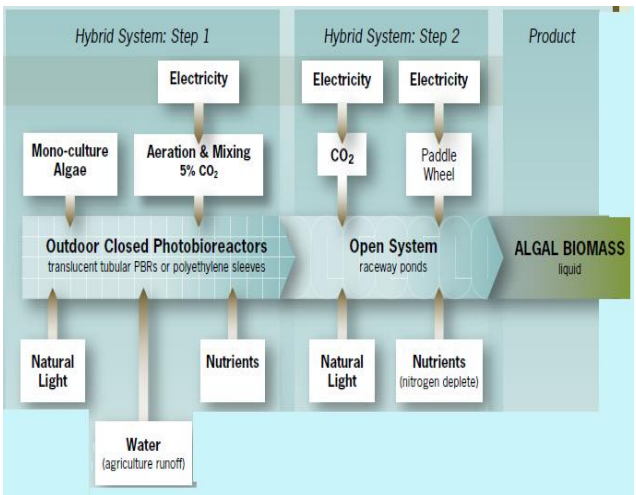

Fig. 6.Hybrid Cultivation System [14]

In closed PBR, algae is cultivated which is enriched in nutrients and then it is supplied to the open pond in which nutrients are mixed. As a result, the growth of algae is high through bio synthesis which cause high yield of oil. In hybrid system, phosphorous and nitrogen in the form of phosphoric acid, ammonium nitrate and urea are added on regular interval to accelerate the growth of microalgae which is not provided by the other cultivation method[14]. Gas transfer is an obstacle for closed PBR. As oxygen is produced during photosynthesis, the open pond system uses paddle wheel system to support the gases. But in PBR, it requires the application of degasification system[14].

The merits of hybrid system are (a) It requires less energy input compared to other closed system; (b) In PBR, the tubes are either horizontal or vertical this increases the area and (c) CO_2 Emissions from industries increase algae productivity.

Although it has some demerits like (a) It is more expensive outdoor system for achieving higher oil due to limitation of daylight; (b) Some system designs may not be able to accommodate wastewater; (c) High evaporation rates could impact water demand and humidity levels and (d) Photo bioreactor maintenance could have an impact depending on cleaning frequencyand method (i.e. chemical, detergent, and water usage) [14].

D. Heterotrophic Fermentation

Heterotrophic fermentation is measurably different approach and it is also known as dark feeding which is an alternative approach for algae cultivation. Heterotrophic systems are similar to closed PBR cultivation in that both pathways can utilize conventional closed bioreactors, such as stainless steel tanks [14]. Heterotrophic cultivation of microalgae offers several advantages over open pond and closed PBR cultivation including elimination of light requirement, good control of the cultivation process, and low-cost for harvesting the biomass because of higher cell density obtained in heterotrophic culture of microalgae [4]. The defining characteristics are that, high density heterotrophic cultivation is achieved with inputs of an organic substrate (sugar) feedstock in a zero-light, low-moisture environment [14]. Heterotrophically grown microalgae usually accumulate more lipids than those cultivated photoautotrophically[4].

E. OMEGA (Offshore Membrane Enclosures For Growing Algae)

The OMEGA stands for Offshore Membrane Enclosures for Growing Algae. It is clearly understood from the name that it is carried out at the seashore. These cultivating method is favourable for country like India whose coastal land is about 7500 km. So there is a big opportunity for cultivating algae at sea shore.

Most of the cities releases the waste water directly to the sea while some cities processes it. But in all cases the water which is released is perfectly suitable for growing algae. The OMEGA is one of the best system for such type of conditions.

In this system, treated waste water and $CO_2$is supplied in to the floating tubular structure similar to horizontal photo bioreactor tube and the waste water provides nutrients to the algae growth. Moreover,CO_2 is also taken from atmosphere in presence of solar energy for growth of algae.

Wave energy of sea water is used for mixing and stirring algae in floating tubes. Also temperature is controlled by surrounding water temperature. The algae that grows in tubular structures emits O_2 as mentioned in the fig.7.

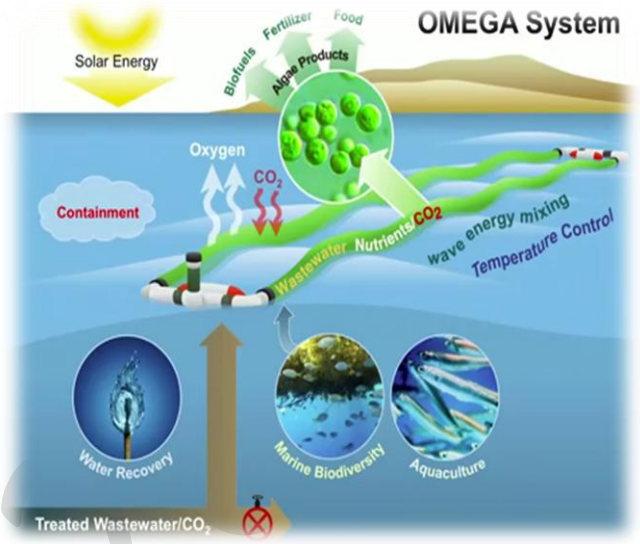

Fig.7.Schematic Diagram of Offshore Membrane Enclosures for Growing Algae[5]

With the help of this system, waste water can be recovered and marine biodiversity can be enhanced on the surface of the sea. Moreover, because of its marine structure, aquaculture activity at offshore, it can be easily carried out in an efficient manner.

CONCLUSION

Algae that double in a massive value, it can be grown only at around for biofuel production. As argued in this paper about different cultivating methods, the cultivating method that seems to be best is open pond cultivating system because of its simplicity and higher growth rates. The CO_2 emitted from the pollution is utilized for growing algae. Algae is best suitable for the wide variety of fuel and feed application. It is sustainable feed, renewable fuel and whole system that maintains net positive CO_2 balance which means to CO_2 credits. If we look at the three major challenges that human being faces today it is CLEAN AIR, SUSTAINABLE FEED AND RENEWABLE FUEL. Algae are the platform that addresses to all the above problems in a viable way. The algae biofuel prove independent security and one of the sustainable energy option for fluctuating prices of petroleum fuel.

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