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IS BIOFUEL FROM AQUATIC ENVIRONMENT IS MORE SUSTAINABLE THAN TERRESTRIAL ENVIRONMENT ?

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Abstract

Due to increase in global population there is constant increase in fossil hydrocarbons requirement. As fossil hydrocarbons are finite resource so renewable energy sources can supplement fossil hydrocarbons. The most promising renewable resources are the biofuels, which can replace fossil hydrocarbons without much alteration in present machineries and equipments. Biofuels are extracted from terrestrial environment like Corn, Soybean, Jatropa etc. but main disadvantage is that it competes with food crops for scarce water and land resources. On the contrary biofuels obtained from aquatic environment like algae donot compete for scarce water and land resources. They can be produce in waste water like sewage,non portable water and barren land without compromising with the nutritional security of the world. It not only provides biofuels but it solves the problem of animal feed as the residue of algal biomass is in rich in nutritional composition. The biofuel production efficiency is more in aquatic environment than the terrestrial environment without hampering the food chain. Hence, biofuels from aquatic environment is more sustainable than terrestrial environment. There is need for research in the field of algal biotechnology where the percentage of starch and oil is to be increased and biorefinery concept is to be adopted for keeping the price at par with the fossil fuel.

Introduction:

As the global population increases fossil hydrocarbon requirement also increases

proportionately. Fossil hydrocarbon are the source for producing plastics, fertilizers and also providing energy required for lightning ,heating and transport. The repercussion of using fossil hydrocarbons leads to increase in atmospheric CO2 and green house gases which leads to climatic change. Fossil fuel is a finite natural resources due to the competition for this natural resource s which leads to the depletion of its reserves or become too expensive to recover(Dyni 2005 and Energy Information Administration,2009).

These are the motive behind the development of renewable energy source that can supplement fossil fuel allow greater access to all fossil deficit countries which leads to drastic reduction in Carbon emission into atmosphere.

There are big array of renewable or low atmospheric pollution technologies that can generate electrical power includingsolar , wind ,hydro electric ,geothermal and biofuel.

However,renewable energy technologies to supplement liquid fuel are still in infant developmental stage. As per the assumption of International Energy Agency , biofuel will contribute 6% of total fuel use by 2030,but its pace could be significantly increase if undeveloped Petroleum field are not accessed or if new oil fields are not identified.

In view of this the most promising sustainable alternatives are the category biofuels.

Biofuels is a fuel whose energy is derivied from the biological carbon fixation.

Types of Biofuels are 1.Bioethanol 2. Biodiesel 3. Biogas 4. Biomass to Liquid 5. Hydrogen Following are the sources of biofuels.

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Component	Bio ethanol	Bio diesel
Sugarcane	*	--
Beetroot	*	--
Corn	*	--
Wheat grain	*	--
Microalgae	*	--
Sunflower	--	*
Soyabean	---	*
Palm oil	---	*
Groundnut	---	*
Jatropa	--	*
Microalgae	--	*

Secondary Impact of biofuels obtained from terrestrial source

1. Rapid conversion of forest to farm land which leads to release heat trapping CO_2 stored in

trees and soils.

2. Growing corn for ethanol production has come at high cost of fresh water resources in several region of the world which leads to the detoriating the health of aquatic environment.
3. Corn is are sourse intensive crop which needs high input of fertilizers ,pesticides and need soil disturbance.
4. To produce 1 gallon of corn ethanol require 500 gallon of water.

. Biomass components which made different type of biofuel

Type of biofuels → / Types of biomass	Biodiesel	Bioethanol	Biogas	BTL	Hydrogen
Whole biomass			*	*	*
Lipid	*				*
Starch/Sugar		*			*
Protein			*	*	*

***BTL=Biomass to Liquid. A technique to generate bio oil pyrogenically from biomass**

Comparison of some source of biodiesel from terrestrial and aquatic environment.

Crop	Oil yield (L/Ha)	Land area needed (Mha)
Corn	172	1540
Soyabean	446	594
Canola	1190	223
Jatropha	1892	140
Coconut	2689	99
Oil Palm	5950	45
Microalgae[b]	136900	2
Microalgae[c]	58700	4.5

(Source: Chisti .,Y.,2007)

[b] 70% of oil (by weight) by biomass.

[c] 30% of oil (by weight) by biomass

As per the oil yield and land needed by the aquatic microalgae it is unanimously proved that aquatic environment is yielding more biofuels as compare to the terrestrial environment.

ADVANTAGES OF MICROALGAE AS A SOURCE OF BIODIESEL

1. High yield of biodiesel from Microalgae,
2. Production cost is low .
3. Algae double its biomass within 24hrs.
4. Algae can grow away from farm land(No destruction of food chain)
5. Sewage water can be used for algal production so no need for scarce water resources..
6. Oil productivity of microalgae is greater than best oil producing terrestrial crop.
7. Deoiled algal biomassis can be used for high grade protein for animals.

Aquatic biomass for biofuels

Aquatic biomass relevant biofuel production mainly concems alge, i.e. macro – and microalgae. Algae are considered to have the potential to yield biofuels in large enough quantities for a realistic alternative to fossil fuel sources. Algal strain or species with high lipid and starch content can be used for biodiesel and bio ethanol production respectively. Combinations are also possible like lipid fraction is used for biodiesel, while the remaining biomass is fermented for biogas production. In some species produce high value compounds (i.e. pigments in microalgae or alginate in macroalgae), which can be isolated and sold separately. Valorization of as many biomass components as possible is crucial to reduce the price of biofuels to the level of fossil fuels .

Bioethanol

Bioethanol production involves a conversion of as much of the biomass as possible to sugar, followed by a conversion of sugar to bio ethanol. The general reaction used in all of these processes involves the use of yeast or other microorganisms to convert sugar into ethanol and CO_2:

$C_6H_{12}O6$ -------- 2 C_2H_5OH+ 2 CO_2 + heat

Bioethanol can be produced from several different biomass feedstock such as sugar or starch crops i.e. .sugar cane crop (Brazil) and Corn,Sugar beet and wheat in United States and Europe. In comparision to traditional crops like sugar cane ,Corn ,Beet root,Wheat algae can provide ahigh yield source of biofuels without compromising food suppy chain. Microalgae like Chlorella, Dunaliella, Chlamydomonas, Scenedesmus, Spirulina are known to contain a large amount (>50% of the dry weight) of starch and glycogen, useful as raw materials for ethanol production (Ueda et al., 1996), (Brányiková et al., 2011).It was found that the structure of algal starch (Chlorella) was similar to that of cereal starches and the gelatinisation temperature of algal starch, as determined by viscosity measurements, also suggests to a structural similarity between algal and cereal starches (Maršálková et al., 2010) .

Finally the ethanol is purified from the fermentation broth by distillation and the obtained concentrated ethanol (95%) can be blended with fossil fuels or directly used as fuel. The solid residue from the process can be used as animal feed or as a feedstock for biogas production .

Biodiesel

Biodiesel is a biofuel that is based on the conversion of vegetable or animal fats and oils into a fatty acid methyl ester of the respective fat or oil.

Biodiesel is produced from oils or fats using transesterification . Transesterification is the process of exchanging the organic group R" of an ester with organic group R' of an alchol. These reaction are often catalyzed by the addition of an acidor base catalyst. The reaction can also be accomplished with the help of enzyme (biocatalyst) particularly lipase.

Biodiesel Production:

Algal oil used in making biodisel consist of Triglycerides in which 3 fatty acid molecule s are esterified with a molecule of glycerol. In making biodiesel ,triglycerides are reacted with methanol in a reaction known as transesterification or alcoholysis . It is catalyzed by acids alkalis and lipase enzymes. Like plants, microalgae use sunlight to produce oils but they do so more efficiently than crop plants. Oil productivity of many microalgae greatly exceeds the oil productivity of the best producing oil crops

Oil content of some microalgae

Microalgae	Oil content (% dry weight)
Botryococcus braunii	**25-75**
Chlorella sp.	**28-32**
Crypthecodinium cohnii	**20**
Cylindrotheca sp.	**16-37**
Dunaliella primolecta	**23**
Isochrysis sp.	**25-33**
Monallanthus salina	**>20**
Nannochloropsis sp.	**20-35**
Neochloris oleoabundans	**35-54**
Nitzschia sp.	**45-47**
Phaeodatctylum tricornutum	**20-30**
Schizochytrium sp.	**50-77**
Tetraselmis sueica	**15-23**

(Source: Chisti .,Y.,2007)

Biogas

Biogas production results from biological breakdown of organic matter in absence of oxygen, called **anaerobic digestion**, Biogas production is a well-established technology, especially in smaller local facilities where organic waste streams are fed into an anaerobic digester and the resulting gas (usually methane) is used to heat the facility or generate electricity..

Biomass with **low lipid content is especially suitable for biogas** production using anaerobic fermentation. In terms of aquatic biomass this means that macroalgae are especially suitable in this case. However, macro algal biomass has some drawbacks over other types of biomass.

Practicable methods of large-scale production are of two types

a. Raceway ponds b. Tubular photo bioreactors

a. **Raceway Pond-** Is made of a closed loop recirculation channel that is typically about 0.3 m deep. Mixing and circulation are produced by a paddlewheel . Flow is guided around bends by baffles placed in the flow channel. Raceway channels are built in concrete, or compacted earth, and may be lined with white plastic. During daylight, the culture is fed continuously in front of the paddlewheel where the flow begins Broth is harvested behind the paddlewheel, on completion of the circulation loop. The paddlewheel operates all the time to prevent sedimentation.

b. **Photobioreactors-** It permit essentially single-species culture of microalgae for prolonged durations. Photobioreactors have been successfully used for producing large quantities of microalgal biomass..A tubular photobioreactor consists of an array of straight transparent tubes that are usually made of plastic or glass. This tubular array, or the solar collector, is where the sunlight is captured . The solar collector tubes are generally 0.1 m or less in diameter. Tube diameter is limited because light does not penetrate too deeply in the dense culture broth that is necessary for ensuring a high biomass productivity of the photobioreactor. Micro algal broth is circulated from a reservoir(i.e. the degassing column) to the solar collector and back to the reservoir. Continuous culture operation is used, as explained above. The solar collector is oriented to maximize sunlight capture. In a typical arrangement, the solar tubes are placed parallel to each other and flat above the ground. Horizontal, parallel straight tubes are sometimes arranged like a fence. The ground beneath the solar collector is often painted white, or covered with white sheets of plastic.

Improving economics of microalgal biodiesel

- Biorefinery based production strategy

- Enhancing algal biology

Biorefinery based production strategy

Biorefinery are like petroleum refinery where each and every component of biomass is utilized to produce useable products. Utilization of all components of biomass leads to lowering the production cost of any given product. These types of biorefineries are in operational condition in countries like Canada, the United States and Germany for producing biofuels and other products like corn and soyabean. This type of approach reduces the cost of extraction of biodiesel from microalgae. Apart from oil microalgae biomass contain significant quantity of proteins, carbohydrates and other nutrients. (Sánchez Mirón et al., 2003).After extraction of biodiesel from biomass, residual components can be utilized for production of animal feed with consideration to its rich proximate composition. Some residual mass may be used for production of methane by anaerobic digestion for generating the electrical power necessary for power requirement of biorefinery facilities.

Enhancing algal biology

I. Genetic and metabolic engineering play vital role for improving the economics of production of microalgae diesel.

II. Molecular level engineering can be used to potentially:

1. Increase photosynthetic efficiency to enable increased biomass yield on light
2. Enhance biomass growth rate.
3. Increase oil content in biomass.
4. Improve temperature tolerance to reduce the expense of cooling.
5. Eliminate the light saturation phenomenon so that growth continues to increase in response to increasing light level.
6. Reduce photo inhibition that actually reduces growth rate at midday light intensities that occur in temperate and tropical zones.
7. Reduce susceptibility to photo-oxidation that damages cells.

Conclusion:

- Microalgal biodiesel is technically feasible.
- It is the only renewable biodiesel that can potentially completely displace liquid fuels derived from petroleum.
- Economics of producing microalgal biodiesel need to improve substantially to make it competitive with petrodiesel
- Improvements to algal biology through genetic and metabolic engineering.

- Use of the bio refinery concept and advances in photobioreactor engineering will further lower the cost of production.

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