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Review Paper

Microalgae Culture for Bio-Fuel Production W.R.T. India: A Review

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Abstract

Because of rapidly increasing consumption and limited sources of non-renewable fuels, Biofuel production from renewable sources is important now and futrue. Its production process is very much similar to Chemical process. Currently it is necessary to develop advanced biofuels besides other bio-products. Researchers look for the production of alternative fuels to replace petroleum derived fuels, including alcohols, higher chain alcohols isoprenoid lipid fuel, and fuels synthesized from CO_2 via photosynthesis. The desire for renewable liquid fuel replacements to petroleum has steadily increased with concerns about the current fuel economy's stability and environmental impact.

Keywords: Bio fuel, Renewable, Micro-algae, Environmental friendly, Global warming, Sustainability.

Introduction

Before the discovery of oil wells, oil was extracted from animals, vegetables and coal and was used mostly for lighting and heating. New types of transportation vehicles, including all types of locomotives consumes the highest quantity of oil. Oil wells were discovered in Pennsylvania by Edwin Drake in 1859 that yielded at least 15 barrels a day. The United States became the nation that exported the most oil, grasping strong hold in economic value. After many years of oil extraction and consumption led to the depletion of the wells, the U S was forced to import oil. Because world is facing peak-oil, a term use that indicates that the cost of extracting and refining oil is more or equal to the cost of oil itself. This means that for one barrel of oil extracted and refined, the process consumes one barrel of oil, hence it is not economically viable[1-3].

Oil and India: For the past decades, oil has become important to the world economy due to its use to energize the world, specially the transportation sector. It is projected that the consumption of liquid fuels will increase from 84 million barrels per day in 2005 to 113 million barrels in 2030. The transportation sector accounts for a 74% increase from 2005-2030, since the new building are design with the purpose of energy efficiencies and sustainability[4].

Oil and Environment: The transportation sector fuels are the fastest growing sources of greenhouse gases. Transportation Sector, states- "The India transportation sector represents ~ 10% of all energy-related greenhouse gas emissions worldwide. Over the next 50 years, rising numbers and use of vehicles could swell greenhouse gas emission from India transportation to 80% above current levels. There are three general approaches for reducing GHG in the transportation sector: i. adopting advance vehicle technologies, ii. switching to low GHG fuels, and iii. reducing vehicle miles traveled."

A wedge analysis of the India transportation sector introduces the concept of stabilization wedges and applies it to the India transportation sector to illustrate the potential approaches that are capable to reduce both GHG and oil consumption. A wedge is an activity that creates 1GtC/Y of carbon reduction[5-8].

Literature Review

The bio fuel production minimize the fossil fuel burning and CO_2 production. The advantage of bio fuel production along with byproducts can provide employment opportunities in rural areas.

Biomass is popular because of carbon neutrality and their widespread accessibility. Among biomass, algae have a higher photosynthetic efficiency. Biodiesel from microalgae is an excellent solution to India, for replacing petro-products. Micro algal species are of great interest for the production of biodiesel because of high oil content[9-11].

Production of Micro Algal Biomass

Micro algal biomass generally produced during daylight through continuous culture. Here, fresh culture medium is fed at a constant rate and the same quantity of micro algal broth is withdrawn. Feeding stops during the night, but the mixing of broth continue to prevent settling of the biomass. There are two following methods for the production of micro algae are:

Raceway Ponds: A closed loop recirculation channel which is 0.3 m deep. Mixing and circulation is through paddlewheel.

Flow is by baffles, placed in the flow channel. Raceway channels are made with concrete and lined with white plastic. After completion of the circulation, loop broth is harvested behind the paddlewheel.

Source: www.googleimage.com

Figure-1
Raceway pond

Photo Bioreactors: It is successfully applied for producing large quantities of micro algal biomass. A glass tube photo bioreactor having an array of straight transparent tubes which is made up of plastic or glass. It is also called solar collector. The diameter of Tubular array is generally 0.1 m or less. Photo Bioreactors permits single species culture of micro algae for prolonged durations[12-17].

Source: www.googleimage.com

Figure-2
Photobioreactor from glass tubes

Research and Data Collection

Research and date collection are given in given in Table 1 to 4.

Table-1
Comparison of Properties[14-16]

Properties	Biodiesel from Micro-algal Oil	Diesel Fuel
Density Kg/L	0.864	0.838
Viscosity Pa S	5.2×10^{-4} (40^0C)	$1.9\text{-}4.1 \times 10^{-4}$ (40^0C)
Flash Point ^{0}C	65-115	75
Solidifying Point ^{0}C	-12	-50-10
Cold Filter Plugging Point ^{0}C	-11	(-3.0) – (-6.7)
Acid Value mg KOH/g	0.374	0.5
Heating Value MJ/Kg	41	40-46
HC Ratio	1.18	1.18

Table-2
Comparison of oil yields from algae[12,13]

Yields	Gallons of oil/acre/year
Corn	19
Soybeans	47
Safflower	43
Sunflower	104
Rapeseed	125
Oil Palm	634
Micro Algae	**5100-15100**

Microalgae Background: Microalgae are autotrophic in nature. The unicellular structure of it permits to convert solar energy into chemical energy. Algae strip environmentally hazardous gasses from different sources. Many of the exhaust gasses from different sources are used by algae as nutrients to grown biomass. Pumping these exhaust fumes, into the algae broth is an excellent idea to "recycle" these gases would be sent into the atmosphere[18-25].

Research and Discussion

Cost of Microalgae: The cost of one Kg microalgae producing is 183 Rs. and 235 Rs. for photobiorectors and raceways, respectively.

Table-3
Comparison of bio fuel feedstock[15-17]

Crop Name	**Products Obtained**	**GHG Emissions (Kg of CO_2 created per mega joule)**	**Use of resources during growing, harvesting and refining of fuel**				**Process**
			Water	Fertilizer	Pesticide	Energy	
Corn	C_2H_5OH	80-84	Excess	Excess	Excess	Excess	Technology relatively cheap; decreases food supply
Sugar Cane	C_2H_5OH	5-13	Excess	Excess	Optimum	Optimum	Technology ready & limited; decreases food supply
Switch grass	C_2H_5OH	-26	Optimum-Less	Less	Less	Less	Technology not ready
Wood residue	C_2H_5OH, Biodiesel	N/A	Optimum	Less	Less	Less	Technology ready; decreases food supply
Soybeans	Biodiesel	48	Excess	Less-Optimum	Optimum	Optimum-Less	Technology ready; decreases food supply
Rapeseed, Canola	Biodiesel	39	Excess	Optimum	Optimum	Optimum-Less	Technology ready; decreases food supply
Algae	**Biodiesel**	**-185**	**Optimum**	**Less**	**Less**	**Excess**	**Huge production levels; technology not ready**

Table-4
Comparative study of various bio fuel crops[15,16]

Name of Crop	**Oil Yield (L/ha)**	**Land area needed (M ha)**
Corn	171-174	1540-1543
Soybean	445-448	594-597
Canola	1110-1193	223-226
Jatropha	1892- 1895	140-144
Coconut	2689-2692	99-101
Palm oil	5950-5954	45-47
Microalgae A	**135-137**	**2-3**
Microalgae B	**57-59**	**4.5-5.0**

A - 70% oil (by weight) in biomass. B - 30% oil (by weight) in biomass.

Table-5
Comparison of energy[20-22]

Algae Oil Content	Calorific Value	Yield Algae	Yield Algal Oil	Yield Algal Oil
% Oil	Kcal/g	Metric Tons/Hectare/Year	US Gallons/Acre/Year	Barrels/Acre/Year
10	4.7	401	4667	111
20	5.2	361	8408	200
30	5.8	328	11474	273
40	6.3	301	14032	334
50	6.8	278	16198	386
60	7.3	258	18057	430
70	7.8	241	19669	468
80	8.4	226	21081	502

Chemical Extraction: Soxhlet method is applied here for the chemical extraction. A soxhlet extractor is used organic solvents to obtain higher yield. Various methods are available: i. **Enzymatic Extraction Method:** Here water is used as solvent which degrades enzymes. The oil is linked with proteins and carbohydrates. Down-stream process fractionates its components. This is the brighter side of this technique. ii. **Ultrasonic Method of Extraction:** In this method sonication generates sound waves which penetrate the liquid media. High-pressure and low-pressure cycles are used alternatively here. Ultrasound ruptured the cell wall, which facilitates the lipids transfer from cell into solvent. After the oil dissolution pulp/tissue is filtered out. Finally oil is extracted from the hexane through distillation. iii. **CO_2 Supercritical Extraction Method:** In this method CO_2 is compressed beyond its supercritical point (31^0C). This supercritical-fluid reacts with algal material in an extraction vessel. In another separate vessel CO_2 is de-pressurized and main substances collected. This is the most advanced oil extraction method[26-29].

Table-6
Benefits[26-28]

S. No.	Property	Benefits of Algae
1	Impressive Productivity	100 times more oil production per acre than any other crop
2	Non-Competitive	Cultivated in large open ponds or closed photo bio-reactors in all seasons
3	Flexible	Algae culture not required fresh water it can also grow in seawater, wastewater etc.
4	Mitigation	CO_2 enriched water is used to cultivate algae which make productive use of the CO_2 from different sources
5	Broadness of Product	Lipids produced by algae further used to produce biofuels and byproduct which posses different applications viz.- to generate heat, to produce methane, to produce ethanol etc.[28-30].

Advantages of Algal Bio Fuel: Algal bio fuel growth rates and biomass productions are very high. It is efficient and cheap source. They decrease GHG in environment and eco-friendly too.

Conclusion

We concludes that microalgae culture for biofuel production has bright future in India and deveploping countries. It also reduces our dependency on non-renewable energy sources.

References

1. Azapagic A. (2014). Sustainability Considerations for Integrated Bio refineries. *Trends In Biotechnology*, January**,** 32(1).

2. Carvalho A.P., Meireles L.A. and Malcata F.X. (2006). Microalgal reactors: a review of enclosed system designs and performances. *Biotechnology Progress*, 22(6), 1490-1506.

3. Michael C. (1999). Shear sensitivity. In: Flickinger MC, Drew SW, editors. Encyclopedia of bioprocess technology: fermentation. *Biocatalysis and bio separation*, 5, 2379-406.

4. Chisti Y. (2007). "Biodiesel from microalgae". *Biotechnology Advances*, 25(3), 294-306.

5. Chisti Y. (2008). Biodiesel from microalgae beats bioethanol. *Trends Biotechnol,* 26, 126-131.doi:10.1016/j.tibtech.2007.12.002

6. Miyamoto K. (1997). FAO Agricultural Services Bulletin-128. (chapter I- Biological Energy Production) [online]. Available: http://www.fao.org/docrep/w7241e/w7241e05.htm

7. García Camacho F., Molina Grima E., Sánchez Mirón A., González Pascual V. and Yusuf Chisti (2001). Carboxymethyl cellulose protects algal cells against

hydrodynamic stress. *Enzyme Microbe Technol*, 29, 602-610.

8. Garcia Camacho F., Gallardo Rodríguez J., Sánchez Mirón A., Cerón García M.C., Belarb E.H., Chisti Y. and Molina Grima E. (2007). Biotechnological significance of toxic marine dinoflagellates. *Biotechnol Adv,* 25, 176-94.

9. Richmond A. (2008). Handbook of micro algal culture. *Biotechnology and applied phycology*. Blackwell, 97-115.

10. Humphrey A.S. (2004). The origins of the SWOT analysis model. Obtained through the Internet: http://rapidbi.wordpress.com/2008/12/29/history-of-the-swot-analysis/, [accessed 12/4/2014.

11. Mazzuca S.T., Garcia C.F., Molina G.E. and Chisti Y. (2006). Effects of agitation on the microalgae phaeodactylum tricornutum and porphyridium cruentum. *Bioprocess Biosyst Eng,* 28, 243-50.

12. Mcardle W., Katch F. and Katch V. (2010). Exercise physiology: nutrition, energy, and human performance. Lippinott Williams & Wilkins.

13. Moheimani N.R. (2013). Production of biofuels from microalgae. Asia Pacific Partnership [Online]. Available:http://www.asiaspecificpartnership.org/pdf/PGTTF/ngf/Wednesday/microalgae%20culture%20project.ppt [Accessed 04/04/2014].

14. Emilio Molina Grima, Jose María, Fernández Sevilla, Francisco Gabriel Acién Fernández (2009). Microalgae, mass culture methods. In: Flickinger M C, Drew S.W, editors. Encyclopaedia of bioprocess technology: fermentation. *Biocatalysis and bio separation*, 3, 1743-69.

15. Molina G.E. (1999). Acien Fernandez F.G., Garcia Camacho F, Chisti Y. Photo bioreactors: light regime, mass transfer and scale up. *J. Biotechnol*, 70, 231-47.

16. Oligae (2010). Oligae Report Academic Edition. Obtained through the Internet: http://www.oligae.com/, [accessed 10/04/2014].

17. Paine R. and Vadas R. (1969). Calorific values of benthic marine algae and their postulated relation to invertebrate food reference.*Marine Biology*, 4, 79-86.

18. Pulz O. (2001). "Photo bioreactors: production systems for phototrophic microorganisms". *Applied Microbiology and Biotechnology*, 57(3), 287-293.

19. Sanchez M.A., Ceron G.M.C., Contreras G.A., Garcia C.F., Molina G.E. and Chisti Y. (2003). Shear stress tolerance and biochemical characterization of Phaeodactylum tricornutum in quasi steady-state continuous culture in outdoor photo bioreactors. *Biochem Eng J.,* 16, 287-97.

20. Spolaore P., Joannis C.C., Duran E. and Isambert A. (2006). "Commercial applications of microalgae". *Journal of Bioscience and Bioengineering*, 101(2), 87-96.

21. Terry K.L. and Raymond L.P. (1985). "System design for the autotrophic production of microalgae". *Enzyme and Microbial Technology*, 7(10), 474-487.

22. Tredici M.R. (1999). Bioreactors, photo. In: Flickinger M C, Drew S W, editors. Encyclopedia of bioprocess Technology: fermentation, biocatalysis and bioseperation Wiley. 395-419.

23. Ronald P. Corbett. (1999)."Up to speed".

24. Eva D. and Ralf R. (2008). Current achievements in the production of complex biopharmaceuticals with moss bioreactors. *Bioprocess and Biosystems Engineering*, 31(1), 3-9.

25. Pulz O. (2001). "Photobioreactors: production systems for phototrophic microorganisms". 57, 287–293.

26. Cotta F., Matschke M., Großmann J., Griehl C. and Matthes S. (2011). "Verfahrenstechnische Aspekte eines flexiblen, tubulären Systems zur Algenproduktion". (Process-related aspects of a flexible, tubular system for algae production); DECHEMA.

27. Großmann Ingenieur Consult GmbH (2011).Aufbau eines Biosolarzentrums in Köthen. 6. März 2011.

28. Richmond A. and Hu Q. (2013). Handbook of microalgal culture. Blackwell Science Ltd. ISBN 978-0-470-67389-8.

29. Spolaore P. et al. (2006). "Commercial Applications of Microalgae". *Journal of Bioscience and Bioengineering* 102: 87–96.

30. Ansari A., Rajwaidya R. and Amlathe S. (2015). "Green Fuel: The Next Generation Eco-Friendly Algal Bio-Fuel". *Research Journal of Chemical Sciences*, October 5(10), Issue 10, 28-32.