Journal of Integrated
SCIENCE & TECHNOLOGY

Integrated Science

Status of biofuel production from microalgae in India

Mukesh Kumar, MP Sharma

Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee, Uttrakhand, 247667, India

Received: 07-June-2014

ABSTRACT

Energy is essential for the economic development of the world and depends on the fossil fuels that are limited in availability and are associated with environmental pollution of air, water, soil etc. Microalgae make use sunlight and CO_2 for their growth and give higher oil productivity more than terrestrial oil seed crops. Biodiesel, as substitute of diesel, can be produced from edible, non-edible and animal fats. Owing to significant advantages over terrestrial oil seed crops, microalgae, is seen as a future third generation source of oil that can be converted into biodiesel. The present paper discusses that the availability of microalgal species, their advantages, oil productivity, land requirement & economics of biodiesel production. The Indian R&D status on various aspects of microalgal biodiesel is also given.

Keywords: Microalgae, microalgal oil, Biodiesel, land area required

INTRODUCTION

India's growing demand for petroleum-based fuel has created challenges for the country's energy security, as almost 90% of its crude oil requirement is imported from oil producing countries. Out of industrial, agricultural & domestic sectors, the transport sector consumes almost 80% of total energy being currently derived from fossil fuels[1]. According to 2012-13 estimates, the annual diesel consumption was 70 million tonnes (Mt) at the growth rate of 6–8% per annum[1]. The rapid depletion of fossil fuel resources and increase in the prices of crude oil has made it inevitable to search for an alternative fuels as substitute of diesel. Due to the similarity in fuel properties of diesel and biodiesel, the later is considered as a substitute of diesel. Accordingly, Government of India has announced Biofuels Policy in the year 2008 to promote the production and the use of biodiesel to achieve a target of blending 20% biodiesel with diesel by 2017[2]. The biodiesel can be produced from edible, non-edible oils and fats. The biodiesel production from edible oils is impractical due to its use for edible purposes and 80% of edible oils are imported. The non-edible resources like *Jatropha*, *Pongamia*, *Neem*, *Sal* etc. are found important sources for biodiesel production. Further, the poor yields of non-edible oils make it inadequate to fulfill the country's energy demand. As a result, microalgae is in focus as a future source of biodiesel due to the advantages of yielding 30 times more oil compared to other oil seed crops[3]. The present paper discusses the status of microalgal biodiesel production in India in terms of possibility of growing, harvesting, oil extraction & biodiesel production. The institutions engaged in R&D area are also given.

MICROALGAE

Microalgae, the small microorganisms, can grow in fresh, marine, waste and saline water. Microalgae have the potential to produce 1,36,900 liters while Jatropha can produce 1,892 liters oil per acre as shown in Fig.1[4,5]. Microalgae can fix large amount of carbon dioxide (CO_2) and contribute about 40-50% oxygen in the atmosphere, thereby, supporting biological life on our planet by producing food, medicines, chemicals etc for human consumption.

Microalgae, with rich biodiversity with over 50,000 species, exist all over the world, but only 30,000 are analyzed so far[6]. It is also known that many species of microalgae have the ability to accumulate lipids as triacylglycerols (TAGs)[7]. The lipid content found in microalgae is more than 70% of the dry cell weight[7]. Apart from the use of microalgal oil for biodiesel production, a number of useful by-products can also be produced that can be used by human[8] as shown in Figure 2.

Address:
Mukesh kumar

Biofuel Research Laboratory, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand-247667, India
Tel: +91 1332 285836
Email: mukeshdce07@gmail.com

Cite as: *J. Integr. Sci. Technol., 2014, 2(2), 72-75.*

 JIST ISSN 2321-4635

ADVANTAGES OF MICROALGAE[9, 10,11,12,13]

Microalgae are becoming important as source of biofuel due to the following advantages:

- Can grow rapidly with solar energy conversion efficiency higher than other terrestrial plants due to their simple structure.
- Oil yield is approximately 30 times more than the terrestrial oil seed plants.
- Can grow on non-arable land.
- Can grow in waste, marine and saline water.
- Can use waste CO_2 sources, thereby, potentially mitigating the release of GHGs into the atmosphere.
- Cultivation consumes less water than land crops.

SELECTION OF APPROPRIATE MICROALGAL STRAIN

Algae can be classified into 12 classes including the green algae (Chlorophyceae), diatoms (Bacillariophyceae), yellow-green algae (Xanthophyceae), golden algae (Chrysophyceae), red algae (Rhodophyceae), brown algae (Phaeophyceae), picoplankton (Prasinophyceae and Eustigmatophyceae). Chlorophyceae (green algae) and Bacillariophyceae (diatoms) are best studied for biofuel production due to their lipid content[14]. Important factors to be considered for selecting suitable microalgae species are[15]:

Cell biomass, lipid content, lipid quality, growth rate, response to conditions such as light, temperature and nutrient input, growth medium.

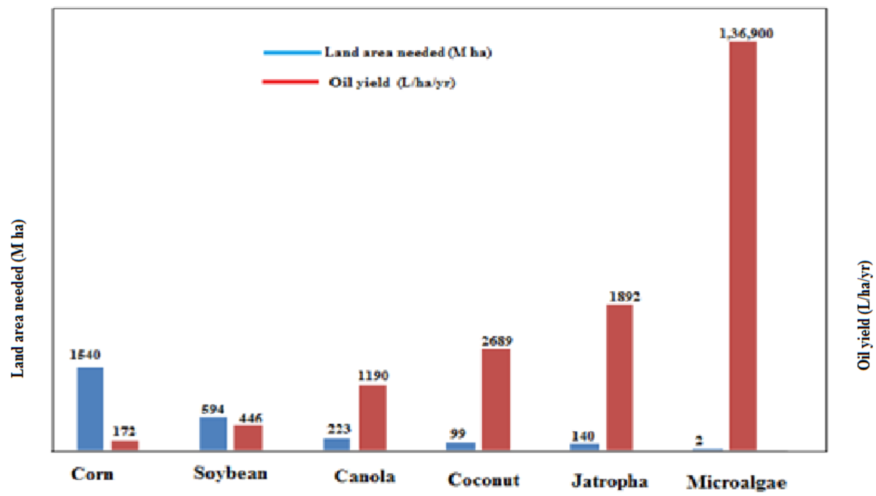

Figure 1. Land required & oil productivities from different feedstocks

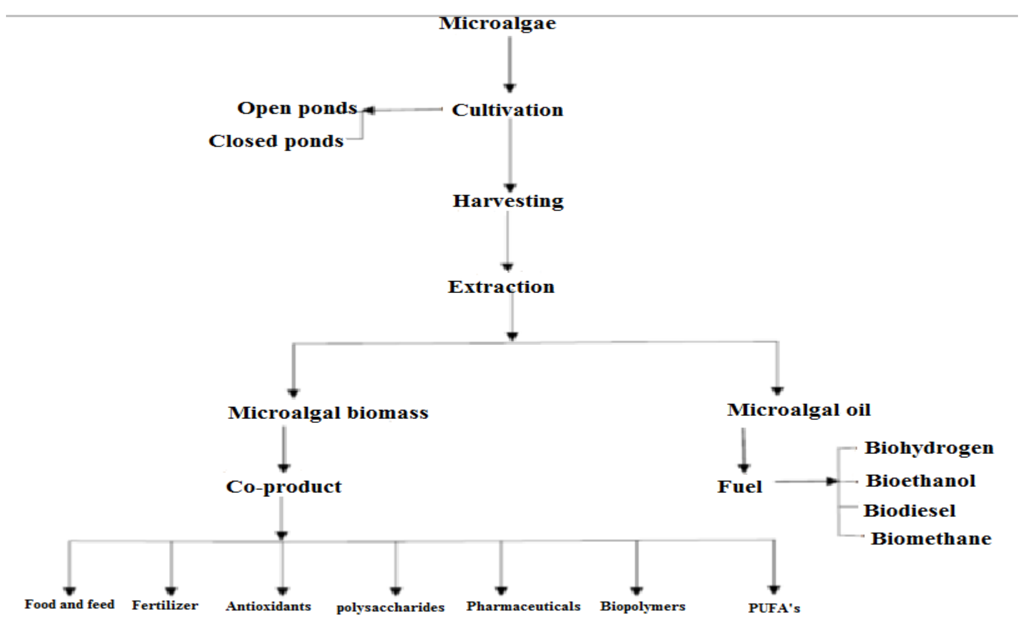

Figure 2. Microalgae biofuel and co-products chain

ECONOMICS OF ALGAL BIODIESEL PRODUCTION[4, 16, 17]

As stated above, the oil yield per acre of microalgal oil is about 30 times more than terrestrial oil seed crops. Microalgae can mature within 2-3 days compared to 2-3 year for *Jatropha*, *Pongamia* etc. and so microalgae can be harvested in a short period of time. The current estimates of the cost of microalgal biofuels are very high, which can be reduced if large-scale microalgal production facilities are available. Production of microalgal strain and optimization of its growth is the most important in determining the economics of biofuel production. However, other factors like the cost of CO_2, water, the harvesting and extraction also have significant impact on fuel cost. Therefore, it is concluded that microalgal biodiesel production can be viable, if well-developed growing, harvesting and oil extraction techniques are available/developed.

ALGAL BIODIESEL OPPORTUNITIES IN INDIA

Sudhakar et al.[17] reported that if microalgae is farmed on 0.06% of the total land area, 75 gm/m^2/day of algal biomass and 35 ml/m^2/day of microalgal oil can be produced. Bajhaiya et al.[16] further reported that if microalgae is cultivated in < 2-3% of total land area, it can fulfill the nation's liquid fuel demand. Molina et al.[18] suggested that Sundarbans delta archipelago of 100 islands (Bay of Bengal) can be used for algal cultivation and extraction of biodiesel. Microalgae have the highest biofuel production potential i.e., 15 to 300 times more than terrestrial oil seed crops on area basis[19]. The microalgae cultivation can be increased by utilization of wastewater from domestic and industrial sectors that contain necessary nutrients for its growth. Compared to edible & non-edible oil based biodiesel, the stability of biodiesel from microalgae is the added advantage, which means that the biodiesel remains unchanged in fuel quality for a longer period of time.

In India, extensive work has been done on the utilization of microalgae for food and the pharmaceutical applications, but very little work on cultivation, harvesting, oil production, biodiesel conversion & its utilization as the engine fuels. Table 1 provides the status of R&D being done in India on various aspects of microalgal biodiesel.

Table 1 Status of R & D work on microalgae in India[20]

Institutions/Organizations	Work on microalgae species	R & D areas
University of Madras, Chennai	*Sargassum*	Cultivation
University of Madras, Chennai	*Seaweeds*	Biogas production
University of Madras, Chennai	*Botryococcus braunii*	Cultivation in open raceway pond
Central Food Technological Research Institute (CFTRI), Mysore	*Botryococcus braunii*	Isolation and characterization of hydrocarbon
Vivekananda Institute of Algal Technology (VIAT), Chennai	*Microalgae*	Development of technology to treat industrial waste water
Central Rice Research Institute (CRRI), Cuttack, Orissa	*Chlorella vulgaris*	Production
Vivekananda Institute of Algal Technology (VIAT), Chennai	*Microalgae*	Biofuel production from diatom species
Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee	*Microalgae*	Conversion of Microalgal oil to biodiesel, its stability and cold flow properties
CSMCRI, Bhavnagar	*Gracilaria, Gelidium, Kappaphycus*	Cultivation
Synthetic Biology & biofuel Group (ICGEB, New Delhi)	*Chlamydomonas, Chlorella sp and cyanobacteria*	Growth and biofuel production
Vivekananda Institute of Algal Technology (VIAT), Kolkata	*Green algae*	Productivity of open pond micro algae production for algal oil
Vivekananda Institute of Algal Technology (VIAT), Rajasthan	*Desmococcus olivaceous*	Pulsed magnetic field (PMF) can be suitably integrated with the existing mass cultivation technology to enhance the bio-fuel quality of algal oil

CONCLUSIONS

In recent times, microalgae has been found to produce 19,000-57,000 liter compared to 2000-2500 liter of biodiesel per acre from edible & non-edible oils. Apart from biodiesel production, a number of byproducts can also be produced such as food, feeder, fertilizer, antioxidant, polysaccharides, pharmaceuticals, biopolymers etc. which can be utilized by human. Approximately 50,000 microalgae species exist all over the world but all species are not suitable for biodiesel production. The present paper discusses that the availability of microalgal species, their advantages, oil productivity, land requirement & economics of biodiesel production. The Indian R&D status on various aspects of microalgal biodiesel is also given. Presently the resources availability is a major concern all over the world. Sincere efforts are, therefore, needed to grow the resources, extract the oil, convert to biodiesel, maintain its fuel quality in compliance with diesel and finally its use for diesel engine operation.

ACKNOWLEDGMENTS

One of the authors (MK) greatly acknowledges the financial support from Ministry of human resources and development, Govt. of India in the form of research scholarship.

REFERENCES

1. Information on www.petroleum.nic.in/pngstat.pdf‛assessed on 09/02/2014
2. Information on www.mnre.gov.in assessed on 21/02/2014
3. Information on http://www.globalbioenergy.org/ assessed on 27/02/2014
4. H.M. Amaro, C. Ângela, A.C. Macedo and F.X. Malcata. Microalgae: An alternative as sustainable source of biofuels? *Energy*, **2012**, 44, 158-166.
5. M. Kumar and M.P. Sharma. Potential assessment of microalgal oils for biodiesel production: A review. *J. Mater. Environ. Sci*, **2014**, 3, 757-766.
6. S. Rajvanshi and M.P. Sharma. Micro Algae: A Potential Source of Biodiesel. *Journal of Sustainable Bioenergy Systems*, **2012**, 2, 49-59.
7. E. Suali and R. Sarbatly. Conversion of microalgae to biofuel. *Renewable and Sustainable Energy Reviews*, **2012**, 16, 4316-4342.
8. A. Parmar, N.K. Singh, A. Pandey, E. Gnansounou and D. Madamwar. Cyanobacteria and microalgae: a positive prospect for biofuels. *Bio.Tech*, **2011**, 102, 10163-10172.
9. I. Rawat, R.R. Kumar, T. Mutanda and F. Bux. Biodiesel from microalgae: A critical evaluation from laboratory to large scale production. *Applied Energy*, **2013**, 103, 444-467.
10. M. Daroch, S. Geng and G. Wanga,Biodiesel production by microalgal biotechnology. *Applied Energy*, **2013**, 102, 1371-1381.
11. Y. Li, M. Horsman, N. Wu and C.Q. Lan and N. Dubois-Calero. Biofuels from Microalgae Biotechnol. *Prog*, **2008**, 24, 815-820.
12. Information on www .nrel.gov/docs/fy10osti/48380.pdf‛ assessed on 12/03/2014
13. M. Kumar and M.P. Sharma. Production Methodology of Biodiesel from Microalgae. *International Journal of Applied Engineering Research*, **2013**, 8, 1825-1832.
14. Information on www.intechopen.com/download/pdf/33981assessed on 15/03/2014
15 Y.C. Sharma, B. Singh and J. Korstad. A critical review of recent methods used for economically viable and eco-friendly development of microalgae as a potential feedstock for synthesis of biodiesel. *Green Chemistry*, **2011**, 13, 2993-3006.
16. A.K. Bajhaiya, S.K. Mandotra, M.R. Suseela, K. Toppo and S. Ranade. Algal biodiesel: the next generation biofuel for India. *Asian J. Exp. Biol. sci*., **2010**, 1, 728-739.
17. K. Sudhakara, M. Premalathab and M. Rajesha. Large-scale open pond algae biomass yield analysis in India:a case stud**y.** *International Journal of Sustainable Energy*, **2012**, 1, 1-12.
18. E.M. Grima, E.H. Belarbi, F.G.A. Fernandez, A.R. Medina and Y. Chisti. Recovery of microalgal biomass and metabolites:process options and economics. *Biotechnol. Advances*, **2003**, 20, 491-515.
19. F. Alam, A. Datea, R. Rasjidina, S. Mobinb, H. Moria and A. Baquic. Biofuel from algae- Is it a viable alternative. *Procedia Engineering*, **2012**, 49, 221-227.
20. M. Kumar, M.P. Sharma and G. Dwivedi. Algae Oil as Future Energy Source in Indian Perspective. *International Journal of Renewable Energy Research*, **2013**, 3, 913-921.