Algae Biofuel: Futuristic Trends in Fuel Industry

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Abstract - *The need of energy is increasing constantly because of increase in population and industrialization globally. Human population, technological integration, and improved lifestyle continuously add the pressure for generation of energy. Energy and related services are the backbone of growth and development of any country. The present scenario indicates use of non-renewable sources namely coal, petrol, diesel, nuclear fuel, natural gas, etc. for the production of energy. Fossil fuels are limited in amount and are major cause for pollution and emission of green house gases (GHG). Hence, efforts are being made to investigate alternative source of energy which must be readily available, environmentally acceptable, technically feasible and economically competitive.*
This research paper talks about energy from biomass (one of the renewable source of energy). Algae can be used as a fuel for the automobile. Sewage water algae are having calorific value around 15000kJ/kg which is comparable with the Indian coal used for power production.

Key Words: fossil fuel, algae, calorific value .

1. INTRODUCTION

Most of the Indian demand of energy is satisfied with the importing petroleum products from the foreign country. Power consumption per capita symbolizes the development of the said country and living standard of their citizens. Affordable energy contributes to rise in productivity, reduction in poverty and improving betterment of life. Reduction in the availability of fossil fuel in the earth with a rising fuel demand causing global worry and hence opens new doors for the research on alternative sources of energy. Hence, efforts are being made to investigate alternative source of energy which must be readily available, environmentally acceptable, technically feasible and economically competitive.

Solar energy, wind energy, tidal energy, hydal energy, energy from biogas, energy from biomass, fuel cell, geothermal energy etc. are different resources for production of energy via renewable energy resources. Biodiesel production from biomass is now considered to be the most recent, challenging and interesting field for researchers.

Recent research shows that biodiesel from algae (third generation for biofuel generation) is the most promising renewable fuel derived from biomass. Figure 1 shows SWOT analysis of potential of biofuel in India.

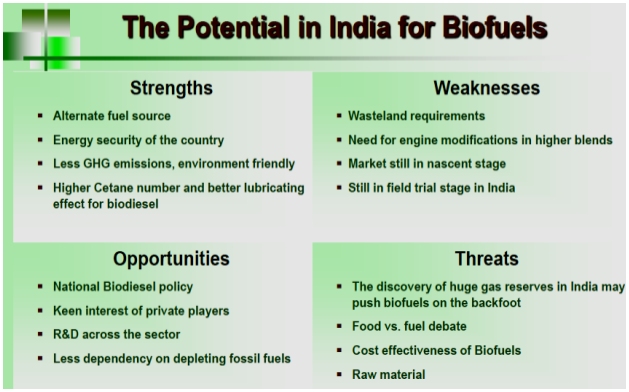

Figure 1: SWOT Analysis [DBT-CII Report 2010][2]

The first generation of biomass was using groundnut, cottonseeds, risebrans, coconut, mustard, palm etc. has a raw material for the production of biodiesel. In above case, there is a matter between food v/s fuel and in that case always food will win. Hence, the first generation of biomass was not feasible solution for production of biodiesel. The second generation of biomass contains jojoba, mahuva, karanj, Jetropha, kokum, castor been, neem etc. as a raw material for the production of biodiesel for production of power or to run vehicles. Table 1 depicts generation of biofuels;

Table 1: Generation of biofuel[3]

First generation Biofuels :	Grains and sugar to Ethanol , Vegetable oil to Biodiesel.
Second Generation Biofuels :	Lignocellulose to Alcohols , Lignocellulose to Green Diesel ,Vegetable oils to Green Diesel.
Third generation Biofuels:	Biomass to Hydrogen , Algal Hydrogen , Algal Oil/Biodiesel.
Fourth generation Biofuel :	Biofuel from high solar , efficiency cultivations

2. ABOUT ALGAE

Algae are one of the most photosynthetically efficient plant sources available in the entire world with the single

cellular structure. There are various ways to classify algae,like;

1) According to plant kingdom,
   - Spore Bearing Plants- algae, ferns, mosses,
   - Seed Bearing Plants- flowering plants,
2) Based on pigment,
   - Green algae,
   - Red algae,
   - Brown algae,
   - Green-blue algae.

Like plants, algae require primarily three components to grow: sunlight, carbon-dioxide and water. Photosynthesis is an important bio-chemical process in which plants, algae, with some bacteria convert the energy of sunlight to chemical energy.

Following unique characteristics of algae makes attentions of researcher, scientist, industrialists, R & D peoples etc, towards it;

a) It is renewable source of energy (cleaner and greener alternative),
b) It is available worldwide,
c) It is eco-friendly in nature or less pollutant, negligible emission of SOx and NOx,
d) In India, algae is not used as a fuel,
e) It requires very less or no need of fresh water for growth,
f) Under optimal conditions, algae mature within 18 to 20 hours (daily production is possible for oil),
g) Algae possess self contained oxygen and hence complete combustion of derived fuel in the engine cylinder is possible,
h) Algae act as cleaning agent. And hence for cleaning of waste water or for water treatment algae can be used,
i) One can earn carbon credit by carbon sequestration using algae,
j) Its co products / process outputs are mainly biochar and glycerol. Biochar can be used as animal feed, seeds for poultry farms, or can be used as fuel pallets for production of biogas / methane for generation of carbon free electrical energy. Glycerol has also many applications in the market.

Algae range from small, single-celled organisms to multi-cellular organisms, some with fairly complex and differentiated form. Algae are usually found in damp places or bodies of water like sea, lakes, ponds, rivers, canals, bogs, marshes, blackish water and swamps - salt marshes ,salt lakes and places where the water is stored and thus are common in terrestrial as well as aquatic environments. Table 2 represents the strong comparison of algae v/s other crops for the production of biofuel.

Table 2: Comparisons of different crops[5]

Sr. No.	Crop	Oil yield (L/ha per year)	Land area needed (M ha)
1	Corn	175	1542
2	Soybean	444	595
3	Canola	1193	225
4	Jetropha	1895	139
5	Coconut	2690	96
6	Oil palm	5951	44
7	Microalgae	136905	2.1

3. STEPS FOR ALGAE TO BIODIESEL CONVERSION

Algae-to-biofuel production is divided into four stages, namely a) Algae cultivation, b) Biomass harvesting, c) Algae oil extraction, and d) oil and residue conversion.

Each of the first four stages is further subdivided into basic, individual, or multiple processes to explain the primary components of algal biofuel production that may have positive or negative environmental externalities [6].

4. COLLECTION OF ALGAE

The saline water which contain more amount of impurities like carbon, phosphorus, sulfur etc. with sufficient 08 to 10 hours of sunlight and average atmospheric temperature of 20^0C to 28^0C cause favorable condition for the algae to mature faster. Hence, test sample from sewage water is collected and laboratory testing (proximate analysis) is decided.

The sample of waste water algae was collected near Panchamahal dairy, Godhra. The cultivated algae was collected, dewatered and dried with help of natural sunlight. The dried algae samples were sent for laboratory test at Vadodara and at Vallabh Vidyanagar, Anand. Figure 2 represents various steps of algae harvesting and dewatering of sewage water algae.

Figure 2: Harvesting and dewatering of sewage water algae

5. RESULT AND DISCUSSION

Proximate analysis [31] is the one in which only fraction of moisture, volatile matter, ash, carbon etc. are determined. Thus proximate analysis is not exact and gives only some idea about the fuel composition.
Proximate analysis of coal gives various constituents in following range, Moisture 3–30%, Volatile matter 3–50%, Ash 2–30% and fixed carbon 16–92%.
Comparison of conventional fuel (diesel and Indian coal) with different collected algae samples using proximate analysis (in which only fraction of volatile matter, ash, moisture content, carbon etc. are determined) is shown in Table 3.

Table 3 : Comparison of various algae samples and other fuels with proximate analysis

Sample Type	Moisture (%)	CV (KJ/Kg)	Ash (%)	FC (%)	VM (%)
Diesel	0	41000-44800	0.006	-	-
Coconut shell powder [32]	----	19601	0.35	20.58	79.07
Almond [32]	----	19582	1.63	21.54	76.83
Coal[29]	4.5	15039	34.56	24.6	25.04
Algae from Sewage Water	5.04	13041.6	37.38	7.01	50.12

- % moisture content in algae is very nearer to the Indian coal used for power production in the thermal power plants.
- Calorific value and fixed carbons in the algae samples are less than the coal .
- % ash content and % volatile matters in algae sample is found more than that of coal.

6. CONCLUSION

From the laboratory test reports, the calorific value of sewage water algae is found competitive with that of coal. So product obtained from the above algae i.e. algae biodiesel may have considerable calorific value compare to the diesel. And hence algae can be used as a fuel and thereby the oil obtained from it may be used as a fuel for automobile.

REFERENCES

[1] A report on Energy Statistics 2013 by Central Statistics Office, National Statistical Organization, Ministry of Statistics and Programme, Implementation, Government of India,2013.
[2] Dr. Swarup Renu, a presentation on Biofuels - The Indian Scenario at TERI, New Delhi, India, 7th December, 2010.
[3] H.N. Chanakya, Durga Madhab Mahapatra, Sarada Ravi, V.S. Chauhan and R. Abitha, "*Sustainability of Large-Scale Algal Biofuel Production in India*" in Journal of the Indian Institute of Science-A Multidisciplinary Reviews Journal, ISSN: 0970-4140 , VOL 92:1, Jan.–Mar. 2012.
[4] Singh Jasvinder , Sai Gu , '*Commercialization Potential of Microalgae for Biofuels Production*", Renewable and Sustainable Energy Reviews ,Vol.14 2010 ,pp-2596–2610.
[5] Mahesh Kumar, M P Sharma, Gaurav Dwivedi,' *Algae Oil as a Future Energy Source in Indian Perspective'*, published in international journal of renewable energy research, voulme3, no.4 , 2013,pp 913-921.
[6] Catie Ryan, "*Cultivating Clean Energy: The Promise of Algae Biofuels*", Report to Natural Resources Defense Council. USA, October 2009.
[7] Mary Solecki, Anisa Dougherty, Bob Epstein, Advanced Biofuel Market Report 2012- Meeting U.S. Fuel Standards, USA, 2012.
[8] Ferrell John, Valerie Sarisky-Reed, National Algal Biofuels Technology Roadmap Workshop and Roadmap sponsored by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Office of the Biomass Program Publication Date: May 2010.
[9] Sayadi M.H., Ghatnekar S.D., Kavian M.F., Article on "*Algae a promising alternative for biofuel*", Proceedings of the International Academy of Ecology and Environmental Sciences, 2011, 1(2):pp-112-124.
[10] Kumar Mukesh, Sharma M.P., Dwivedi Gaurav, "*Algae Oil as Future Energy Source in Indian Perspective*", International Journal of Renewable Energy, Vol.3, No.4, 2013, pp13-921.
[11] Angeles Cancela , Rocio Maceiras , "*Microwave-Assisted Transesterification of Macroalgae*", Energies 2012, 5, 862-871; doi:10.3390/en5040862.
[12] Nafisa M. Aminu, Nafi"u Tijjani and Y.Y. Aladire, "*Overview of Biodiesel Production from Algae in Nigeria and Some Developing Countries*", International Journal of Scientific & Engineering Research ,ISSN 2229-5518,Volume 4, Issue 1, January-2013 ,pp 1-9.
[13] Nailwal Shweta, Nailwal Tapan Kumar, Sharma Meenakshi, "*Physico-Chemical Characterization*

of Algal Oil of Kumaun Himalayan Origin for Potential Biofuel Application', Journal of Applied Phytotechnology in Environmental Sanitation, 2013,2 (4): 91-98.

[14] Kanyaporn Chaiwong , Tanongkiat Kiatsiriroat , et al., '*Biochar production from freshwater algae by slow pyrolysis",* Maejo Int. J. Sci. Technol. , ISSN 1905-7873,2012, 6(02),2012 ,pp186-195.

[15] Qingyu Wu, Xiaoling Miao, A presentation on "*Biofuels production from Microalgae after heterotrophic growth* " from Department of Biological Sciences and Biotechnology, Tsinghua University, Beijing 100084, P.R. China.

[16] A. K. Bajhaiya, S. K Mandotra, M.R. Suseela, Kiran Toppo ,S. Ranade, "*Algal Biodiesel: the next generation biofuel for India",* Asian J. Exp. Biol. Sci. Vol 1 (4) ,2010, 729-739.

[17] Rajvanshi Shalini, Mahendra Pal, *"Microalgae: A Potential Source of Biodiesel",* http://dx.doi.org/10.4236/jsbs.2012.23008, Journal of Sustainable Bioenergy Systems, 2012, 2, 49-59 .

[18] Leonard Wagner, Research report on Biodiesel from Algae oil to MORA ASSOCIATES, July 2007.

[19] Deep Satapathy, *"New Dimension to Algae Fuel: Far from Light and Closer to Human Needs",* Open Access Scientific Reports, http://dx.doi.org/10.4172/scientificreports.671, Volume 2 , Issue 3 , 2013.

[20] Antonio Jose de Jesus de San , Juan Bosco Echevarria Parres, *"Process and Apparatus for Extracting Biodiesel from Algae",* United states Patent Application Publication, US2011/0189741 A1, Aug 4, 2011.

[21] Daniel Chaumont, *"Biotechnology of algal biomass production: a review of systems for outdoor mass culture",* Journal of Applied Phycology 5: 593-604, 1993.

[22] Al Darzins and Philip Pienkos , *Algae as a Feedstock for Biofuels -An Assessment of the Current Status and Potential for Algal Biofuels Production*, NREL, US, July, 2011.

[23] Benemann J., *"Japanese NEDO RITE Project 1990-2000, Overview: Algae Oil to Biofuels*, November 3, 2008, http://www.nrel.gov/biomass/pdfs/benemann.pdf.

[24] A. Annam Renita, D. Joshua Amarnath, and S. Sivasubramanian, *"A Study on the Optimization of Algal Biodiesel Reaction Parameters Using Response Surface Methodology",* International Journal of Chemical Engineering and Applications, Vol. 3, No. 5, October 2012,pp 311-314.

[25] Carbon Sequestration - Access Engineering from McGraw-Hill http://accessengineeringlibrary.com/browse/energy-systems-engineering-evaluation-and-implementation-second-edition/c9780071787789ch07 #ch07 pp1/29.

[26] Chee Loong Teo, Ani Idris, '*Rapid alkali catalyzed transesterification of microalgae lipids to biodiesel using simultaneous cooling and microwave heating and its optimization'*, published in journal of Bioresource Technology 174 ,2014, pp311–315.

[27] Bhaskar Singh, Abhishek Guldhe, Ismail Rawat, Faizal Bux, '*Toward sustainable approach for development of biodiesel from plant and microalgae',* published in journal of Renewable and Sustainable Energy Reviews29, 2014, pp216–245.

[28] Beatriz Castillo López et al., '*Production of biodiesel from vegetable oil and microalgae by fatty acid extraction and enzymatic esterification'* , article in press in journal of Journal of Bioscience and Bioengineering ,VOL. xx No. xx, 2014, pp1-6.

[29] Anudhyan Mishra,' *Assessment of Coal Quality of Some Indian Coals',* a thesis submitted at NIT Rourkela, 2009.

[30] Zoran K. Morvay , Dusan D. Gvozdenac,' Fuels, Combustion and Environmental Impact', toolbox-5 from a book of Applied Industrial Energy and Environmental Management by John Wiley & Sons, Ltd.

[31] Onkar Singh, Applied Thermodynamics', third edition, New Age international Publishers, New Delhi.

[32] Jigisha Parikh, S.A.Channiwala, G K Ghosal, *'A correlation for calculating HHV for proximate analysis of solid fuels'*, Fuel, 84,2005, pp. 487-494.

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