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Algae Farming: A Way Towards Prosperity

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Abstract

Affordable energy contributes betterment of life, increasing productivity and reducing poverty thereby increase living standard of citizens of country. Increase in population causing utilization fossil as well as natural resources for various forms of energy production. So one has to think for production and use of such fuel which is not only potential alternative for fossil fuel, but also eco-friendly in nature and causing improvement in life standard.

This research paper is talking about reasons for algae farming at Godhra, a small city of Gujarat state, India. Biodiesel from algae (third generation) is promising resource to improve living standard of people from Godhra of Panchmahal district of Gujarat state, India. According to the laboratory test results, the calorific value of the algae sample collected from sewage water is around 13041kJ/kg which is nearer to the calorific value of Indian coal(15039 kJ/kg) used in the power plants. Hence algae farming may be the way towards prosperity as algae biodiesel can be used as a fuel.

Keywords: *calorific value, algae, biodiesel*

1. Introduction

Requirement of different forms of energy is essential for survival, development and for better living standard. The industrial growth and economical expansion in India is largely due to the fossil fuels. Majority of the petroleum products are transported from the other countries or in other words, for petroleum products, the country is dependent on upon countries like Iran, Iraq, Saudi Arabia *etc.*,

The products of crude oil (fossil fuel) content coal, crude oil, natural gases etc. Fossil fuels are limited in amount and they are continuously depleting. Hence daily changes in their prices in the international markets cause drastic changes in Indian economy. Indian economy is a DIESEL DRIVEN economy and hence the changes in the diesel prices in the international market cause large change in the various commodity prices. Out of the revenue generated by selling the products by India to the other foreign countries majority of the amount is consumed to purchase crude oil and related products from foreign countries. In this research paper, main concentration is focused upon replacement of diesel which is used as fuel for automobile and for power production. Figure 1 shows the diesel consumption in the year 2005-06 by different sectors in India.

In India, the fossil fuel is used in the power plants for production of electrical energy and in the vehicles for transportation of goods and various commodities *etc*. Use of fossil fuel cause formation of exhaust gases containing CO, CO_2, NO_X, SO_X, particulates *etc*. known as green house gases (GHG) liable for harmful effects on human, animal and plants lives as well as spoil land. They are also responsible for increase in the average temperature of atmosphere especially in the summer seasons which causes, high temperature and play a vital role in the global warming. These gases are main reasons for

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many diseases and responsible for unexpected changes in the climate conditions, land, water and air pollutions.

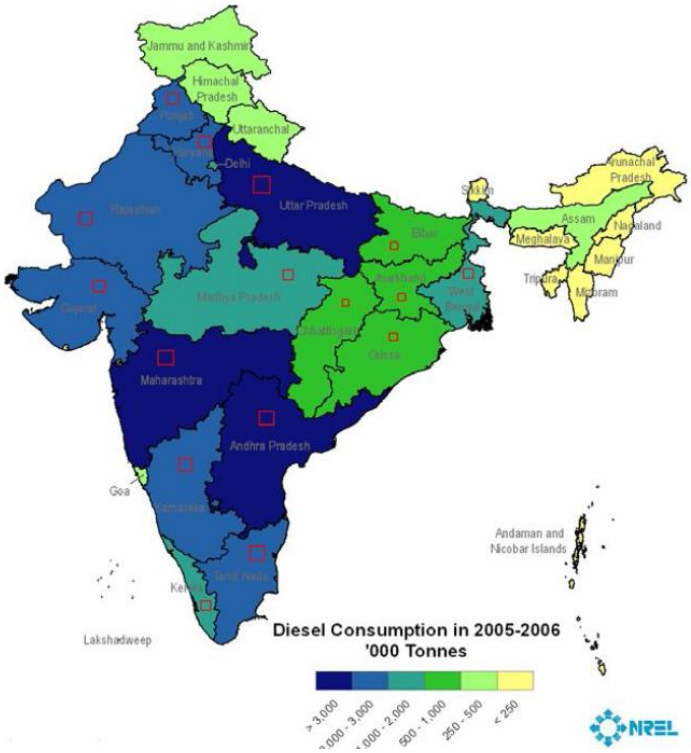


Figure 1. Annual Diesel Consumption in India [1]

Figure 2 represents the emission of carbon dioxide gas by large stationary plants in India of year 2007.

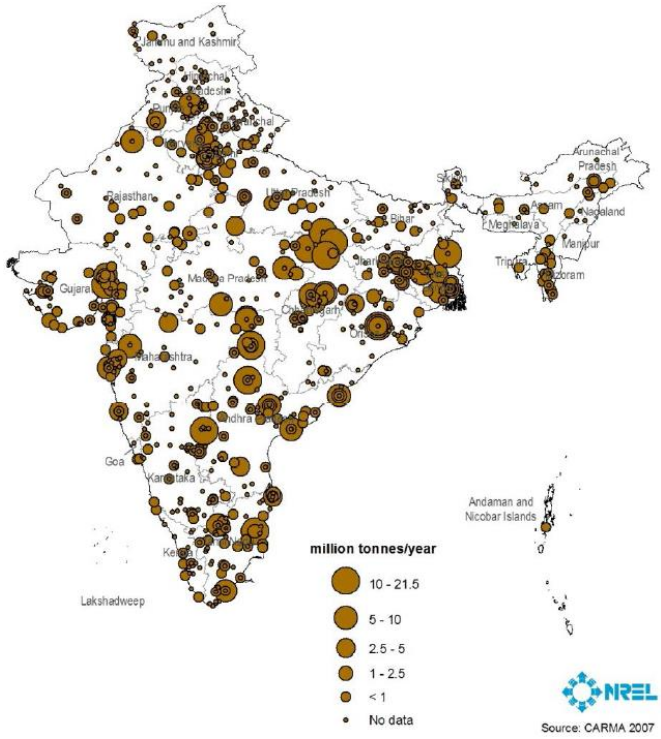


Figure 2. CO_2 Emission from Large Stationary Sources in 2007 [1]

Gujarat is one of the most famous states of India. It is the birth place of freedom fighters Shri Mahatma Gandhi, Shri Sardar Vallabhbhai Patel *etc*. well known in the world. Gujarat is also famous for industrial hub for fastest growing sector like automobile, textile, dairy and information technology. The total population of the state is more than 7 crores. The state is having more than 80 lacs of vehicles. The annual diesel consumption of state is around 2850000 tonnes as per the survey of 2005-06[1] and at the end of 2015 it is expected to be 10000000 tonnes. Transportation sector is consuming large amount of petrol, diesel or gases as fuel compared to industrial, agriculture and domestic sectors at Gujarat. The emitted GHG gases are equally responsible for highest temperature (more than 45^0C) during summer season, abrupt changes in the climate conditions, land, and water and air pollution. It has waste land (approximate 19602400 ha) [1] (refer Figure 3).

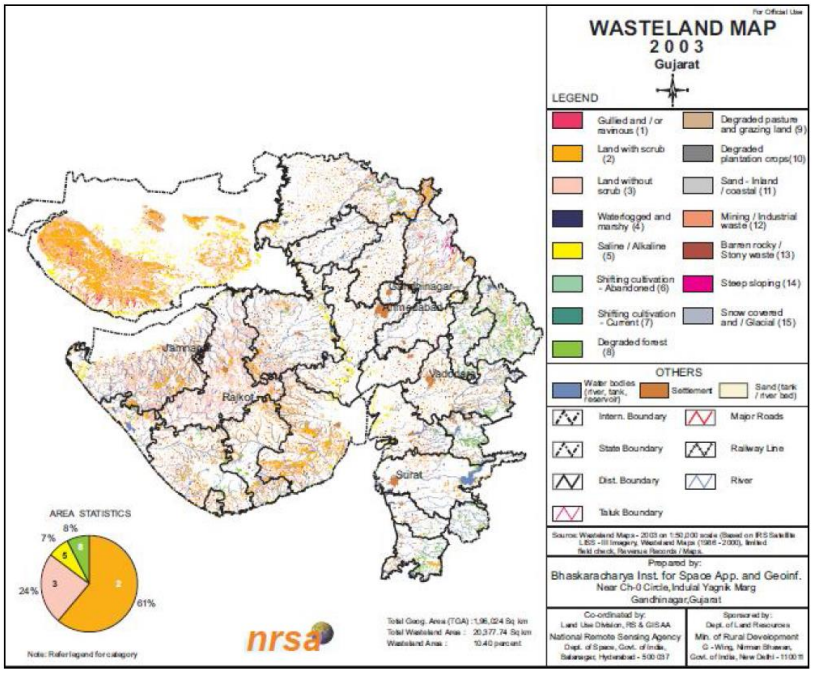


Figure 3. Waste Land in Gujarat [1]

Dependency for crude oil upon foreign countries, huge fluctuation of crude oil prices in international market, emission of GHG, limited in amount, adverse effect on earth causes researchers to find out alternate way to replace petroleum products.

2. Renewable Energy

The renewable energy is available large in amount, available at free of cost and eco-friendly. So one can think for renewable energy sources like solar energy, wind energy, hydro energy, geothermal energy, tidal energy, energy from biogas *etc.*, According to the available technology, one has to find out the feasible solution to minimize GHG emission/ pollution as well as to utilize available waste-land, saline/waste water to improve life standard of people of the state.

In Gujarat, geothermal energy and energy from biomass cannot be used for conversion into useful energy/ electrical energy as there are very less sources availability. The state possesses long seashore but due to limited technology, the use of tidal energy and wind energy is providing electrical energy at very high cost and hence it is not considered. Due to availability of water in the entire year, very few hydro power plants are available in the state and they are providing electrical energy to the fraction part of the state. In the state annual average solar radiation intensity is approximately 4kWh/m^2 per day (approximately 13.7MJ/ m^2) (refer Figure 4) which is encouraging use of solar water heater, solar street lights, solar cookers, solar lanterns, solar stove *etc*. All above equipments are costlier, take more time than the conventional systems, take considerable time in payback and hence very few peoples (for domestic purpose as well as for industrial purpose) are utilizing above source of energy.

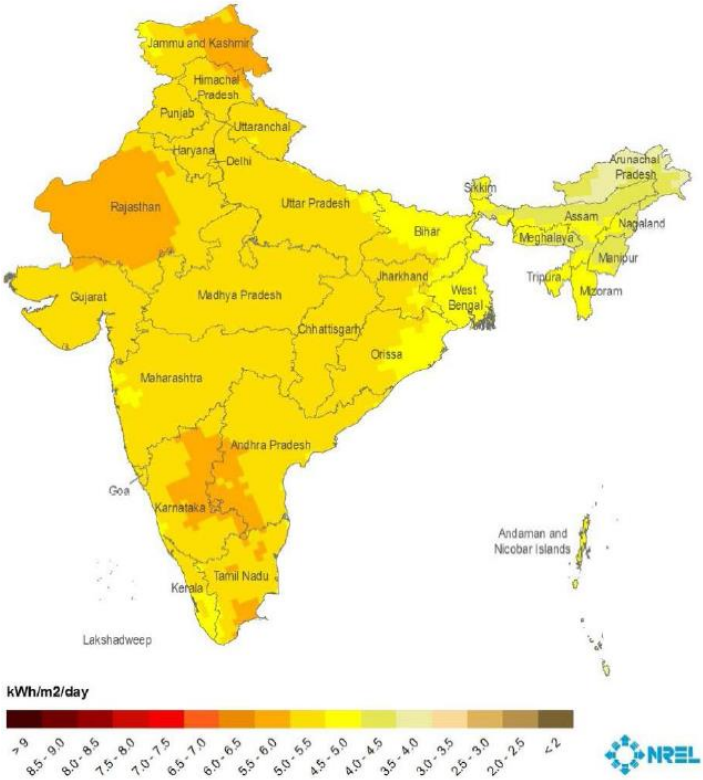


Figure 4. Annual Average Horizontal Solar Radiation in India[1]

The mission is to use the most suitable form of renewable energy which neither give only reduction in GHG emission/ pollution, nor only providing energy but also to improve the living standard of the people. For the mission, Godhra city of Panchmahal district from Gujarat state is selected and research is made start. Lots of places in the Panchmahal district of Gujarat are falling under tribal zone.

The peoples are very poor with having lowest level of living standards. So the peoples from Panchmahals are migrated for earning at various places in the state and doing labor work to satisfy their daily needs. The major reasons for the poverty are illiteracy, large amount of waste land, very less amount of water for the irrigation etc. Solar energy, hydro energy, tidal energy, geothermal energy, wind energy, energy from biogas is not effectively used here because of cost, illiteracy, lack in technical knowledge *etc*. So one has to think for some other alternate source of renewable energy source *i.e.*, biomass.

3. About Algae

Compare to all other sources of renewable energy sources like solar energy, geothermal energy, tidal energy, wind energy, energy from biogas, hydro energy *etc.*, algae biodiesel has proved its importance by considering following factors;

a)Renewable, b) worldwide available, c) eco-friendly, d) not a FOOD in India, e) no/ less pollutant, little emission of SOx and NOx, f) blending may possible with existing fossil fuels, g) cleaner and greener alternative, h) less or no requirement of fresh water for growth, i) mature within 18 to 20 hours (daily production is possible for oil), j)carbon credit by carbon sequestration, k)self contained oxygen and hence complete combustion is possible in engine, l) act as cleaning agent in waste water for water treatment.

In the biomass, biodiesel production from algae(third generation) is selected because of single cellular structure, worldwide availability, photosynthetic organism, no leaf, no roots, grow faster in blakish water, sea water, saline water, *etc.*, mature within maximum

of 18-20 hours, absorb CO2, release fresh oxygen, very low sulphur content, *etc*. Thus under optimal conditions, it can be grown in massive, almost limitless amounts [3, 4](refer table 1).

Table 1. 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

Figure 4 depicts blakish ground water availability in India. From above figure, Gujarat is having salinity in ground water is more than 3000µs/cm at 250C which is equivalent to 2100mg/lit or ppm [1].

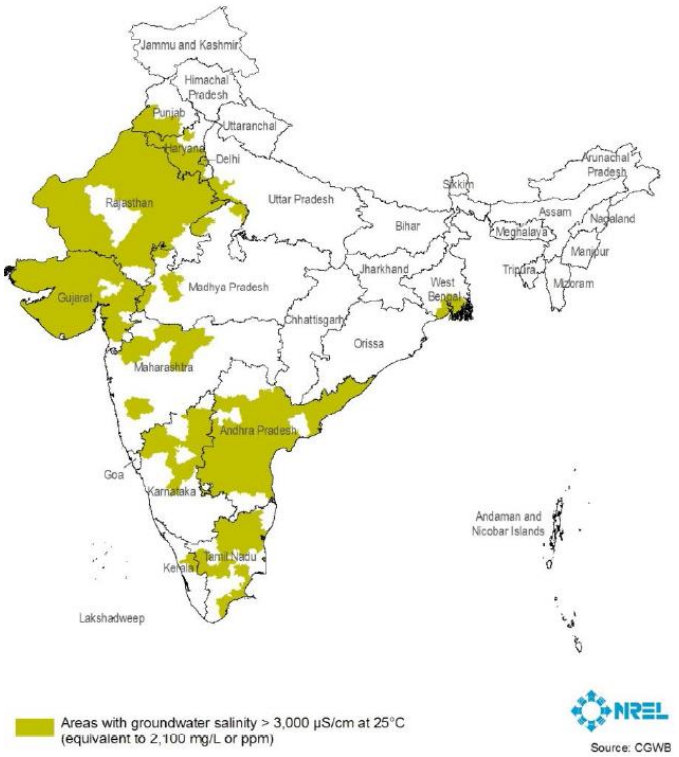


Figure 4. Blackish Groundwater in India[1]

For the algae cultivation and growth, sufficient amount of solar radiation (minimum 09 hours per day), water (drinkable/saline/blackish) and carbon dioxide, nutrients are required in ample amount.

So the first target is to prove that algae can be used as a fuel. For that one has to collect algae samples and go for laboratory testing of samples. Comparison of calorific value with the conventional fuel is made and algae characterization of algae is done. For that the algae samples are collected from various places of Godhra.

4. Collection of Algae

The initial task is to prove algae can be used as a fuel. The algae samples are collected from sewage water near Panchmahal Dairy, waste water available near Bhuravav cross road, river behind Seva Sadan, Godhra. The algae samples are collected washed. The collected algae samples are dried using sunlight. All the dried mass of algae is send to laboratories for various tests.

4.1. Algae Collected from Waste Water

The sample of waste water algae was collected from the waste water sump nearer to Bhuravav cross road, Godhra. The cultivated algae was collected in a jar and dried with help of sunlight on the terrace of Government Engineering College, Godhra. Figure 5 represent algae harvesting and dewatering of algae from waste water.

(a) Harvested Algae (b) Dry Algae

Figure 5. Sample of Waste Water Algae

4.2. Algae Collected from River

The sample of waste water algae was collected from the river near Seva Sadan, Godhra. The cultivated algae was collected in a jar and dried with help of sunlight on the terrace of Government Engineering College, Godhra. Figure 6 represent algae cultivation and dewatering of algae from river water.

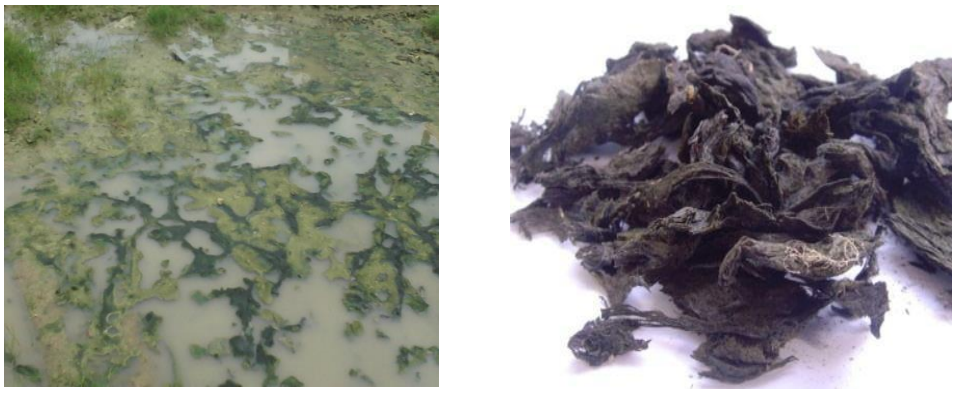
(a) Cultivated Algae (b) Wet Algae

Figure 6. Sample of River Water Algae

4.3. Algae Collected from Sewage Water

The sample of waste water algae was found near Panchamahal dairy, Godhra. The cultivated algae was collected in a jar and dried with help of sunlight on the terrace of

Government Engineering College, Godhra. Figure7 represent various stages of algae harvesting and dewatering of algae from sewage water.



(a) Cultivated Algae (b) Dry Algae

Figure 7. Sample of Sewage Water Algae

5. Result and Discussions

Comparison of conventional fuel (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 2.

Table 2. Comparison of Laboratory Test Results of Various Algae Samples and Indian Coal using Proximate Analysis

Sample Type	Moisture (%)	CV (KJ/Kg)	Ash (%)	FC (%)	VM (%)
Indian Coal[6]	4.5	15039	34.56	24.6	25.04
Algae from Sewage Water	5.04	13041.6	37.38	7.01	50.12
Algae from Waste Water	3.68	4401.54	76.56	1.07	18.68
Algae from River	5.4	5952.53	44.51	3.01	47.08

- % 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.

Comparison of conventional fuel (diesel and Indian coal) with different collected algae samples using ultimate analysis (individual elements such as carbon, hydrogen, oxygen, nitrogen, sulpher, ash present in the fuel are determined on mass basis).

Table 3. Comparison of Laboratory Test Results of Various Algae Samples and Indian Coal with Ultimate Analysis

Sample Type	Carbon (%)	Hydrogen (%)	Nitrogen (%)	Oxygen (g/kg)	Sulpher (g/kg)
Indian Coal[7]	0.847	0.026	0.01	0.016	0.011
Algae from Sewage Water	14.96	1.47	4.27	1.32	0.88
Algae from Waste Water	5.39	1.07	3.51	3	2
Algae from River	13.63	2.13	3.94	0.8	0.6

- Percentage of carbon, hydrogen, oxygen, nitrogen, sulpher, ash is 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 coal. And hence algae can be used as a fuel and thereby the oil obtained from it may be used as a fuel for automobile. Thus the use of algae as a fuel for automobiles leads towards minimum emission of green house gases (GHG) to the environment and keeps the earth CLEAN (non-polluted) and GREEN.

From the reports, calorific value of sewage water algae is found higher than that of river water algae due to the fact that more amount of carbon, metals and nutrients like phosphorus, sulpher etc., available in the sewage water .

7. Future Scope

- ❖ Set up will be designed for conversion of algae to algae oil to algae biodiesel.
- ❖ The obtained biodiesel will be tested in the laboratory and comparison will be made with the conventional fuel (diesel).
- ❖ Performance test of IC engine using blending of biodiesel and exhaust gas analysis may also be done.

References

[1] A. Milbrandt and E. Jarvis, "A report on 'Resource Evaluation and Site Selection for Microalgae Production in India", submitted to NREL (national renewable energy laboratory) USA, **(2010)**.
[2] A. Mehta and N. Mehta, "Conversion Techniques for Oilgae to Biodiesel for Automobile: Overview in Context to Indian Perception", published in International Journal of Research and Scientific Innovation (IJRSI), vol. I, no. VII, **(2014)**, pp. 614-616.
[3] T. J. Lundquist, I. C. Woertz, N. W. T. Quinn and J. R. Benemann, "A Realistic Technology and Engineering Assessment of Algae Bio-fuel Production", Energy Biosciences Institute, University of California, Berkeley, **(2010)**.
[4] A. Mehta and N. Mehta, "A Review on Algae Biodiesel: A Novel Source of Renewable Energy in India", published in International Journal on Recent and Innovation Trends in Computing and Communication (IJRITCC), vol. 2, no. 9, **(2014)**, pp. 2566-2568.
[5] M. Kumar, M. P. Sharma and G. Dwivedi, "Algae Oil as a Future Energy Source in Indian Perspective", published in international journal of renewable energy research, vol. 3, no. 4, **(2013)**, pp. 913-921.

[6] A. Mishra, "Assessment of Coal Quality of Some Indian Coals", a thesis submitted at NIT Rourkela, **(2009)**.
[7] Z. K. Morvay and D. D. Gvozdenac, "Fuels, Combustion and Environmental Impact", toolbox-5 from a book of Applied Industrial Energy and Environmental Management by John Wiley & Sons, Ltd.
[8] S. Renu, "A presentation on Biofuels - The Indian Scenario at TERI", New Delhi, India, 7th December, **(2010)**.
[9] P. T. Pienkos, "The Potential for Biofuels from Algae, A presentation at Algae Biomass Summit", San Fransisco, CA, **(2007)**.
[10] S. Jasvinder and S. Gu, "Commercialization Potential of Microalgae for Biofuels Production Renewable and Sustainable Energy Reviews", vol. 14, **(2010)**, pp. 2596-2610.
[11] C. Ryan, "Cultivating Clean Energy: The Promise of Algae Biofuels", Report to Natural Resources Defense Council, USA, **(2009)**.
[12] M. H. Sayadi, S. D. Ghatnekar and M. F. Kavian, "Article on Algae a promising alternative for biofuel", Proceedings of the International Academy of Ecology and Environmental Sciences, vol. 1, no. 2, **(2011)**, pp-112-124.
[13] A. Krasowska, "Microalgae – Biodiesel Potential Producers: A Review", Proceedings- 1st Annual International Interdisciplinary Conference, AIIC 2013, Azores, Portugal, **(2013)**.
[14] R. Shalini and M. Pal, "Microalgae: A Potential Source of Biodiesel", http://dx.doi.org/10.4236/jsbs.2012.23008, Journal of Sustainable Bioenergy Systems, vol. 2, **(2012)**, pp. 49-59.
[15] L. Wagner, "Research report on Biodiesel from Algae oil to MORA ASSOCIATES", **(2007)**.
[16] A. Milbrandt and E. Jarvis, "A report on 'resource evaluation and site selection for microalgae production in india", submitted to NREL (national renewable energy laboratory)USA, **(2010)**.
[17] M. Solecki, A. Dougherty and B. Epstein, "Advanced Biofuel Market Report 2012", Meeting U.S. Fuel Standards, USA, **(2012)**.
[18] F. John and V. 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, **(2010)**.
[19] K. Bracmort, "A Report on Algae's Potential as a Transportation Biofuel", Congressional Research Service, **(2013)**.
[20] A. Darzins and P. Pienkos, "Algae as a Feedstock for Biofuels-An Assessment of the Current Status and Potential for Algal Biofuels Production", NREL, US, **(2011)**.
[21] Y. Wang, a master's thesis on "Microalgae as the third generation Biofuel: Production, Usage, Challenges and Prospects", submitted at Uppsala University, Uppsala, **(2013)**.
[22] S. Panchal, M. Patel, P. Patel, P. Darji and A. Mehta, "A Review on Cultivation of Green Crude in India", published in International Journal of Research and Scientific Innovation (IJRSI) ISSN 2321-2705, vol. I, no. VII, **(2014)**, pp. 166-170.
[23] J. H. Shah, A. Deokar, K. Patel, K. Panchal and A. Mehta, "A Comprehensive Overview on Various Method of Harvesting Microalgae According to Indian Perspective", published in International Journal of Research and Scientific Innovation (IJRSI), vol. I, no. VII, **(2014)**, pp. 313-317.

