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ALGAE - The Potential Bio-fuel

INTRODUCTION

Algae are a very large and diverse group of simple, typically autotrophic organisms, ranging from unicellular to multicellular forms and most are photosynthetic and "simple" because they lack many of the distinct cell organelles and cell types found in land plants.

Algal growth occurs at an exponential rate in a matter of weeks and it can grow in saline water, freshwater or even contaminated water at sea or in pond and on land not suitable for food production. Algae require sunlight and carbon dioxide as building block for growth. It is interesting to note that land for algae cultivation not in conflict with land for food crops and forest lands.

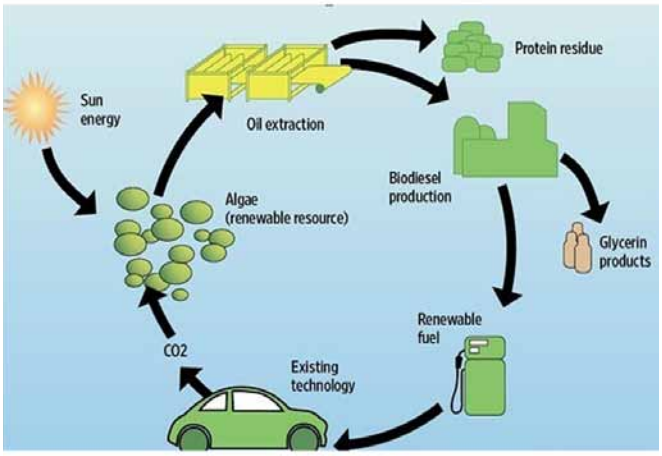
Multiple uses

Algae is potential fuel source that can produce biodiesel, methane and hydrogen. Moreover it is a Fuel source for Biodiesel, Methane and Hydrogen (fuel cell), Bioethanol /biobutanol. Also algae serves as an excellent food supplement as most of the algae have essential complete protein with essential amino acids and it contains high amount of simple and complex carbo-hydrates besides having an extensive fatty acid profile, including Omega 3 and Omega 6 which is very good for health.

Algal biofuel

Algae are potential biofuels and are termed as third generation biofuels as algae produce 70-100 dry tons of biomass per ha as against 12-25 dry tons per ha for terrestrial plants. Moreover, wastelands and wastewaters can effectively be tapped for bio fuel production. Bioremediation property of algae makes it an excellent player in this regard. Simpler nature of algal biomass without lignin component suits well for biomethanation process and daily harvest is possible which make algae more attractive to be potential biofuel in the near future. Algae have the potentiality to yield upto 10000 gallon of oil per annum per acre.

Tamil Nadu with a coastal line of 1076 km and with wastelands of about 4.0 lakh hectares provide ideal ground for large scale algal biofuel production. Moreover, Tamil Nadu owing to its strategic geographic location provides ample scope for algae production as the State has been endowed with abundant solar energy for most part of the year.



Sustainability Concerns for Large-Scale Development of Algal Biofuels

Concerns of High Importance

- *Strain*
- *Quantity of water*
- *Supply of the key nutrients – N, P & CO_2*
- *Appropriate land area with suitable climate and slope*
- *Energy return on investment*
- *GHG emissions over the LC of algal biofuels*

Concerns of Medium Importance

- *waterborne toxicants in cultivation systems*
- *Effects from land-use changes*
- *Air-quality emissions over the life cycle of algal biofuels*
- *Potential effects on local climate*
- *potential alteration of species composition*
- *Effects on terrestrial biodiversity from changing landscape pattern*
- *Waste products from processing algae to fuels.*
- *Potential presence of pathogens and unexpected algal toxins*

Concerns of Low Importance

- *Accidental releases of culture water and infiltration of nutrients and chemicals*
- *Seepage of culture water*
- *Potential presence of mosquitoes and mosquito-borne diseases*

Status of Algal research

Extensive research and development work are on in Europe and America on algae cultivation and production of derivative products. Large commercial scale algae bio-fuel/ biomass plants are likely to be in operation in the developed countries in the next 3 years.

Several governments abroad give special grants to encourage and support algae R&D efforts, particularly in USA. However, little R & D work has been carried out in India on algae biodiesel. There is no experience in setting up commercial plants in India. Therefore, initiation of Research and Development work, forge technology alliance with overseas companies is need of the hour and the possibility of algae cultivation in two million hectares along with biodiesel and power projects by 2021 to be explored.

With this in view, an interactive workshop has been organized at State Planning Commission, Chennai under the Chairmanship of Vice Chairman, SPC on 20.03.2014 in which policy makers, academicians, industrialists and consultants involved in production, multiplication of algae participated and the summary of delibrations of the workshop is as under:

Workshop brief of Algal Bio fuel Energy held on 20.3.2014 at State Planning Commission

The meeting was chaired by Tmt. Santha Sheela Nair, IAS.,(Retd.), Vice Chairperson, State Planning Commission. Dr. Sugato Dutt, IFS, Member Secretary (Full Additional Charge), State Planning Commission welcomed the participants.

Dr. S. Karthikeyan, Professor of Micro Biology, Department of Bio-energy, Tamil Nadu Agricultural University (TNAU), Coimbatore made a presentation on "Algae – sustainable bio-fuel energy". The advantages, limitations and the processing involved in algae cultivation, bio mass and energy production were presented in detail. The potentials of algae cultivation viz. it's 4-10 times productivity over conventional crops, array of strains, short period of cultivation, production at very low nutrient concentration, a non-competitor for food crops and can be grown with waste water were explained. This characteristic of cultivation of algae paves way for the effective utilization of barren lands and industrial & domestic waste water which is abundant in the country.

It was pointed out that though this source of energy is endowed with the above advantages, its cultivation and production is still in infant stage in the country because of non availability of developed processing technology and high cost involved in processing. The research and development initiatives undertaken in this field were explained. Also the importance and significance of various components in algae cultivation and its processing in the sustainability of this source of energy were explained.

The role and requirement of various inputs in algal fuel sustainability

Water - Algae can well be grown using brackish/saline groundwater, co-produced water, agricultural drain waters and other wastewaters thus not putting additional demand on freshwater. Saline water surfaces evaporate less than freshwater surfaces.

Land - Degraded cropland and pasture/ grazing land, degraded forest, industrial/mining wastelands and barren lands (India has about a total of 55.24 million hectare of waste land)can effectively be roped in the cultivation of algae. The country can produce algae with yield 22-55Mt of algal oil by dedicating a meager 10% of these waste lands for algae cultivation. This volume - of fuel output facilitates the displacement of 45-100% of current diesel consumption, of algae production offsets 26-67% of current CO_2 emissions. Algae can be cultivated in puddle fields, open pond system and closed pond system.

Climate - A major part of our country is being endowed with ample sunshine with a span of 250 to 300 sunny days (sunshine hours ranging between 2300 and 3200 hours) thus providing conducive weather for algae cultivation. Solar radiation of 4.0kWh/m^2/day is considered adequate for algae production. Production of algal biomass and oil yield in three different scenarios of sunlight and oil fraction were discussed. The problem of more evaporation in longer sunshine can be overcome by adopting certain process in cultivation.

Box : Algae – Potential GHG reducer

Per capita water supply in India is 188.73 lpcd (litres per capita per day) (CPCB, 2011) and sewage generation is 138 lpcd.

Algal systems are practiced in WWT – oxidation pond /suspended algal raceway type oxidation type.

Algal communities in sewage fed water bodies are responsible for 76% N and 60% C removal -0.06 - 0.2g dry algae/l/d or 10g dry algae /m^2/d can be harvested from sewage ponds.

Large scale reduction in methane emissions

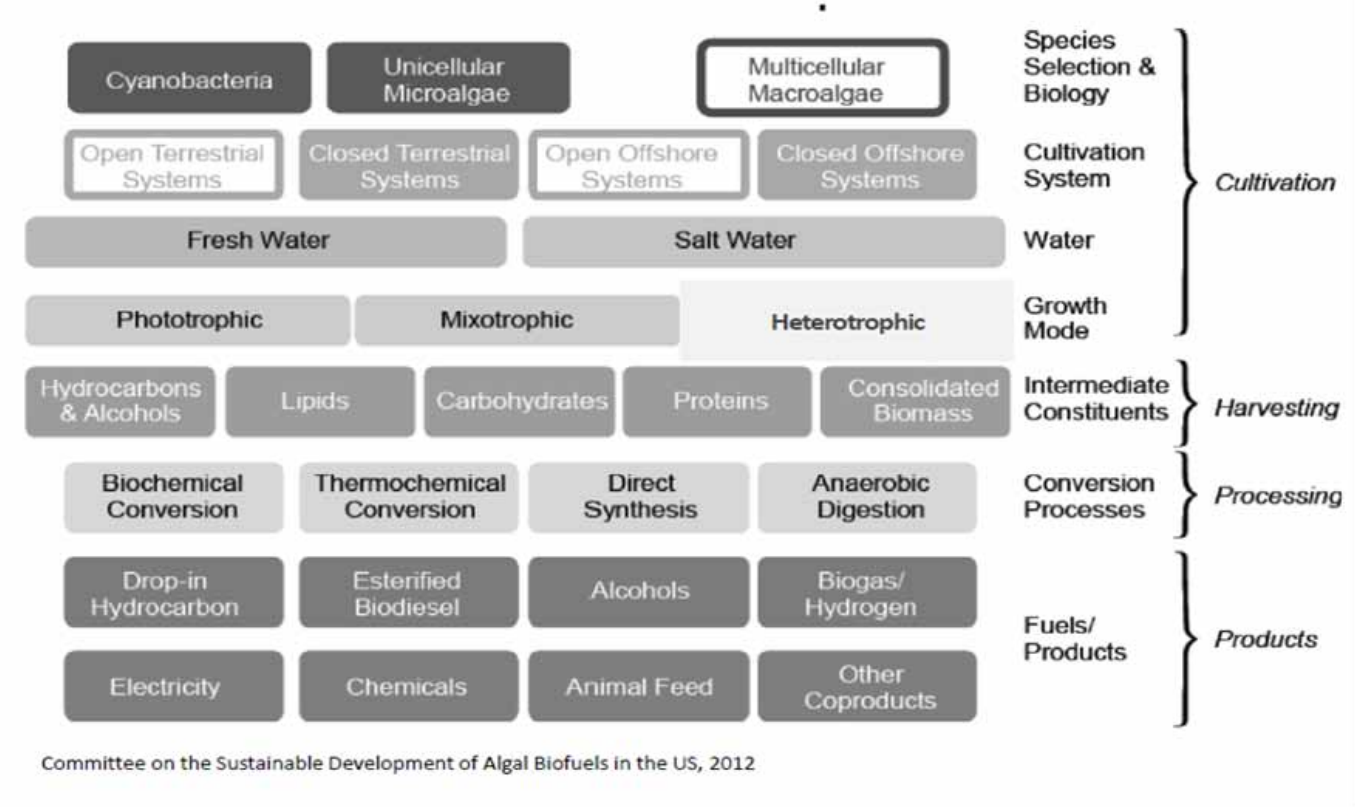
For an estimated 60 billion litres per day sewage, the expected biogas production (@200 L biogas/kL sewage) would be 12mm^3 biogas/d (0.00514 Mt methane and 0.108 Mt CO_2 equivalent per day or 39.40 Mt CO_2 per annum.

Nutrients : Carbon dioxide is essential nutrient for the growth of algae. In this regard, various potential nutrient sources locations of the country and the carbon dioxide emissions from large stationary sources like cement factories, thermal power plant were discussed.

It was informed that for production of a kg. of algal biofuel, 0.3 – 0.5 kg nitrogen to be supplied to algal ponds.

In this context, it was informed that while N and P concentrations of municipal wastewaters of large metros of the country range from 30-100 ppm(parts per million) N & 10-45 ppm P, agricultural wastewater contains over 1000 ppm thus serving as one of the richest resources for algae cultivation. Further, algae cultivation in sewage fed water bodies removes 76% N and 60% C from the water bodies and produces 10 g dry algae/m^2/day apart from fixing methane emissions (21% more pollutant than CO_2 emission). In reduction of carbon emission, algae has advantageous effect over plants (algae reduce carbon 58-90 ton/ha/year while plants reduces 25 ton/ha/year).

Pathways for cultivating & processing algae to fuels and their products



Committee on the Sustainable Development of Algal Biofuels in the US, 2012

Research findings on CO_2 enhanced algae cultures viz. low nutrient levels combined with accelerated algae production, decreased harvesting costs(due to bioflocculation - ("a process of contact and adhesion whereby the particles of a dispersion form larger-size clusters".) and 30-34% lipids (one of a group of chemical compounds that do not dissolve in water; include oils and fats) production were briefed.

Location of the Units – The need for co-locating the algae production units with domestic & industrial waste water treatment plants was emphasized and other co processing units like ethanol plants apart from establishing dedicated algae production facilities were also discussed.

The VC, SPC suggested that a detailed study on the cost of production of algal bio-fuel may be done at practical field level. It was informed that as the technology is in infant stage, cost of production is high and explained that if the cost of production of bio mass works out to Rs.15/kg, it is feasible but the current cost is at Rs.200/kg.

Thiru N.S. Venkataraman, Director, Nandini Consultancy Centre, Chennai presented on "Algae-India's opportunities" and the Indian fuel demand /supply situation and how the algal bio fuel can play a crucial role in reducing the impending energy crisis were explained. It was also pointed out that from 1000 acre of algae farm, an yield of 20,000 metric tonnes /per annum of algae biofuel can be harvested besides obtaining an yield of 2000 metric tonnes of glycerine per annum and generation of 4MW power. The initiatives available in the country and global levels were enumerated. More research and development activities should be encouraged to take the present biofuel production from microalgae on a semi commercial/ commercialized basis was emphasized. The need for necessary policy initiatives by the Government to support this renewable source of energy was also stressed.

Dr. Senthil Chinnasamy, Chief Technology Officer, Aban Infrastructure Private Limited, Chennai, made a presentation on "Algae for Advanced Biofuels". The potentiality of utilizing the abandoned prawn ponds, salt pans to integrate for algae cultivation was discussed.

Thiru. P.K.N. Panickar, President, Chemical Industries Association, Chennai insisted that to take forward this technology, government

shall create an exclusive Board namely Algae Development Board, initiate study focusing the problems in this field, encourage the R& D activities to scale up the present technology VC, SPC suggested that since this source of energy production involves many stakeholders viz. algae growers, chemical engineering industries, other cogenerating industries, Energy Department, Industry Department, more education about the subject and convergence among the various departments should be undertaken before going for any policy initiatives. Towards this, it was suggested that Department of Industries can take a lead. Moreover, the VC, SPC suggested that since TNAU, Coimbatore has already done more research and development activities in this field, the University can prepare and send a concept paper focusing on the potential of this resource of energy, research & development activities required to take this technology to semi commercialized activity, establishing a module, making adequate provision on pollution control norms/ requirements and suggesting policy initiatives by the government to the State Planning Commission for consideration of funding a Study on Potentials of Algal Biofuel Energy under Innovative Scheme of the Department of Industries.

The workshop concluded with a vote of thanks extended by Dr. K.R. Jahanmohan, Head of Division (APP), SPC.

Special Thanks to
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