Research Paper

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Freshwater Microalgae of Kashmir Himalaya: An Overview of their Potential Utilization for Biodiesel Production

Environment

KEYWORDS : Microalgae, Biodiesel, Kashmir Himalaya, Environment.

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ABSTRACT

In order to achieve a secure and stable energy supply that does not cause environmental damage, renewable energy sources must be explored and promising technologies should be developed. Biodiesel derived from oleaginous crops is a potential renewable and carbon neutral alternative to petroleum fuel, while as it cannot realistically satisfy even a small fraction of the existing demand for transport fuel. Biodiesel from microalgae seem to be the most promising renewable biofuel that has the potential to completely displace petroleum derived fuel without having adverse affects on the supply of food. Algae have received global attention as a renewable resource for biodiesel production. A variety of green algae, blue green algae and diatoms are found in the lentic water bodies of Kashmir Himalaya of Indian Subcontinent, however their oil potential for biodiesel production have remained untapped.

Introduction

The basic sources of the energy are petroleum, natural gas, coal etc. The major disadvantage of using petroleum based fuels is that they cause atmospheric pollution by emanating contaminants like nitrogen oxides, sulphur oxides, carbon monoxide, particulate matter, volatile organic compounds etc and also are major source of greenhouse gases. The continuous use of petroleum sourced fuel is now widely recognized as unsustainable because of depleting supplies and the contribution of these fuels to the accumulation of carbon dioxide in the environment (Chisti 2007). Our reliance on fossil fuels especially coal which produces greater carbon dioxide emissions than oil and has caused carbon dioxide enrichment in the atmosphere, which is the primary contributor to the generally accepted phenomenon called as global warming (Campbell, 2008).

Recently, because of increase in crude oil prices, limited resources of fossil oil and environmental concerns, many nations have encouraged their researchers to look for new and alternative sources of energy for heating, electricity, and transportation. One potential source, biomass (any organic matter which is available on a renewable basis), is an attractive option because it is renewable and can provide all forms of energy we need. Unlike finite deposits of coal, oil, and natural gas, biomass can be produced almost anywhere and under a wide range of environmental conditions. As a biodegradable, renewable, and nontoxic fuel, biodiesel fuel which is made from renewable biological sources such as vegetable oils and animal fats had received considerable attention in recent years. It also contributes no net carbon dioxide or sulphur to the atmosphere and emits less gaseous pollutants than conventional diesel fuel. As a result it has the potential to reduce the level of pollutants and the level of potential or probable carcinogens (Chisti 2007). In many countries biodiesel is produced mainly from soybeans. Other sources of commercial biodiesel include canola oil, palm oil, corn oil, waste cooking oil, and jatropha oil (Kulkarni and Dalai, 2006; Barnwal and Sharma, 2005).

Algae – Novel Source of Renewable Energy

Algae are simple mainly aquatic, chlorophyll bearing suspended microscopic organisms. They have feable movement and wander at the mercy of winds, currents and tides. There are two main populations of algae: filamentous and phytoplankton algae. These two types, particular phytoplanktons increase in numbers rapidly to form algal blooms. Most algal species exist as single cell in aqueous habitats, but some are organized in simple, usually filamentous, colonies. Almost 20,000 species of algae have been identified and grouped into divisions. The photosynthesis in algae is similar to that found in all plants, but algae are especially effective in converting CO_2 and other nutrients into organic compounds. The ability of algae to fix carbon dioxide can also be an interesting method of removing gases from power plants by locating algal farms adjacent to power plants (Gouveia and Oliveira, 2009). The flue gases from these power plants can be diverted into these algal ponds. There by it shall help to reduce its emissions in the atmosphere and combating climate change with a higher production microalgal biomass and consequently higher biodiesel yield.

The recent research has proved that oil yielding algae are clearly superior to that of oleaginous terrestrial plants such as rapeseed or soybeans because they are unicellular, their cultivation in a liquid environment allows them better access to water, CO^2, and minerals. Due to this reason, algae are capable of synthesizing 30 times more oil per hectare than the terrestrial plants (Tickell 2000).The annual oil productivity of algae is around 90,000 L ha^{-1} which is far greater than seed crops viz soybean = 450 L ha^{-1}, canola = 1200 L ha^{-1}, palm = 6000 L ha^{-1}, jatropha = 1892 L ha^{-1}, and corn = 172 L/ha (Haag 2007). Another important advantage of algae is that, its doubling time is very short (within 24 hours) and during exponential growth the doubling time is as short as 3-4 hours (Schneider 2006). Under ideal conditions, algae can double their weight three to five times a day which makes it exceptionally good for biodiesel production.

Algae contain lipids and fatty acids as membrane components, storage products, metabolites and sources of energy. Under unfavourable environmental or stress conditions, they will stop growing and dividing and will transfer most of their energy into lipids as storage products for survival. Under these conditions, some strains can accumulate more than 80% of their weight as lipids (Metting 1996; Spolaore 2006). The oil levels of 20 – 50% in algal cells are quite common as shown in the table 1 (Chisti 2007; Becker 1994). Accumulation of neutral lipids mainly occurs in the form of triacylglycerides that can be processed by transesterification with primary alcohols into diesel oil or gasoline. This high yield, high density biomass can be an excellent source for algal oil which in turn is utilized to produce biodiesel.

Table 1: Lipid content of some important microalgae

Microalgae	Lipid content (%dry weight)
Schizochytrium species	*50-77*

Botryococcus braunii	*25-75*
Nannochloropsis species	*31-68*
Neochloris oleoabundans	*35-65*
Nitzschia species	*45-47*
Scenedesmus species	*12-40*
Nannochloris species	*20-35*
Chlorella species	*28-32*
Chlamydomonas rheinhardii	*21*
Euglena gracilis	*14-20*
Spirogyra species	*11-21*
Spirulina maxima	*6-7*
Spirulina platensis	*4-9*

The other important characteristics that algae possess are that they don't require fresh water for their growth as nutrients can also be supplied by wastewater and do not displace the food crops, their production is not seasonal and can grow and harvest round the year as compared to other oleaginous crops, such as rapeseed, soybean sunflower, jatropha and palm etc. To reduce micro-algal biomass overall production costs, the biomass cake remaining after oil has been extracted can be used as fertilizer or feed, can undergo anaerobic fermentation to obtain biogas and or pyrolysis process or to extract high value chemical compounds (Danielo 2005).

Transportation Fuel -Overview in India

Biodiesel is becoming increasingly attractive fuel because of its environmental benefits and the fact that it is made of renewable resources. India's transportation fuel requirements are unique in the world. According to an estimate, automobiles alone contribute to 70 per cent of the total diesel consumptions. The demand for the fuel has been growing continuously and it is expected that crude oil production has start declining from 2012. Therefore alternative energy source is the only option to fulfill requirement in future. India needs 200 billion gallons of biodiesel/anum to replace all the transportation fuels used (Khan and Rashmi 2008). To fulfill the above said biodiesel demand we required 384 million hectare of land for jatropha cultivation which is a big constraint because India has only 2.4% (i.e. 329 million hectare of land) of the worlds land area (Khan and Rashmi 2008). While as only 5.4 million hectare area of algae ponds are required to replace all petroleum transportation fuels (Khan and Rashmi 2008) and it is possible that the Indian demand for liquid fuel could be achieved by cultivating algae.

Microalgae of Kashmir Himalaya

Kashmir valley is one of the divisions of Jammu and Kashmir, which is bestowed with number of world famous lentic water bodies viz. Dal lake, Wular lake, Mansbal lake etc. These lakes always remain in a eutrophic state during the summer season with highest standing crop of algae in spring-summer interphase and depression during winter. The early ecological studies conducted in these lakes by many researchers reveal that the lakes are having a great diversity and abundance of algae especially microalgae (Kant and Kachroo 1971, 1974; Zutshi *et al.*, 1980; Mir and Kachroo 1982; Rather 1994; Jeelani *et al.*, 2007; Singh *et al.*, 2007; Qadri and Yousf 2007;). The important oil yield phytoplanktons found in these Himalayan lakes are *Ankistrodesmus sp., Botryococcus sp., Chlorella sp., Nitzschia sp., Navicula sp., Scenedesmus sp., Spirogyra sp., Spirulina sp.* etc. Hence to widen basic understanding of the oleaferous algae in Himalayan lakes, which is very much relevant to the need of biofuel industry in Kashmir, it is necessary to identify and screen out potential oil yielding algal isolates and to characterize their biochemical and physico-chemical studies.

The collection (seasonal), identification, culturing, isolation and purification to obtain pure isolates of microalgae have already been started and are being done successfully in the Algology laboratory, of National Botanical Research Institute -Lucknow. At present the laboratory is maintaining the pure isolates of many algal strains viz *Ankistrodesmus sp., Chlorella spp., Chlamydomonas sp., Nanochloropsis sp., Scenedesmus dimorphus, S. quadricauda, S. bijugatus, S. armatus var. major, S. armatus var. bicaudatus, Selenestrum sp.,* Diatoms etc., These strains were obtained by following tedious isolation procedures involving enrichment of natural waters and agar plating using different media like BG-11 media, BBM, CHU-13 etc., Further work of isolating, mass culturing in lab-scale ponds, their biochemical analysis and physico-chemical studies of algal oils are in progress. All these strains are known to accumulate high intra-cellular lipid contents as their storage products. Thus these strains can be successfully exploited for obtaining algal oil and then its biochemical conversion to Biodiesel.

Conclusion

Energy security especially transportation fuel has become a national issue and production of biodiesel from microalgae is the only sustainable way that can potentially completely displace petroleum **derived fuels and can realistically satisfy the fuel demands.**

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