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Microalgae as Promising and Renewable Energy Source: A Review

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Abstract

Nowadays security of energy is a very serious problem across the world, various researches are taking place which are looking forward for reliable and safe for environment researches. For this purpose the solution which meets the requirement is the use of renewable source of energy. There are various types of sources which are being used to produce renewable energy. The production of carbon neutral fuels have more potential. Microalga species have special features, like they can grow in open pond by using sunlight and CO_2 available in the environment. They don't need freshwater necessarily for growth; they can grow and survive in waste water with maximum lipid production. In production of biofuel the technology used should be cost effective with maximum amount of lipid extraction. Microalgae produces higher amount of lipid, carbohydrate and nutrients as compared to other feed stocks that is why it is attracting interest of researchers in current scenario of energy production. All the properties mentioned above makes microalgae a good source for biofuel production like bioethanol, biodiesel and bio methane. Microalgae are also used in various pharmaceutical and nutritional products. By the help of this review it is shown that how microalgae are more efficient for the commercial production of biofuels. This show all the stages of microalgae, e.g.-its cultivation, assessment of life cycle and concept behind the algal refineries, has been studied thoroughly and overall critical observation has been presented. According to the information's available it is clear that economic feasibility and compatibility of the whole process with maximum production of oil containing microalgae and lower down the cost of maintenance and operation of process are the major and most important factor for successful production of microalga biofuel.

Keywords: Microalgae; Biodiesel; Green House Gas; Bioethanol

Introduction

Environmental problems regarding to greenhouse gases (GHG) together with the increase in global demand of motor and power generating fuels has dragged the interest of many technologists and scientists to search for many other sources of energy generation. In last few years, scientists has a lot many efforts to find out the biomass feedstock from various types of sources, which can be converted into energy generating liquid and gas fuels.

Different types of biomass feedstock have been seen as alternate source of energy fuels. This biomass can vary from different kinds of bio-wastes, e.g. food wastes, municipal wastes, agricultural wastes etc.; energy crops, e.g. edible and non-edible seed which produces oils; and different types of water plants examined and considered as source for feedstock for bio oil. In past few years a lot of effort has been put on to figure out the possibilities of using algae as a source of bio oil and biogas for use for energy generation.. Fossil fuels are available in less amount as compared to the increasing consumption of it and lot many environmental problems are associated with it, so the researchers are considering biodiesel and bioethanol as a substitute for fossil fuel in future. In production of sugar based biodiesel we need to develop method of conversion of lingo-celluloses in biodiesel and there also a huge competition with food supplies. Biodiesel production from edible oils can also not be considered as a good option because there is huge competition with seed plants. Biodiesel production from oil of other plants which are non-edible oils is considered as a option because that do not have any competition with food supplies however they require large land areas for their cultivation. Other than these non-edible oil sources, we can consider microalgae as a very rich source for biodiesel production, it contains high percentage of oil. They have unicellular or simple multicellular structure which helps them grow in harsh condition of environment. It has been found that there are more than 50000 species of microalgae but only 30000 species are known and studied yet [1]. If microalgae are given ideal condition for growth, microalga biodiesel can completely replace diesel without disturbing food and oil supply of agricultural products [2].

What is algae?

Microalgae are photosynthetic eukaryotic or prokaryotic microorganism; they can grow at high rate and survive even in adverse condition because of their unicellular and simple structure. Cyanobacteria (Cyanphyceae) are example of prokaryotic microorganism and green algae (Chrolorophyta) are example of eukaryotic microalgae [3]. In all existing ecosystem microalgae is present, they are not only present in water but also in forests, they represent a major type of species which live in a huge range of different conditions of environment. It is found that there are more than 50,000 algal species are present on planet, but only a 30,000 species have been analyzed and studied. In last few years a collection of microalgae has been created in different countries by researches who have worked on it. It is considered that University of Combra (Portugal) has one of the world's largest fresh water microalgae collections. It has more than 100 species and 4000 strain. This collection is available to be used in various applications, for example value added pharmaceutical products, for consumption of humans in different ways, food crops and as energy source.

Across the world there are many other collections which attest for the many different products produced by algal strains. A very good example is the strain collection of Gottingen University, Germany (SAG), it was established in early years of 1920, and it has 1273 species and 2213 strains. In total SAG collection 77% of the strains are green algae, 8% of the strain are cyanobacteria. Other than there some of the strains are red algae's of fresh water and some from saline environment. Another well-known collection of algal cultures is The University of Texas.

Algal Culture Collection was established in year 1953. It has 2300 various types of strains of fresh water algae (edaphic green algae and cyanobacteria), they represent most of the major alga taxa, which includes various red and green algae species.

The National Institute for Environmental Studies Collection (NIES) situated in Ibaraki, Japan has a collection of around 2150 strains and 700 species of various types of algae, in Asian continents. In Australia, CSIRO Collection of Living Microalgae (CCLM) has around 800 strains of different type of algae, which includes some freshwater microalgae and major classes of marine microalgae, most of the strains are isolated from waters of Australia. Various microorganisms which are photosynthetic and grow in marine or aquatic environment are divided into macro algae, microalgae and emergent [4]. These simple and unicellular microorganisms have large surface area with ratio to volume which helps in taking properly a good amount of nutrients. Their simple structure helps in the process of photosynthesis more efficiently as compared to higher plants.

What is biofuel?

Environmental problems related to greenhouse gases (GHG) together with the increase in global demand of motor and power generating fuels has dragged the interest of many technologists and scientists to think about many other sources of energy generation. In past few years a lot of effort has been put on to figure out the possibilities of using algae as a source of bio oil and biogas for use for energy generation. Different types of biomass feedstock have been seen as alternate source of energy fuels. These biomass can vary from different kinds of bio-wastes, e.g. food wastes, municipal wastes, agricultural wastes etc.; energy crops, e.g. edible and non-edible seed which produces oils; and different types of water plants examined and considered as source for feedstock for bio oil. Fuels produced from biological feedstock have been considered as a very promising and potential alternate energy source because of the major global concern for change in climate and oil prices are also varying dramatically [5]. Biofuels are considered as one of the very interesting and promising pathway for reducing the dependence on world on fossil fuel, lowering CO_2 emission and in few cases, supporting local and developing economies and that is why it is being promoted [6]. Algae ranges from unicellular to multicellular forms, they are photoautotrophic which comes under a very diverse and large group of simple organisms. The potential for production of per hectare lipid and biomass from algae is greater in amount as compared to any other type of feedstock or terrestrial plant. monoalkyl ester of long-chain fatty acids converted from biological feed stocks, such as vegetable oil or animal fats is known as biodiesel [7]. Biodiesels are non-toxic, biodegradable and most renewable fuel as compared to others, these are the basic and primary advantages of biodiesel [8]. Biodiesel is nowadays come to make a very particular and modified type of chemical change in oils which are produced naturally. It has been mentioned by many authors that crops of oilseed like rapeseed and soybean oil have been examined and evaluated as a strong source of biodiesel [7,9].

Biodiesel can be used in all the diesel car engines without any change or modification and it can also be blended in any ratio with the petroleum diesel which is being used, that is the major advantage of biodiesel in comparison of other alternative fuels for the transportation. The trend followed nowadays in use of energy and its supply is unsustainable for environment, effecting economy and social concerns. If any action will not be taken for settling this issue, the emission of greenhouse gases and energy related to this will be higher than double till 2050 and the demand of oil will catalyze in increasing the problems related to security of supply of fuels.

The way we are today should be and can be changed. Avery important and major role will be played by energy-carbon technologies to make this change happen and for the energy revolution required [10].

Biodiesel and bioethanol are marketed biofuels nowadays. There are a various types of biofuels with advance features and conventional technologies for conversion. Despite of the fact that processes of conventional biofuel are already available at commercial scale it has continued to improve efficiently and economically. The advance and modern ways of conversion are either moving in demonstration phase or they have already reached there [11]. Biodiesel is a type of biofuel, it is renewable and produced for the use with compression, ignition in internal combustion engine, and it also plays a role in reducing temperature of earth everywhere and health issues. It mixes very well if blend with diesel oil containing mineral and increases lubricity of fuel which improves performance of engine. It helps in providing employment and source of income, it is non-toxic and biodegradable.

Biofuel from microalgae

In last few years, various thousand types of algal species and species of cyanobacteria are found very rich in lipid content, among all these several hundred of oil producing species has been isolated characterization have been taken place in laboratory and outside the laboratory culture conditions. Oil producing species of algae can be found in different taxonomic groups. Within a group or in between different taxonomic groups the total percentage of lipid content in dry biomass differs in different type of species or strains. In all the taxonomic groups among which the strains have been examined, green algae found with largest number of oil producing candidate.

On an average it is found that total lipid content in green algae is 25.5% of dry cell weight. When the cells are exposed to unfavorable condition of culture like starvation of nutrients and photo oxidative stress, the content of lipid increases and it doubles or triples it lipid content.

Some type of skepticism is created among scientists by the first generation of biofuel. The limits have been set for the increasing production of first generation of biofuel because it has an impact on environment and carbon balance. The basic disadvantage of biofuel from first generation is the debate on food vs. fuel, one of the reasons for rising food prices is due to the increase in the production of these fuels. Additionally it is claimed that biodiesel is not a cost efficient emission abatement technology.

Therefore, feedstock from lignocellulose material has the potential to produce new biofuels, which are considered as second generation of biofuel [12]. Biofuels of second generation are basically from biomass

of plant feedstock and which are majorly made up of lignocellulosic materials, maximum large amount of nonfood materials from plants and cheaper in cost are possible because of these lignocellulosic materials. But there are various technical problems related to biofuel production from lignocellulosic material, to realize the potential we need to correct the problems related to it because in current situation production of second generation biofuel is not cost effective. Most insufficiently used and available in larger amount biological source present on earth are represented by plant biomass, and it is found a very promising material source for production of biofuel and its raw material [13].

Components of typical microalgae

The most important constituent of typical feedstock of algae are lipids, protein, carbohydrates and various other important components like pigment, vitamins, antioxidants, fatty acids etc. Figure 1 shows a flowchart listing main components of microalgae.

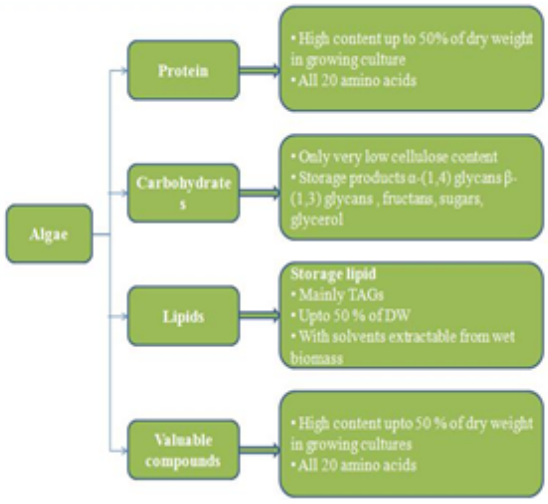

Figure 1: Components of typical microalgae.

Algae shows response to the changes which takes place in environmental conditions, like ; to a larger extent it shows tremendous diversity and many times unusual pattern of cellular lipids and have the power to modify efficient metabolism of lipid and this is all because algae have the capability to survive or differentiate on even various change in environment [14-16].

The lipids include polar lipids, wax esters, sterols, hydrocarbons and natural lipids, it includes some derivatives of prenyl like; tocopherols, terpenes, ceratenoids, quinines and some derivative of phytylated pyrrole for example chlorophyll, but it is not limited to any of them listed above.

In optimum conditions for growth, algae principally goes for synthesis of fatty acid which goes for esterification in glycerol based membrane lipids, which includes about 5-20% of total dry cell weight.

In last few years, various thousand types of algal species and species of cyanobacteria are found very rich in lipid content, among all these several hundred of oil producing species has been isolated characterization have been taken place in laboratory and outside the laboratory culture conditions.

Oleaginous algae can be found among diverse taxonomic groups, and the total lipid content may vary noticeably among individual species or strains within and between taxonomic groups. Of the strains examined, green algae represent the largest taxonomic group from which oleaginous candidates have been identified. Oleaginous green algae show an average total lipid content of 25.5% DCW. The lipid content increases considerably (doubles or triples) when the cells are subjected to unfavorable culture conditions, such as photo-oxidative stress or nutrient starvation. Under stressed condition it was found that oleaginous green algae have increased its total lipid up to 45.7% of its dry cell weight. Of all the criteria used for nutrient evaluation, the only and most critical nutrient which affects the metabolism of lipid in algae is limitation of nitrogen. In many strains and species of Different taxa of algae a common pattern of accumulation of lipids, especially TAG has been observed in response to deficiency of nitrogen [15,17-23].

Lipid extraction

The major problems in this twenty-first century are the concerns related to environment and very alarming crises of energy. To solve these problems related to environment, it is necessary to create green environment which should be pollution free

All the activities are done by energy in nowadays scenario of world; in spite of knowing all the environmental concern, energy is unavoidable. Various sources and methodologies have been explored till date for the generation of energy; energy can be generated by the help of tidal, solar, mechanical, hydro, nuclear power, thermal power and fossil fuels (Figure 2). About 85% of the total energy which is used by us comes from fossil fuels for example: different natural gases, oil, coal, whereas nuclear power and energy sources which are renewable have contributed only 6.5% and 13.5% in the total energy required in year 2007 [24-26].

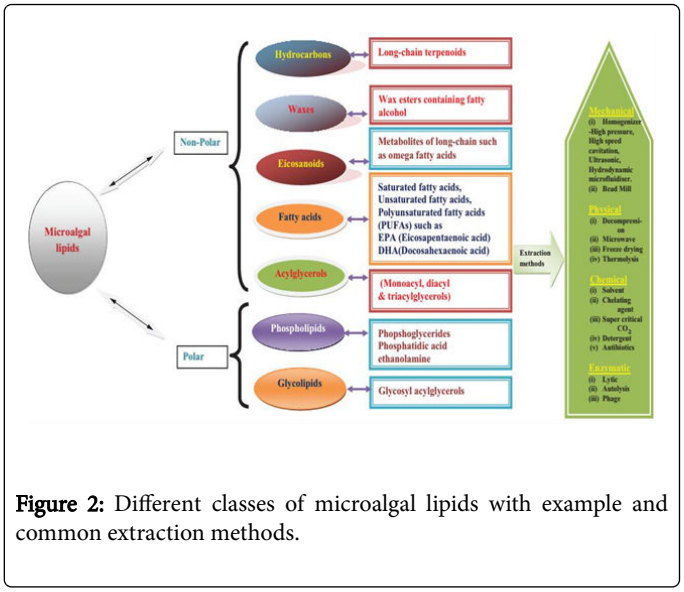

Figure 2: Different classes of microalgal lipids with example and common extraction methods.

Microalgae are found to be very promising and sustainable feedstock for producing biofuels. Production of different types of biofuels can be done on the basis of chemical composition of algal biomass feedstock. There are various types of biofuels, which are: biodiesel, bioethanol, bio methanol, jet fuels, biobutanol, bio hydrogen

and products from thermochemical conversion like; bio-oil, bio crude, syngas [27].

For development of microalgal biodiesel technology a lot many systematic investigation is being carried out by performing bio prospecting of strains which contain high lipid and higher amount of lipid production by the help of different physiological methods and genetic manipulation of strains. Therefore for the production of algal biodiesel extraction of lipid is a very important process.

There are various other type of methods for example: For production of different type of algal products algal bio refineries are present and for production of bio crude different kind of thermo technologies. As biofuels are product of raw material or agricultural materials, even in integrated concept the extraction process of lipids from algae is technically and economically viable.

The extraction of lipid for the production of biodiesel from strains which contain even 10% lipid content of dry cell weight is feasible, if it is produced in larger amount [28].

Conclusion

This review throws some light on biofuel production of from microalgae as a renewable energy resource and easing of Green House Gas related impacts of petroleum derived fuels. Possible high production of lipid and biomass along with some useful co-products could increase economic feasibility of algae as a source of biofuels [29].

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