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Review Article

Biodiesel Production From Algae to Overcome the Energy Crisis

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ABSTRACT

The use of energy sources has reached at the level that whole world is relying on it. Being the major source of energy, fuels are considered the most important. The fear of diminishing the available sources thirst towards biofuel production has increased during last decades. Considering the food problems, algae gain the most attention to be used as biofuel producers. The use of crop and food-producing plants will never be a best fit into the priorities for biofuel production as they will disturb the food needs. Different types of algae having the different production abilities. Normally algae have 20%–80% oil contents that could be converted into different types of fuels such as kerosene oil and biodiesel. The diesel production from algae is economical and easy. Different species such as tribonema, ulothrix and euglena have good potential for biodiesel production. Gene technology can be used to enhance the production of oil and biodiesel contents and stability of algae. By increasing the genetic expressions, we can find the ways to achieve the required biofuel amounts easily and continuously to overcome the fuels deficiency. The present review article focusses on the role of algae as a possible substitute for fossil fuel as an ideal biofuel reactant.

1. Introduction

Energy crisis is among the biggest problems, leading the world to be unsafe and non-peaceful. The demand is increasing day by day. The available resources are rapidly decreasing and indication is, soon will be vanished. In such situations, more attention is needed to be given towards renewable energy sources. Fossil fuels are used on a large scale in the world, but unsustainable because they increase CO_2 level and accumulate greenhouse gases which make the environment unhealthy. To keep the environment clean and maintain sustainability, renewable and environmentally friendly fuels are needed to be produced (Schenk, 2008). Biofuels are defined as the liquid fuels produced from the biomass of different agricultural and forest products and biodegradable portion of industrial waste (Dufey, 2006). Biodiesel is extracted from vegetable oils (Shay, 1993), biobutanol (Dürre, 1997), *Jatropha curcas* (Becker and Makkar, 2008) and algae (Roessler et al., 1994; Sawayama et al., 1995; Dunahay et al., 1996; Sheehan et al., 1998). Brazil, the United States and the European Union are the world's largest biodiesel producers (Balat 2007). Biofuel production has been estimated to be 35 billion litres (O European Commission, 2006).

The algae are now becoming the main source of biofuel production in the world. They are considered as the safer, non-competitive and rapidly growing organisms among those could be used for biodiesel production. They have the abilities to grow without much care on waste nutrients (Roberts, 2013), and are considered the better source of biodiesel production as other sources can cause food problems as they are mainly including those plants which are used for food (Patil et al., 2008). Moreover,

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biodiesel contents of crops are less sustainable and less in quantity as compared with algae (Charles et al., 2007). Algae have around 80% energy content to that contained by petroleum (Chisti, 2007, 2013). Algal cells have 30% lipid content (Lam and Lee, 2012), which is higher than other sources including soybeans and palm oils (Lam and Lee, 2011; Kligerman and Bouwer, 2015). Microalgae have 30%–40% lipid contents by dry weight and this value raises to 85%. *Botryococcus braunii* is a microalga which is having 30%–40% hydrocarbon content which can be extracted easily (Mirza et al., 2008). Algae can efficiently remove the toxic components from water, so playing a role in waste water treatment. Their remediating role in waste water treatment and rich sources of biodiesel make them suitable sources to be grown on large scale (Pittman et al., 2011; Kligerman and Bouwer, 2015).

Micro as well as macro algae can be cultivated on large scale in short period. Micro algae are photosynthetic and heterotrophic having the potential to be grown as energy crops. They have the ability to produce certain economically important compounds including fats and oils (Rawat et al. 2011; Pittman et al. 2011). Algal biofuel does not have harmful chemicals, so environment can be kept clean after the combustion.

Pakistan state oil has currently started work on biodiesel production and successfully cultivated *J. curcas* plant to produce biodiesel. Drying needs energy in the case of crops and food-producing plants; but in the case of algae, it is economical to dry them with sun light. Thermo chemical drying process is also easy in algae in comparison with other plants (Banerjee et al. 2002; Tsukahara and Sawayama, 2005). Biomass is treated with anaerobic microorganisms to produce biogas which is having high content of methane, so it can be used as an alternate source of energy (Mes et al. 2003). Algae cells have the bio fuel contents inside the cells, and the cell wall retains these components intact, so the cell wall must be broken; and in most cases, anaerobic digestion is preferred, which is the most prominent method of extracting these components from the cells (Reith, 2004). The algae with high biofuel contents and easily cultivatable are preferred. The objective of this review article was to critically describe various aspects of algae as an ideal target for biofuel productions.

2. The Processes for Biofuel Production Using Algae

Algae have oil contents with different compositions depending on the specie types. Some species were identified that they have good fatty acid values. In the same way, some algae have more components of fatty acids by their dry masses. Micro algae can grow in different conditions even in availability of fewer nutrients. They are best to be chosen for cultivation. The collection of sample needs care so that the whole biofuel contents could be obtained through careful handling of the instruments. The growth is also affected by different environmental factors which are not specifically known for every region, so the process needs careful attention accordingly (Richmond, 2004).

The simple method of fatty acids extraction and separation of biodiesel is the blending method on small or experimental scale. This process consists of several steps which have been shown in Figure 1.

It is also necessary to know about the cultivation unit of the algal cultivation, whether it is good to choose the closed system or open system. The process either batch or continuous is confirmed depending on the conditions and facilities, including pH, temperature, type of algal specie and the amount of algal biomass (Kaewpintong, 2004; Chojnacka and Marquez-Rocha, 2004; Chojnacka et al. 2005). Harvesting techniques are finalized based on the location and conditions (Grima et al. 2003). Most favourable harvesting techniques suggested are based on settling pond or sedimentation tank. Density and moisture adjustment is required during the whole process of biodiesel production. The drying technique mostly used is spray drying, drum drying was also

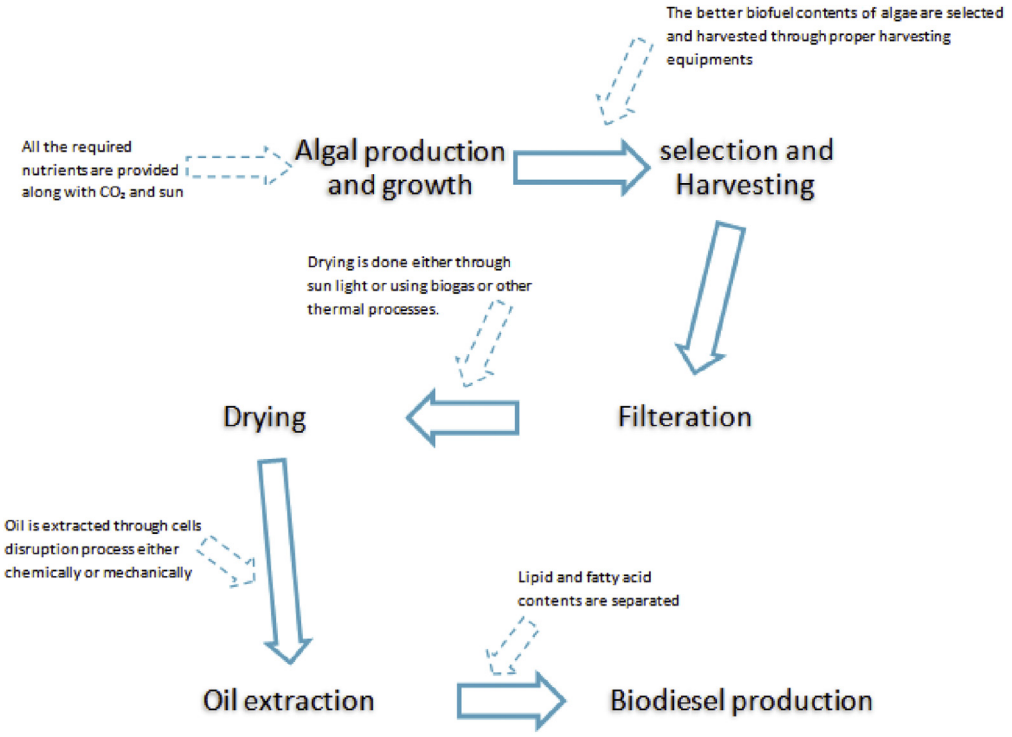

Figure 1. This figure illustrates the general process of biodiesel production from algae on small scale and for experimental purpose. This method could be used to compare different algal species for the oil contents. Dotted arrow indicates the addition to specific steps which have been highlighted with bold letters and full lined arrows.