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Editorial

Algal Biodiesel: Challenges and Outcomes

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Editorial

Fuel production either from fossil or biological feedstock's is an essential requirement for transportation sector. In recent years, biological feedstock's for fuel production mainly algae has gained much momentum due to less resources required viz. water, energy, land, and nutrients etc [1]. Still research is going on for cost effective and efficient conversion of algal oil to biodiesel at commercial scale. Algal biodiesel production is technically sound, still need economic, environmental, and social sustainability to develop a useful replacement for petroleum based fuels (Figure 1). For which continuous monitoring of all energy and cost inputs is needed at pilot scale settings. Certain algae species have high biomass production along with high oil yield. Doubling time of algae species is very less even few can double their number every few hours and biomass can be collected every day. They have prospective to produce and compete with most productive crops in terms of biomass and biodiesel production.

Energy is stored in the form of fats and carbohydrates in algae. It has been estimated that they can produce approx. 2,000 -5,000 gallons of biofuels/acre/year [2]. Along with high yield, they consume CO_2 during photosynthesis more efficiently than terrestrial plants [3]. Algal cultivation facilities can be set up at infertile land thus minimizing the land issue and competition with food crops. Microalgae biomass can be used as feed, fuel and food. Algal biomass is composed of protein, carbohydrate and lipid, which can be used for production of biofuels, animal feeds or nutritional supplements. Additionally, these are also rich in micronutrients which can be used as dietary supplements for advancement of human health. They can grow in sea water, brackish water and even wastewater, thus does not require fresh water resources. Algae habituate nutrient-rich waters (wastewater streams) and produce valuable biomass utilizing waste nutrients from wastewater. Algae industry is a job creation engine. Algal mass cultivation facilities, extraction and biofuel conversion units need manpower. This will create a huge job requirement throughout the world in various sections viz. research, engineering, construction, algae farming, marketing and other financial services. It has been found that Algal Biomass Organization projects have potential for creation of 2, 20,000 number jobs by 2020 [4].

Besides these advantages, there are concerns which need to be minimized in point view of economic and environmental sustainability. This is true that algae can grow in saline/brackish water still quantity of water needed is a major concern. As approx. 3 to 3600 liters of water is needed for production of 1 liter algae biofuel [5]. The National Academy of Science's report (NAS) says, production of biofuels from algae require approx. 15 million metric tons of N and 2 million metric tons of P, unless elements are used for synthesis or production of byproducts [6]. This excess use of N and P fertilizers can cause pollution to natural water bodies. The report says that overall, the energy produced from algal biofuel is quite low in comparison to the energy required for its production. For large scale production, it is quite necessary to get huge amount of biomass which can be achieved only by culturing algae in open ponds or giant tanks.

Algal cultivation in open ponds system is cost effective as compared to closed photobioreactors. However, open systems have their own disadvantages such as fast evaporation, less efficient nutrient uptake and carbon dioxide capture, contamination with unwanted species resulting in lower biomass production etc. Contamination with unwanted algal species is an issue in the open pond system which is also cause for low biomass productivity. In addition to above, maintenance of optimal culture conditions is quite difficult in open environment, and biomass recovery from such dilute solutions becomes an expensive approach. High evaporation losses from open ponds further results in salt build up resulting in decreased biomass production [7]. U.S. Department of energy reported evaporation of hundreds of liters of water per liter of algae produced in an open pond system in arid, hot, and humid regions of the continental United States. Pienkos [8] have estimated that 60 to 454 trillion liters/year of water would be needed for production of 227 billion liters biodiesel/year from algal oil. In 2010, it was analyzed that petroleum-based fuels have been consumed at the rate of 783 billion liters per year by U.S. transportation sector and was reported by Energy Information Administration [9]. Water requirement for algal biofuel production is greater than petroleum-based fuels.

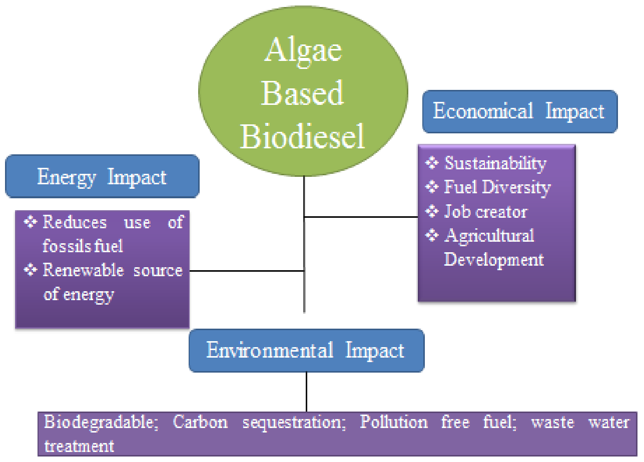

Figure 1: Schematic representation of impacts from algae based biodiesel.

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Thus, freshwater sustainability needs to be deliberated carefully in perspective to regional accessibility and other challenging issue was reported by National Research Council [10]. Such issues have been overcome by analysis done by Pate et.al. [11] with deviation of irrigation water from agricultural field to algae cultivation for fuels production. More over other options viz. wastewater from municipal, industrial sources; agricultural runoff; coastal marine water; and salted or saline groundwater will be cost effective, recovering the loss of water through evaporation.

Closed pond system sorts out the issues such as evaporation, contamination etc. but there exists sunlight related problems, as light permeation is inversely proportional to algal cell density. In photobioreactors, attachment of algal cells to reactor walls is quite common which results in less light penetration. Reactors are more expensive and scale up to commercial level is very difficult and cost intensive. Photobioreactor costs $150/m^2, which is almost ten times costlier than open pond systems [12]. In addition to the cost, providing efficient sunlight is also a major issue as biomass yield depends on amount of sunlight.

Algae have also been explored as potential candidate for biofertilizers. Some algal species present in raw or semi-decomposed form can be applied to land or field as an organic fertilizer [13]. It can also be used to prevent fertilizer runoff from farms by growing them in agricultural areas. This further helps in collection of nutrient-rich algae which can be used as fertilizer, potentially reducing crop-production costs.

Microalgae are photoautotrophic species which perform photosynthesis and absorbs carbon dioxide. Algae cultivation farm can be built close to power plant or industrial settings for utilization of CO_2 from exhaust gases as carbon source for algal biomass production and carbon emissions to environment would be decreased by reprocessing discarded carbon dioxide into biodiesel. Various commercial algae based fuel production facilities are coming up throughout world in recent years. Still research and development is needed to successfully bring the technology at commercial scale with further reduction in cost and energy issues.

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