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Original Research

Algal biomass as a global source of transport fuels: Overview and development perspectives

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Abstract

As a result of the global fuel crisis of the early 1970s, coupled with concerns for the environment, the use of biofuel has been on the increase in many regions throughout the world. At present, a total of approximately 30 billion (30×10^9) liters of biofuel are utilized worldwide annually, although most countries rely hugely on the first generation biofuel. The limitations of the first and second generation biofuel gave rise to current interest in algae as a promising alternative to these conventional biofuel sources. Algal biomass could provide a lion's share of the global transport fuel requirements in future. The present review highlights some important developments in, and potentials of algaculture as a major biomass resource of the future. However, the major constraint to commercial-scale algae farming for energy production is the cost factor, which must be addressed adequately before its potentials can be harnessed.

Keywords: Algae; Biofuel; Economic feasibility; Energy production; Transport fuels

1. Introduction

With current global oil production approaching its peak, along with billions of tonnes of carbon emissions released into the atmosphere leading to global warming, threats of climatic change coupled with great obstacles to further development of conventional energy sources, it is very important that the great attention will be given to a range of environment-friendly renewable energy resources which are expected to play an important role in averting an impending future energy crisis.

Limiting global greenhouse gas concentrations to levels below the currently high 550 ppm carbon dioxide equivalent would require drastic emissions reductions equivalent to a phase out of all fossil fuel emissions in developed countries by 2050, if developing country emissions continue to grow as expected [1,2]. The use of energy accounts for a major fraction of all anthropogenic emissions of greenhouse gases [3,4] and in most industrialized countries the use of transportation fuels and electricity accounts for a lion's share of all energy related emissions. It is a known fact that at the present moment renewable energy contributes only 11% to global primary energy, although it is expected that 60% of all our energy will come from renewable sources by the year 2070.

The transportation sector accounts for 21% of the current global fossil fuel CO_2 emissions to the atmosphere, second only to emissions from power production (Fig. 1). With global economic growth assumed to average 3.2% per year to 2030, growth in energy demand for transport is forecast to increase at

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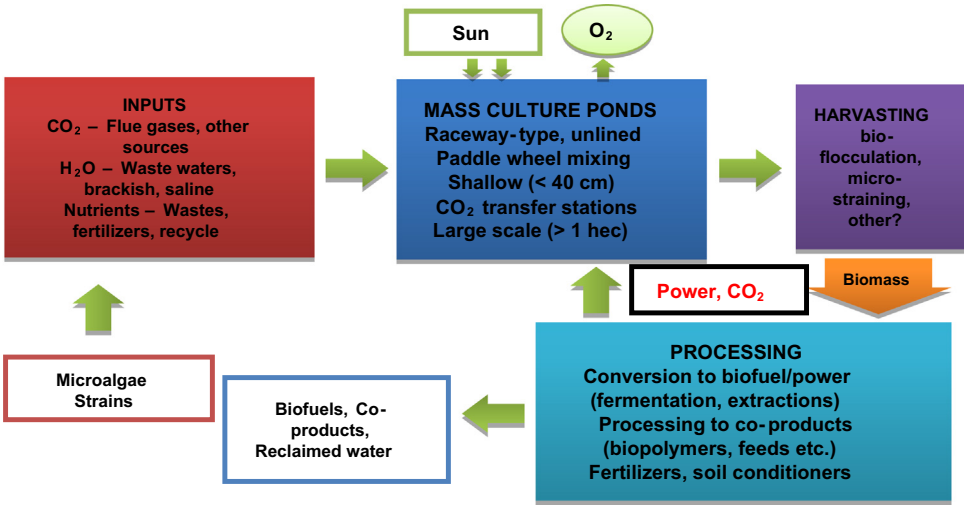

Fig. 1. CO_2 sequestration using algae. *Source* [17].

an average annual rate of 2.1% over the same period. Transport sector contribution to total anthropogenic greenhouse gases (GHG) emissions is projected to increase to 23% in 2030 [5]. Bioenergy has been recognized as a significant component in many future energy scenarios. Substitution of fossil fuels by biofuel appears to be an effective strategy to meet not only future world energy demands but also the requirement for reducing carbon emissions from fossil fuels. Although there is increasing demand for fossil energy due to rising economic activities in the emerging markets, especially China and India, soaring oil prices have encouraged major consumers worldwide to sharply increase their use of "green" biofuel.

The use of biofuel is, therefore, increasing in many regions throughout the world. At present, a total of approximately 30 billion (30×10^9) liters of biofuel are used annually in Europe, North America, and South America. This amount is expected to grow significantly as the demand for sustainable transportation fuels increases. According to recent IEA estimation bioethanol and biodiesel have the potential to reach 10% of world fuel use for transport by 2025 [6,7].

First generation biofuel sources have been exploited for nearly three decades but have proven grossly inadequate to augment rising global requirements. Instead, their continued use has contributed towards global food for fuel crisis, necessitating a gradual shift towards second generation biofuel sources, which offer greater potentials. However, the main argument against the second generation fuels is based on land availability and protection of global ecosystems. It is true that these fuel sources have immense potentials but there are indications that algal biomass (third generation biofuel sources) could well be the panacea to rising global demands for transport fuels. Various assessments advanced by different scholars indicate that algae offer great potentials as a biomass resource for the provision of future green transport fuels but also for direct use in carbon sequestration in many parts of the world.

Although the precise quantity of algae that can be grown, harvested and processed in a sustainable manner appears unclear, much effort has been made in the application of algae as a biomass resource especially for the provision of food supplements and specialty products. The present communication highlights the evolution of transport biofuel while giving priority attention to algal biomass as a potential source of future biofuel. Areas requiring further R&D as well as some limitations of certain technological approaches will be discussed.

2. Land based biofuel sources

The oil crisis of the early 1970s triggered the interest in the adoption of land-based agriculture-derived fuels known as biofuel (bio-organic fuels) in a bid to augment the supply of fossils. Although, it was thought that mass cultivation of these first generation biofuel resources such as sugarcane, corn, soybean, rapeseed (canola), oil palm trees etc. could resolve both problems of edible oil and fuel at the same time, it became obvious with time that the increasing global demand for fuel could not be met sustainably by these fuel sources. Thus, emerged the adoption of non-edible (second generation) biofuel sources as supplementary and alternative to fossil-derived fuels, which are finite in nature and portend a great source of greenhouse gas pollutants to the environment.

Although established technological approaches for transport biofuel production—such as the American corn to ethanol and soybean to biodiesel programmes; the European Union rapeseed to biodiesel and sweet sorghum to ethanol programmes; the Brazilian sugarcane to ethanol process; the Malaysian palm oil to biodiesel experience etc.—are still heavily dependent on first generation sources, they only generate about 0.3% of all global transport fuels presently [8].

No doubt, bioenergy with the potential to meet 50% of world energy demands while reducing carbon emissions from fossil fuels appears to be a potential energy resource but increased biofuel production on arable land could have long term severe consequences for global food supply.