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Prospects for Making Biofuel from Microalgae: A Review

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ABSTRACT

The depletion of fossil resources, increasing prices, demand, and global warming worries have all contributed to the urgency with which individuals are searching for sustainable alternative fuels. Some microalgae strains collect more lipids, develop faster, and produce more photosynthetic energy than land plants, making them a promising candidate as a biofuel feedstock. Although algae biofuels show promise as an alternative to fossil fuels, several challenges must be conquered before they can successfully compete in the fuel market and be widely embraced. Strain identification and improvement for oil productivity and farming techniques, fertilizer and budget utilization and usage, and co-product generation to enhance the system's overall profitability are all issues that need to be addressed. There is much more to be done in the sector, even though there is much enthusiasm about the possibilities of algal biofuels. Algae's generation capacity was all the rage in the green technology scene a decade ago. Compared to traditional feed stocks derived from plant commodities like sugar cane and maize, or even vegetable and animal waste streams, algae fuel, also referred to as third-generation biofuel, offers many significant benefits. In light of recent successes in genome editing in microalgae, we emphasize prospects for speeding up the strain incentive programme.

KEYWORDS: *algae; biodiesel; large-scale production; transport*

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INTRODUCTION

Algae are single-celled organisms that thrive in aquatic environments and generate energy through photosynthesis in the presence of oxygen. That is indeed right, there are a pair of macroalgae, and microalgae are both types of algae. It is possible to harvest macroalgae, which are large, multicellular algae, from ponds, proportional to inches. These more prominent algae may develop in many ways. The noun "seaweed" is shorthand for most extensive multicellular algae, like the kelp plant, which may reach over 100 feet. In contrast, microalgae, on the other hand, are single-celled organisms that develop in water and have a micrometre-scale size.

Production of polymers and fertilisers; generation of electricity for homes and businesses; operation of heating, cooling, and transportation systems; The use of fossil fuels is essential to the world economy. As our population and economy grow, we will have a greater need for carbon-based fuels Information suggests that when nations raise their GDP per capita, their need for fossil fuels will increase, as will competition for these resources these restricted means. Additionally, there is an increase in atmospheric CO2 concentration and the potential for substantial climatic change, apparently affecting the whole planet due to human-caused greenhouse gas emissions. But, then, petroleum, which comes partly from preserved algal deposits, is a finite resource that will be costly to acquire.

Pollution of the air, water, and land is directly attributable to using fossil fuels, which are a non-renewable energy source. Weather patterns shift. Most of the world's fossil fuels are used for fuel in cars, trains, planes, boats, and generators. However, as the number of transportation hubs rises, the volume of the globe confronts the issue of meeting the growing demand for energy while simultaneously decreasing supplies of traditional fuels. A rise in energy use and fuel exploitation has been noticed across the globe as developing economies seek to meet rising global standards in countries, particularly in India and Africa, throughout the last several decades. Significant issues with our present energy system factors that raise the likelihood of disaster include the widespread use of fossil fuels in industrial production, the high cost of gasoline, and the growing dependency on food and water supplies.

There is a severe threat to human civilisation from Middle Eastern oil suppliers and the ill effects of burning fossil fuels, which increase global warming and have a detrimental effect. The reasons, which range from other nations' hunger to environmental shifts, are complicated and must be managed by pollution levels and international tensions over fossil fuel use. More and more people are interested in biofuel since it is not just a sustainable energy source that is safe to use, biodegradable, and has little impact on the environment and climate. Biomass fuels are many energy sources sourced from or manufactured using organic matter.

Compared to wind, tidal, and solar power, all examples of sustainable, liquid, and solar energy may be stored and utilised in conventional vehicles and power plants using biofuels. Biodiesel and bioethanol are the most popular types of biofuels. Some others are green diesel, vegetable oil, biogas, and natural gas. Worrying reports of global warming, a worsening energy problem, and rapidly dwindling fossil fuel reserves have contributed to a growing interest in renewable energy worldwide compared to renewable sources like solar, tidal, and wind. Because of their portability and versatility, liquid biofuels have replaced solar and wind power as the most sought-after form of renewable energy production. Energy needs may be met globally using organism-based feedstocks like land plants and aquatic microalgae. Most of India's energy needs are met by importing petroleum products from other countries.

Symbolically, a country's per-person electricity usage advancement of such nation and its people's level of life. A gain in productivity, a decrease in poverty, and an overall higher quality of life are all aided by cheaper energy. However, there is a growing concern worldwide due to the decreasing supply of fossil fuels and the increasing fuel demand, which raises new questions about potential alternative energy sources. Therefore, efforts are being made to study alternative energy sources that meet the following criteria: they are easily accessible, ecologically acceptable, technically possible, and economically competitive.

BENEFITS OF ALGAE BIOFUEL

They are very effective in removing nutrients from the water and can be cultivated on the ground that is otherwise unsuitable for traditional agriculture. In addition, they can be grown on land that can be used for agriculture. In this way, not only does the development of algal biofuels need less land area than the production of biofuels from terrestrial plants, but waste streams would also be able to be cleaned up as the plants were being grown. Before being released into the environment, wastewater undergoes treatment to remove nitrates and phosphates. Coal or combustible-based power plants collect exhaust gases to gather sulphates and carbon dioxide. It is also possible to bioengineer the algae strains used to produce biofuels. This opens the door to creating specialised traits and producing valuable by-products, which might help algae-based biofuels compete financially with petroleum. Algae are a platform with great potential for manufacturing cost-effective biofuels due to their properties, which are as follows: India is a heavily industrialised nation striving to satisfy the fundamental energy requirements of its population. This endeavour will allow India to maintain pace with its accelerating economic development. India's transportation fuel needs are unique in the world. It burns more than five times the amount of diesel fuel as it does gasoline, in contrast to practically every other nation on the planet, which burns more gasoline than diesel fuel. India is the country most dependent on coal to satisfy its energy requirements. Mining coal reserves is an essential step in accomplishing the goal of providing electricity to every single person.

Coal is the most affordable fuel, yet it produces the most pollution. Producing biofuels on a domestic scale would cut emissions from coal-fired power plants, which would, in turn, have less effect on climate change. Because of this, the search for alternative forms of energy is of utmost significance in India, and biodiesel is far more significant for our country than for the rest of the globe. India is the global leader in the use of biomass energy, which ranks as the world's fourth most significant energy source. Algae cultivation to extract biofuel will not harm the agricultural production of food, fodder, or other commodities. Even though experts tend to believe that current gasoline prices are not high enough for algal biofuel to become competitive, frequent attempts are made to harness the potential of algae. These attempts are made even though there are regular attempts.

STEPS FOR ALGAE TO BIODIESEL CONVERSION

The manufacture of biofuel from algae may be broken down into four distinct stages: a) the growing of algae; b) the harvesting of biomass; c) the extraction of algae oil; and d) the conversion of oil and residue.

To explain the significant components of algal biofuel generation, each of the first four steps is further broken into essential, individual, or numerous processes. These processes may have either positive or negative environmental externalities.

METHODOLOGY

As a result of the microalgae-based biofuels' superior sustainability to that of terrestrial feedstock, they have the potential to serve as a suitable replacement for fossil fuels. *Microalgae* are unicellular and straightforward multicellular autotrophic microbes with a high degree of photosynthetic and nutritional consumption, respectively. There is a large population of microalgae in the environment, particularly saltwater, freshwater, and wastewater. Due to their high biomass productivity and ability to reduce CO2 emissions, microalgae have great potential as a feedstock for biofuel production. Furthermore, microalgae accumulate lipids, making them an excellent source of fuel. For the generation of biofuels, several species of microalgae have a high lipid content, and the growing method for these organisms is far less complicated than that of other plant crops. Microalgae have the potential to create a wide variety of biofuels, including but not limited to biodiesel, bio methanol, bioethanol, and biohydrogen. Since microalgae are grown yearly, a method that produces biofuels from microalgae may one day help satisfy the growing need for energy. The production of biofuel from microalgae requires the use of a few different techniques. The steps involved in producing hemp oil are cultivation, harvesting, drying, and oil extraction operations. Over the years, several writers have analysed these procedures. [1] has written a piece for publication that discusses the process of turning microalgae into biofuel.

Following his reasoning, he concluded that improving the agricultural process would result in a more effective biofuel conversion. In addition, he offered several suggestions about the kinds of growing techniques that should be used to maximise the output of microalgae. Following this research, [2] reviewed the technological processes involved in the manufacture of algae biofuel, including its processing and extractions. It was suggested to couple the conversion of algae to biofuel with the sequestration of carbon and the treatment of wastewater to increase the yield and reduce the expenses associated with its production. Not just on the macro side of production but also delving deeper into the algal cell, [3] highlighted the prospect of algal production by genetic modification to create more algal oi. This would be done to increase algal oil output. Because they can be burnt to create vast quantities of energy, fuels are vital in today's world. Fuels are essential to several elements of day-to-day life, particularly the transportation of products and people. Fossil fuels, which include gasoline, diesel, coal, and natural gas, are the primary sources of the world's supply of usable energy. Fossil fuels meet eighty per cent of the world's energy requirements. The manufacturing process in the majority of industries is carried out by equipment that runs on diesel. In transportation, private automobiles, public transit vehicles (such as buses and trucks), and maritime vessels are all significant consumers of diesel and gasoline. Because of this, our day-to-day lives have become very reliant on fossil fuels.

On the other hand, the increase in the country's crude oil output is not enough to support the expansion in the population [2, 3]. This is because fuels such as fossil oils are derived from the remains of long-extinct animals and microbes.

The creation of fossil fuels takes place over millions of years. As a result, fossil oils are examples of non-renewable sources of energy. Moreover, a strong correlation exists between a rise in oil prices, economic downturns, and global and international wars.

The significant growth in the economy brought about by fossil fuel resources will be depleted in just 65 more years, particularly in particular nations still building their economies. In addition, burning fossil fuels results in emissions, which further contribute to air pollution and global warming [4-6].

As a result, renewable and environmentally friendly alternative fuel sources have garnered considerable interest for both present and future applications. In this day and age of rapid technological and scientific innovation, we are confronted with issues such as air pollution, global warming (also known as the greenhouse effect), and ozone depletion, amongst others. We must implement highly effective solutions to these issues, such as using alternative fuels like biodiesel and biofuels. At this time, microalgae hold tremendous promise as a potential source of biofuels that might eventually wholly replace fossil fuels. Compared to terrestrial feedstock, microalgae have distinct advantages, the most notable of which are their higher photosynthetic efficiencies [4] and their higher productivity, which can produce significantly higher biomass yields per day and per unit of cropping area [5, 6]. These advantages are not the only ones that microalgae have to offer. The number of research that has been conducted to investigate the possibility of using raw algal oil in a motor needs to be revised to get a comprehensive grasp of the expected performance of this fuel [7]. During the trans esterification reaction required to make biodiesel, using raw algal oil as an alternative to more costly chemicals and processes may help solve the issues arising from their use. This research aimed to investigate the viability of utilising algal oil as an alternative fuel for diesel engines, following the growth, harvesting, and extraction of oil in a controlled environment.

BIOFUELS PRODUCTION PROCESSES FROM MICROALGAE

The cultivation of microalgae to harvest their biomass for use in the manufacturing of biofuels is, in general, a more costly and technologically complex endeavour than crop farming. This is because the development of photosynthetic organisms in Microalgae can only survive if they have access to light, carbon dioxide, water, and inorganic salts.

It is necessary to have stringent control over the temperature regime.

Temperatures between 20 and 30 degrees Celsius are optimal for developing most microalgae. Despite daily and seasonal shifts in the amount of natural light that is available, the manufacture of biodiesel has to depend on sunshine since it is freely accessible [7, 17-20]. This is necessary to keep costs down. Converting microalgae's biomass into usable energy forms may be done in several methods, the most common of which are as follows: a) biochemical conversion; b) chemical reaction; c) direct burning; and d) thermochemical conversion.

Figure 1 is a schematic representation of the methods used to produce biodiesel and bioethanol utilising microalgae as the feedstock [10]. As was mentioned earlier, microalgae provide significant advantages over plants and seeds because they: I synthesise and accumulate large quantities of neutral lipids (20 50% dry weight of biomass) and grow at high rates; ii) are capable of all year-round production. Therefore, oil yield per area of microalgae cultures could significantly exceed the yield of the best oilseed crops; iii) require less water than terrestrial crops, thereby reducing the load on freshwater sources; and iv) (1 kg of dry algal biomass utilises about 1.83 kg of CO_2). In addition, microalgae can remove NH_4, NO_3, and PO_4 from wastewater sources (such as agricultural run-off, concentrated animal feed operations, and industrial and municipal wastewater). This process is known as effluent bioremediation. Due to their capacity to thrive in more challenging environments and lower nutrient requirements, microalgae can be grown in brackish water, coastal seawater, or even on land unsuitable for crop production. They do not compete with conventional agriculture for available resources.

Other compounds, such as polyunsaturated fatty acids, natural dyes, polysaccharides, pigments, antioxidants, high-value bioactive compounds, and proteins, may also be extracted from microalgae, depending on the species of microalgae. These compounds have valuable applications in various industrial sectors, including a wide range of fine chemicals and bulk products. Other compounds that may be extracted include pigments, antioxidants, and high-value bioactive compounds.

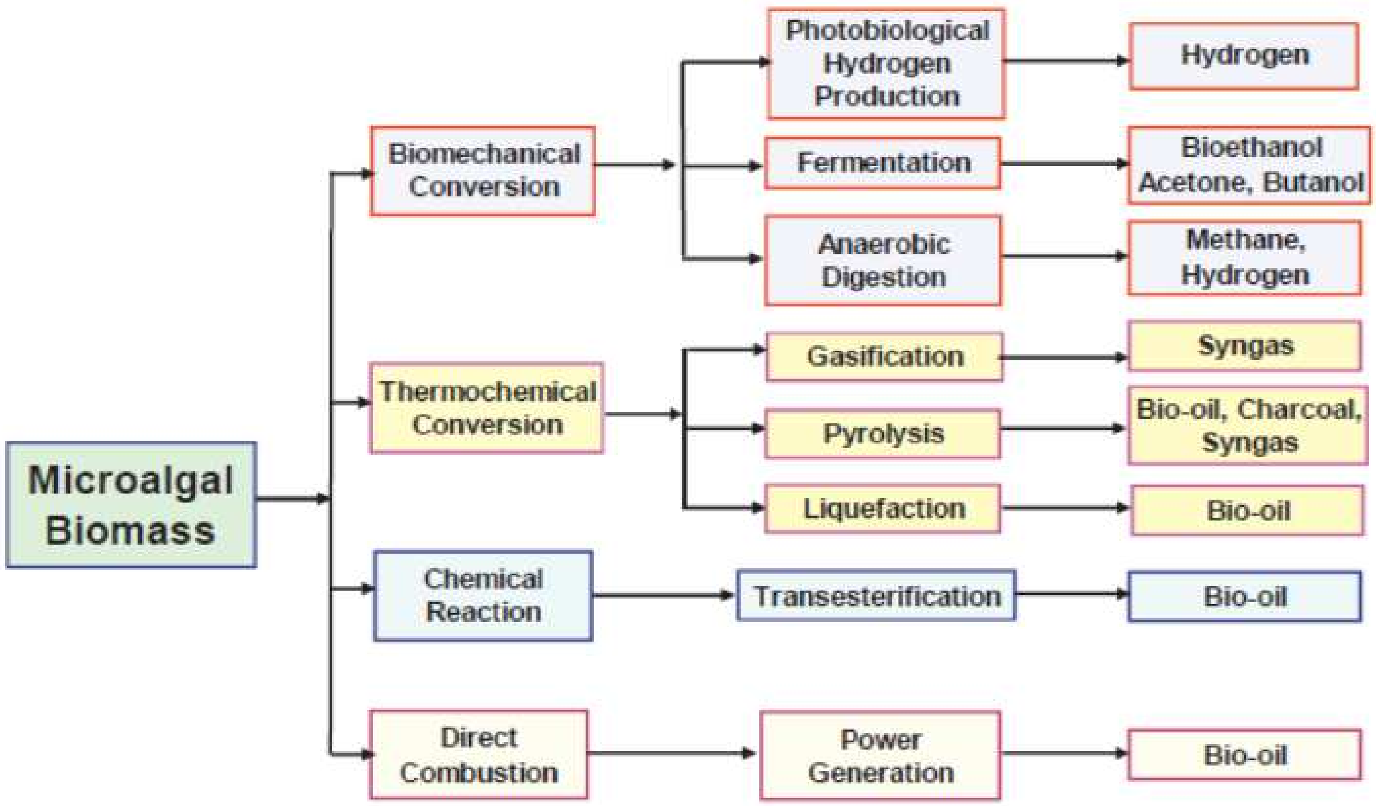

Figure 1 Biofuels production processes from microalgae biomass

Table 2 Production Averages for Common Oil Crops

Production Averages for Common Oil Crops		
Plant	**Lb. oil /acre**	**Gallons of biodiesel/acre**
Algae	6,757	700
Coconut	2,070	285
Jatropha	1,460	201
Rapeseed	915	126
Peanut	815	112
Sunflower	720	99
Soyabean	450	62

It is proposed that carbon dioxide from power plants that burn coal could be used to cultivate algae, which could then be utilised in producing biodiesel and natural gas. Lipid build-up in algae happens most often at times of environmental stress, such as the development of organisms in settings when nutrients are in short supply. Studies using biochemical techniques have led researchers to hypothesise that an enzyme called acetyl-CoA carboxylase (ACCase), which contains biotin and is responsible for catalysing an early step in the fatty acid biosynthesis, may play a role in the regulation of this lipid accumulation process. Therefore, genetic engineering may increase this enzyme's efficiency to facilitate increased lipid synthesis rates. By isolating this gene, research into the cloning of the gene that encodes ACCase from the eukaryotic alga Cyclotella cryptica has been initiated.

The amino acid sequence of ACCase deduced from this gene exhibited a high degree of similarity to the sequences of animal and yeast ACCases in the biotin carboxylase and carboxyltransferase domains. However, a lesser similarity existed in the biotin carboxyl carrier protein domain. This was discovered through research.

The existence of two introns in the gene was discovered using an analysis that compared the nucleotide sequence of the genomic DNA to the sequences of the cDNA clones. To facilitate the overexpression of ACCase in C. cryptica and other species of algae, research teams are now working on constructing expression vectors that include this gene and the development of methods for algal transformation.

Algae- the new hope of future energy but a long way to go.

Microorganisms can produce a more tremendous amount of biofuel than other types of available biomass. Interestingly, developing butanol, ethanol, and jet fuel all start with algae, a treasure hunt for civilisation. There is no doubt that the algal bloom is simple to cultivate in sterile environments such as open ponds or closed sewage systems. Since algal oil is inedible, it is not relevant to debates about food supply and should not be included in non-such discussions. Because algae have more lipids and fatty acids than most other plant materials, they can be successfully converted into biofuel. The excitement around algae as a potential biofuel source is understandable, but advocates must also be willing to acknowledge some of the technology's shortcomings. Businesses such as Algenol, Solazyme, and Sapphire Energy were successful in luring investments from the private sector, amounting to hundreds of millions of dollars, with the guarantee of producing millions of gallons of gasoline in a concise amount of time. However, because the industrial objectives were not met, the significant amount of money and time committed was for nothing. In 2017, Professor Kevin Flynn from Swansea University estimated that the algae needed to be farmed in ponds that are three times the size of Belgium to equalise 10% of the fuels that are employed in the transportation sector in Europe. In addition, fertilizers should be needed at an abnormally high level, around fifty per cent of what European agricultural plants need. Consequently, the corporations decided to redirect their efforts into producing cosmetics and animal feed since the project was expected to provide a low return on its massive expenditures. Even though the study was unsuccessful, the remarkable accomplishments should not be forgotten.

Conclusion

Since the beginning of this decade, there has been a growing interest among the public and the scientific community in algal biofuels for many reasons, one being environmental concerns. The potential growth of this region is affected by several different factors, some of which are positive and others that are not. The findings of the SWOT analysis show that there are specific vital strengths, weaknesses, opportunities, and threats. One of the essential advantages of algae is that its output is much higher than that of most fruitful crops. It is possible to cultivate many species of algae. Algae biodiesel emits less CO_2 than standard diesel. The synthesis of biodiesel from algae is a process that requires a significant amount of energy and, in certain instances, might result in a loss of energy balance. The production costs are much greater than those associated with producing regular diesel. There is a considerable impact on the water supply. Optimising the biodiesel production process utilizing machinery that requires less energy is one of the most critical opportunities—utilization of water recycling after the harvest. Algae cultivation uses the carbon dioxide (CO_2) released as a by-product of combustion.

The cultivation of algae, the treatment of wastewater, and the generation of biogas from algal waste biomass are all related to one another. They are increasing the number of available jobs in the community. Other forms of renewable energy, like hydrogen, are emerging as critical competitors in the transportation sector—a rise in the number of battery-powered electric vehicles being put into use. The generation of biogas from algae may provide higher profits than biodiesel production. Compared to biodiesel from algae, manufacturing biodiesel from lignocellulose raw materials is considered more ecologically beneficial. Many countries' authorities target diesel vehicle manufacturers and their market share. Stakeholders and policymakers can better understand the algae-derived biodiesel production issue by analysing these strengths, opportunities, weaknesses, and threats. As a result, they will be able to make more informed decisions regarding whether to invest in specific research related to improvements in biodiesel production technology and microalgae cultivation. The high costs of infrastructure, operation, and maintenance, in addition to the intense rivalry from the usage of electric cars, are the primary factors preventing large-scale biodiesel production from algae.

One key goal when scaling up algal biodiesel production is minimising or reducing the footprints left using energy, water, and land. The author believes that vast quantities of algae biodiesel will not be employed in the transportation industry anytime soon due to the severity of the problems and the development achieved over the previous decade. The continued use of conventional fossil fuels pushes humankind to study the possibility of developing energy sources that are both renewable and sustainable. The use of biomass presents the most promising prospect for producing biofuels that meet the criteria set out for alternative fuels. Many nations believe in biofuels that produce biodiesel, which is made up of entire algae and oil that is recovered from algae via various conversion processes.

Even if algae development is based on a straightforward idea, there are challenges to be solved in areas such as producing feedstock with a high lipid content and harvesting. Nevertheless, the possibility of turning algae into gasoline of the highest possible quality is exciting. Even though algal biofuel performs very well in engines, it is still necessary to comprehensively analyse the fuel compatibility criteria. However, a significant amount of work must be done before algae biofuel can be considered an economically viable alternative to fossil fuel.

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