Algae is an Efficient Source of Biofuel

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Abstract— The search for a sustainable alternate fuel has already been fuelled by the depletion of fossil resources, rising costs, rising demand, and global climate change concerns. Microalgae have emerged as a possible biofuel feedstock because certain strains accumulate more lipid, grow faster, and have higher photosynthetic output than terrestrial plants. Algae biofuels have the potential to be a viable alternative to fossil fuels; nevertheless, this technology must overcome a lot of barriers before it can compete in the fuel market and be extensively adopted. These concerns include strain identification and improvement in terms of both oil productivity and crop protection, fertiliser and resource allocation and use, and the production of co-products to improve the overall economics of the system. Although there is considerable excitement about the potential of algae biofuels, there is much more work to be done in the industry. A decade ago, algae's energy potential was all the rage in the world of green technology. Algae fuel, also known as third-generation biofuel, includes numerous considerable advantages over earlier feedstocks based on plant crops such as sugar cane and maize, as well as vegetable or animal waste streams. We highlight the opportunities for hastening the strain incentive program that have arisen as a result of recent advances in the use of genome editing in microalgae.

Keywords— algae; biodiesel; large-scale production; transport

I. INTRODUCTION

Algae are creatures that grow in water and create energy through photosynthesis with the help of oxygen. There are two kinds of algae: macroalgae and microalgae. Macroalgae are massive, multicellular algae that grow in ponds and can be measured in inches. These larger algae have the potential to grow in a variety of ways. The term "seaweed" refers to the largest multicellular algae, such as the massive kelp plant, which may grow to be over 100 feet long. Microalgae, on the other hand, are minute, unicellular algae that grow in suspension inside a body of water and are measured in micrometres.

From the manufacture of plastics and fertilisers to the provision of energy for lighting, warmth, and transportation, the global economy is dependent on fossil fuels to function. Our expanding population and economy will need more use of fossil fuels. Data show that as countries' GDP per capita rises, so will their need for fossil fuels, as will competition for these limited resources. In addition, there is a rise in atmospheric CO2 concentration, as well as the likelihood of significant greenhouse gas-mediated climate change, which now appears to affect all parts of the earth. Finally, petroleum, which is derived in part from ancient algae deposits, is a limited resource that will eventually run out or become too expensive to obtain.

Fossil fuel is a non-renewable energy source that is directly linked to pollution of the air, water, and land, as well as climate change. A substantial amount of fossil fuels is utilised as motor fuel in various forms of transportation, power plants, and agriculture. On the other hand, as the number of transportation facilities increases and, as a result, the amount of fuel consumed, the world faces the challenge of finding alternative fuels as fossil fuel reserves dwindle.

To satisfy growing standards, the world has seen a growth in energy consumption and fuel exploitation by emerging nations, especially India and Africa, during the previous few decades. The main concerns associated with current energy insecurity include increased industrialization based on fossil fuels, record high gasoline prices, increased reliance on Middle Eastern oil suppliers, and the negative impact of fossil resources on greenhouse gas emissions, which puts societal pressure on. The factors are difficult and must be handled, ranging from individual national thirst to changes in the environmental picture and tension between nations over fuel usage. Biofuel is gaining popularity since it is not only a renewable energy source, but it is also non-toxic, biodegradable, and has a minimal environmental and climatic effect. They are commonly referred to as solid, liquid, or gas fuels derived from or produced from biomass, which is biological material derived from living creatures. Unlike other forms of renewable energy such as wind, tidal, and solar, liquid biofuels allow solar energy to be stored as well as used directly in existing engines and transportation infrastructure.

The most common biofuels are biodiesel and bioethanol. Among the others are green diesel, vegetable oil, biogas, and syngas. Depleting fossil supplies, soaring global crude oil prices, the energy crisis, and alarming global warming reports have all increased global interest in alternative renewable energy sources. In comparison to solar, tidal, and wind energies, biomass-derived liquid fuels have emerged as the most desirable source of renewable energy since they are easily stored, transported, and used directly in automobiles and other transport engines. Biofuels generated from photosynthetic organism-based feedstocks, such as land plants and aquatic microalgae, have the ability to fulfil global energy demands while also offering carbon-neutral solutions and permitting carbon dioxide sequestration from the atmosphere.

Terrestrial crop cultivation for biofuel feedstock competes with food crops for arable land, reduces the price of edible oil if utilised as biofuel, and typically meets less than the biofuel's total energy to input energy demands throughout the life cycle. As a consequence, it appears that sustainable biofuel production using feedstocks other than terrestrial crops is extremely promising. When compared to big energy-seeking countries, a tiny number of countries are limiting global oil consumption. For the purpose of energy security, it is necessary to seek for new oil sources, such as Nigeria and Angola, where output might reach 10 million barrels per day by 2030. With a sense of urgency and insecurity in its energy supply, China is sourcing its load from more than 20 countries across the world. Putin's administration has begun planning a route from the Pacific coast to the Siberia field to meet Russia's energy needs. This illustrates that, on a global scale, the hunt for new sources is a crucial issue in the search for novel fuel. Beginning around 2005, algae-based biofuel companies such as Algenol, Sapphire Energy, and Solazyme raised hundreds of millions of dollars in private sector investment on the promise that chemically engineering algae could scale up to produce tens of millions of gallons of fuel in a matter of years, at prices comparable to fossil fuels. The high lipid content of algal feedstock allows for efficient fuel conversion. Lipids are fatty, oil-containing acid molecules that may be removed and used to produce biofuels. As a major topic of global debate, it is now clear that first- and second-generation biofuels are limited in their ability to satisfy biofuel production, climate change mitigation, and economic growth requirements.

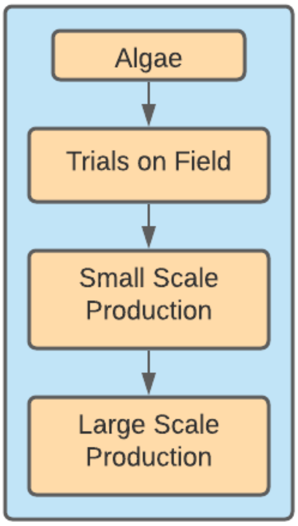

Fig 1. Algae to Biofuel steps

Despite their allure, they have several drawbacks, including the requirement for vast amounts of farmland, natural resources, and irrigation water. Third-generation biofuels, such as algal biofuel, require greater research and development since they provide far more benefits than drawbacks and may provide a consistent supply of energy in the future. Many studies have found that algae can generate around 30% more power per unit area than first and second-generation biofuel production systems. Algae generate 100 times more oil per acre than soybeans or any other terrestrial oil-producing crop, according to the US Ministry of Power.

II. BENEFITS OF ALGAE BIOFUEL

Microalgae are a diverse group of single-celled organisms with the potential to supply a variety of solutions for our liquid transportation fuel needs. Algal species may grow in a wide range of aquatic environments, from freshwater to saturated saline. Algae consume CO_2 effectively and contribute for more than 40% of worldwide carbon fixation, with seaweed accounting for most of this productivity. All algae can produce energy-rich oils, and several microalgal species have been identified to accumulate substantial quantities of oil in dry matter biomass on their own.

With potentially millions of species, algal diversity provides researchers with several options for identifying production strains as well as sources of genetic information that may be used to improve these production strains. The microalgal species being researched as potential biofuel crops are derived from groups with significantly more ancestral links than the most diverse terrestrial plants, resulting in a richness of genetic variety. Microalgae have various advantages over terrestrial plants. Because they are single-celled organisms that multiply by division, high-throughput methods may be employed to rapidly generate strains. In algae, processes that take years in agricultural plants can be condensed to a few months. Algae have a lesser environmental impact than terrestrial biomass sources utilised for biofuels.

They may be grown on land that would otherwise be unsuitable for conventional agriculture and are particularly good at removing nutrients from water. Thus, not only would the production of algal biofuels consume less area than the production of terrestrial plant biofuels, but waste streams could be repaired throughout the growing process. Municipal wastewater is treated to remove nitrates and phosphates before disposal, and flue gas from coal or other combustible-based power plants is collected to collect sulphates and CO2. Algae producing strains may also be bioengineered, allowing for the development of specific characteristics and the manufacture of valuable by products, perhaps allowing algal biofuels to compete economically with petroleum. Because of these characteristics, algae are a platform with a high potential for creating cost-effective biofuels. As a rapidly developing country, India is extensively industrialised and seeking to meet its people's basic energy demands, which should keep up with increasing economic advancement. India's transportation fuel requirements are unique in the globe. It uses more than five times as much diesel fuel as gasoline, whereas almost every other country in the world uses more gasoline than diesel fuel. India is currently the most reliant on coal to meet its energy demands. The exploitation of coal resources is critical to achieving the goal of supplying power to everyone.

Coal is the cheapest, but also the dirtiest, fuel. Domestic biofuel production would reduce emissions from coal power stations and have a less impact on climate change. Thus, in India, the quest for alternative energy sources is especially important, and the use of biodiesel is significantly more important for us than it is for the rest of the world. Biomass energy is the world's fourth largest source of energy and India's first. The use of algae to produce biofuel will not jeopardise agricultural output of food, fodder, and other commodities. Attempts to tap the potential of algae are attempted on a regular basis, even though analysts appear to feel that current gasoline prices are not high enough for algal biofuel to become competitive.

III. MEHODOLOGY

The study's content is based on papers given at conferences, journals, and specialised scientific publications, as well as scientific databases such as Science Direct, Scopus, MDPI, Google Academic, Google Scholar, and unique web site topics. This study also takes use of papers and information on algae biodiesel production made available by the European Union, the International Renewable Energy Agency, and the European Environment Agency. Internet sites and scientific papers that lacked trustworthy and cited data sources were excluded. A wide range of algae production technologies, including open ponds and closed photobioreactors, fermentation tanks, hybrid systems, and those that combine these processes, are presently being developed. Simply said, there is no one approach for mass-producing algae, and one of the benefits of algae is its versatility. In most cases, the technique is implemented solely to promote algae growth to produce fuel chemicals or other industrial items. The precise functionality of these devices is primarily dictated by their position and the desired end-product. This section looks at the many types of algae growing systems that are presently being installed across the United States.

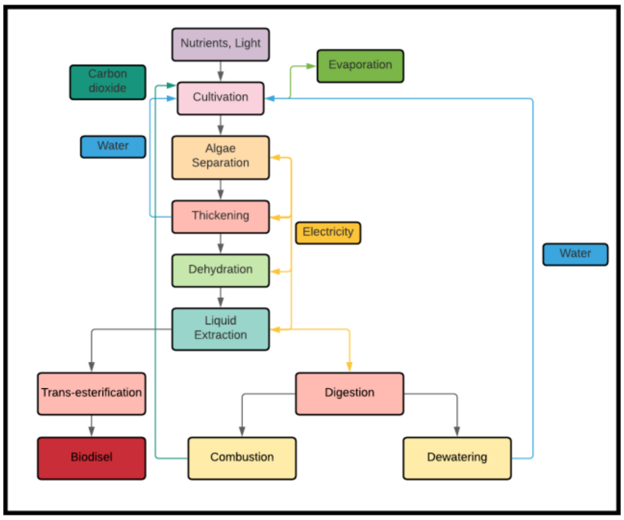

Fig 2. Schematic Representation of biodiesel production from Algae

As a result, global feedstock potential from algae production is limited to areas with enough radiation, water, and nutrients. Temperatures ranging from 20 to 30 degrees Celsius are preferred by the majority of algae species. However, the actual biomass output of algae has been far lower thus far. Today, numerous algae farming technologies are being developed efficiently, spanning from outdoor ponds to inside photoautotrophic, mixotrophic, and hybrid processes. Each system aims to hasten the growth of algal biomass to produce biofuels or other industrial commodities. Algae may thrive in areas that are unsuitable for growing food crops, and since they can utilise saltwater, there is less need for fresh water, which is in limited supply.

The production of hundreds or even thousands of barrels of diesel per day consumes slightly under 1% of the land utilised for soybean and maize crops. When compared to traditional biofuel plants, algae can generate oil per hectare of land occupied. It is vital to identify an appropriate site when picking an algae farming system in order to get the required outcomes. Algae farming systems are currently available in a variety of configurations. Raceway or circular open pond systems, with or without water churning, are the most prevalent. Unstirred ponds are the most basic since they lack a water stirring device and, as a result, are the least expensive.

The most common form of algae growing system is an open pond system, which is now being used commercially in the United States to produce nutritional items and remediate wastewater. The ponds are usually referred to as raceway ponds because to their configuration. They usually use paddle wheels or other water moving devices to keep the algae running. The harvesting technique is typically a two-stage operation, depending on the characteristics of the algae and the process requirements. Every day, a part of the pond water is removed, and the algal biomass contained inside it is concentrated. The biomass is then processed further, for example, to extract the oil for conversion into biodiesel, jet fuel, or another oil-based product. A Photobioreactor differs from an open system in that the algae are enclosed in a transparent vessel, which can be as simple as a greenhouse, but is more commonly a tubular bag-type or panel design, available in a range of shapes and sizes and oriented vertically or horizontally. Some systems even use artificial light to boost output, while others rely totally on it. One of the primary benefits of PBRs is that they may better match the ideal environment and development requirements of types of algae that are difficult to grow in open ponds.

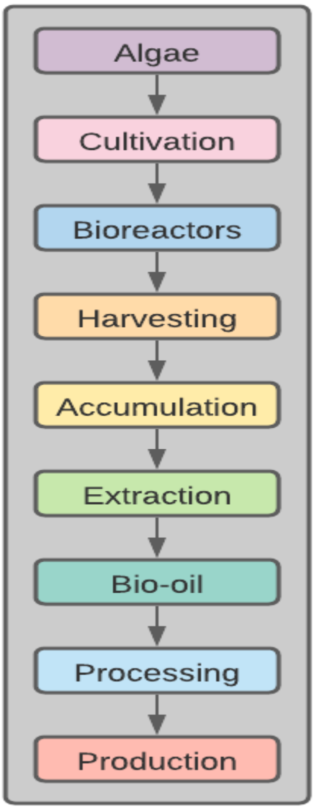

Fig 3. Biofuel culture for commercial Production

Some academics and companies are investigating an alternative technique of growing algae that does not rely on sunlight; they grow them in the dark on sugars in a process known as heterotrophic fermentation. Algae transform carbohydrates into oils or biomass, which may subsequently be utilised to generate biofuels, chemicals, nutritional products, cosmetics, and other products. Salarymen, a California company, has already generated tens of thousands of gallons of algae-based fuels as part of their research and development agreement.

This category takes use of algae's ability to treat wastewater by collecting nutrients and CO2, as well as breaking down and removing unwanted, even deadly, substances. The algal biomass produced by such wastewater treatment facilities might be used to produce methane, fertiliser, oil, and other liquid fuels. Many firms are attempting to modify algae to make biofuel. In other words, instead of gathering oils in the biomass, the algae would excrete useful compounds into the culture or medium in which they are grown. This approach has the advantage of requiring only a tiny quantity of algae biomass to begin generating oils, removing the need for harvesting and processing, which can significantly raise total costs.

IV. CONCLUSIONS

Algal biofuels have aroused the interest of the public and scientific community in the recent decade for a variety of reasons, including environmental concerns. Various influences, both good and negative, have an impact on the future expansion of this area. The results of the SWOT analysis reveal significant strengths, weaknesses, opportunities, and threats. One of the most significant benefits of algae is that its production exceeds that of most successful crops. Algae of several kinds may be cultured. Algae biodiesel emits less CO2 than regular diesel. The production of biodiesel from algae is an extremely energy-intensive process that, in certain cases, results in a negative energy balance. The manufacturing expenses are substantially higher than those of normal diesel. The water footprint is significant. One of the most significant potential is to optimise the biodiesel manufacturing process using less energy-intensive equipment. Water recycling after harvest is employed. CO2 emitted by exhaust emissions is utilised to grow algae.

Algae farming, wastewater treatment, and biogas production from algal biomass waste are all interconnected. Improving local employment opportunities. Other renewable energy sources in transportation, such as hydrogen, are posing a significant threat. Increasing the usage of electric cars powered by batteries. Biogas production from algae is more profitable than biodiesel production. The manufacturing of biodiesel from lignocellulose raw materials is more environmentally friendly than the production of biodiesel from algae. Many nations' policies are aimed at reducing the production and sale of diesel automobiles. Based on these strengths, opportunities, weaknesses, and threats, stakeholders and policymakers can gain a better understanding of the issue of algae-derived biodiesel production and, as a result, make more informed decisions about investing or not investing in specific research related to improvements in biodiesel production technology and microalgae cultivation. The key barriers to large-scale production of biodiesel from algae appear to be high infrastructure, operating, and maintenance costs, as well as strong competition from electric car use.

Minimizing/reducing energy, water, and land-use footprints should be a primary objective of scaling up algal biodiesel production. Given the intensity of the concerns and the progress made in the past decade, the author feels that large amounts of algae biodiesel will not be used in transportation anytime soon. The usage of traditional fossil fuels compels humanity to investigate the development of renewable and sustainable energy sources. The greatest option for creating biofuels that fulfil the final standards of alternative fuels is biomass exploitation. Many countries have placed their trust in biodiesel-producing biofuel, which is composed of whole algae and oil extracted from algae via conversion techniques. Though the premise of alga cultivation is simple, there are problems in developing feed stock with high lipid content and harvesting that must be overcome. The prospect of transforming algae into optimal fuel is enthralling. Although algal biofuel operates well in engines, a detailed assessment of the fuel compatibility requirements is required. However, algal biofuel has a long way to go before it becomes a commercially viable alternative to fossil fuel.

V. FUTUREWORK

We discussed ways to make algae-based fuels competitive with petroleum fuels in terms of cost. Bioprospecting is essential for discovering algae species with desired traits that can thrive on low-cost media. Despite its potential, bioprospecting is unlikely to yield species that are cost competitive with petroleum, and that extra genetic engineering and breeding would be required to bring these strains to economic viability.

Engineering algae offers a wide range of potential uses, including increased lipid synthesis and crop protection, as well as the production of key enzyme or protein co-products. Any sustainable technology has challenges, but uncritical marketing of such technologies without an honest assessment of the long-term implications may lead to the adoption of strategies whose long-term consequences outweigh their short-term benefits. We have listed what we think to be the most critical present and future concerns in algae biofuels, but like with any new business, the more we learn, the more challenges we discover that we had not expected.

Despite these uncertainties, we believe that fuel production from algae will be cost competitive, widely scalable, and deployable within the next 7–10 years, but only if we continue to expand our understanding of these amazing organisms while also expanding our ability to engineer them specifically for the task of developing a new energy industry. A big section of India is submerged under water. Experts believe that algae growing on less than 2% of India's total geographical area may make the country self-sufficient in liquid petroleum. The anticipated yield of algae in one acre of wasteland is 30 times that of Jatropha, thus algae farming also solves the food vs. fuel dilemma. Most Indian experts feel that the Sundarbans delta, a remote deltaic wetland, might be used for algae cultivation and biodiesel production. On the Indian side of the Bay of Bengal, the Sundarbans delta, the world's largest mangrove swamp, is becoming a breeding ground for eco-friendly energy sources.

Currently, an effort is being made to experiment with algae growth to extract biodiesel. If this initiative is successful, it will herald in a new age in the realm of renewable energy resources in India. Algae has been promoted as a future significant source of biofuel. Algae farming does not require prime agricultural land and may be grown in desert-like environments with brackish and salty waters that are unsuitable for terrestrial crops. Water used for algae production is not incompatible with agriculturally important processes. Algae biofuel production is a low-cost and ecologically beneficial technique of manufacturing biofuel. It is being used all around the world since it is safer and creates less emissions during combustion. Algae biofuel is produced by algae, and numerous types of algae are known to produce algae biofuel. Green biodiesel made from algae. Algae biofuel has the potential to replace liquid fossil fuels. Algal fuel generation is larger than that of present technology. To address the requirement for fuel as raw energy, algae-derived biodiesel might be used in diesel engines. Algae biofuel is both ecologically beneficial and safe. Algae biofuel benefits the environment by eliminating poisonous gases created during combustion.

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