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Organic nitrogen application on algal growth for biodiesel applications

Shivani Saklani [a], Bindiya Barsola [a], Priyanka Kumari [a], Diksha Pathania [b,*]

[a] School of Biological and Environmental Sciences, Shoolini University of Biotechnology and Management Sciences, Solan 173229, India
[b] Animal Nutrition Division, ICAR-National Dairy Research Institute, Karnal 132001, India

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ABSTRACT

Development in science and technology has led to many innovations and made human life better in every aspect. With the increasing rate of human development, there has been a tremendous increase in environmental pollution and over-exploited natural resources. The hunt for innovative and ecologically sound renewable energy sources has been sparked by the global energy crisis and rising greenhouse gas emissions. Modern humankind is experiencing a number of issues, many of which are the results of rapid industrialization, increased population expansion, and usage of fossil fuels which boosts atmospheric CO_2. Biofuels made from algae are both technically and financially feasible. They are cost-effective, require no new lands, use very little water, and reduce atmospheric CO_2. Biofuels can be one of the finest alternatives to conventional fuel sources.

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1. Introduction

The viability of microalgae as a source of clean energy has attracted a lot of attention. Microalgae -based biofuel production aims to be sustainable and profitable, additional mass culture optimization is necessary. Despite a sevenfold increase in global biofuel output since 2000, only 2.3 % of total liquid fuel demand has been satisfied [1]. The estimated rise in global energy consumption in 2007 from 522 exajoules (EJ) to 780 EJ in 2035 is 49 %. Microalgae have caught the interest of the scientific society on a global scale, since they are nearly carbon neutral, have an elevated lipid content, and are favourable to alternative biofuel sources [2]. Highly effective wastewater treatment technologies are now required because of the escalating wastewater pollution caused by the rapidly increasing population, quick industry, and rapid urbanization [3].

Microalgae are practical resources that can be used to create a circular green economy, because of their rapid growth rate, great resistance to a variety of abiotic stimuli, and sophisticated metabolic capabilities [4,5]. Autotrophic microalgae break down carbon dioxide to create lipids, proteins, and carbohydrates that can be used as a feedstock for biofuels like butanol, biodiesel, biogas, biohydrogen, bioethanol, bio-oil, char, and even electricity [6–8]. It is also helpful in maintaining ecological balance as microbe-based degradation and sophisticated oxidation processes, may be used to remove contaminants in the ecosystem [9]. Biofuel from combustible sources is now acknowledged as a substitute and environmentally friendly renewable fuel for the generation of sustainable energy in the near future (including biodiesel, bioethanol, and biogas) [10]. The photosynthetic microorganisms known as microalgae are piquing the interest of researchers, the government, and both domestic and foreign businesspeople. The usage of liquid biofuels has significantly increased recently, especially in the transportation industry [11].

Greener methods are essential from an economic and environmental perspective [12]. Although there has been a lot of interest in the potential of microalgae as a renewable energy source and is both financially viable and sustainable, further its culture optimization is necessary [10,13]. The function of DON (dissolved organic nitrogen) in many aquatic systems and its increasing study interest. The significance of DON as a possible source of accessible Nitrogen for bacteria and algae in estuarine and coastal environments has recently been highlighted by various research. In addition to the fundamental issues causing a discrepancy between theoretical forecasts, empirical assessments, commercialization

* Corresponding author.
E-mail address: dikshapathania198@gmail.com (D. Pathania).

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can be achieved by addressing laboratory testing, profitability, their possible solutions, and field-deployable possibilities, ensuring the capacity for future generations to uphold sustainable communities [14].

2. Production of microalgae biomass and biofuel

There are two main ways upstream and downstream processes for the production of biofuels (Fig. 1) [15].To increase biomass quality and quantity, many cultivation techniques are used in the upstream phase like cultivation strategies, molecular analysis, and relations between microalgae and bacteria whereas the development of sustainable biofuels and harvesting technologies for example collecting and drying, removing impurities, purifying, and converting biochemically are highlighted in the downstream stage (Fig. 2).

3. Algal growth effectiveness in wastewater

Numerous factors affect how effectively microalgae grow in wastewater. The growth medium's pH and temperature, as well as the level of vital elements like N, P, and organic carbon (and the ratios of these components), as well as the availability of light, oxygen, and carbon dioxide, are all crucial factors [17]. The elevated levels of micronutrients, such as N and P, in wastewater, make it significantly different from conventional growth media. Ammonia, which can hinder algae development at high concentrations, makes up a significant portion of the N [18]. Pathogenic bacteria and predatory zooplankton are two examples of biological elements that may have a deleterious effect on algae growth. Another important element for the growth of microalgae in wastewater is the existence of toxins like cadmium or mercury or organic compounds [18]. The growth medium's concentration, temperature, and pH of vital nutrients, such as N, P, and organic carbon, are all crucial factors in any growth media.

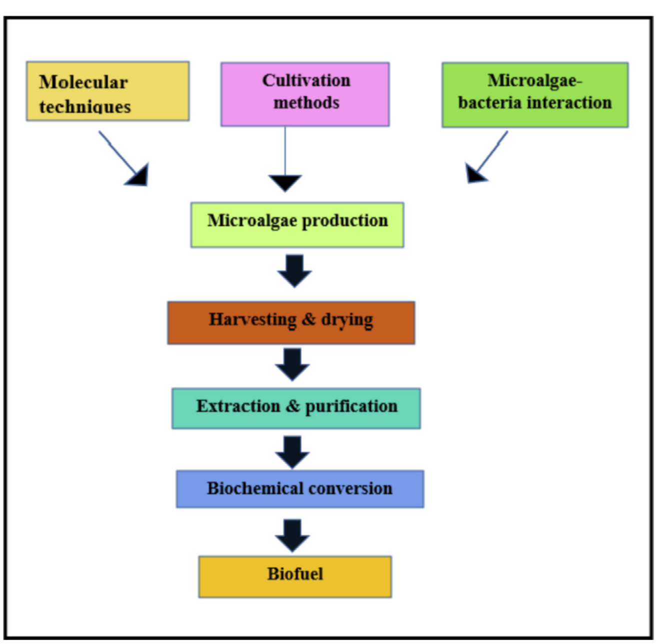

Fig. 1. Biofuel production [15].

4. Algal species

Some common microalgal species can grow to high concentrations of desired biofuels as mentioned in Table 1. For instance, *Chlorella protothecoides* are regarded as the ideal feedstock for biodiesel since they can collect 55 % of lipids when grown heterotrophically with nitrogen limitation [19]. Species, like *Spirulina* sp., have the ability to create biomethanol by gasification or fermenting anaerobically [20]. Researchers have found the suitability of *S. obliques* to produce biohydrogen [21]. Additionally, it was discovered that the algal consortia may use wastewater effluent as a nutrient broth in open ponds, and the obtained biomass can be used as a feedstock for biochar [24].

5. Role of organic nitrogen

Waste water is the major source of nitrogen in microalgae propagation. Algae has the potential to absorb nitrogen and phosphorus from water [26,27]. Since the production of their proteins requires a lot of nitrogen and phosphorus (which make up 45–60 % of their dry weight), phospholipids and nucleic acids for which microalgae are an effective way to extract considerable amounts of nutrients [28]. While at least 50 % of the phosphorus in sewage effluent comes from synthetic detergents, the majority of the nitrogen comes from biochemical interconversions of other derived chemicals [29].

6. Possibility of producing biofuels sustainably

In contrast to many plant-based biofuel crops, microalgae may be successfully cultivated in conditions requiring little freshwater input, and they can be grown on land that would otherwise be unsuitable for growing crops, which makes the process potentially more efficient [30,31]. [32] explained that microalgae are an incredibly appealing option for environmentally friendly and inexpensive wastewater treatment due to their capacity to grow well in to effectively absorb nutrients and metals from wastewater and flourish in nutrient-rich environments.

7. Benefits of microalgae as a biofuel resource

If compared to conventional crops like soybeans and maize, microalgae possess a higher level of areal biomass productivity, and their oil content can surpass 80 % of their dry weight in biomass [33]. The manufacturing of superior chemicals, wastewater treatment, and the generation of biofuels using algae can all be combined. There are numerous microalgae species that produce a substantial amount of lipid that can be transesterified into biofuel [34,35]. Traditional methods of generic seasonal toxic chemical spraying have a detrimental impact on the environment and people's health [36]. Microalgae help in reducing the toxicity of wastewater [37]. In addition, residual algal biomass, which is primarily made up of proteins and carbohydrates, can be transformed into a range of biofuels, such as fuels made of alcohol and hydrocarbons, as well as other non-fuel byproducts that can be recovered and turned into high-value goods like nutraceuticals, pharmacology, and livestock feed [36–39]. Biofuels are environment friendly and have a number of other benefits (Fig. 3.).

8. Discussion

Concerns over the creation of ecologically friendly fuels, such as biofuels, have grown as a result of the rapid processes of economic development and energy consumption, as well as the crisis of scarce fossil fuel resources and the ever-rising demand for environ-

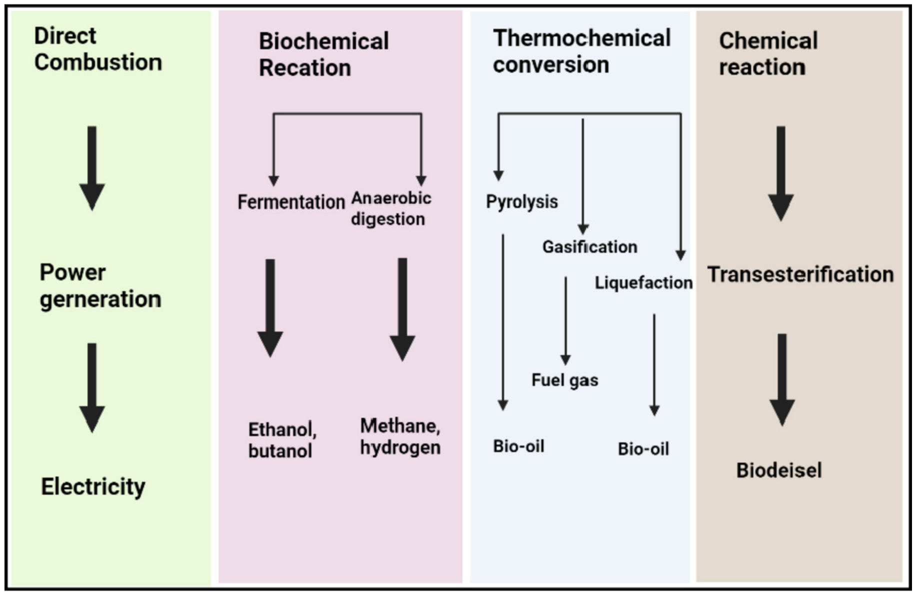

Fig. 2. Process for biomass conversion [16].

Table 1
Different microalgal species are used for biofuel production.

S.No.	Algal species	Produced Biofuels	References
1.	*Chlorella protothecoides*	Biodiesel	[19]
2.	*Spirulina* sp.	Bioethanol	[20]
3.	*Scenedesmus obliques*	Biohydrogen	[21]
4.	*Chlorococum* sp.	Bioethanol	[22]
5.	*Microalgal consortium*	Biochar	[23]
6.	*Nannochloropsis salina*	Biogas	[25]

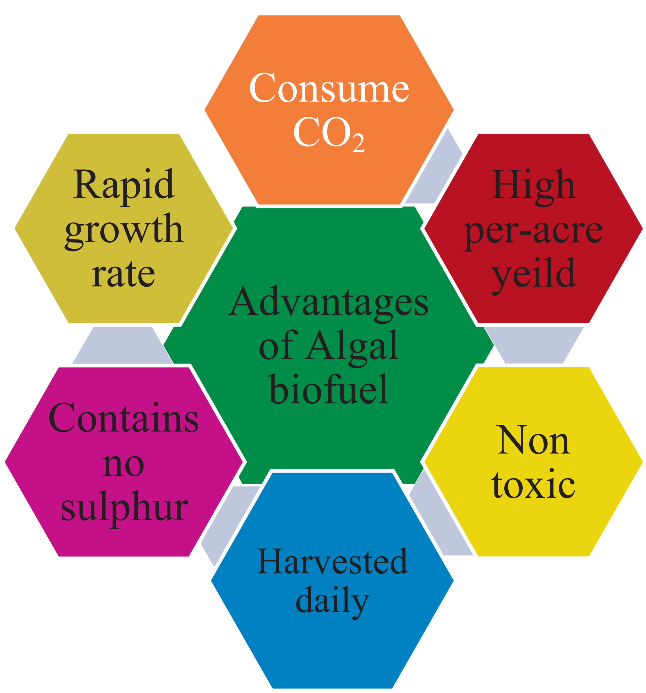

Fig. 3. Advantages of Algae-based biofuels.

mental protection. This study also examined an innovative algae E2 -Energy system. Algal biomass production is integrated into the production of biofuels during the hydrothermal liquefaction of wastewater and into bio-crude oil as the capacity to consume nutrients more than once to develop numerous rounds of algal biomass, increasing the amount of bioenergy that can be produced.

CRediT authorship contribution statement

Shivani Saklani: Conceptualization, Data curation, Project administration, Writing – review & editing. **Bindiya Barsola:** Data curation, Formal analysis, Writing – original draft. **Priyanka Kumari:** Conceptualization, Data curation, Formal analysis, Project administration, Writing – review & editing. **Diksha Pathania:** Project administration, Writing – review & editing.

Data availability

No data was used for the research described in the article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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