Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 8, S. 702-705, 2, 2024

Araştırma Makalesi

https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 8, pp. 702-705, 2, 2024

Research Article

Biofuel Production from Water Cyanobacteria: A Review

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(Received: 12 March 2024, Accepted: 14 March 2024)

(4th International Conference on Innovative Academic Studies ICIAS 2024, March 12-13, 2024)

ATIF/REFERENCE: Sevgili, İ., Yalçın, Z. G. & Dağ, M. (2024). Biofuel Production from Water Cyanobacteria: A Review. *4th International Conference on Innovative Academic Studies*, 8(2), 702-705.

Abstract- Water stands as the quintessential resource vital for sustaining life forms on our planet. However, its integrity is continually jeopardized by human, industrial, agricultural, and livestock activities, resulting in a spectrum of repercussions that are notably challenging to rectify. Among these ramifications, the proliferation of toxic cyanobacteria, commonly known as blue-green algae, emerges as a particularly dire consequence. The prevalence of these cyanobacterial species, predominantly toxic in nature, not only disrupts aquatic ecosystems but also poses significant threats to human health due to their persistent and recalcitrant nature. Nevertheless, recent scientific inquiries have illuminated a potential avenue for repurposing toxic cyanobacteria as a viable biofuel source. The prevailing reliance on environmentally detrimental fossil fuels, constituting approximately 80% of the energy matrix, underscores an urgent imperative to explore alternative energy reservoirs. The depletion of fossil fuel reserves coupled with escalating environmental degradation has spurred concerted efforts within the scientific community towards identifying sustainable alternatives. This paradigm shift has propelled renewable energy sources, encompassing solar, wind, oceanic wave, hydroelectric, and biofuel technologies, to the forefront of contemporary discourse on energy sustainability. Of particular interest, cyanobacteria, recognized for their rapid proliferation in conductive environments, offer a promising prospect for biofuel production due to their innate ability to yield high thermal energy output when processed in suitable biomass contexts. Consequently, this study endeavors to elucidate the influence of cyanobacteria on the coagulation and flocculation processes employed in treating water extracted from reservoirs designated for potable use, while also scrutinizing its economic ramifications.

Keywords: Cyanobacteria, Blue-Green Algae, Sustainable Energy, Renewable Resources, Biofuel Production.

I. INTRODUCTION

The ongoing climate change worldwide has begun to adversely affect all living organisms on land and in water. With the increase in temperatures, various changes are occurring both on land and in water [1-2]. As a result of these changes, extreme temperatures in lakes, rivers, and reservoirs have led to a decrease in oxygen levels. This has resulted in the death of organisms living in water. Additionally, unwanted microorganisms, especially cyanobacteria, have been observed to increase toxin formation. Cyanobacteria are naturally present [3], but it is known that toxic types form in aquatic environments due to human, animal, agricultural, and industrial pollutants.

Cyanobacteria constitute a portion of the phytoplankton found in oceans and freshwater bodies [4]. However, toxic types of these bacteria, also known as blue-green algae, are significant contributors to the pollution of aquatic environments. Various efforts have been made to mitigate this pollution [5].

Cyanobacteria play a crucial ecological role by fixing atmospheric carbon through photosynthesis. From ancient times to the present, it has been thought that fossil remnants of cyanobacteria have influenced the formation of petroleum. However, the use of cyanobacteria in biofuel production is also noteworthy today [4]. Particularly, the rapid increase in energy demand has intensified interest in studies such as bio-oil production from cyanobacteria.

The lack of sustainability and rapid depletion of traditional energy sources such as coal, oil, and lignite have increased interest in sustainable energy sources. One of these sources is obtaining biofuel from cyanobacteria, which produce toxic substances [5]. In an oxygen-free environment, the biomass of cyanobacteria leads to the formation of biogas containing methane and carbon dioxide. Additionally, wastewater containing cyanobacteria can undergo various chemical processes to produce biodiesel, referred to as third-generation fuel. Furthermore, direct fuel production from water and CO_2 is referred to as fourth-generation fuel [5].

II. STUDIES ON CYANOBACTERIA FOR BIOFUEL AND PIGMENT PRODUCTION

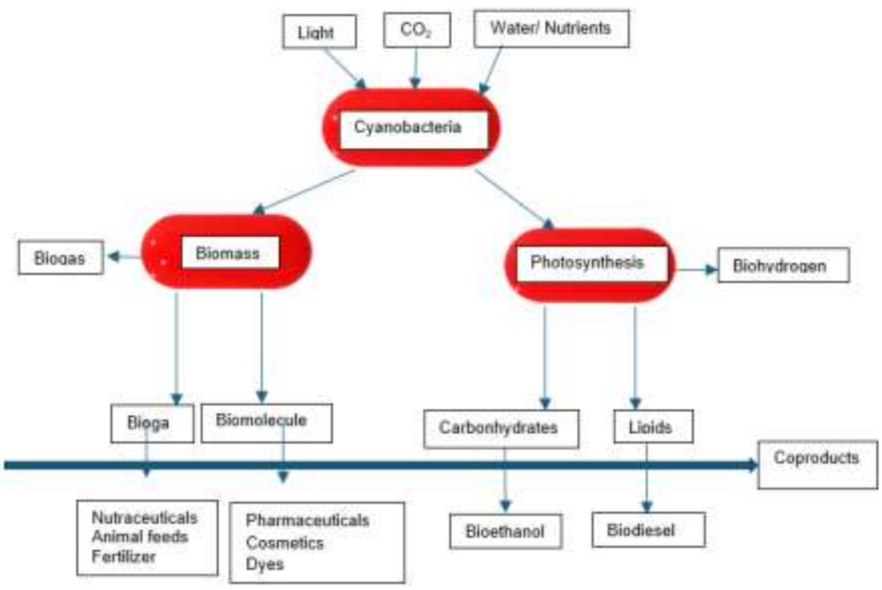

Figure 1. Conversion of Cyanobacterial Biomass into Biofuels [6]

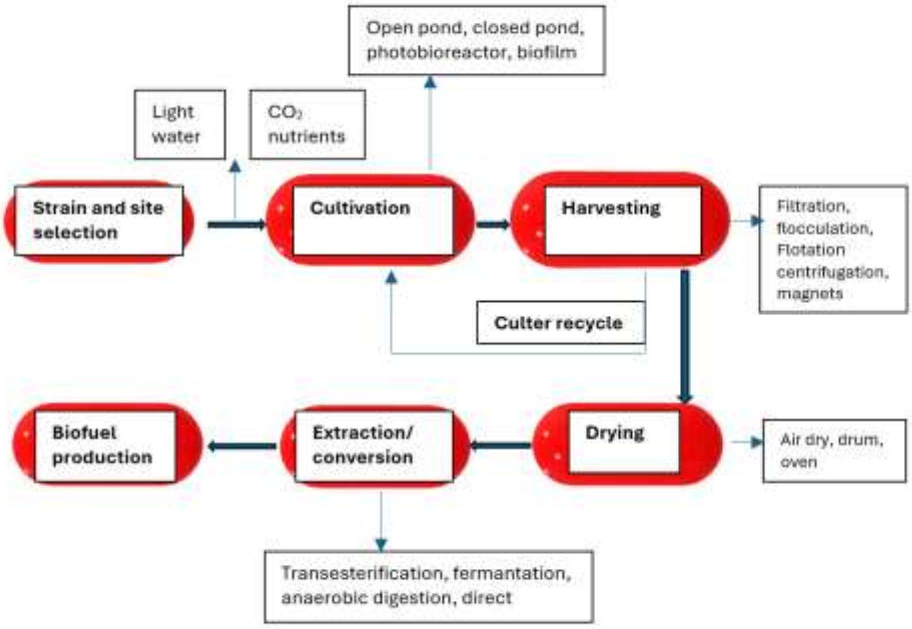

Figure 2. Flow Diagram of Biofuel Production [6]

In their study, Sadvakasova et al. isolated cyanobacteria (Geitlerinema amphibium) from thermal water to produce fatty acids, biodiesel, and pigments in two culture media. They cultured G. amphibium in WC (Wright's Cryptophyte) and BBM (Bold's Basal Medium) environments, maintaining the cultures at 40°C for 48 hours. They achieved higher biomass productivity in BBM, with G. amphibium producing higher biodiesel in WC and higher pigment in BBM environments. The thermal treatment increased the biodiesel content by 350% [5].

Zeng et al. washed cyanobacteria collected from Lake Taihu with clean water. They subjected the washed cyanobacteria to drying at 100°C in a solar oven and then ground them into powder. Through pyrolysis, they converted the cyanobacteria into bio-oil with an aromatic content of 9.1% by weight and a high bio-oil yield of 32.3% by weight at 450°C. Using catalysis, they obtained biofuel with a heat value of 32.60 MJ/kg [7].

D'Alessandro et al. produced biodiesel and pigments from cyanobacteria in their study. They collected cyanobacteria from thermal water and isolated them in two culture media to produce fatty acids, biodiesel, and pigments. They observed significantly higher biodiesel production from cyanobacteria at 40°C for 48 hours [8].

III. CYANOBACTERIA: RAPID GROWTH AND ADVANTAGES IN BIOFUEL PRODUCTION

Cyanobacteria have the unique ability to rapidly grow and regenerate themselves in sunlight and water, feeding on nitrogen and phosphorus [9]. Studies have shown that cyanobacteria, with their prokaryotic cells, perform well in the production of fourth-generation biofuels. Among their significant advantages is their ability to grow rapidly and multiply their biomass without the need for large cultivable land areas. Cyanobacteria have been found to utilize dissolved CO_2 from both the atmosphere and water for biofuel production. Unlike algae, which produce fuel within their cells, cyanobacteria are observed to produce fuel outside their cells, providing an important advantage for practical applications [4].

IV. THE KEY ADVANTAGE OF PRODUCING BIOFUEL FROM CYANOBACTERIA IS ITS COST-EFFECTIVENESS

One of the most significant advantages of producing biofuel from cyanobacteria is its affordability. Traditional biofuel derived from bacteria has been found to be cost-effective. However, producing biofuel from toxic cyanobacteria requires the use of aromatic compounds such as Phenol (C_6H_6O), Phenol,4-methyl (C_6H_8O),1,4-Benzenediol, 2-methoxy ($C_7H_8O_3$), Indole (C_8H_7N) 1H-Indole,2-methyl- (C_9H_9N),1.8 p-Xylene (C_8H_8), Styrene (C_8H_{10}), Benzenepropanenitrile (C_9H_9N), nitrogen compounds including Acetamide, Propanamide, Hexadecanamide, 2-5 Pyrrolidinedione, 1-2-4-Triazine-3,5(2H, 4H)-dione, Pyrrole, 1H-Pyrrole, 2-methyl-, Pentanenitrile, 4-methyl-, 1H-Imidazole, 2-methyl-, Acetyl-1-methylpyrrole, Pyridine, 3-methoxy-, and oxygenated compounds such as Acetic acid, Propanoic acid, Pentanoic acid, n-Hexadecanoic acid, Methyl alcohol, 2-Pentanone, 4-hydroxy-4-methyl-, Methyl Palmitate), among others. Large-scale production with these chemical components is quite expensive [7] [10].

V. RESULTS AND DISCUSSION

Research into cyanobacteria has revealed their potential to serve as a sustainable energy source, despite their notorious role in causing unwanted pollution in reservoirs, seas, and lakes, essentially contaminating all water sources on Earth. However, recent studies have unveiled a promising aspect of these toxic cyanobacteria: under suitable conditions, they can be cultivated to produce high-energy biofuels, yielding positive results. While the processes involved may incur significant costs, it is believed that adopting more economically viable methods will enhance the importance of such research endeavors.

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