Chapter 9
Biofuels From Macroalgae: A Sustainable Alternative to Conventional Energy Resources

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ABSTRACT

The steep rise in human population together with the simultaneous growth of urbanization and industrialization has triggered overuse of fossil fuels in the recent years. However, they are non-renewable and release carbon dioxide causing global warming. In this context, biofuels come as excellent substitutes because they are renewable and eco-friendly. They are obtained from biological products and include biodiesel, biomethane, bioethanol, and biohydrogen. They are classified into first, second, and third generation fuels depending on the biological feedstocks being used. Of these, the third-generation fuels, obtained from marine resources like algae, have attracted special research interests because they do not rival the food crop production or depend on land and freshwater for their cultivation. However, the potentialities of macroalgae as a biofuel resource have not been investigated thoroughly. The chapter tries to outline all the aspects of biofuel production from macroalgae pointing out the scopes for future research.

INTRODUCTION

Overexploitation of the fossil fuels and the non-renewable energy resources like coal, petroleum and natural gas in the last few years has not only led to the depletion of resources but has also added carbon dioxide (CO_2) to the atmosphere. Needless to say, CO_2 is a major greenhouse gas (GHG) and causes global warming (Naik et al., 2010). The problem has been projected to rise in the years to come. This necessitates the development of alternative energy sources to meet the growing demands of the burgeoning popula-

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tion as well as reduce the adverse environmental effects (Mabee et al., 2005). According to Naik et al. (2010), eco-friendly and sustainable energy resources are the need of the hour for sustainable growth of the economy and industry of a nation. In this regard, several attempts have been taken by researchers to utilize plant biomass and/or organic wastes for extraction of energy. The lipid and carbohydrate contents of these substances have mainly been targeted by hydrolytic degradation, fermentation, pyrolysis and various other techniques to procure the fuels (Gao et al., 2020). They have been termed as 'biofuels' and have emerged as promising alternatives of conventional energy sources. Because of their renewability and sustainability they have been proposed as the 'future energy resources' (Reid et al., 2020). Their extraction from plant derivatives gives an added advantage of maintaining carbon balance in the atmosphere. According to Gao et al. (2020), plants help to sequester atmospheric CO_2 by photosynthesis. As such, burning of the fuels obtained from them does not become an additional source of CO_2 emission. Therefore, biofuels can combat global warming to a large extent (Kumar et al., 2016). Another advantage of biofuel production is its ability to generate new employment opportunities (Stevens & Verhe, 2004).

The biofuels sector is, however, in its stage of infancy because of several issues and challenges associated with their production that need to be addressed before they can be manufactured in large-scales (V. G. S. et al., 2021). The common challenge lies in the development of technological sophistication to extract the biofuels with minimum loses such that the final products do not exceed the price of conventional fuels. Otherwise, it will reduce their marketability (Gao et al., 2020). Currently, this field is being explored by various researchers in different parts of the world. The other problem is the direct confrontation of biofuel production with food resources because they have often been attempted to be derived from crop plants accelerating two pertinent issues – global water crisis and food scarcity (Naik et al., 2010). Land availability for cultivation of these crops is another problem under the current conditions of explosive population growth because of increasing land requirements for human habitation (Naik et al., 2010). Land is also required for augmenting crop production to meet the demands of the expanding population. Adequate freshwater supply is equally important to maintain agricultural productivity. Using freshwater for cultivation of terrestrial plants to be used as feedstock for biofuel manufacture will trigger competition between the biofuel and agricultural industries. These problems have encouraged the researchers to explore non-consumable raw materials (that are not terrestrial derivatives) for biofuel production (V. G. S. et al., 2021). Consequently, the marine resources primarily consisting of the micro and macroalgae have emerged as the preferred candidates for biofuel extraction. Some workers like Liao et al. (2021) have used the term 'blue bioeconomy' to describe the economy dependent on such biofuel resources. They offer several advantages over terrestrial plants the most important being their rich carbohydrate and lipid contents together with low (to almost zero) proportions of lignin facilitating the extraction of biofuels by employing cheaper technologies (Gao et al., 2020). Furthermore, they can be cultivated in unused, rejected or barren lands with saline water and wastewater and can withstand adverse environmental conditions (Gao et al., 2020). Despite these advantages, they have certain drawbacks that have prevented them from gaining popularity. They need further developments both in terms of technology and overcoming certain serious environmental issues associated with their production (Hughes et al., 2012; V. G. S. et al., 2021).

The current chapter tries to give a comprehensive review of the advantages of using macroalgae as the source of biofuels by going through some recent publications in this field. It discusses about the advantages and limitations of microalgae while referring to the potentialities of macroalgae as a biofuel resource. It also highlights about the various challenges and environmental issues of biofuel production