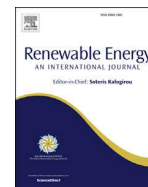




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Microalgae in a global world: New solutions for old problems?

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ABSTRACT

The human population blast has brought several problems related with the overconsumption of a wide range of feedstocks and natural resources conducting to their risk of depletion. The consumption of fossil fuels is an example, with increasing levels of exploitation and negative impacts caused by their use. Anthropogenic activities have triggered the over accumulation of many hazardous substances and wastes which are regarded to be detrimental to life in the Earth and to the various planet ecosystems. There is an urgent need to restore natural resources and unwanted residues and wastes to levels prior the demographic explosion. Microalgal biotechnology appears to be pivotal to achieve this goal in a near future to come. This review presents the current resource problems affecting the Earth and how microalgae are expected to be an important part of the solution, discussing how the production of renewable energy from microalgae can help in an integrated way to mitigate different environmental problems. Microalgae are able to convert wastewaters, CO₂ and organic residues in marketable biomass for different uses, including biofuels, converting waste in value. An inventory of current microalgal-based biorefineries in operation as well as a directory of companies, products and applications are also presented.

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1. Introduction

The first step in solving a problem is to recognize its existence. Currently, serious environmental problems, such as water scarcity and climate change, which can trigger serious social problems on a global scale, are related to the exponential growth of population, urbanization intensive, use disordered land and fossil fuels. In this context, the United Nations launched the 2030 Agenda, establishing 17 sustainable development goals (SDGs), setting objectives in different sectors of society, with the aim of guiding actions towards improving people's living conditions [1].

SDG addresses 7 issues related to affordable and clean energy. The use of fossil fuels such as oil, coal and natural gas, emits approximately 6 billion t of carbon dioxide (CO₂) into the

atmosphere [2]. In 2018, the energy consumed worldwide was in the order of 14,279,569 ktoe, of which approximately 14% came from renewable sources, such as hydropower, solar, wind, biofuels and waste [3]. Despite the advancement of renewable energy alternatives in recent years, their use is limited in view of the potential that presents [4] and mainly, in view of the urgent need for a paradigm shift in the sector.

In this context, the use of microalgae for the production of 3rd generation biofuels is gaining more and more attention. Algal biomass can be used to produce different biofuels, such as biodiesel, biogas, bioethanol and bio-oil, overcoming some of the main difficulties of 1st and 2nd generation biofuels [5]. The energy content of biofuels obtained from microalgae can reach values of the order of 35,800 kJ kg⁻¹ for crude oil [6], 38,100 kJ kg⁻¹ for bio-oil [7] and 39,900 kJ m⁻³ for biogas [8]. Microalgae have a high photosynthetic rate compared to higher plants [6], which means high biomass productivity. In addition, they can develop in areas unsuitable for agriculture [9], avoiding conflict related to food security and can be

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