Valorization of Microalgal Biomass

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Abstract

The use of microalgae for high value applications such as food ingredients, feed proteins, cosmetics, pharma and nutraceuticals represents a promising way of increasing the cost competitiveness and diminishing the pressure on land resources. The laboratory of Phycobiotechnology of the Institute of Microbiology and Biotechnology of the Academy of Sciences of Moldova has developed a series of innovative technologies for the cultivation of microalgae, separation of the chemical components present in biomass and their valorization into high added value applications. Based on an ecological approach, these technologies concern the production of antioxidants and pigments (β-carotene, astaxanthin, phycocyanin, phycoerythrin), proteins and essential amino acids, polysaccharides, lipids and unsaturated fatty acids, bio components and bio additives, etc., using new strains of Arthrospira (Spirulina) platensis, Nostoc linckia, Dunaliella salina, Haematococcus pluvialis and Porphyridium cruentum. The studies include optimization of the cultivation, separation, extraction and purification process and evaluation of the bioactive properties in view of their application. Moreover, our recent studies have focused on the use of microalgae cultures to synthesize nanoparticles as an alternative to chemical approach.

Introduction

Microalgae attracts huge interest among researchers as a possible feedstock for the assembly of eco-friendly biofuel, due to its superiority over other energy crops and having other environmental benefits microalgae offer many advantages of getting higher rate of growth , biomass and lipid productivity, photosynthetic efficiency, CO_2 biofixation rate and therefore the capability for bioremediation of wastewater. Some researchers also reported that microalgae might be successfully used for simultaneously upgrading biogas production systems and facilitating anaerobic digester slurry treatment. However, the chief problem for microalgal based biofuel is its cost and having different expenditure during microalgae cultivation mostly the large requirement of freshwater, inorganic nutrients and artificial CO_2. Therefore, to form biofuel production commercially successful, it's essential to form the method of generating microalgal feedstock economically feasible. Due to rapid industrialization, the concentration of CO_2 within the atmosphere has risen to an alarming level of 400 ppm. Nearly 22% flue gas emission is especially due to coal-fired power plants, which cause severe damage to our eco-system. Microalgae-based CO_2 bio-fixation is a cheap and eco-friendly approach to mitigate CO_2 emissions and simultaneously, produce algal biomass for biofuel production. As documented earlier, approximately 1.8 kg of CO_2 is required to get 1 kg of microalgae biomass. Exhaust flue gases mainly from coal-fired power plants are often captured as a cheap CO_2 source for the cultivation of microalgae. This method of using coal-fired flue gas because the carbon source for microalgal cultivation concurrently diminish the biomass cost and also counterbalance CO_2 emissions to the atmosphere. Weissman and Goebel showed that there's substantial economic benefit which will be accrued by extracting CO_2 from flue gas rather than purchasing CO_2. Typically, the coal-fired flue gas contains CO_2 concentrations starting from 10 to fifteen (v/v), which can be an honest resource of carbon for the expansion of microalgae. However, it's necessary to provide optimal concentration of flue gas CO_2 to realize favorable microalgal biomass growth.

On the opposite hand, the continual release of domestic wastewaters into the aquatic ecosystem causes pollution . Microalgal based wastewater treatment is an eco-friendly and sustainable option over conventional technologies, thanks to their nutrient removal capability at the tertiary stage of treatment, while potentially generating algal biomass for biofuel production using nutrient rich wastewater. Wastewater utilization as a nutrient source wouldn't only eliminate the utilization of fertilizer, but also offset the assembly costs of large-scale algal cultivation. Woertz et al., demonstrated that algae are efficient means for wastewater treatment with nutrients removal capacity of quite 99% for ammonium and orthophosphate when supplemented with CO_2. Some previous studies have indicated that domestic wastewater may be a good nutrient source for microalgal production of biomass because the biofuels feedstock. Therefore, the mixture of microalgal culture systems with coal-fired flue gas because the source of carbon and wastewater because the nutrient source might be a useful strategy to chop down the input expenditure of freshwater, synthetic CO_2 and nutrients required for cultivation process of microalgae, and simultaneously facilitate in CO_2 mitigation and wastewater treatment. This combined use of flue gas and wastewater helps to make environmental and economic credits by opposing the utilization of pure CO_2 and artificial nutrients for algal growth. An analysis by Lundquist et al., establishes that the method can generate enough revenue stream to form the method economical. Cultivation of microalgae in open raceway ponds are greatly prized as they're inexpensive to construct and its convenient operation no matter their lesser biomass yields as compared to closed photobioreactors. Microalga, Scenedesmus sp., is taken into account as a possible source of lipid for biodiesel production. Also, some species of Scenedesmus are ready to grow and sustain with supplementation of flue gas because the source of carbon. However, there are few reports on the integrated system for microalgae cultivation using coal-fired flue gas CO_2 and domestic wastewater in closed and open culture systems.

Considering the urgent need for green and cost-effective process development on the idea of performance evaluation of the closed and open culture systems, while valorizing polluting wastes, this study was undertaken to determine an integrated system for flue gas CO_2 fixation, wastewater remediation and biomass feedstock generation for sustainable biofuel application. Primarily, this study evaluates the effect of using different concentration of real coal-fired flue gas CO_2 in domestic wastewater for biomass growth, lipid and carbohydrate production, CO_2 bio-fixation rate and nutrient removal efficiency of Scenedesmus sp. within the photobioreactor. Consequently, the suitability of growing microalgae in open raceway pond using coal-fired flue gas and domestic wastewater was demonstrated as a feasible strategy for algae biomass production. The experiments were performed in two phases. within the first phase, the experiment was performed to pick an optimum flue gas CO_2 concentration (%) consistent with biomass and lipid yield after 7 days of cultivation of Scenedesmus sp. using domestic wastewater. The second phase of the study was administered in open raceway pond in batch experiments to work out the performance of algal biomass production. The concentrations of the flue gas CO_2 was varied to 2.5%, 5% and 10% by mixing with air, and therefore the ambient air (0.03% CO_2) supply was used because the control. During incubation, 5 mL of culture was collected everyday for analytical study. Microalgae have recently been considered as a beautiful and renewable feedstock not just for biofuel production but also for the assembly of the many value-added products like nutritional supplements, pigments, steroids, cosmetics, and pharmaceuticals because they exhibit a better rate of growth and a shorter growth period, and requires less water and acreage compared to traditional crops. However, harvesting and dewatering of microalgal biomass from the culture broth remains a serious challenge thanks to their small cell size (3–20 μm), low biomass concentration, and colloidal stability of microalgal cells. it's been estimated that the value of biomass harvesting generally accounts for quite 30% of the entire cost of microalgal biofuels. Various harvesting strategies are developed to separate the microalgae cells from their culture broth, including centrifugation, air flotation, ultrasound, filtration, flocculation, electrolytic method, magnetic coagulant, gravity sedimentation, and bio-flocculation supported algal/bacterial, algal/fungal, or algal/algal interactions Centrifugation, air flotation, and ultrasound aren't economical for large-scale harvest of microalgae thanks to the need of high energy inputs. Filtration is merely suitable for the massive multicellular microalgae, and therefore the frequent filter changes increase its operational complexity. Magnetic coagulant and electrolytic method are reported to be ready to enhance the harvest efficiency of certain microalgal species; however, they're also expensive and can contaminate the microalgae biomass. Although fungal-assisted algae harvest is found to be effective for a few microalgae, it's a challenge for this method to separate the fungi and microalgal cells. and therefore the harvest method supported mixing self-flocculating and non-flocculating microalgae is merely suitable for specific microalgae. Flocculation is understood together of the cheap strategies for microalgae harvesting which may increase the aggregation size of microalgae, and thus enhance the efficiency of gravity sedimentation or flotation.