Microalgae for urban wastewater treatment and fermentative biohydrogen production

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Abstract

Concerns about climate changes and global water crisis are increasing, considering the low freshwater resources, pollution, and changes in the hydrological cycle. Therefore, water is a precious scarce resource being crucial to develop wastewater treatment and recovery processes to improve water resources management. On the other hand, the problematic of fossil fuels leads to its replacement by biofuels. Thus there are studies [1] to combine wastewater treatment with microalgal biomass as 3rd generation biofuel sources. This study pretends to apply the biorefinery concept to an innovative photobioreactor (PBR) to treat wastewater with microalgae and later valorise the biomass by producing biohydrogen. It is intended to reduce CO_2, phosphorus, nitrogen, ammonium and other pollutants presents in wastewater, according EC targets, since microalgae consume the nutrients for growth thus removing them from the wastewater. Within the WW-SIP Life project, a new type of PBR for urban waste water treatment plant (UWWTP) effluents has been designed and will be scaled up. The tubular vertical PBR prototype (150 L) placed outdoor has an air compressor to perform agitation, a membrane module to permeate the treated water and a settler to concentrate the biomass. The results will be used to scale up a PBR of 1500 L.

The PBR was fed with primary effluent from Águas da Figueira (PT) UWWTP and inoculated with Chlorella vulgaris, Scenedesmus obliquus and a consortium of microalgae (Consortium C) isolated from the wastewater. The PBR was operated in fed-batch mode and the culture parameters (e.g. pH, air-bubbling, recirculation flow) were optimized. The highest productivity was attained by C. vulgaris (2.4 $gL^{-1}day^{-1}$) and efficient nutrient removal (>75%) was observed for all algae.

The microalgal biomass was then submitted to a nutritional stress for sugar and oil accumulation. Furthermore, the potential of the biomass as substrate for biofuel ($bioH_2$) production by anaerobic fermentation in mesophilic conditions (T=30ºC) was evaluated. Batch trials were conducted in encapsulated glass serum bottles using 2.5 g/L alga and 10% (v/v) of a strain of the bacteria Enterobacter aerogenes. Fermentation kinetics were monitored by biogas analysis with GC-TCD showing that $bioH_2$ production stabilized after around 6h. The specific production was around 45 mL $H_2/g_{alga.}$

This integrated wastewater treatment/biofuel production approach seems to be promising. In the future the production of other biofuel/biomaterials/added-value compounds will also be considered using microalgae grown in this membrane-based PBR.

References: [1] He PJ, Mao B, Shen CM, Shao LM, Lee DJ, Chang JS. (2013). Cultivation of Chlorella vulgaris on wastewater containing high levels of ammonia for biodiesel production. Bioresource Technology, 129, 177-181.