Environmental Technology, 2013
Vol. 34, Nos. 13–14, 1877–1885, http://dx.doi.org/10.1080/09593330.2013.812670

Taylor & Francis
Taylor & Francis Group

Algal biomass production and wastewater treatment in high rate algal ponds receiving disinfected effluent

Aníbal Fonseca Santiago[a]*, Maria Lucia Calijuri[a], Paula Peixoto Assemany[a], Maria do Carmo Calijuri[b] and Alberto José Delgado dos Reis[c]

[a]*Department of Civil Engineering, Federal University of Viçosa, Viçosa, Brazil;* [b]*School of Engineering of São Carlos - University of São Paulo, São Carlos, Brazil;* [c]*National Laboratory of Energy and Geology, Lisbon, Portugal*

(*Received 28 April 2013; final version received 31 May 2013*)

Algal biomass production associated with wastewater is usually carried out in high rate algal ponds (HRAPs), which are concomitantly used in the treatment of such effluent. However, most types of wastewater have high levels of bacteria that can inhibit the growth of algal biomass by competing for space and nutrients. The objective of this study was to assess the influence of ultraviolet (UV) pre-disinfection on the performance of HRAPs used for wastewater treatment and algal biomass production. Two HRAPs were tested: one received effluent from an upflow anaerobic sludge blanket (UASB) reactor—HRAP—and the second received UASB effluent pre-disinfected by UV radiation—$_{UV}$HRAP. Physical, chemical and microbiological parameters were monitored, as well as algal biomass productivity and daily pH and dissolved oxygen (DO) variation. The $_{UV}$HRAP presented highest DO and pH values, as well as greater percentage of chlorophyll a in the biomass, which indicates greater algal biomass productivity. The average percentages of chlorophyll a found in the biomass obtained from the HRAP and the $_{UV}$HRAP were 0.95 ± 0.65% and 1.58 ± 0.65%, respectively. However, total biomass productivity was greater in the HRAP (11.4 gVSS m^{-2} day^{-1}) compared with the $_{UV}$HRAP (9.3 gVSS m^{-2} day^{-1}). Mean pH values were 7.7 ± 0.7 in the HRAP and 8.1 ± 1.0 in the $_{UV}$HRAP, and mean values of DO percent saturation were 87 ± 26% and 112 ± 31% for the HRAP and the $_{UV}$HRAP, respectively. Despite these differences, removal efficiencies of organic carbon, chemical oxygen demand, ammoniacal nitrogen and soluble phosphorus were statistically equal at the 5% significance level.

Keywords: high rate algal ponds; wastewater; ultraviolet disinfection; algal biomass production; algae/bacteria systems

Introduction

Reducing input costs (water, nutrients, etc.) is one of the main challenges in making algal biomass production economically feasible for its several purposes. According to Wijffels and Barbosa,[1] the production of biofuel from microalgae, for instance, requires approximately 1.5 L of water per kilogram of biofuel produced. Water use can be much larger if losses by evaporation in open systems and water use for cooling closed systems are taken into account. In open systems, the annual water consumption in ponds for microalgae production is in the range of 11–13 million of L per ha.[2] Thus, we highlight the importance of reusing wastewater, which also enables nutrient recycling.

Algal biomass can be grown as a by-product of high rate algal ponds (HRAPs) operated for wastewater treatment.[3] HRAPs are raceway-type ponds with depths in the range of 0.2–0.5 m, hydraulic retention times (HRT) from 3 to 10 days, and paddlewheels to provide mixing.[4–6] Algal photosynthesis produces the oxygen required for degradation of organic matter by heterotrophic bacteria. Nutrients and the CO_2 resulting from oxidation are assimilated by the algae. The gentle mixing in HRAPs serves several purposes, including prevention of cell settling, elimination of thermal stratification, and promotion of growth of algae that form colonies which can be more easily removed by gravity settling. Additionally, mixing promotes better nutrient distribution, improves light utilization efficiency, and removes the photosynthetically produced oxygen, which improves the air–liquid transfer and avoids inhibition of photosynthesis by excess of this element.[7]

Fallowfield et al. [8] state that the adaptation of HRAP shapes and paddlewheel systems aims to improve efficiency in wastewater treatment and reduce land area requirements by optimizing algal photosynthetic oxygen production. According to Craggs et al.,[6] despite some differences when compared with other stabilization ponds, HRAPs retain the advantages of simplicity and economy, and overcome disadvantages such as poor and highly variable effluent quality and limited nutrient and pathogen removal.

Craggs et al. [6] presented a concept for using HRAPs for wastewater treatment and algal biomass cultivation for purposes of energy production (biofuel). The options

*Corresponding author. Email: anibalsantiago@gmail.com