Bioresource Technology 128 (2013) 324–329

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

High pH-induced flocculation–sedimentation and effect of supernatant reuse on growth rate and lipid productivity of *Scenedesmus obliquus* and *Chlorella vulgaris*

M. Castrillo [b,a,*], L.M. Lucas-Salas [a], C. Rodríguez-Gil [a], D. Martínez [a]

[a] Eolican, Research and Development Department, 1 Rualasal St., 39001 Santander, Cantabria, Spain
[b] Water and Environmental Science and Technology Department, Environmental Engineering Group, University of Cantabria, 39005 Santander, Cantabria, Spain

HIGHLIGHTS

- ► $Ca(OH)_2$ showed higher recovery efficiency but $CaCO_3$ appeared in the pellet.
- ► Mg^{2+} is not the sole factor affecting high pH induced flocculation with Na(OH).
- ► Medium reuse after centrifugation and flocculation is a viable way to save water.
- ► Biomass and lipid productivity were higher in reused media than in fresh media.
- ► Lipids from microalgae grown in reused media were rich in unsaturated fatty acids.

ARTICLE INFO

Article history:
Received 24 April 2012
Received in revised form 4 October 2012
Accepted 8 October 2012
Available online 2 November 2012

Keywords:
Flocculation
Harvesting
pH increase
Microalgae
Medium reuse

ABSTRACT

High pH-induced flocculation–sedimentation of *Scenedesmus obliquus* and *Chlorella vulgaris* was studied with the objective of improving the efficiency of microalgae harvesting, since it is one of the most expensive steps of production of microalgae. Desired pH values were achieved by addition of NaOH and $Ca(OH)_2$. Growth rate and lipid productivity in fresh media prepared with tap water and with analytical-grade water, and in reused media prepared with culture centrifuged supernatant and the supernatant from high pH-induced flocculation–sedimentation were compared. Since the growth rates for reused media were about 1.7 times higher than in fresh media, and the lipid productivities were about 25 and 26 mg L^{-1} d^{-1} in flocculated and centrifuged reused media respectively, medium reuse is a suitable method of saving water and nutrients.

1. Introduction

Lipids produced by microalgae are viewed as a good alternative for fossil fuels (Chisti, 2007); however, large-scale production of microalgae-derived fuels is not yet cost-effective on a large scale (Wijffels and Barbosa, 2010).

The cost of microalgae biomass harvesting strongly influences the cost of the final product, and may be up to 60% of the total cost of biofuel or other extracted chemicals (Grima et al., 2003). There are several problems that make microalgae recovery process difficult, such as the small size of the cells and electrostatic repulsion due to their negative surface charge (Papazi et al., 2010). Furthermore, biomass contents usually are in the range of 0.1–1 g L^{-1}, requiring handling of big volumes to harvest a small amount of biomass. An optimal harvesting technique should be independent of the cultured species, consume little energy and chemicals and not be harmful to the valuable products extracting process (Chen et al., 2011).

Centrifugation, filtration and gravity settling are current harvesting methods. These processes may be preceded by a flocculation step. Centrifugation is the most rapid and reliable method, but due to its high cost, its implementation at large-scale is not considered (Christenson and Sims, 2011). Flocculation–sedimentation is assumed to be more effective than centrifugation and gravity settling, since it allows treating large culture volumes and does not consume much energy. It can be also considered as a step for improving centrifugation or filtration yields (Lee et al., 2012). Several cell coagulants have been proposed, among them a wide variety of salts (Papazi et al., 2010) chitosan (Morales et al., 1985; Ahmad et al., 2011) and starch (Vandamme et al., 2010). Flocculation by using a flocculating microalgae to concentrate a

* Corresponding author at: Water and Environmental Science and Technology Department, Environmental Engineering Group, University of Cantabria, 39005 Santander, Cantabria, Spain. Tel.: +34 942075507.

E-mail addresses: maria.castrillo@alumnos.unican.es (M. Castrillo), lucasml@biobas.es (L.M. Lucas-Salas), rodriguezc@biobas.es (C. Rodríguez-Gil), martinezd@biobas.es (D. Martínez).

0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.10.114