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Separation efficiency of a vacuum gas lift for microalgae harvesting

Bertrand Barrut[a,*], Jean-Paul Blancheton[b], Arnaud Muller-Feuga[c], François René[b], César Narváez[b,d], Jean-Yves Champagne[d], Alain Grasmick[e]

[a] ARDA, Station Marine du Port, Port Ouest, Hangar 10, 97420 Le Port, Reunion Island, France
[b] IFREMER, Station d'Aquaculture Expérimentale, Laboratoire de Recherche Piscicole de Méditerranée. Chemin de Maguelone, 34250 Palavas-les-Flots, France
[c] Microphyt, 713 route de Mudaison, 34670 Baillargues, France
[d] LMFA, UMR CNRS 5509, Université de Lyon, Ecole Centrale de Lyon, Université Lyon 1, INSA de Lyon, ECL, 20, avenue Albert Einstein - 69621, Villeurbanne Cedex, France
[e] Institut Européen des Membranes (UMR–CNRS 5635), Université Montpellier II, CC005, Place Eugène Bataillon, 34095 Montpellier Cedex 05, France

HIGHLIGHTS

- ▶ Determination of microalgae harvesting efficiency and concentration factor.
- ▶ Demonstration of positive effect of airflow rate and bubble size reduction.
- ▶ Demonstration of positive effect of harvest volume reduction on concentration factor.
- ▶ Measurement of harvesting energy costs below 0.2 kWh kg^{-1} DW.

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ABSTRACT

Low-energy and low-cost separation of microalgae from water is important to the economics of microalgae harvesting and processing. Flotation under vacuum using a vacuum gas lift for microalgae harvesting was investigated for different airflow rates, bubble sizes, salinities and harvest volumes. Harvesting efficiency (*HE*) and concentration factor (*CF*) of the vacuum gas lift increased by around 50% when the airflow rate was reduced from 20 to 10 L min^{-1}. Reduced bubble size multiplied *HE* and *CF* 10 times when specific microbubble diffusers were used or when the salinity of the water was increased from 0‰ to 40‰. The reduction in harvest volume from 100 to 1 L increased the *CF* from 10 to 130. An optimized vacuum gas lift could allow partial microalgae harvesting using less than 0.2 kWh kg^{-1} DW, thus reducing energy costs 10–100 times compared to complete harvesting processes, albeit at the expense of a less concentrated biomass harvest.

1. Introduction

Microalgae may be used as an alternative to land crops for the production of oil with many advantages: (1) biomass productivity is significantly superior to that of land crops (Chisti, 2007; Borowitzka, 2008; Chen et al., 2011; Park et al., 2011) and fatty acid content is high, (2) microalgae production does not compete with food production for agricultural land because arid and saline land are suitable for the cultivation of microalgae (Amaro et al., 2011), (3) to the best of our knowledge, there is no need for pesticides or herbicides and (4), microalgae production could be a solution for industrial carbon dioxide bioremediation (Borowitzka, 2008). However, fuel produced from microalgae is not yet cost-competitive with fossil fuel (Park et al., 2011).

The choice of microalgae harvesting method is of great importance as it represents 20–30% of the total production cost (Molina Grima et al., 2003; Brennan and Owende, 2010). Lowering the energy costs of algae harvesting is thus considered a major challenge for full-scale production of algal biofuel (Sturm and Lamer, 2011; Christenson and Sims, 2011) and for other uses of microalgae biomass, such as animal feed or chemicals. The high cost is largely due to the small size of algal cells (<20 μm) which have a density similar to water and are thus very difficult to collect without energy intensive processes (Molina Grima et al., 2003; Park et al., 2011).

The selection of the most appropriate harvesting technique depends on microalgal density, size and hydrophobicity (Golueke and Oswald, 1965; Park et al., 2011). It also depends on culture conditions such as water composition and salinity (Demirbas, 2010), particularly when diffused air flotation (DAF) systems are employed since bubble size depends strictly on salinity (Ruen-ngam et al., 2008; Kawahara et al., 2009; Barrut et al., 2012).

* Corresponding author. Tel.: +33 6 08 92 02 30; fax: +33 4 67 13 04 58.
E-mail address: bertrandbarrut@yahoo.fr (B. Barrut).

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