Bioresource Technology 129 (2013) 329–334

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

# Small doses, big troubles: Modeling growth dynamics of organisms affecting microalgal production cultures in closed photobioreactors

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## HIGHLIGHTS

- Model realistically simulates growth of contaminants in a production photobioreactor (PBR).
- "Sudden" onset of contamination can be attributed to exponential growth.
- PBR management protocols can reduce the risks of serious contamination.
- Small numbers of sufficiently fast-growing contaminants can lead to loss of algal cultures in days.
- A simple and cheap protocol for short-term prediction of severe contaminants in PBRs is presented.

## ARTICLE INFO

*Article history:*
Received 13 June 2012
Received in revised form 14 November 2012
Accepted 19 November 2012
Available online 29 November 2012

*Keywords:*
Microalgae culture management
Grazers
Growth prediction

## ABSTRACT

The destruction of mass cultures of microalgae by biological contamination of culture medium is a pervasive and expensive problem, in industry and research. A mathematical model has been formulated that attempts to explain contaminant growth dynamics in closed photobioreactors (PBRs). The model simulates an initial growth phase without PBR dilution, followed by a production phase in which culture is intermittently removed. Contaminants can be introduced at any of these stages. The model shows how exponential growth from low initial inocula can lead to "explosive" growth in the population of contaminants, appearing days to weeks after inoculation. Principal influences are contaminant growth rate, PBR dilution rate, and the size of initial contaminant inoculum. Predictions corresponded closely with observed behavior of two contaminants, *Uronema* sp. and *Neoparamoeba* sp., found in operating PBRs. A simple, cheap and effective protocol was developed for short-term prediction of contamination in PBRs, using microscopy and archived samples.



## 1. Introduction

Just like terrestrial plant crops, microalgae in large-scale biomass cultures can be beset by pests and weeds. Grazing organisms, including protozoa and microinvertebrate animals, can be devastating pests. Complete destruction of microalgal crops has been recorded in as little as 48 h from first detection of an aggressive grazer (Moreno-Garrido and Cañavate, 2001). This phenomenon is consistent with what has been observed for microalgae in nature (Sherr and Sherr, 2002; Narwani and Mazumder, 2010). Fast-growing non-target algal weeds may degrade the quality of the product and can even displace the target strain entirely, as has been observed in natural populations (Sieracki et al., 1993).

Despite the obvious risks, little has been published on this aspect of microalgal cultivation, and the research and development needs are considerable (Day et al., 2012a). Most grazers have been identified to the genus level at best, with many known to no greater accuracy than (for example) 'amoeba', 'ciliate', or 'rotifer' (Post et al., 1983; Moreno-Garrido and Cañavate, 2001). Without an accurate identification, information on the distribution in nature, life history, growth rate, and prey choice of the contaminating organism is not accessible – assuming that such information even exists – leaving a production team to guess whether a particular contaminant poses a risk to cultivation, and if it does, how grave is the situation. Chemical control of an established, aggressive contaminant is problematic (Moreno-Garrido and Cañavate, 2001), and other means of control have hardly been investigated (Day et al., 2012a).

Given the large number of contaminant species that can infest algae production cultures (Post et al., 1983), and the lack of information on the biology and control of practically all of these

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0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.11.082