Calibration of a Bio-Kinetic Model to Simulate Microalgae Growth

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Abstract

Mathematical models for wastewater treatment ponds and photobioreactors are increasing in popularity for design of new systems and for improving understanding of the complex biokinetic processes occurring inside. However, models in these systems are still not a common practice because the complex bioprocesses and hydrodynamics make them very difficult to translate into accurate mathematic description.

The aim of present work is to present and calibrate a new mechanistic model that includes physical and biokinetic processes to reproduce the algae growth in photobioreactor or ponds during long-term scenarios. The model implements the microalgae processes mainly based on River Water Quality Model 1 (RWQM1) (Reichert et al., 2011) into COMSOL Multiphysics®. The main innovation of the model is that it takes into account dissolved carbon as a limiting factor for the growth of microalgae. Furthermore the model considers the growth of microalgae as a function of light intensity and temperature, and as well other nutrients such as nitrogen. The model was calibrated thought a case study based on the cultivation of few microalgae species in a tertiary treated municipal wastewater (Min-kYu Ji et al., 2013). The microalgal cells were cultivated in a shaker incubator at 150 rpm and a 27 °C under fluorescent light illumination (alternate light/dark periods of 16h/8h) at an intensity of 45-50 µmol photon m-2s-1 for 7 days.

Many parameters present in this model can be obtained from the existing River Water Quality Model (Reichert et al., 2001). Other parameters such as the µALG (maximum growth rate of microalgae) and the parameters of liquid-gas transfer in the atmosphere were calibrated by comparing simulated and experimental dates curves (Fig.1).

Results indicate that the model was able to accurately reproduce the microalgae growth in the experiment. The concentration of TN and TC were decreased within 4 days of cultivation, which was caused by increase of biomass of microalgae.

Furthermore the growth of algae under different light/dark cycles and PDF in the model was fitted. The model is able to represent the complex system of photosynthetic growth with simultaneous photoinhibition and photolimitation.

The next step will be to reproduce the hydraulic and hydrodynamic behaviour in a wastewater pond. Another important objective will be to complete the model with implementation of the processes of bacteria.

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Figures used in the abstract

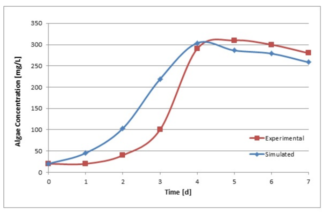

Figure 1: Fig. 1. Comparison between experimental and simulated curves.

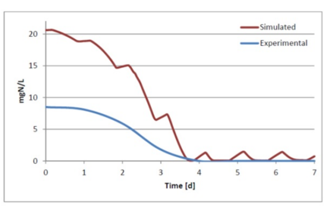

Figure 2: Fig.2. Comparison between simulated and experimental total nitrogen curve

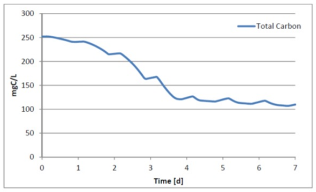

Figure 3: Fig.3. Simulated total carbon curve