RAD-13-SO2

RADIATION TRANSFER IN COMMON OUTDOOR PHOTOBIOREACTORS

Euntaek Lee*, Xing He, Ramakanth Munipalli**, and Laurent Pilon***
*Mechanical and Aerospace Engineering Department Henry Samueli School of Engineering and Applied Science University of California, Los Angeles 420 Westwood Plaza, Eng. IV 37-132, Los Angeles, CA 90095, USA
**HyPerComp, Inc. 2629 Townsgate Rd., Suite 105, Westlake Village, CA, 91361
E-mail: pilon@seas.ucla.edu

ABSTRACT. This study provides design and operational guidelines for achieving maximum biomass productivity in outdoor (i) open ponds, (ii) vertical flat-plate, and (iii) tubular photobioreactors (PBRs) exposed to solar radiation. It presents coupled light transfer and growth kinetics simulations of microalgae batch culture in these different PBRs. Particular attention was paid to the effects of black or reflecting walls, refraction by transparent walls, initial microalgae concentration, PBR geometry and dimensions on the overall microalgae growth rate and production rate. The three-dimensional radiative transfer equation in PBRs was solved numerically. Simple Model of the Atmospheric Radiative Transfer of Sunshine (SMARTS) was used to predict the spectral incident collimated and diffuse solar irradiance at different times on June 21 in Los Angeles. The temporal evolution of microalgae concentration was predicted using the Monod growth kinetics model accounting for light saturation, photoinhibition, and respiration. The green microalgae *Chlamydomonas reinhardtii* was used for illustration purposes. The study establishes that the two-flux approximation can predict the local fluence rate within 10% in open pond and vertical flat-plate PBRs. In addition, the average growth rate in the PBR should be estimated by volume-averaging the local growth rate instead of using the average fluence rate. The maximum daily productivity per unit footprint of tubular PBRs was larger than that of open ponds. Both were found to be unique functions of the product $X0L$ where $X0$ is the initial microalgae concentration and L is the depth or diameter of the PBR. Moreover, the daily productivity per unit illuminated surface area of vertical flat-plate PBRs depended on the product $X0L$.