Local volumetric rate of photon absorption inside tubular photobioreactors

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One of the main parameters affecting autotrophic algae culture performance is photon absorption rate distribution inside photobioreactors.

The importance of radiative field has been demonstrated in a number of investigations on photosynthetic activity relation with the radiation field involved. The knowledge of light distribution inside the photobioreactor is essential especially when photobioreactors are operated at high microalgal cell concentrations. This clearly depends on the geometry of both the radiation source and the photobioreactor, as well as on algae suspension optical properties.

Considering a uniform cells distribution, in order to properly model the radiation field inside photobioreactors, the relevant balance equation, known as the Radiation Transfer Equation (RTE), should in principle be solved. This would allow the computation of the local volumetric rate of photon absorption (LVRPA), a quantity strictly related to photosynthetic growth rate and biomass generation. This is however an impossible task in most practical situations.

In this work the local volumetric rate of photon absorption LVRPA in a cross section of a horizontal-pipe photobioreactor was investigated by means of simplified Monte Carlo simulations. In particular, the fate of a number of photons perpendicularly hitting the photobioreactor circular section was simulated in relation to different values of algae concentration. The model takes into account refraction/reflection phenomena at the air/photobioreactor-wall interface. Simulation results show that radiation distribution inside the photobioreactor is quite strongly affected by reflection/refraction at the air-reactor interface. In particular, dark zones (not revealed when neglecting reflection/refraction phenomena) are observed in conjunction with unexpected radiation intensification in other zones. These phenomena are bound to affect photobioreactor performance and should therefore be considered if effective photobioreactor models are sought.