Design of a Cylindrical Photobioreactor with Central Orifice for the Production of Microalgae

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Introduction: It is desired to design a photobioreactor for the production of voluminous samples of microalgae for lipid quantification. The reactor should provide good growing conditions even with periodic withdrawal of samples. It also should be compact for better use of laboratory space. Therefore, a photobioreactor with concentric tubes was modelled to verify the circulation of the culture medium.

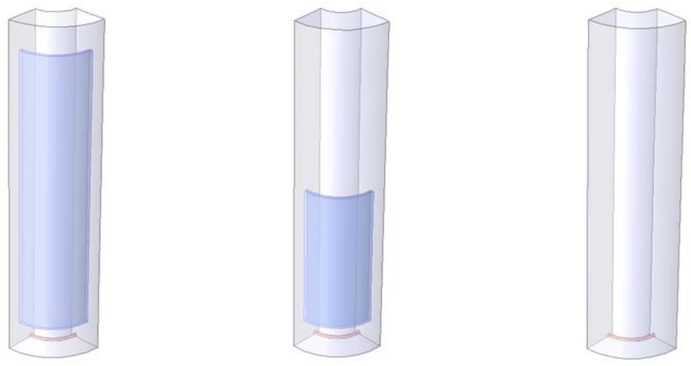

Figure 1. Air-lift photobioreactors (View of a fourth part): (a) full plate (FP); (b) half plate (HP); (c) no plate (NP)

Computational Methods: The physics interface used was Turbulent Bubbly Flow with low gas concentration approximation and k-ε turbulence model. Fluid properties were the default for water (liquid phase) and air (gas phase). Boundary conditions were no gas flux for the walls, a flux of 1gal/min through the aerator increasing smoothly from zero within 1 second with the Heaviside function flc1hs, and gas outlet for the upper fluid boundary. A gravity of "–g_const" in the z axis was assumed.

A pseudo-transient analysis was used to obtain the stationary flow, initial values were motionless liquid phase (u,v,w=0), liquid column pressure ("g.rho.h"), zero effective gas density. Turbulent dissipation rate and turbulent kinectic energy were default. The total simulated flow was 40 seconds.

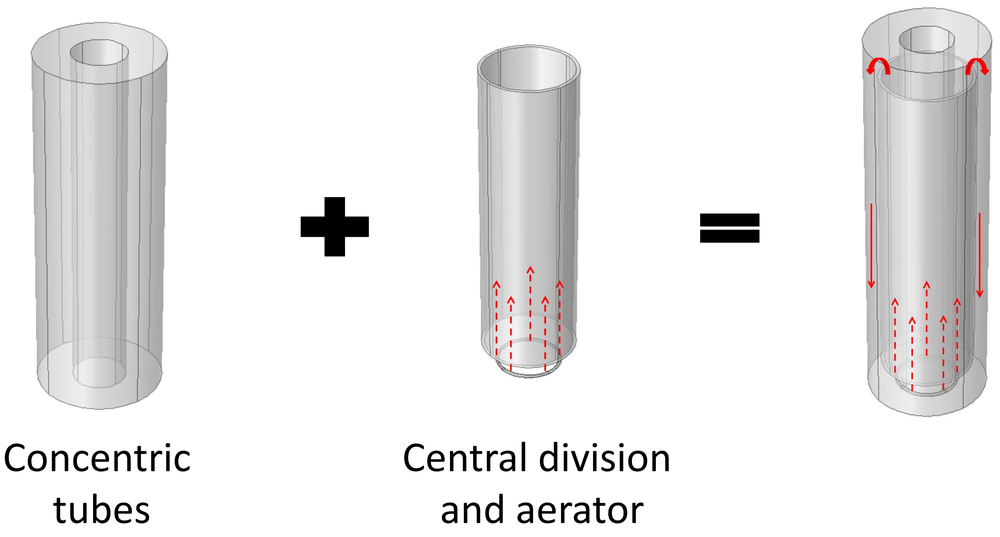

Figure 2. Schematic diagram of the set-up of the photobioreactor

Results: The velocity profile had a similar shape for the three cases. Rising and falling velocities of the liquid phase were proportional to the height covered by the internal plate, having a maximum around 0,3 m/s for FP, around only one third of that maximum for NP and two thirds for HP.

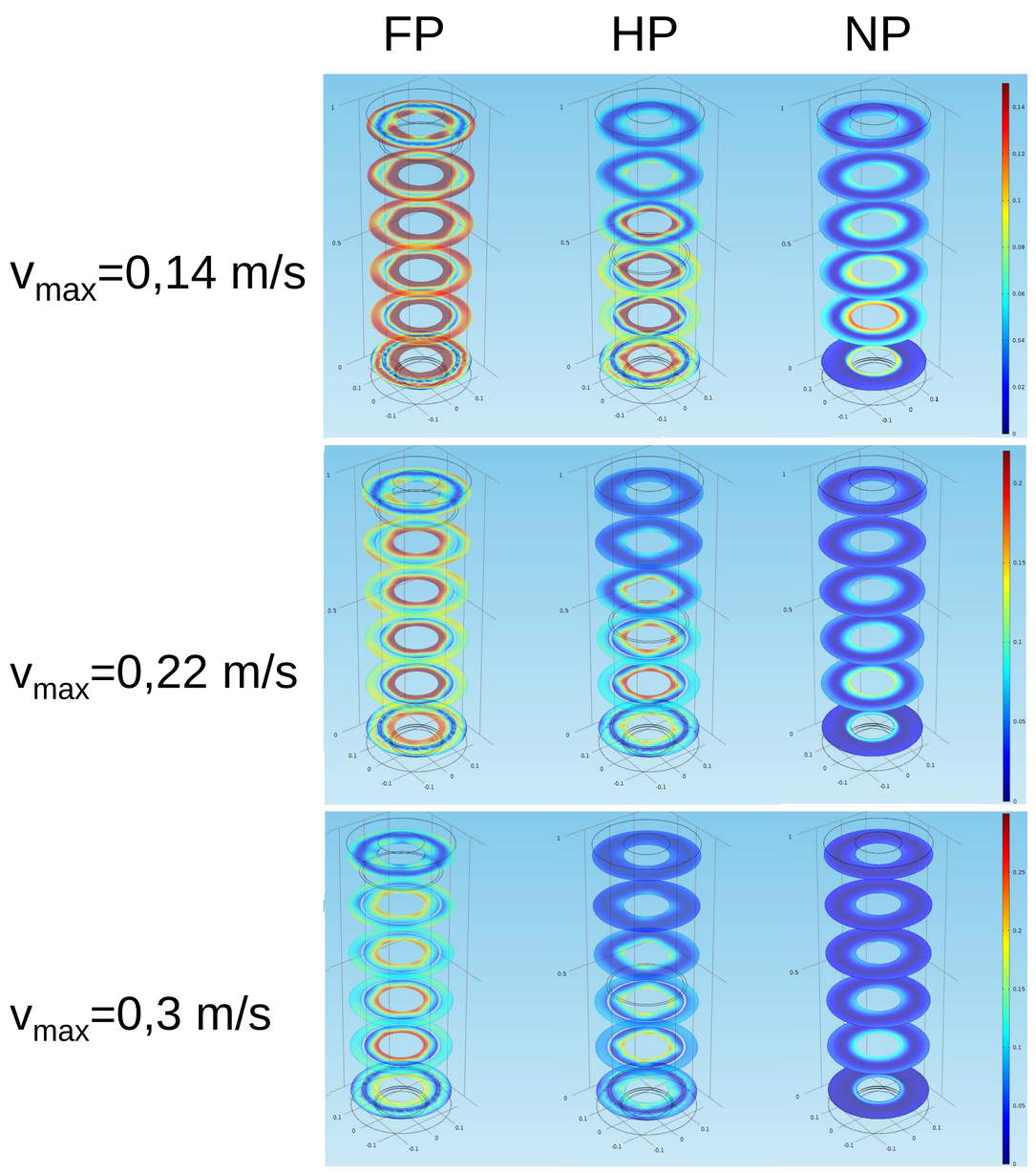

Figure 3. Velocity profiles weighted considering v_{max} from FP, HP and NP

Conclusions: The chosen reactor is HP, because of its superior rising velocity compared to NP. The half plate also offers more volume to sampling (bleeding), above the internal plate, justifying its choice rather than FP. Future studies include modeling of the liquid phase real characteristics and simulation of different levels of liquid with a same plate.

References:

1. Gris LRS *et al*., Laboratory apparatus to evaluate microalgae production. Braz J Chem Eng.;30:487-497(2013)
2. Zhang Xu *et al*., A simple and low-cost airlift photobioreactor for microalgal mass culture, Biotechnol Lett , 24, 1767–1771 (2002)