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## Design of photobioreactors for microalgae production using computational fluid dynamics

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Computational fluid dynamics (CFD) was utilized to investigate the flow hydrodynamics of cylindrical bubble column type photobioreactors (PBRs). A review on the application of CFD in the design of PBRs was conducted. The CFD approach to correctly simulate the flow hydrodynamics with the proper implementation of the different type of multiphase models' turbulence models was reviewed. To establish the reliability of the simulation study, the CFD model was validated using particle image velocimetry (PIV) data under various air flow rates. In engineering perspective, the structural configuration and design of the PBRs have critical role in the flow hydrodynamics inside the reactor. There were 32 simulation cases for the CFD study comprising two PBR designs, four air flow rates and four nozzle size diameters. Hydrodynamic analyses such as % volume of dead zones, average circulation time and turbulence intensity inside the simulated PBRs were evaluated. A criterion on each parameter was set and elimination technique was executed in the 32 simulated cases until some appropriate PBRs suited for microalgae production were selected. Results have shown that the most appropriate PBR for microalgae cultivation was a design with internal baffle and an extended cone-shaped bottom section. Practical evaluation through laboratory experiments has further confirmed the results of the study where the biomass concentration of *Chlorella vulgaris* from the proposed PBR was significantly higher compared to the standard PBR design. The improved PBR can be seen to be more effective in culturing microalgae particularly for larger scale mass production.

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