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Evaluation of different drag models for simulations of a bubbly flow in a flat-panel photobioreactor

Ing. Miroslav Rebej

rebej@fme.vutbr.cz

Institute of Process Engineering
Faculty of Mechanical
Engineering
Brno University of Technology

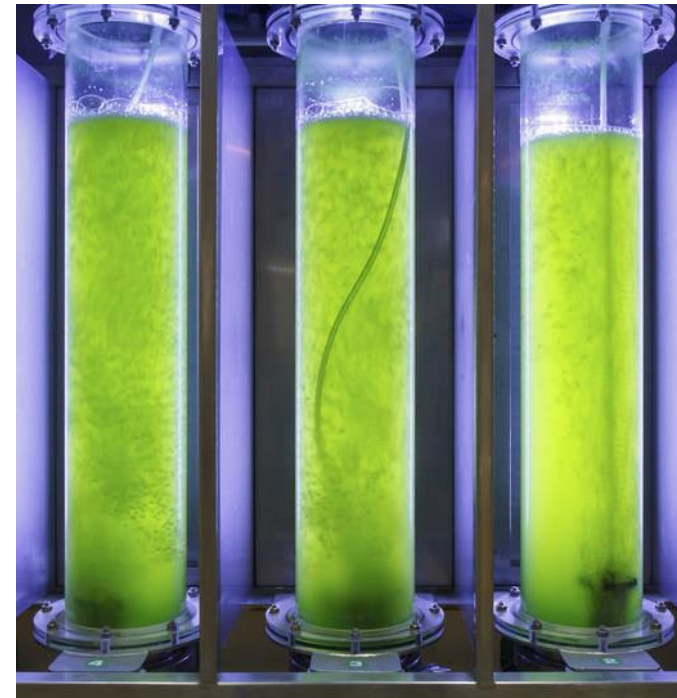
Simulations of Photobioreactors

- Front-line research to understand culturing systems
- Characterization of growth parameters
- Target application

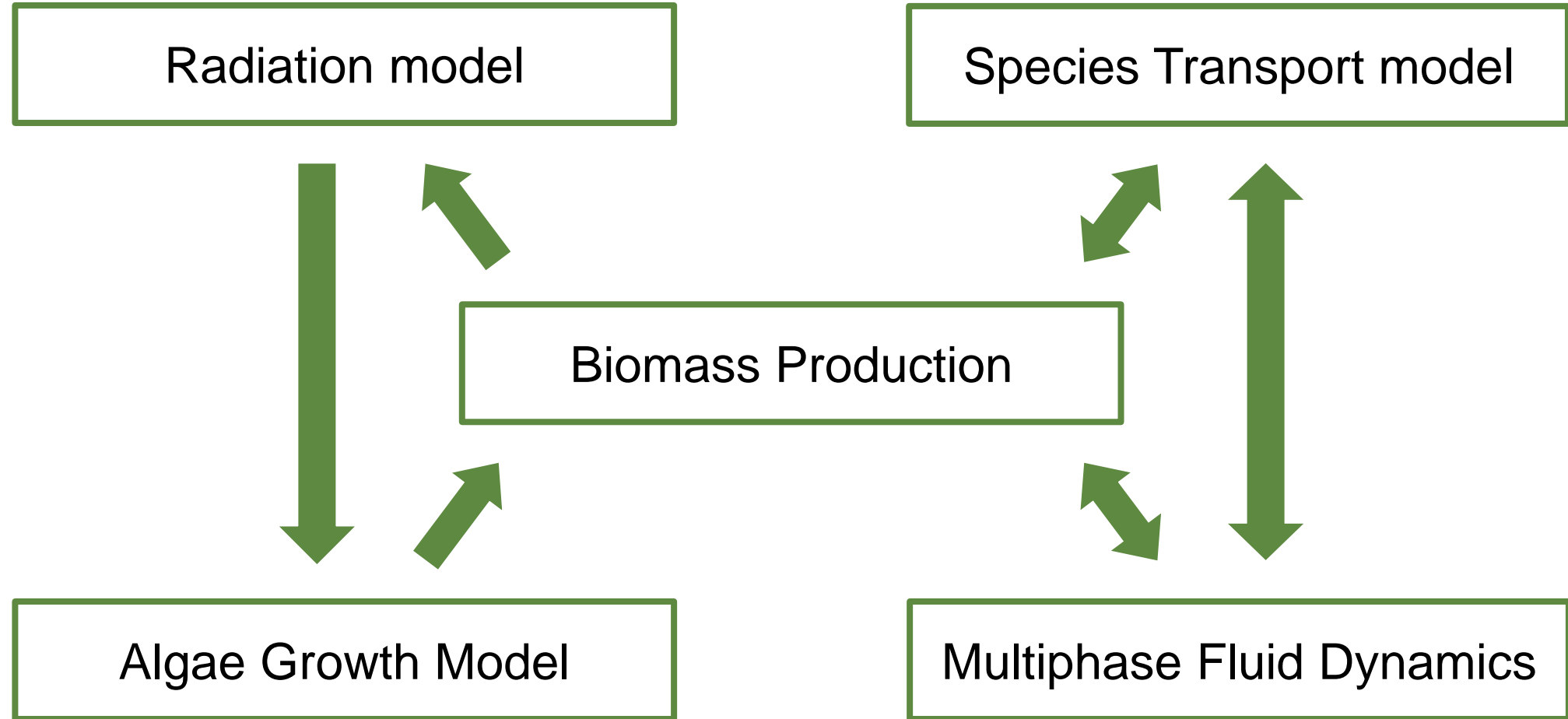


Reduction of CO₂ emissions
from waste incineration plants

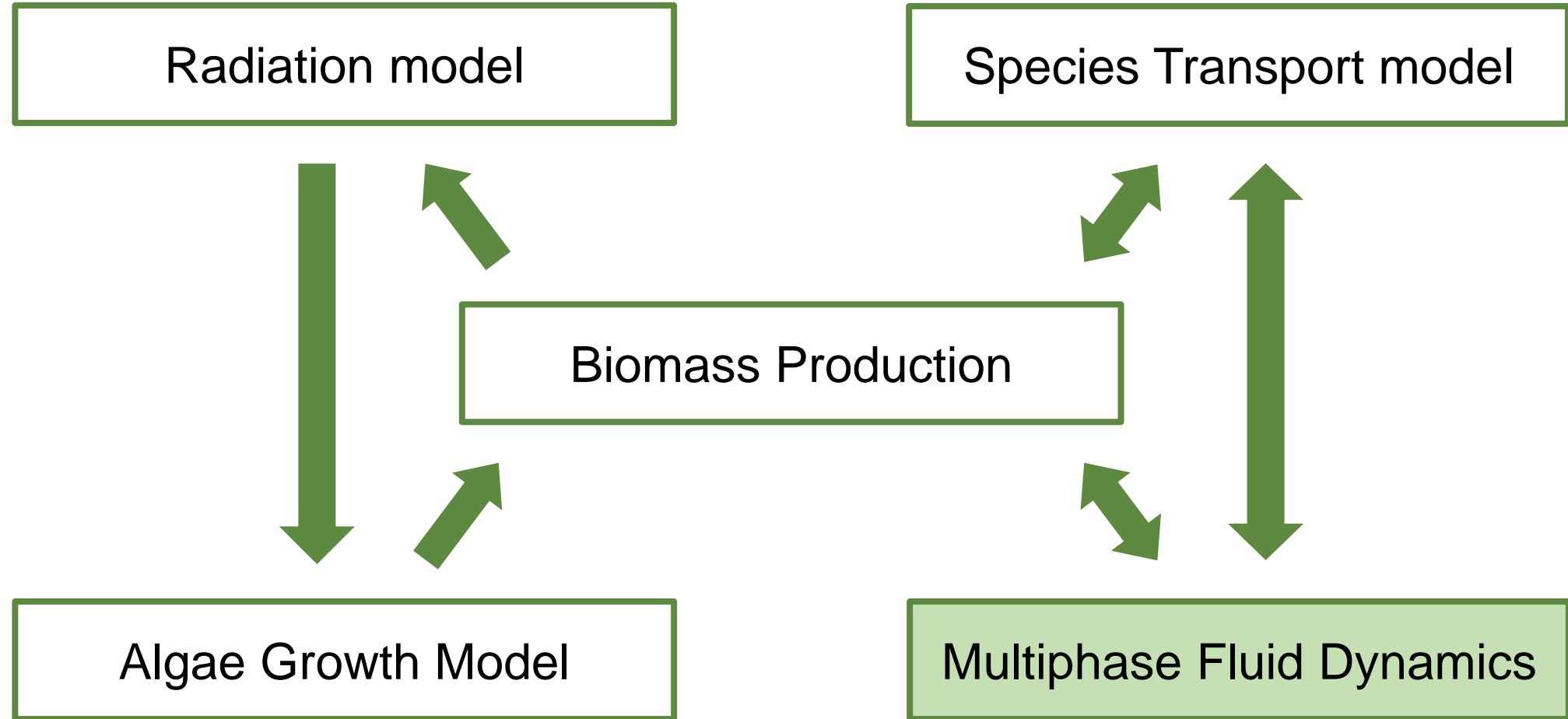
Source: phys.org



Comprehensive model

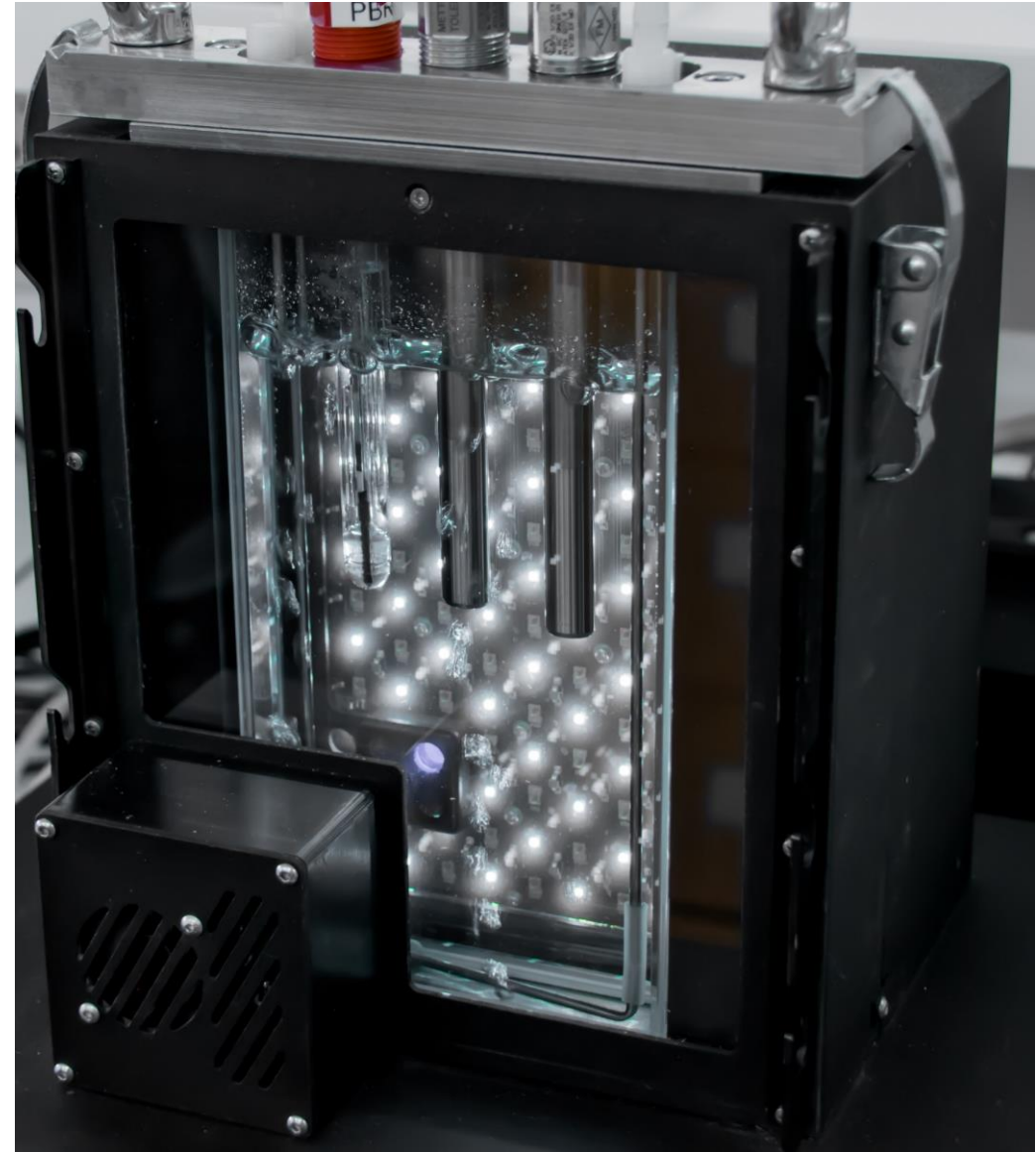


Comprehensive model



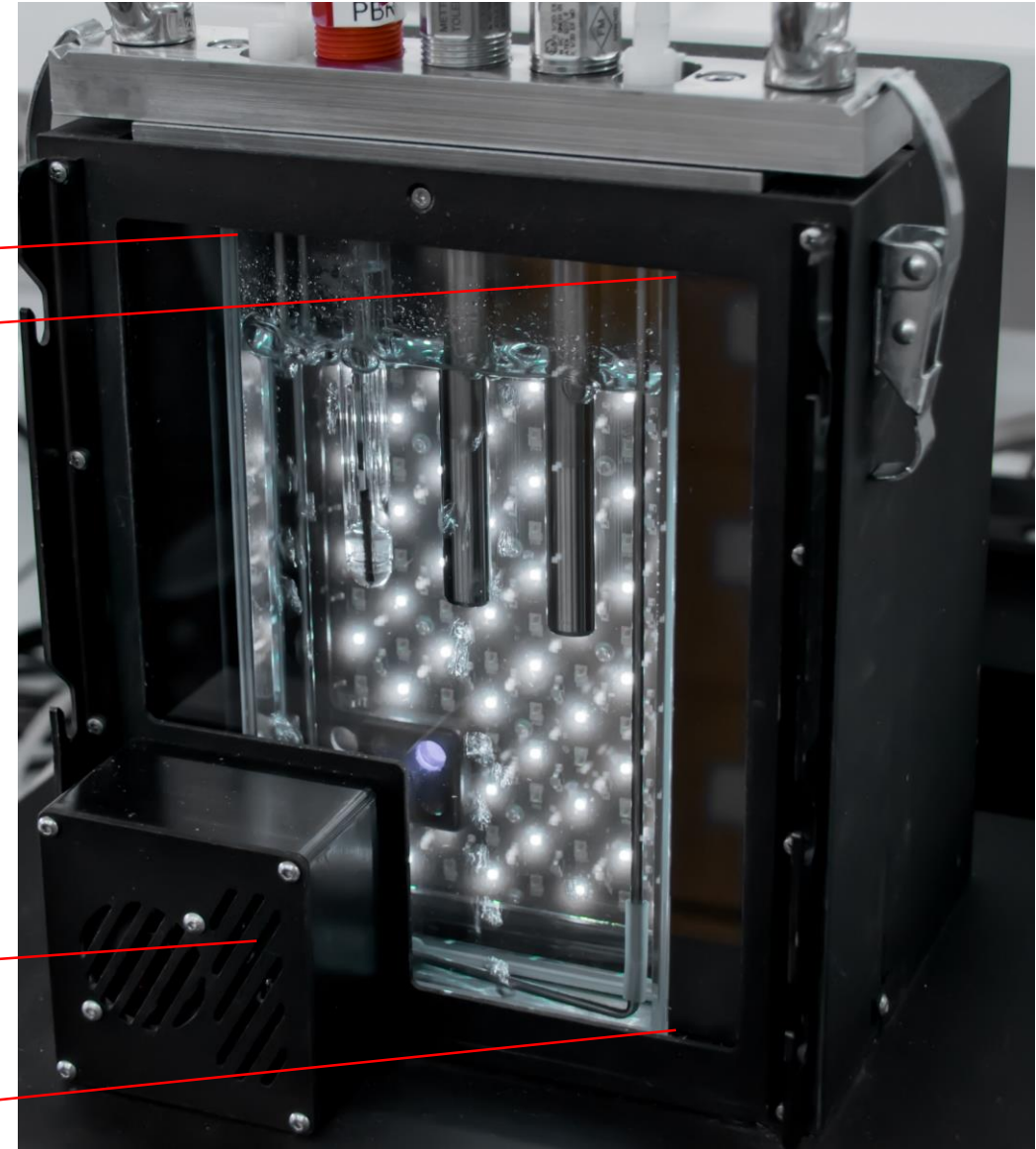
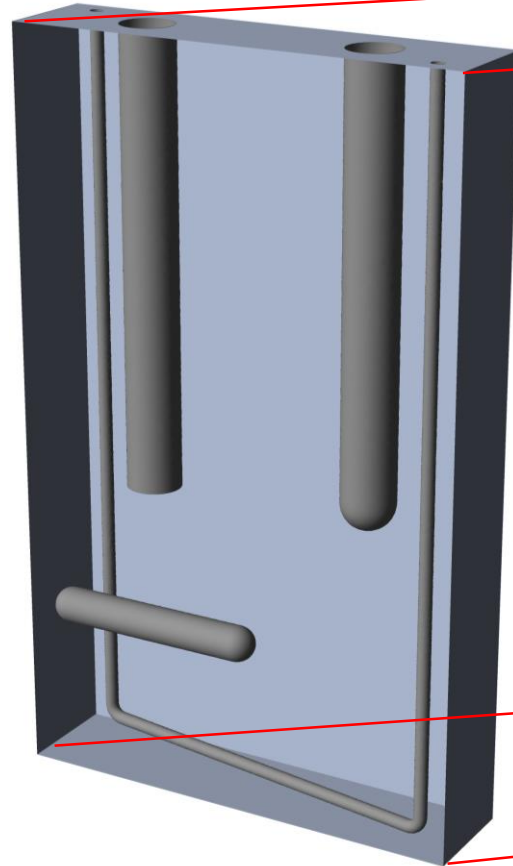
Photobioreactor

- Lab-scale vessel
- Different operating conditions
 - Agitation speed
 - Gas flow rate
 - Irradiation patterns



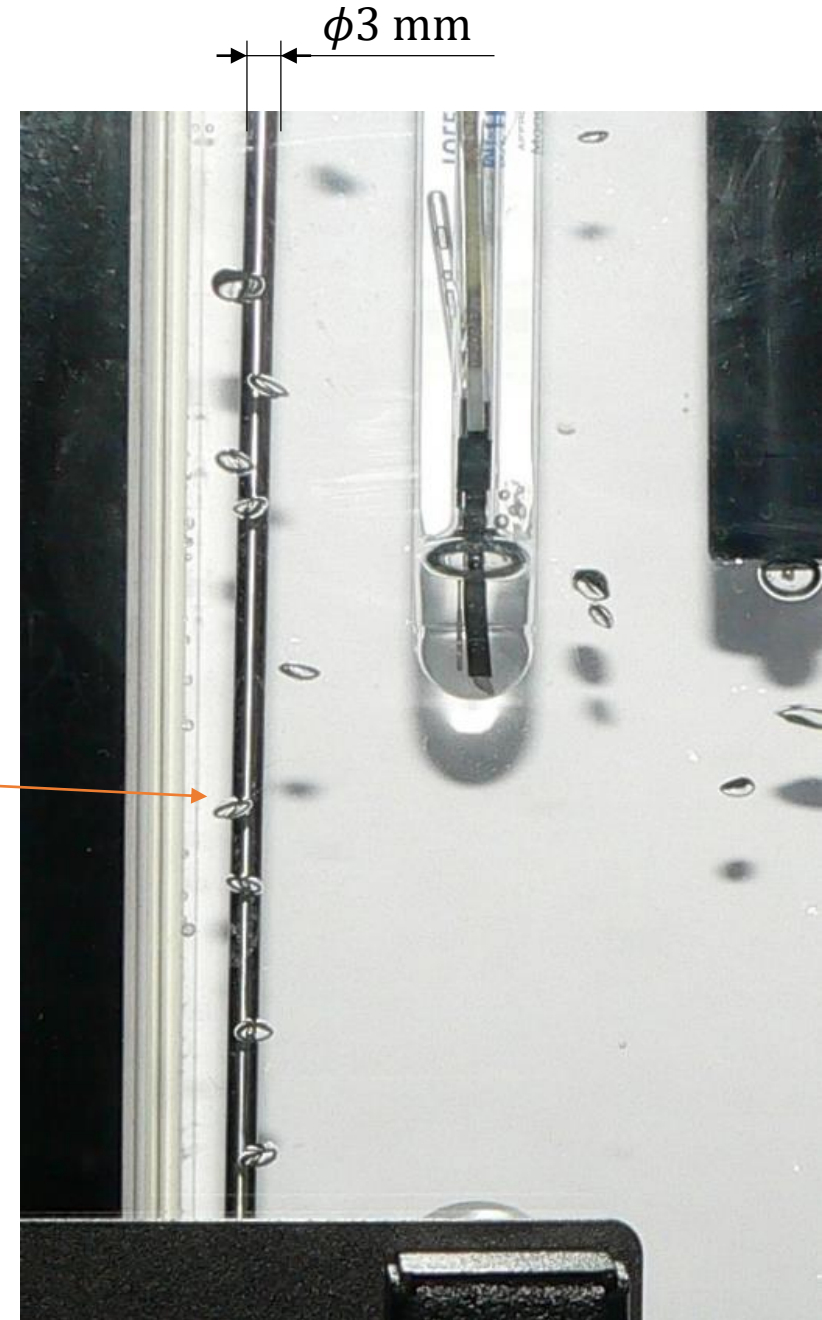
Photobioreactor

- Assessment in CFD software ANSYS Fluent
- Eulerian multiphase model for the gas-liquid system



Multiphase Fluid Flow

- Considered phases: Water_(l) & CO_{2(g)}
 - $V_G = 200$ ml/min
- Multiphase model with constant bubble size
 - $d_B = 3.5$ mm
- Interaction of phases
 - Drag (Grace, Tomiyama, Ishii-Zuber)
 - Surface tension ($\sigma = 0.072$ Nm⁻¹)
- No turbulence model included

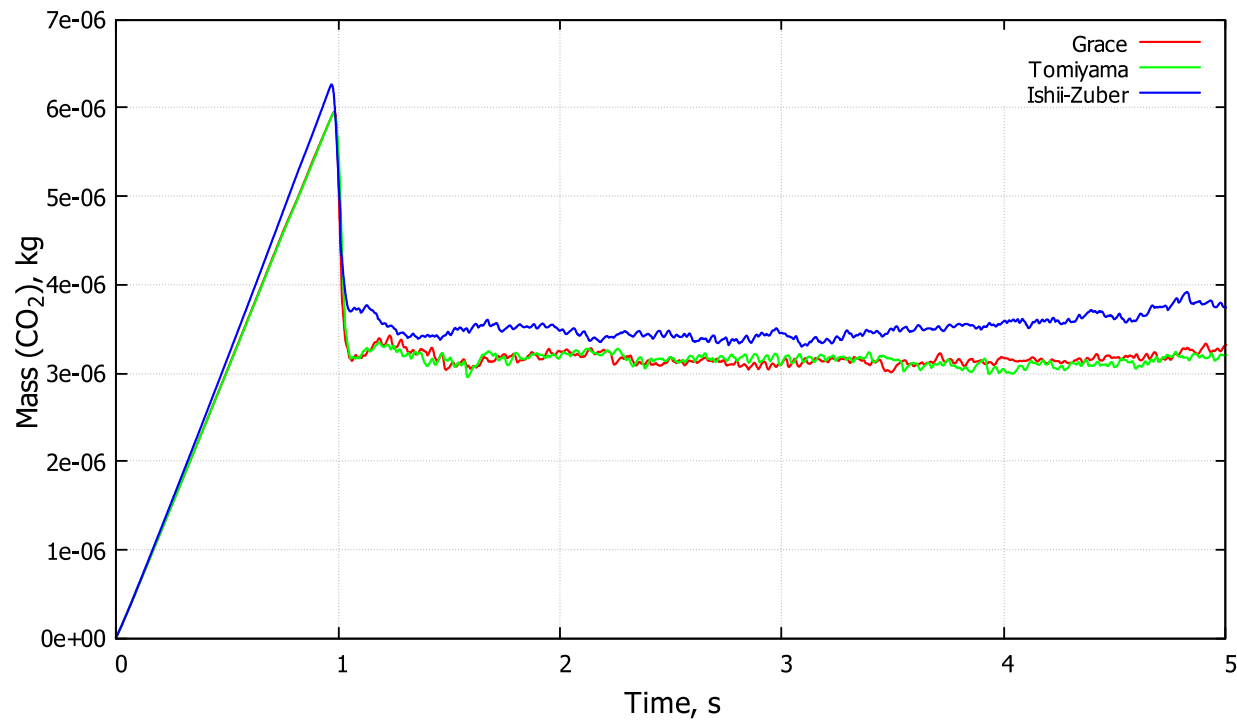


Multiphase Fluid Flow

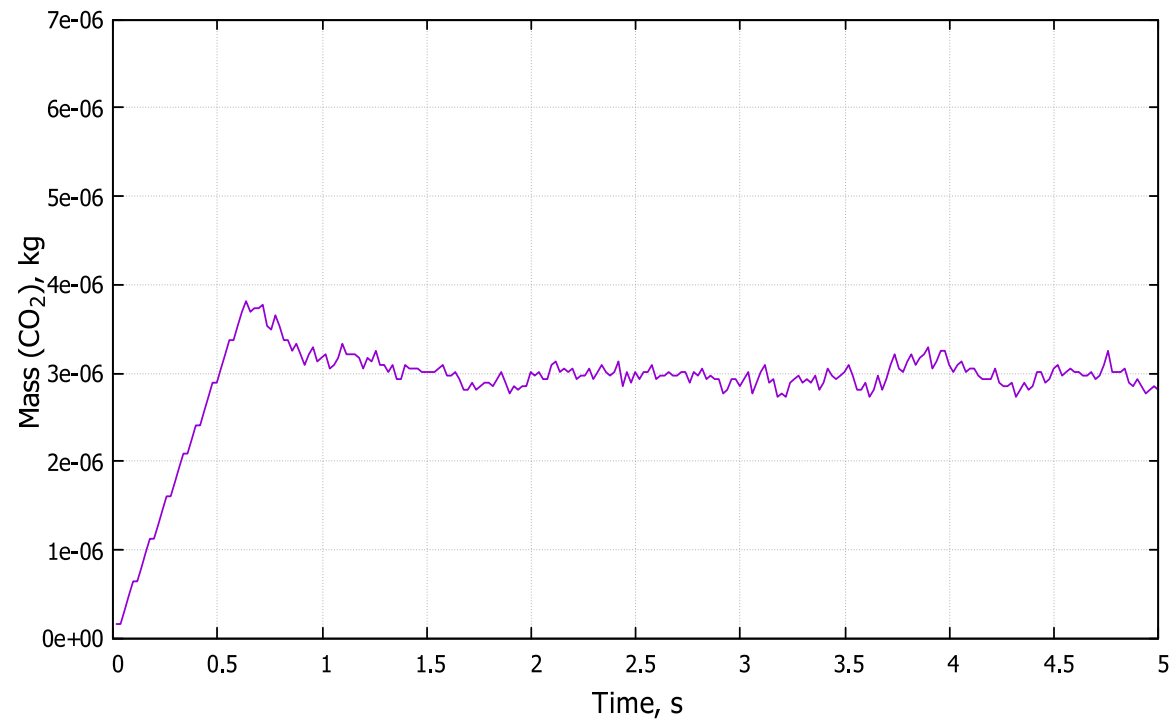
- 3 cases considered
 - Difference in the drag model
 - 1) Grace
 - 2) Tomiyama
 - 3) Ishii-Zuber
- Focus on
 - Gas hold-up
 - Time to reach the stabilised state
 - Bubble trajectory observation

Gas hold-up

Eulerian approach

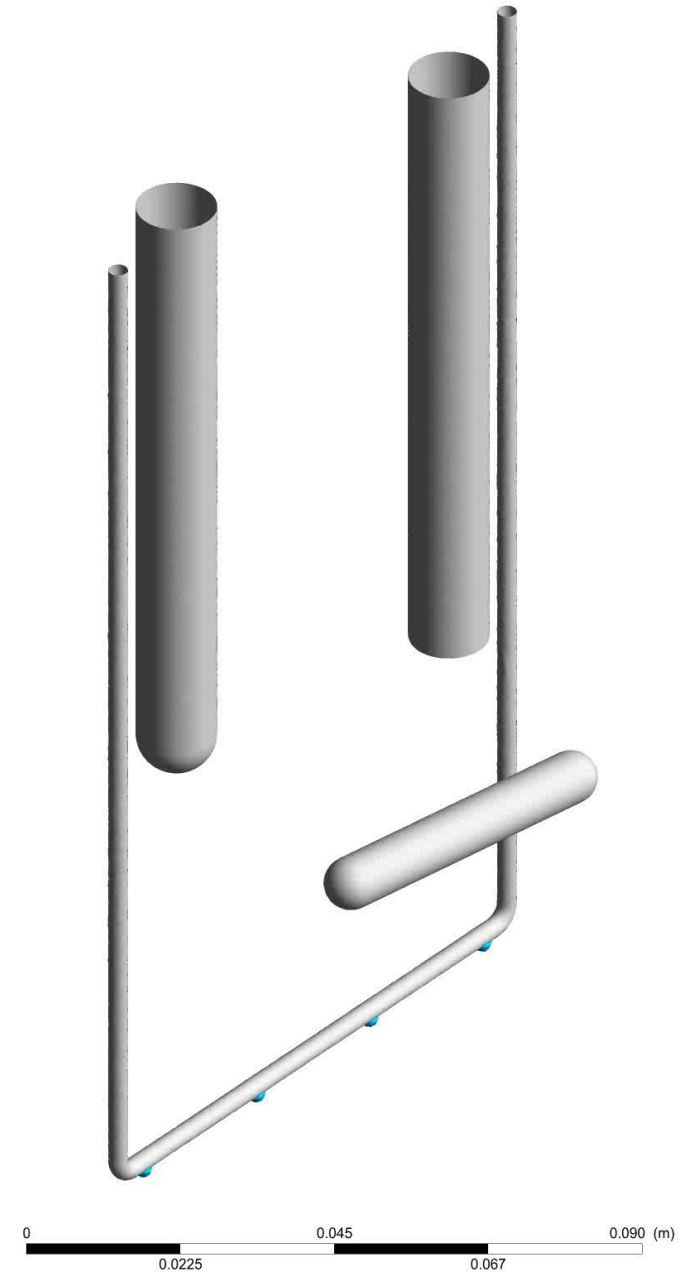
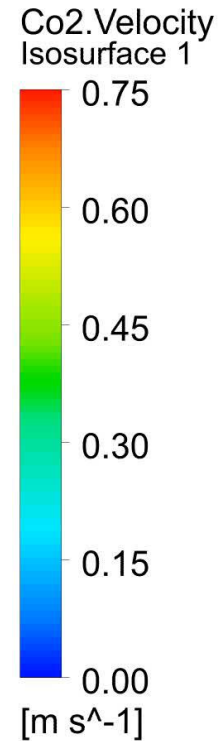


Discrete approach



Bubbles

- Animation of bubble formation and trajectory
- Grace drag model
- $V_G = 200$ ml/min
- Observed bubble adherence to walls



Bubbles

- Video of bubble formation and trajectory
- Lab experiment
- $V_G = 200 \text{ ml/min}$
- No bubble adherence to walls observed



Conclusions

- Grace and Tomiyama models predict the same gas hold-up
 - Comparable results with a discrete phase simulation
 - The Ishii-Zuber predicts a higher value
- All models predict the same time to reach stabilised state
- No bubble adherence to walls observed in lab experiments
 - Inclusion of other interaction models needs to be considered



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