Operating strategy to reduce the energy input of a flat-panel airlift photobioreactor with intrinsic static mixers

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Abstract
- Industrially relevant, dense phototrophic microalgal cultures in PBRs always experience photolimitation
- Turbulence is essential to frequently translocate cells to illuminated zones, but its generation comes at a cost
- FPA-PBR operating strategies reducing the mixing-related energy input were developed addressing
  - indoor cultivations by applying intermittent aeration and
  - outdoor cultivations by adapting the aeration rate
- Energy reductions of 37 % and 66 % were achieved respectively, without negatively influencing growth kinetics

Materials and Methods
- Process development followed two routes for outdoor bulk product and indoor high added-value compound production
- For outdoor cultivations:
  - FPA-PBR setup: 2 L FPA-PBR - PFD: 180-780 µmol m⁻² s⁻¹ - Aeration: 0.11-0.83vvm - 6 % v/v CO₂
- For indoor cultivations:
  - Intermittent aeration 2 L FPA-PBR - C. sorokiniana SAG211-8k - PFD: 450 µmol m⁻² s⁻¹ - Aeration: 0.24 vvm - Pulses: 5s on : 5s..20s off - 5 % v/v CO₂

Results and Conclusion
- With biomass concentrations exceeding 3 gDW L⁻¹ and PFDs increasing from sub- via quasi- to supra-saturating (180, 405 and 780 µmol m⁻² s⁻¹ respectively), increase in aeration rate results in
  - increased productivity
  - increased final biomass concentration
- During outdoor cultivations, aeration rate should be adjusted using PFD and biomass concentration as control parameters allowing for
  - increased productivity at intense light and high DW concentration
  - low-energy cultivation at dim light and low DW concentration
- Translated outdoors, this may reduce the energy input by 37 %

- During indoor cultivations
  - with static light supply, energy consumption can be reduced by intermittent aeration
  - Pulses up to 5 s on : 10 s off show no negative effect on culture proliferation
  - Prolonged pause intermittency results in reduced final biomass concentration as well as biofilm formation

Summary and Outlook
- Sophisticated strategies to manage the induction of turbulence within microalgal cultures were developed for outdoor and indoor applications
- These are capable of significantly reducing operational expenditures with respect to culture mixing
- The strategies will be further refined, adapted to other species and validated on larger scale, indoors and outdoors

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