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Exploring Strategies for Optimisation of Microalgae Biofuel Feedstocks Production Using Mechanistic Modelling

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Algae biofuels have been promoted as a replacement for fossil fuels, based on claims that microalgal biomass can provide a highly productive source of feedstocks for sustainable transport fuels. However, non-experts may lack the technical means to test the claims made by proponents of this technology and determine whether they are genuinely achievable or mere hyperbole. Even with the necessary technology in place, production optimisation of algal biofuels is highly challenging; there are many operational permutations while geographical variations can localize effective methods of cultivation.

Identifying optimal production strategies thus becomes key to making algae-based biofuel technology commercially viable. To that end, we discuss results of rigorous *in silico* explorations of the commercial potential for algal biofuels based on mechanistic principles. Use of fast, relatively inexpensive, computational techniques makes it possible to accurately simulate a broad range of production scenarios, enabling limits on industrial-scale algal biodiesel production to be quantified. Production is optimised by varying parameters describing strain, nutrient availability and dilution rate under geographically and seasonally varying illumination and by comparison of harvesting methods. We demonstrate how trade-offs between conflicting factors combine to keep commercial algal biofuels production sub-optimal; for industrial-scale solar-powered cultivation of microalgae, biodiesel production is limited to ca. 6,000 L ha^{-1} y^{-1}. We consider the implications for the sustainability and economic viability of microalgae biofuels by placing our results in the context of existing economic models and life cycle analyses. This will enable specialists and non-specialists alike to become better informed about how realistic the prospects for algal biofuels are and how to exploit them most effectively.

Keywords: Microalgae, Biofuels, Biomass, Modelling, Optimisation