**LIGHT, MICROALGAE AND MATHEMATICAL MODELS: MAKING SENSE OF PHOTOSYNTHESIS**

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**ABSTRACT**

Microalgae are of substantial biotechnological interest due their polyphyletic nature which grants them access to a wide array of high-value metabolites. However, photoautotrophic process optimisation is far from trivial due to the unique characteristics of incident light as a critical process parameter (CPP) and its complex interactions with other CPPs. Optimised artificial illumination strategies offer a readily available, cost-effective and non-invasive method to control biomass productivity and to direct uptaken carbon towards high value metabolic products. The aim of this combined mathematical and experimental study is to highlight some of the key issues that need to be addressed in order to consolidate microalgae as a viable bio-production platform.

Light in and of itself is complex in nature as it can vary in terms of intensity, spectral composition (colour), photoperiod and duty cycle. In the first part of this study we focus on the detailed characterisation of the combined effects of wavelength selection and trophic strategy on the growth kinetics and gene expression profile of the model microalgae *Chlamydomonas reinhardtii* grown under moderate to high light intensity (400 µmolph·m-2·s-1). The aim is twofold: (a) to establish a list of reliable housekeeping genes valid for quantitative comparisons across several combinations of different wavelengths and trophic strategies and (b) to enable the investigation of the response of central carbon metabolic pathways under these process conditions.

In the second part of this study a formalised statistical Design of Experiments (DoE) approach is employed for the multiparametric optimisation of phototrophic growth of *C. variabilis* in closed, controlled and artificially illuminated batch cultures. Initially, the process design space comprising six CPPs, three related to the quality of incident light and three related to the culture environment, was explored using a fractional factorial screening design. Subsequently, a higher resolution face-centred central composite design involving the three most influential parameters identified from the screening round was used for process optimisation.

Mathematical models are employed throughout this study to analyse experimental findings, consolidate data and elicit system-wide behavioural patterns of cellular metabolism. Several challenges in modelling photosynthetic organisms were identified and appropriate solutions were proposed and validated.

**KEYWORDS:** microalgae, biomass productivity, light intensity, optimization, modelling