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Artificial neural network model for predicting production of *Spirulina platensis* in outdoor culture

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HIGHLIGHTS

- Outdoor algal cultivation is influenced by many uncontrollable input variables.
- Artificial neural network model predicts outdoor *Spirulina* growth accurately.
- Simple to measure input parameters identified for the growth prediction model.
- Two weeks' data sufficient to give robust model for growth prediction.
- Precise output prediction will help better management of uncontrollable processes.

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ABSTRACT

Process variables contributing to describe the growth of *Spirulina platensis* in outdoor cultures were evaluated. Mathematical models of the process using inputs which were simple and easy to collect in any operating plant were developed. Multiple linear regression (MLR) and artificial neural network (ANN) modelling procedures were evaluated. The dataset contributing to the growth prediction model were biomass concentration, nitrate concentration, pH and dissolved oxygen concentration of culture fluid, light intensity and days in culture, measured once a day. Datasets of 12 days were sufficient to develop a model to predict the succeeding day's biomass concentration with a coefficient of determination of greater than 0.98 under outdoor growth conditions. Insufficient number of datasets resulted in overestimation of the predicted output value.

1. Introduction

Microalgae find applications in diverse markets such as health food, beauty products, feed supplements, nutraceuticals and pharmaceuticals, research reagents, fuels, etc. They have the potential to be produced employing abundantly available inexpensive ingredients – sunlight and CO_2. However in practice, there is a large gap between the potential and the reality. *Spirulina*, a prime example of commercially exploited microalga, grows well in tropical and subtropical climatic condition and has the ability to grow under autotrophic, mixotrophic and heterotrophic condition (Kim et al., 2007; Lodi et al., 2005; Ogbonda et al., 2007). It is organized as cylindrical cells arranged in unbranched, helicoidal trichomes (Ciferri, 1983; Vonshak, 1997). *Spirulina* being a rich source of proteins, water soluble vitamins, β-carotene, iron and polyunsaturated fatty acids is produced in large scale for the health food market. Owing to its ability to grow under fairly high alkaline conditions, it can be cultivated in open-air cultures and can remain largely free from contamination by other microorganisms (Chaumount, 1993).

For large-scale production of *Spirulina*, its growth and biomass productivity depends on several factors: solar radiance in the photosynthetically active range, pH, presence of contaminants, temperature, dissolved oxygen concentration, salinity, mixing and nutrient availability (Colla et al., 2004; Ogbonna et al., 1995; Vonshak, 1997). These factors can influence the growth of *Spirulina* and the composition of the biomass produced by causing changes in metabolism, which considerably modify the time course of the accumulation of the main biomass components (Richmond and Grobbelaar, 1986). Commercial production involves cultivation of *Spirulina* in open pond raceways. The outdoor cultivation of *Spirulina* has limitations mainly due to lack of control over key growth parameters including light intensity, temperature and dissolved oxygen concentration (Chaumount, 1993).

Despite their lower specific yield, open-channel raceways generally cost less to build, operate, and maintain than closed photobioreactors. Although raceways are currently used for lower-cost

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