Modelling the Growth and Succession in Microalgal Comminity following the Gradual Warming of the Environment

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Most of model simulations of phytoplankton growth as a function of temperature have been concerned only with the range of temperatures stimulating the plankton growth. Operation of powerful thermal and nuclear power stations, as well as global warming of climate, result in gradual warming of waters in natural water bodies, which may exceed the optimal temperatures for some phytoplankton species, thus causing the thermal succession of original species to more thermophylic species.

The temperature dependence of phytoplankton growth is described by two-exponential equation, reflecting the exponential increase with temperature of both metabolic processes of biosynthesis and biodegradation:

$$\mu = -\varepsilon_0 - \varepsilon_d \exp\left(\alpha_d TEMP\right) + \beta_s \exp\left(\alpha_s TEMP\right) \frac{S}{K+S}, \qquad (1)$$

where μ is the specific growth rate of micro-algae, S is concentration of limiting nutrient in water, K is the half-saturation constant; ε_0 describes the basic level of metabolic losses, $varepsilon_d$ and α_d characterizes the temperature dependence of the decomposition processes, β_s and α_s describes the temperature dependence of the synthesis processes, TEMP is temperature in °C.

The numerical analysis has been performed to estimate the exponential model parameters. It was shown, that the values of α_d and α_s parameters, which describe the temperature dependence of phytoplankton growth, lay in the narrow ranges: $\alpha_s = 0.05 - 0.08$ and $\alpha_d = 0.15 - 0.25$. At these ranges the temperature dependence of the micro-algae specific growth rate has a typical form of asymmetric bell [1]. Comparison of the two-exponential model predictions with the experimental thermotolerance curves for several micro-algae species with temperature optima within the range 11-37 °C demonstrated the good fitting between the calculated and experimental values. Practically, the exponential values can be fix at constant levels with low uncertainty: $\alpha_s = 0.065$ and $\alpha_d = 0.2$.

Use of these values of the exponential indices in simulation models of phytoplankton growth may considerably simplify the procedure of model validation, reducing it to linear algebraic task. The method makes it possible to simulate the succession of phytoplankton species in gradient of temperatures above values typical for a given water body.

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References

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