A note on the modelling of the algal blooms in the Vaal River: The silicon effect

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Abstract

In a recent article published in this journal, the authors described the basis of a mathematical model aimed to simulate the total planktonic biomass in a river. Taking only two fundamental environmental variables, light and temperature, into account, they developed a simple model that is able to give a good qualitative description of the winter algal bloom in the Vaal River (South Africa). However, some discrepancies between the simulated amplitude of certain algal blooms and field measurements were observed. In the present study, it is shown that this problem may, to a large extent, be solved by updating the model in order to take the Si uptake by diatoms into account.

Introduction

The prediction of the development of algal blooms in a river is of great importance in water resource management (Walmsley and Butty, 1983; Pieterse, 1986). Recently Cloot et al. (1992) introduced a mathematical model for algal growth with the intention that it should eventually be able to assist researchers and the relevant authorities by providing a tool which can lead to a better understanding of aspects of algal growth, and which might enable meaningful short- and long-term water quality predictions. In its original version, algal growth was modelled by taking only water temperature and underwater light climate variations into account. Within this framework, and assuming that assemblages containing up to JV algal groups are responsible forthe blooms, we derived abasic scheme that may be used for the modelling of algal growth. This scheme is illustrated in Fig. 1.

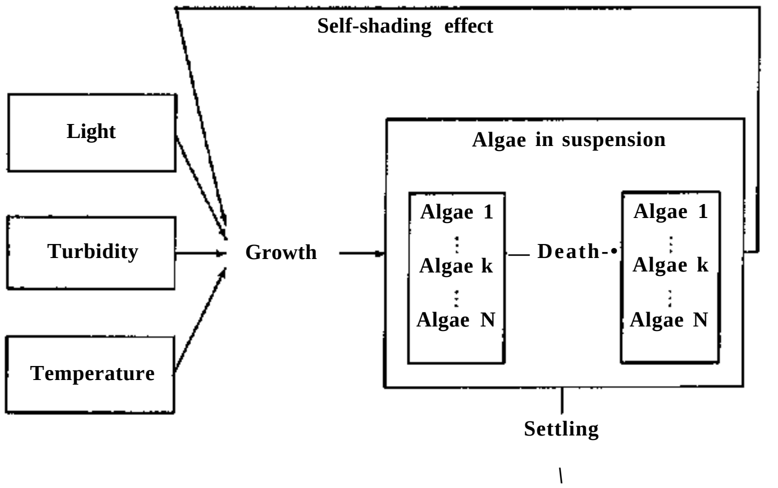

Figure 1
A schematic representation of the basic light-temperature Vaal River N-algal growth model

The transcription of the scheme in Fig. I in terms of mathematical relations leads to a system of *N* pairs of coupled non-linear differential equations:

$$\dot{x}_{1i} = [-k_{D_i} + k_{S_i}) + k_{G_i}(T, I, \underline{K}_j; j = 1, N)]x_{1i}$$
$$\dot{x}_{2i} = k_{Di}x_{1i} - k_{S_i}x_{2i} \qquad (1)$$

that depend explicitly on parameters which could be classified in two categories, namely environmental variables and variables that are specific for a particular algal group. The environmental parameters that were needed for this basic model, are given in Table 1.

Furthermore, the reactions of algae to variations in environmental variables differ from group to group (Hoogenhout and Amesz, 1965), and the sensitivity of the i-th algal group can be represented by a set of parameters $\underline{K}_i$ of which the components are given in Table *2,*

TABLE 1
ENVIROMENTAL PARAMETERS

I_{max}	:	maximal irradiance available on the water surface
$u(t)$	:	cosine of solar zenith angle
T	:	the water temperature
$S(t)$	:	total concentration of inorganic material suspended in the water
[illegible]	:	depth of the mixed layer
K	:	light extinction coefficient for pure water
c_s	:	light extinction coefficient for suspended inorganic solids

This model was calibrated on data available from the Vaal River and tested on *in situ* measurements from the Stilfontein site, during a three year period starting January 1985.

During the winter to spring period of each of these years, two

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Received 11 March 1994; accepted in revised form 15 March 1995.