

Seasonal variation of phytoplankton biomass in the Middle Vaal River, South Africa

Jan C Roos^{1*} and AJH Pieterse²

¹ Department of Botany and Genetics, University of the Orange Free State, PO Box 339, Bloemfontein 9300, South Africa

² Department of Plant and Soil Sciences, Potchefstroom University for CHE, Private Bag X6001, Potchefstroom 2520, South Africa

Abstract

The chlorophyll-*a* concentration in the Vaal River (at Balkfontein; 1985 to 1989) was high (av. = 67 $\mu\text{g}\cdot\text{l}^{-1}$) and displayed great variation (8 to 360 $\mu\text{g}\cdot\text{l}^{-1}$). An increasing concentration trend of 20 $\mu\text{g}\cdot\text{l}^{-1}\cdot\text{a}^{-1}$ was shown. The hydrology, particularly episodic floods through inputs from summer rain, plays an important role not only in the chemistry, but also in the biology of the Vaal River. The chl-*a* concentration was usually the lowest after the summer rain period. It stayed low for about two months and was then followed by a maximum concentration (bloom) in late winter to spring. The early bloom was dominated by diatoms, followed by a bloom usually dominated by green algae. The bloom was followed subsequently by a population crash. The enrichment of the river during floods by nitrogen (N) and phosphorus (P), usually leads to large phytoplankton blooms that occur approximately two to four months after floods. The average chl-*a* concentration in the Vaal River was statistically significant, correlated with the average total phosphorus (TP) concentration. Approximately 1 $\text{mg}\cdot\text{l}^{-1}$ increase in the average TP concentration will probably be associated by about 225 $\mu\text{g}\cdot\text{l}^{-1}$ increase in the average chl-*a* concentration. This aspect could make it fairly simple to predict and possibly control the standing crop in the Vaal River.

Introduction

Rivers are complex physical, chemical, and biological systems (Petts, 1984). Qualitative and quantitative information of organisms growing in an ecosystem is of fundamental importance in understanding the *functioning of ecosystems* (Volleuweider et al., 1974). The dynamics of phytoplankton in rivers has not been investigated as much as it has in lakes and estuaries. Particularly, the relationship between phytoplankton and discharge, which is the main diagnostic feature of rivers when compared to lentic habitats, seems not yet to be fully understood.

The quality of many water sources in the Republic of South Africa (RSA) is declining. The decline is primarily a result of salinisation, eutrophication and pollution by trace metals that are micro-pollutants (DWA, 1986). This type of pollution applies especially to the Vaal River system (Braune and Rogers, 1987). Massive development of phytoplankton and macrophytes, especially water hyacinths (*Eichhornia crassipes*), occurs as a result of pollution and eutrophication (Pieterse, 1986; Roos, 1992). The Vaal River is the most important river in South Africa and can justifiably be called "the main artery of the South African heartland" (Braune and Rogers, 1987). However, only limited ecological studies on the river have been undertaken in the past.

Preliminary observations on spatial and temporal heterogeneity in phytoplankton and environmental variables as well as primary productivity in the Vaal River were made by Pieterse et al. (1986). Pieterse and Roos (1987; 1992), and Roos and Pieterse (1992). Physical and chemical aspects of the environment that influence phytoplankton were evaluated by Roos and Pieterse (1994; 1995b) and seasonal and related aspects of N and P were presented in Roos and Pieterse (1995a). They emphasised the important contribution of annual spates to TN and TP concentration, with suspended solids as an important transport agent in the Vaal River. However,

seasonal variation of phytoplankton and quantitative evaluation of the relationship between various environmental variables have been investigated only for a brief period (Pieterse, 1986).

In the present study, phytoplankton biomass and environmental variables that influence their abundance are emphasised, and reference is made to specific algal species. In addition, the conditions that possibly cause the development of annual spring blooms of phytoplankton have been investigated, as well as which variable(s) possibly govern(s) the upper limit of phytoplankton biomass during blooms in the Vaal River.

Materials and methods

The present study was done in the lower region of the middle Vaal River system (South Africa) at the water intake (pumping station) of the Balkfontein purification plant (lat. 27° 23' 45"; long. 26° 30' 30") situated at a height of 1 240 m above mean sea level (see Roos and Pieterse, 1994; 1995a; b for map of the region). The width of the river at the sampling site is about 70 m, while the maximum depth is 6 m and the average depth is about 4 m.

In situ measurements in the Vaal River were done monthly over a period of four years (August 1985 to November 1989). Dissolved oxygen ($\text{mg}\cdot\text{l}^{-1}$) and temperature ($^{\circ}\text{C}$) were recorded at noon ($12:00 \pm 1$ h) at the surface and at each 0.5 m depth down to 3 m. A Yellow Springs YSI Model 54 A oxygen/temperature meter was used. It was calibrated with saturated (stirred) river water, taking the atmospheric pressure and temperature into account.

Surface pH was recorded with an Orion Research Model 231 digital pH meter that was calibrated (2-point method) with buffer solutions at pH 7 and pH 10. Turbidity was recorded with a Chemtrix Type 10 Turbidimeter and quantitatively expressed in terms of the scattering coefficient, i.e. in nephelometric turbidity units (NTU). A 100-ml subsurface water sample was collected and preserved in 2% formalin (final concentration) for algal identification (Wetzel and Likens, 1991). The algal species with the greatest number of cells per unit volume of water was considered to be the dominant alga. However, co-dominance was frequently encountered

* To whom all correspondence should be addressed.

(051)401-2265; Fax (051) 448-8772; E-mail pjcr@rs.uovs.ac.za

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