The application and testing of diatom-based indices in the Vaal and Wilge Rivers, South Africa

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Abstract

Chemical monitoring of water resources is time-consuming and comparatively expensive and may not always provide a composite reflection of actual water quality. Biotic indices using faunal elements, such as macroinvertebrates and fish, are already in place in South Africa as part of the National Biomonitoring Programme for Aquatic Ecosystems (NBPAE). As yet periphyton communities are not included in this programme due to perceived difficulties in the application of these methods. Diatom samples were collected from 10 sites in the Vaal and Wilge Rivers for a period of one year. Diatom cells from these communities were enumerated and diatom-based indices were calculated using OMNIDIA v.3. Diatom index scores were correlated to physical and chemical water quality variables over different time periods and at different concentrations. It was found that the tested diatom indices in general have the best correlation with average chemical data for a one-month period, starting six weeks prior to biological sampling. The Biological Diatom Index showed the strongest relationship to general water quality, while the Eutrophication and Pollution Index showed the strongest relationship to dissolved inorganic phosphorus. Results of correlation analyses obtained in South Africa were comparable to those obtained in several European studies. Hence, it is concluded that diatom-based indices, if implemented in South Africa, will provide a valuable addition to South Africa's suite of tools for the biological monitoring of water quality.

Keywords: diatoms, water quality, indices, Vaal River, Wilge River

Introduction

The assessment of the general quality of a water resource requires regular monitoring. Chemicals and chemical compounds constantly fluctuate in the river system; they are broken down, and dissolved by environmental conditions such as light and heat energy, they are also constantly removed from the system via uptake by organisms and sedimentation. Chemical components in a river system may also be diluted by inflows of rainwater or augmented from runoff from point (mine, sewage, storm water drainage) and diffuse sources (agricultural runoff, groundwater seepage from settling ponds), or become concentrated during times of drought and low flow. These factors make it difficult, if not impossible, to provide anything other than a fragmented overview of the state of a river along its complete length using conventional chemical monitoring techniques. Rapid efficient and cost-effective techniques, such as diatom-based pollution indices, are therefore required for the routine monitoring of rivers.

The monitoring of South African waterways has traditionally been carried out by two means, firstly by chemical analysis determining the water quality, and more recently by the use of various biomonitoring techniques such as the South African Scoring System (SASS) and the Fish Health Index (FHI). These techniques were introduced as part of routine monitoring programmes due to certain shortcomings in standard physical and chemical methods. These monitoring techniques form part of the National Biomonitoring Programme for Aquatic Ecosystems (NBPAE; Hohls, 1996). It has become important to use various methods as alternatives to chemical analyses as these techniques provide, at best, a fragmented overview of the state of a river as sporadic or periodic sampling cannot reflect, e.g. fluxes of effluent discharge, dumping or storm events. In contrast, the community structure of a given group of riverine organisms will be shaped by the chemical and physical nature of their habitat. Changes in water chemistry will inhibit the multiplication of some of the species originally present, and encourage that of others, so that primarily the association, i.e. the percentage composition of certain species within a community will be changed (Cholnoky, 1960). These changes in species composition can in turn be used to reflect changes in water quality in a more integrated manner than traditional chemical sampling.

The potential of diatoms as indicators of water quality was realised early on in South Africa by Cholnoky (1968), Archibald (1972), Schoeman (1976) and Schoeman (1979). Schoeman (1979) tested Lange-Bertalot's (1979) method in the upper Hennops River and found the method successful, with a good correlation between the species composition of the diatom communities studied, and the water quality. Diatoms, as indicators of water quality, were only again investigated in depth in South Africa by Bate et al. (2002). They came to the conclusion that benthic diatoms could be a useful addition to the NBPAE as the diatoms give a time-integrated indication of specific water quality components. However, Bate and co-workers went on to state that the particular data set tested in their study (that of Van Dam et al., 1994), could not be transposed directly for use under South African conditions. For this reason the present study has investigated the potential use of several other diatom indices in the Vaal River system as part of a national investigation into the efficacy of these indices for use in bio-monitoring of South African rivers.

It is generally accepted that invertebrate-based indices do not provide a reliable indication of eutrophication and for this reason it is better to take direct measurements of the photo-

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