The application and testing of diatom-based indices of stream water quality in Chinhoyi Town, Zimbabwe

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ABSTRACT

Aquatic ecosystem biomonitoring tools are largely lacking for many developing countries, resulting in adoption of tools developed from other countries/regions. In many instances, however, the applicability of adopted tools to the new system has not been explicitly evaluated. The objective of this study was to test the applicability of foreign diatom-based water quality assessment indices to urban streams in Zimbabwe, with the view of stimulating research to develop improved approaches for assessing ecological integrity of lotic systems in the country. The study evaluated the relationship between measured water quality variables and diatom index scores. The study found a high degree of concordance between water quality variables and diatom index scores. Thus, the indices proved useful in providing an indication of the quality of the investigated waters. This could be attributed to the occurrence of many widely distributed diatom species that have similar environmental tolerances to those recorded elsewhere. Diatom indices which exhibited consistent classifications and strong correlations with water quality variables such as Trophic Index, Saprobic Index, Pampean Diatom Index, Biological Index of Water Quality and Leclercq Index are recommended for use in the country. However, ecological requirements of some diatom species from Zimbabwe need to be clarified and incorporated in a diatom-based water quality assessment protocol unique to the country.

Keywords: biological monitoring, pollution, benthic diatoms, biotic indices

INTRODUCTION

The relation between diatom communities and environmental variables in aquatic systems is robust and quantifiable (Wehr and Sheath, 2003; Azim et al., 2005; Bere and Tundisi, 2010a, 2010b; 2011a). Each particular species requires different structural, physical and chemical characteristics intrinsic to its habitat. Whenever these characteristics are subject to slight variations, due to natural or anthropogenic activities, associated diatom communities respond rapidly, often changing in both taxonomic composition and biomass (Wehr and Sheath, 2003; Azim et al., 2005; Bere and Tundisi, 2009; Lavoie et al., 2008; Smucker and Vis, 2011; Stenger-Kovacs et al. 2013). Thus, pollution-monitoring programmes routinely include the examination of diatoms to investigate the water quality of aquatic systems (Watanabe et al., 1986; Descy and Coste, 1991; Kelly and Whitton, 1995; Prygiel et al., 1996; Biggs and Kilroy, 2000; Lobo et al., 2004; Taylor et al., 2007a, 2007b; Phiri et al., 2007; Lavoie et al., 2008; Bere and Tundisi, 2011c, 2011d, 2011e).

Biological monitoring is a fast and cost-effective approach for assessing the effects of environmental stressors, making it a particularly essential tool for the management of rivers in developing countries (McCormick and Cairns, 1994; Taylor et al., 2007a; Harding et al., 2005, Bere and Tundisi, 2010a). Unfortunately, diatom-based biological monitoring tools are largely lacking for many developing countries, resulting in the adoption of tools developed from other countries/regions. In many instances where these tools are adopted, their applicability to the new system has not been explicitly evaluated. However, there is evidence that diatom metrics or indices developed in one geographic area are less successful when applied in other areas (Pipp, 2002). This is due not only to the floristic differences among regions (Potapova and Charles, 2002; Rimet et al., 2004; Taylor et al., 2007a; Chessman and Townsend, 2010), but also to the environmental differences that modify species responses to water-quality characteristics (Potapova and Charles, 2007). Endemic diatom species may also occur in different regions, necessitating development of region-specific indices. Thus, strict testing of these borrowed indices is required to ensure that diatom index scores give a realistic reflection of the specific type of environmental pollution being tested (Taylor et al., 2007a).

The use of diatoms as indicators of water quality changes has relatively few precedents in Zimbabwe. Phiri et al. (2007) studied periphytic diatoms attached to the leaves of the submerged macrophyte *Vallisneria aethiopica* in the shallow waters of the Sanyati Basin in Lake Kariba, Zimbabwe. They concluded that diatoms may potentially be useful in assessing ecological conditions or the impact of human activities within the shallow marginal waters of the lake. Besides this study, there are no other detailed studies exploring the potential use of diatoms as indicators of water quality in aquatic systems. Diatom communities and their ecological requirements have largely been unexplored in the study region, hampering the use of diatoms as ecological indicators. The objectives of the present study were twofold: (i) to assess epilithic diatom community structure and composition in streams in relation to environmental conditions, and (ii) to test the applicability of the diatom-based water quality assessment indices developed in other regions, and calculated by the OMNIDIA version 5.3 software, to the study area. Diatom index scores were calculated and correlated to concurrent physical and chemical water quality data. The results of these correlation analyses were compared to results obtained in similar studies carried out elsewhere, e.g., in South America (Brazil), Europe and South Africa.

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