Towards integrated water quality monitoring: Assessment of ecosystem health

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Abstract

National water quality monitoring in South Africa has in the past mainly focused on measuring physical and chemical variables. However, it is increasingly realised that measuring physical and chemical variables on their own cannot provide an accurate account of the general "health" of an aquatic ecosystem. Biological communities, on the other hand, are accurate indicators of overall environmental conditions. This paper examines the potential and feasibility of incorporating biological monitoring in a programme designed to assess ecosystem health. The current status of biomonitoring within the RSA Department of Water Affairs and Forestry is outlined and challenges for the future are discussed. It is concluded that biomonitoring should form an essential part of ecosystem health assessment, and research and development in this field is encouraged. The developmental process should be a collaborative partnership between resource managers and researchers.

Introduction

For almost 30 years after the enactment of the Water Act in 1956 (Act 54 of 1956), water pollution in South Africa was controlled primarily by applying a uniform effluent standard, i.e. an emission-based approach. Recognition of the need to account for the effects of effluents on receiving water led to the introduction of the special effluent standard, which imposed stricter limits on the quality of discharged effluents, and was applied in certain specified catchments. All effluents subject to regulation were required to meet either the general effluent standard or the special effluent standard (Van der Merwe and Grobler, 1990).

In a review of water quality management policies and strategies, the Department of Water Affairs and Forestry (DWAF, 1991) presented a revision of its policy, adopting a receiving-water-quality-based approach for non-hazardous substances and a pollution prevention approach for hazardous substances. The focus of the Department's water quality management has therefore changed in recent years, from controlling pollution at source to a user-based philosophy. This shift in policy towards a more integrated resource-based approach represents an important advance which essentially enables the establishment of a limit on levels of pollutants according to the water quality requirements of each user in a particular water system.

One of the users that must be considered in terms of water quality requirements is the aquatic environment. Unfortunately the status of our aquatic environments is currently not well documented, making it difficult to reliably assess the extent of alteration and the rate at which changes in water quality are occurring. Also, information for evaluating the effectiveness of water quality management plans, for identifying emerging problems and for anticipating future conditions under different management options is fundamental to the continuing process of developing and implementing policies and programmes to protect legitimate uses of water resources. Clearly, therefore, comprehensive monitoring and assessment programmes are needed to establish regional and national baselines of the chemical, physical and biological resource characteristics. Only then can the status of the changes in quality be assessed, and the overall effectiveness of the Department's water quality management policies be measured with confidence.

This paper addresses various aspects of biological monitoring and examines their potential and the feasibility of supplementing chemical and physical monitoring of water quality in South Africa.

Ecosystem health assessment

It is generally agreed that measuring only the physical and chemical attributes of water cannot provide the sole assessment of the health of an aquatic system (Gaufin, 1973; Lawrence and Williams, 1991 and Ten Brink and Woudstra, 1991). Amajor reason for this is our limited knowledge of the effects of toxic variables on biota. A further limitation of chemical monitoring is that it does not account for many man-induced perturbations, such as flow alterations and habitat degradation, which impair biological health. Physical and chemical information is, furthermore, biased towards the momentary conditions that exist at the time the sample is collected, often missing short-term events which may be critical to ecosystem health. Biological communities, on the other hand, are accurate indicators of overall environmental conditions, since they are subject to the totality of chemical and physical influences and integrate their effect over time.

Although up to now researchers have found it difficult to define ecosystem "health" (Chapman, 1992), the concept has often been considered as analogous to the human condition (Calow, 1992). As with the human condition, the absence of ecosystem health is often easily recognised or detected (Cairns and Pratt, 1992). Effects of contaminants on an ecosystem, that may lead to a decrease in the health of that system, can be scaled at different levels: organism, population, community and ecosystem level (Akkerman et al., 1991). In order to quantify the condition of an ecosystem, indicators of ecosystem health/disfunction should be consistent with the common symptoms of ecosystem health/degradation. Such symptoms may include: changes in the biotic size spectrum to favour smaller life forms, increased circulation of contaminants, reduced species diversity, increased dominance by exotic species, shortened food-chain length, increased disease prevalence, and reduced population stability (Rapport, 1992). In South Africa different geographic regions have different "natural" water quality, with the result that "natural" diversity (in structural terms), both with respect to quality and quantity of taxa, also varies. To use ecosystem dynamics effectively for baseline representation of ecosystem

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