The design and research potential of an artificial stream system for the investigation of macroinvertebrate water quality tolerances

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Abstract

An artificial stream laboratory has been developed at Rhodes University, in collaboration with the Water Research Commission and the Department of Water Affairs and Forestry. It provides a controlled environment, with a defined and replicated range of hydraulic conditions, so that experimental research can be conducted using rheophilous organisms. In the first instance, research will focus on [he response of riverine macroinvertebrales to changes in water quality. The system is also ideal for the investigation of hydraulic requirements of riverine taxa. In this paper we describe the role artificial stream research can play in waterquality management, briefly review artificial stream designs, and provide design details of the artificial stream system which has been built.

Introduction

Water quality management in South Africa has recently changed from the uniform effluent standard approach, to the receiving water quality objectives (RWQO) approach (Van der Merwe and Grobler, 1990). The implementation of the RWQO approach aims at the maintenance of water quality in a state "fit for use" by any or all of 5 designated water resource users: industry, agriculture, domestic supply, recreation and the environment (Department of Water Affairs and Forestry, 1993). Water is a limited resource which is unevenly geographically distributed, and users compete for water supply. However, the allocation of water to the natural environment, in terms of both quality and quantity, needs to be considered separately from the other users, because the maintenance of river ecosystems and catchments in a state of ecological integrity, where biological processes remain functional, is a prerequisite for meeting most other user requirements. If water quantity and quality are inadequate for the maintenance of ecological function, then many other user requirements cannot be met either. It is therefore imperative that realistic environmental requirements are defined, and management objectives provided.

The Department of Water Affairs and Forestry (DWA & F) has prioritised setting water quality guidelines for all the user sectors. Guidelines for 4 users, but not for the natural environment, have been published (DWA & F, 1993). Setting environmental water quality guidelines that are appropriate to the South African situation has proved to be difficult. Various information sources are available: the historical patterns of chemical concentration can be used; published water quality guidelines set for other countries can be consulted; the natural distribution patterns of freshwater biota can be related to regional patterns of water quality; and ecotoxicological studies can provide experimental results concerning the tolerance limits of specific taxa. These taxa can either be standard laboratory organisms, such as *Daphnia* (Roux et al., 1993), or local South African riverine taxa.

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An artificial stream system has been designed and built with the specific aim of providing a controlled flowing water environment, where riverine organisms from local rivers can be subjected experimentally to changes in water quality. In this paper we present:

- a brief review of artificial stream designs;
- a description of the selected design; and
- the operation, and planned experimental use of the system.

Artificial streams - Design alternatives

One of the most obvious features of natural ecosystems is the complexity of interactive effects between abiotic and biotic variables. In an experimental approach, the general aim is to maintain certain variables constant while investigating the effects of others by altering them within controlled limits. Artificial stream research is based on the further premise that the provision of a flowing water environment is fundamental to any experimental research on riverine organisms (Frutiger, 1984).

At the more natural end of artificial stream design spectrum are outdoor systems which allow control of selected variables while leaving others, such as light, daylength and temperature to fluctuate with the natural environment. Such designs offer less experimental control and are favoured by those who believe that "conclusions and generalities from artificial stream systems which incorporate more of the characteristics of natural environments are more directly related to those environments" (Clark et al., 1980). Outdoor systems vary in '"naturalness" from channels placed in a stream and naturally colonised (Hildebrand, 1974; Kowanacki et al., 1985; Poff and Ward, 1990); through channels next to a stream with stream water diverted through them (Clark et al., 1980; Bothwell, 1988; Allard and Moreau, 1985; 1987; Eichenbacher et al., 1985 Arthur, 1988); to large recirculating systems (Ladle, 1976, 1977; Reynolds et al., 1990).

Ladle and Frutiger (1991) both regard artificial stream research in large outdoor systems as useful, but caution that it is capital intensive, and requires considerable manpower both for maintenance, and sample and data processing. Other difficulties include