The application of bioassays in the resolution of environmental problems; past, present and future

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Key words: freshwater, water quality, assessment, prediction

Abstract

Literature on bioassays for freshwater systems has been reviewed (between 1979 and 1987) and classified into studies concerned with prediction and assessment and, within these categories, into studies concerned with single- and multi-species bioassays. Changing trends in the response criteria and types of organisms used in the predictive tests are judged against results from a similar review carried out in 1979. This leads to the conclusion that though there may have been changes in detail, bioassays have remained surprisingly unchanged in general features over this time. The relative merits of, and relationship between single- and multi-species studies for both predicting and assessing the biological impact of toxicants are discussed. The conclusion is that some bioassays have more severe problems than others, but a concern with all of them is that responses observed in particular systems may not be relevant in general. The possibility of developing a general theoretical infrastructure for bioassays that addresses this problem is considered.

Introduction

Environmental bioassays involve the use of biological systems of varying levels of complexity to predict or assess the impact of pollutants on ecosystems. That biological systems should be capable of assaying ecological disturbance is self-evident, since without biological effects there is no disturbance. But this is a superficial view, for in developing bioassays there is often a need to simplify and generalize and this raises difficult questions such as: To what extent can one species or species group act as proxy for another? And, to what extent can bioassays be simplified, e.g. from multi- to single-species systems and from ecosystem to individual and even cellular and molecular systems? With these issues in mind, we here critically review bioassays that have been developed for both the prediction and assessment of pollution impacts in freshwater systems. It is not surprising that practicality and convenience have been dominant in determining which bioassays have been used, but this often involves selecting particular test systems or assays for general use; i.e. to predict general environmental impact effects from particular test results, or to assess impact from correlations between presence/absence of species and species groups and particular stressors that have been observed in previous instances. These are dubious practices philosophically (Saarinen, 1980; Mentis, 1988), and an important need is to develop a mechanistic understanding of particular effects so that a general theoretical framework can be developed for bioassays.
Framework for this review

In carrying out this review we distinguished between those bioassays concerned with prediction (anticipating environmental impacts) and assessment (monitoring actual impacts) and, within each of these categories, between bioassays employing single and many species. A comprehensive review of the literature was carried out up to 1979 by Murphy (1979) for predictive studies, so we concentrated on papers published post-1979 to 1987. A computer search was carried out using 3 databases (BIOSIS – Biological Abstracts; ASFA – Aquatic Sciences & Fisheries Abstracts; AQUALINE – WRc). The search concentrated on 2 subject areas (environmental/industrial toxicology & limnology) and key words included: indicator species, toxicity test, biotic indices, hazard assessment and evaluation, impact assessment and evaluation. The complete review is documented in WRc Report PRS 1715-M* and here we only draw attention to general features and trends.

Predictive Studies

More than 90% of all the studies that we classified as predictive were single-species laboratory tests. The kinds of criteria used in these are summarised in Fig. 1 together with the frequencies of papers that fell into each category. By far the

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* Can be obtained from Water Research Centre, Medmenham Laboratory, PO Box 16, Henley Road, Medmenham, Marlow, Bucks. SL7 2HD, UK.