PLANT BIOMONITORS IN AQUATIC ENVIRONMENTS

Assessing Impairment Via Plant Performance

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1. INTRODUCTION

In this review we focus on use of the aquatic macrophyte, *Vallisneria americana*, as a biomonitor of overall environmental conditions in the Laurentian Great Lakes. An array of measures of plant performance have been investigated; estimates of the leaf-to-root surface area ratio have proved to be the most consistently effective and useful. The species has been used in many different ways to characterize plant response to single organochlorines and metals, PCB mixtures, and as a bioassay of sediment toxicity, in the lab and in the field, to evaluate designated Areas of Concern, and to focus upon individual microsites and point source impact zones.

1.1. Assessment and Biomonitoring

As the burden of persistent toxic compounds discharged into waterways continues to increase, there is a growing need for simple, relatively inexpensive methods to assess site quality in aquatic ecosystems, and to identify degraded microsites requiring remediation (Dolan and Hartig, 1996). Historically, much water quality assessment has been carried out by researchers with backgrounds in chemistry or engineering, hence chemical analysis was a dominant form of assessment. However, chemical analyses, particularly of such materials as organochlorines and polyaromatic hydrocarbons, can be very expensive, and local environmental factors may cause the actual exposure of an organism to be little correlated with chemical concentrations in the surrounding water or sediments. Furthermore, the utility of chemical analyses can be restricted by their detection limits. Often toxicants can cause adverse biological effects at concentrations below the detection capabilities of
analytical tests (Lovett-Doust et al., 1994a). To a large extent, toxicity testing has proceeded independently of environmental quality assessment in situ. Biological assessment of aquatic pollution has proven itself to be a very valuable, efficient and accurate tool.

Biotic assessment in its most basic form involves the simple tracking of mortality in exposed organisms. However, in most natural environments it is extended, chronic exposure to contaminants that has the most wide-ranging and significant repercussions—thus measures of sub-lethal impairment are favored. Biomonitoring has been defined as the use of organisms in situ to identify and quantify toxicants in an environment (Chaphekar, 1991). This procedure takes advantage of the capacity of living organisms to uptake and accumulate contaminants in their tissues through bioconcentration (uptake from the ambient environment) and biomagnification (uptake through the food chain) (see Gobas et al., 1991). In contrast to chemical analyses of abiotic samples that simply reflect the concentration of contaminants present in an area, the ability of biota to accumulate contaminants over time enables them to indicate the total pollutant loadings present in an environment (Lovett-Doust et al., 1994a,b).

The sampling of endemic organisms from naturally-occurring populations, and the subsequent chemical analysis of their tissues is referred to as passive biomonitoring (Chaphekar, 1991). Passive biomonitoring is perhaps the most frequently-utilized approach to biomonitoring and, if designed appropriately, such surveys of naturally-occurring organisms can yield valuable insights regarding the spatial distribution of the bioavailability of pollutants (Kauss and Hamdy, 1985). In contrast, active biomonitoring refers to the intentional introduction of well-defined organisms into field sites for a known period of time (Koutsandreas, 1980). Active biomonitoring may be especially useful in aquatic ecosystems (Lovett-Doust et al., 1993, 1994a).

1.2. Aquatic Plants As Biomonitor

Although they have been largely overlooked as biomonitoring candidates (but see Wang et al., 1997), there are significant benefits to using aquatic plants as biomonitors of environmental quality in aquatic ecosystems and several reasons why they are actually more appropriate than animals (Lovett-Doust et al., 1993, 1994a,b; Biernacki and Lovett-Doust, 1997; Powell, 1997; Anderson et al., 1997; Lewis and Wang, 1997; Puri et al., 1997). Since plants exist at the base of most food chains they will experience effects of toxic compounds released into the water sooner than organisms at higher trophic levels. In this respect, plants may be able to act as an “early warning signal” of impending contaminant impacts on other trophic levels in aquatic environments (Lovett-Doust et al., 1994a). Thus, correlations between concentrations of contaminants and observable impacts on plants that can be determined in toxicity tests should facilitate the prompt and timely detection of pollutants in aquatic environments. As largely sessile organisms there is no need to cage rooted macrophytes, unlike most animal biomonitors. Another benefit of being stationary is that macrophytes will directly reflect their local surroundings, in contrast to many fish, which are more mobile, or top predators such as birds, whose