Perspective

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Current Scientific Understanding Concerning the Phytotoxic Effects

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Description

Phytotoxicity data for aquatic plants have served a relatively minor role in regulatory decisions concerning the environmental hazard of most potential contaminants. A variety of phytotoxicity tests have been conducted with freshwater green algae, duckweed, blue-green algae, diatoms and rooted macrophytes (whole plants and seeds). Several test methods have been standardized for microalgae which are used primarily with chemicals, effluents, contaminated sediment elutriates and hazardous waste leachates. Current scientific understanding concerning the phytotoxic effects of these contaminants is based mostly on results for a few green algae. The greatest limitation of these results is their uncertain environmental relevance due to the large interspecific variation in response of standard algal test species and the unrealistic experimental test conditions. Results of the few field validation toxicity tests conducted to resolve this uncertainty have been chemical-specific and unpredictable.

Wetland Protection

Aquatic vascular plants have been used less frequently than algae as test species. Duckweeds have been used more often than rooted submersed species but the uncertain nature of their sensitivities relative to animal and other plant species has limited their use. Regulatory interest in wetland protection, contaminated sediment evaluations and sediment quality criteria development will result in increased use of whole rooted plants and their seeds as test species. Overall, regardless of the test species, if phytotoxicity data are to be more available and effective in the hazard assessment process, additional information concerning species sensitivity and environmental relevance of the results will be needed. Aquatic vascular plants have been used less frequently than algae as test species. Duckweeds have been used more often than rooted submersed species but the uncertain nature of their sensitivities relative to animal and other plant species has limited their use. Regulatory interest in wetland protection, contaminated sediment evaluations and sediment quality criteria development will result in increased use of whole rooted plants and their seeds as test species. Overall, regardless of the test species, if phytotoxicity data are to be more available and effective in the hazard assessment process, additional information concerning species sensitivity and environmental relevance of the results will be needed.

Severe Phytotoxicity

The physiology of Zn phytotoxicity in leaves is complicated, resulting from Zn interference in chlorophyll biosynthesis, and other biochemical reactions. In acidic soils, Zn usually causes severe Fe-deficiency chlorosis in dicots. Crops such as lettuce, mustard, and beet are highly susceptible to excessive soil Zn. In strongly acidic soils, grasses are usually much more Zn tolerant than dicots. However, in neutral or alkaline soils, Poaceae species are more sensitive to soil Zn than are dicots, apparently due to the interference of Zn in phytosiderophore function. Zn and other strongly chelated metal ions are able to displace Fe from mugineic acid and cause severe phytotoxicity. The natural increased secretion of phytosiderophores at alkaline pH increases the dissolved Zn in the soil, increases convective and diffusive movement of Zn to the root, and causes relatively greater susceptibility to soil Zn in grasses than other species. Researchers are presently studying Zn and Cd metabolism in species such as Thlaspi in order to develop a Phyto-Remediation crop which can be used to “depollute” contaminated soils, allowing the shoot Zn to be recycled as an ore. Plants need to be included to develop a comprehensive toxicity profile for nanoparticles. Effects of five types of nanoparticles (multi-walled carbon nanotube, aluminum, alumina, zinc, and zinc oxide) on seed germination and root growth of six higher plant species (radish, rape, ryegrass, lettuce, corn, and cucumber) were investigated. Seed germination was not affected except for the inhibition of nanoscale zinc (nano-Zn) on ryegrass and zinc oxide (nano-ZnO) on corn at 2000 mg/L. Inhibition on root growth varied greatly among nanoparticles and plants. Suspensions of 2000 mg/L nano-Zn or nano-ZnO practically terminated root elongation of the tested plant species. Fifty percent inhibitory concentrations (IC50) of nano-Zn and nano-ZnO were estimated to be near 50 mg/L for radish, and about 20 mg/L for rape and ryegrass. The inhibition occurred during the seed incubation process rather than seed soaking stage. These results are significant in terms of use and disposal of engineered nanoparticles.