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Environmental hazards of aluminum to plants, invertebrates, fish, and wildlife.

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Abstract

Aluminum is extremely common throughout the world and is innocuous under circumneutral or alkaline conditions. However, in acidic environments, it can be a major limiting factor to many plants and aquatic organisms. The greatest concern for toxicity in North America occurs in areas that are affected by wet and dry acid deposition, such as eastern Canada and the northeastern U.S. Acid mine drainage, logging, and water treatment plant effluents containing alum can be other major sources of Al. In solution, the metal can combine with several different agents to affect toxicity. In general, Al hydroxides and monomeric Al are the most toxic forms. Dissolved organic carbons, F, PO(3)3- and SO(4)2- ameliorate toxicity by reducing bioavailability. Elevated metal levels in water and soil can cause serious problems for some plants. Algae tend to be both acid- and Al tolerant and, although some species may disappear with reduced pH, overall algae productivity and biomass are seldom affected if pH is above 3.0. Aluminum and acid toxicity tend to be additive to some algae when pH is less than 4.5. Because the metal binds with inorganic P, it may reduce P availability and reduce productivity. Forest die-backs in North America involving red spruce, Fraser fir, balsam fir, loblolly pine, slash pine, and sugar maples have been ascribed to Al toxicity, and extensive areas of European forests have died because of the combination of high soil Al and low pH. Extensive research on crops has produced Al-resistant cultivars and considerable knowledge about mechanisms of and defenses against toxicity. Very low Al levels may benefit some plants, although the metal is not recognized as an essential nutrient. Hyperaccumulator species of plants may concentrate Al to levels that are toxic to herbivores. Toxicity in aquatic invertebrates is also acid dependent. Taxa such as Ephemeroptera, Plecoptera, and Cladocera are sensitive and may perish when Al is less than 1 mg.L-1 whereas dipterans, molluscs, and isopods seem to be tolerant. In Al-sensitive species, elevated levels (approximately 500 micrograms.L-1) affect ion regulation and respiratory efficiency. Toxicity tends to be greatest near a species' threshold of pH sensitivity. At lower pHs, Al may have a slight ameliorative effect by interfering with H+ transport across membranes. Aquatic invertebrates can accumulate very high levels of Al, but most of this appears to be through adsorption rather than assimilation. Aluminum concentrations may be as high as 5000 mg.kg-1 in insects and greater than 17,000 mg.kg-1 in other invertebrates. (ABSTRACT TRUNCATED AT 400 WORDS)

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