Effects of reduced atmospheric deposition on soil solution chemistry and elemental contents of spruce needles in NE-Bavaria, Germany

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The decrease in anthropogenic deposition, namely SO42- and SO2, in European forest ecosystems during the last 20 years has raised questions concerning the recovery of forest ecosystems. The aim of this study was to evaluate if the long term data of element concentrations at the Fichtelgebirge (NE-Bavaria, Germany) monitoring site indicates a relationship between the nutrient content of needles and the state of soil solution acidity. The soil at the site is very acidic and has relatively small pools of exchangeable Ca and Mg. The trees show medium to severe nutrient deficiency symptoms such as needle loss and needle yellowing. The Ca and Mg concentrations in throughfall decreased significantly during the last 12 years parallel to the significant decline in the throughfall of H+ and SO42- concentrations. Soil solution concentrations of SO42-, Ca and Mg generally decreased while the pH value remained stable. Aluminum concentrations decreased slightly, but only at a depth of 90 cm. Simultaneously a decrease in the molar Ca/Al and Mg/Al ratios in the soil solution was observed. Ca and Mg contents in the spruce needles decreased, emphasizing the relevance of soil solution changes for tree nutrition. The reasons for the delay in ecosystem recovery are due to a combination of the following two factors: (1) the continued high concentrations of NO3- and SO42- in the soil solution leading to high Al concentrations and low pH values and, (2) the decreased rates of Ca and Mg deposition cause a correlated decrease in the concentration of Ca and Mg in the soil solution, since little Ca and Mg is present in the soil's exchangeable cation poets. It is our conclusion that detrimental soil conditions with respect to Mg and Ca nutrition as well as to Al stress are not easily reversed by the decreasing deposition of H+ and SO42-. Thus, forest management is still confronted with the necessity of frequent liming to counteract the nutrient depletion in soils and subsequent nutrient deficiencies in trees.

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