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Aluminum in Soil Solutions of Forest Soils: Influence of Water Flow and Soil Aluminum Pools

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ABSTRACT

The Al^{3+} saturation of soil solutions of acid forest soils (defined as pAl^{3+}-3pH) is highly variable with time and soil depth under field conditions. We hypothesized that the release of Al from soil solids into the soil solution is kinetically restricted. This hypothesis was tested by evaluating soil solution data from a field site and in an experiment with large undisturbed soil columns from two acid forest soils. Soil columns of 40-cm diameter and 90-cm height were established in six replicates at 10°C and irrigated in a steady-state flow with an artificial acid throughfall (pH 3.5 and 2.8) at rates of 1, 4, and 12 mm d^{-1}. Soil solutions from the columns as well as in the field were taken by suction lysimeters from various depths and the Al^{3+} saturation of the soil solutions was related to the extractable soil Al pools and water flow rates. Under field conditions, undersaturation was related to high water flow rates through the soil profile at both the 20- and 90-cm depths. This was attributed to preferential flow in the soil profile. In contrast with the field results, Al^{3+} saturation of soil solutions from the column experiments was not affected by flow rate despite a large variation in flow rate, acid input, and ionic background. In the column study, the Al^{3+} saturation differed between soils, soil horizons, and replicates; increased with soil depth; and was undersaturated with respect to gibbsite in the upper soil profile. The Al^{3+} saturation of soil solutions was spatially highly variable both in the field and in the column experiment corresponding to the heterogeneity of soil extractable Al pools. The relation of soil extractable Al to the Al^{3+} saturation was different for the two soils. The modeling of soil solution Al and pH under equilibrium assumptions and without kinetic constraints is rather uncertain when short-term variations and different soil horizons are considered.

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