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Experimental studies of aluminum mobility in organic rich riparian soil and stream water in Sweden

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The role of organic acids in mobilizing and controlling aluminum (Al) from a riparian soil profile into a small humic-rich stream draining a forested catchment area was studied in Northern Sweden. Three in-situ soil and stream water manipulation experiments were performed by changing total concentrations of Al and silica while keeping pH constant between 4.8 and 5.6 to decipher the processes regulating stream Al solubility and export. Removal of added silica could not be observed along the 80 m stream reach during the stream manipulation despite a saturation index for Proto-Imogolite higher than 2.5. Removal of dissolved Al and DOC in the stream and the superficial soil solutions of the unsaturated zone occurred at molar Al/DOC ratios above 0.13±0.01. For the lower soil horizons that are in permanent contact with groundwater (45-65 cm) and supply the stream with water during the largest part of the year a ratio above 0.073±0.01 was sufficient to induce Al removal. In all experiments (lab and field) an apparent ion activity product (IAP) for $Al(OH)_3$ of 10.5±0.5 was necessary to induce Al removal. This IAP is rarely reached in the soil solutions or the adjacent stream despite large temporal fluctuations of both TOC and pH during the last 10 years. Al/TOC ratios in both environments are independent of pH and have a constant Al/TOC ratio with minimal variation; 0.013±0.002 (n=61) for the stream and 0.037±0.010 (n=135) for the riparian soil waters within the catchment. The similarities in the riparian soil depth profiles for BaCl2 exchangeable Al and TOC concentrations indicate that the soil organic exchanger complex may explain the small variability of the Al/TOC ratio in the soil. The loss of Al from the soil water during the transport through the riparian zone into the stream might be controlled by organic matter and not an inorganic Al bearing phase. However, to decipher the exact mechanism for the fixation of more than 70% of the soil solution Al in the riparian zone further studies on the exchange of Al with the soil complex are necessary.

Analyses of long time series of streams and rivers of different size (2-40000 km2) all within the boreal zone show average ratios of Al/TOC between 0.002-0.016 (n=20). Many of these ratios are quite constant over many years. This range is within that reported by other authors and may indicate that such specific ratios contribute to control aluminum release in boreal landscapes.