Solute geochemical mass balance and forest biomass in small Appalachian Blue Ridge watersheds

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Weathering rates of rock-forming silicate minerals in natural forested catchments of the US Department of Agriculture - Forest Service Coweeta Hydrologic Laboratory (North Carolina, USA) are calculated using a system of geochemical mass-balance equations to calculate mineral weathering rates from solute fluxes. The equations are constructed and constrained by petrologic, mineralogic, hydrologic, botanical, and aqueous geochemical data. The number of mineral-weathering rates that can be determined is limited by the number of elements for which solute mass-balance equations can be written. Where simplifying assumptions can reduce the number of mineral reactions that need to be considered to a number less than the number of mass-balance equations, the rate of element transfer into or out of biomass can be solved as one of the unknowns. Uptake of major cations by aggrading forest vegetation can act as an intracatchment sink for at least some mineral-derived elements, producing mineral weathering rates higher than would be estimated from solute fluxes alone.

Biomass has the least influence on weathering rates of minerals whose rate is determined by the mass balance for botanically unimportant elements (e.g., sodic plagioclase). The largest biotic effects on weathering rates are for minerals that supply important nutrients to the forest biomass (e.g., biotite mica). Six of seven Coweeta control watersheds aggraded deciduous forest biomass during the solute-flux period-of-record. In the best-constrained, the annual increment of biomass uptake of Ca and Mg equalled the rate of atmospheric deposition of these nutrients. Forest demand for K exceeded atmospheric inputs and required uptake of K released by mineral weathering. The seventh Coweeta control watershed lost biomass and nutrients due to natural infestation by defoliating organisms and consequent decay of defoliation products, which acted as a non-mineral source of alkalis and alkaline earths to streams. The magnitude of the biotic effect on silicate weathering rates in Coweeta control watersheds depends on the history of natural disturbance of the forest ecosystem in each individual control watershed, and the botanical significance of specific elements in the mass-balance equations from which weathering rates of specific minerals are calculated.

Solute behavior in agricultural vs forested watersheds during storm events: Implications for DOC sources

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Background

Two paired watersheds were monitored during storm events to use perturbations in solute concentrations to help understand the source of dissolved organic carbon (DOC) to the stream system. To test the effect of land use, one watershed is forested and the other is under cultivation, primarily for corn. The two Southeast Pennsylvania watersheds have similar characteristics of slope, aspect, and bedrock geology.

Results and Discussion

Streamwater chemistry evolves in the agricultural watershed following hysteresis loops according to the contributions of endmember water sources, most likely defined as throughfall, shallow soil water, and groundwater. During the rising limb of the hydrograph, the sequence of solute concentration maxima is (from earliest to latest arrival): potassium, turbidity, DOC, iron and manganese. At the peak of the hydrograph, minima of sodium, silica and conductivity are observed. On the falling limb, potassium and turbidity return to pre-event conditions followed by sodium, and silica. After the event, DOC remains lower than pre-event concentrations for at least several days. Potassium, turbidity, DOC, iron, and manganese all follow clockwise hysteresis loops, while conductivity, sodium, silica, and calcium follow counterclockwise loops. The forested watershed stream pattern is similar, though solutes follow more similar pathways on the rising and falling limbs of the hydrograph, creating narrower hysteresis loops. The forested watershed also takes longer to return to pre-event chemical conditions.