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Acceleration of chemical weathering related to intensive agriculture: evidence from groundwater dating

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Agricultural pollution is a matter of political and scientific concern throughout the world. Intensive agriculture can cause nutrient contamination of groundwater and surface water. Nutrient pollution causes eutrophication in freshwater and estuarine ecosystems. A secondary effect of agricultural intensification is river acidification. Oxidation of chemical fertilizers such as ammonium (NH4+) to nitrate (NO_3-) produces H+ ions that cause leaching of cations from soil and deeper material to maintain charge balance. Monitoring of various rivers in Brittany (western France) revealed that agriculture intensification has led to increased cation export starting in the 1980s. From the cation ratios, we deduced that cation increase comes approximately equally from dissolution of carbonate added to soil (liming practices) and silicate dissolution. Cation export represented about 30% of the soil cation exchange potential. If compensated by liming, it may constitute a non-negligible source to atmospheric CO_2 (Aquilina et al., 2012).

We further investigated the potential for silicate dissolution through the use of groundwater dating in various sites of Brittany. Coupling chemical analyses to groundwater ages in a large range of aquifers and a large range of depths (down to 110m) allowed us to reconstruct a chronicle for the last 50 yrs of the cation concentrations of groundwater. It clearly shows a contemporaneous increase in sodium and nitrate and a decrease in calcium, with the most dramatic changes occurring during the 70s and 80s.

Using groundwater dating, we were also able to determine a silica production geochronometer. A tight and linear relationship between silica concentration and groundwater age (Figure) was observed and allowed a production rate in groundwater to be determined. Except for short residence-times (Kerrien), the silica production rate for different granitic catchments was consistent, ranging from 0.3 to 0.4 mg.L-1.yr-1.

To assess the role of anthropogenic activity in silica production rate, we compared production rates from Brittany with catchments in the Vosges Mountains, a relatively pristine area. Dissolution rates were much higher in the Brittany catchments, indicating the effect of human activities on chemical weathering and cation export at the catchment scale.

Aquilina L. et al., 2012 - Long-term effects of high nitrogen loads on cation and carbon riverine export in agricultural catchments. Env. Sci & Technology 46-17, 9447-9455..