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The silica dynamics of deforestation: new evidence for a biologically controlled Si cycle

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Amorphous, biogenic Si (ASi) is stored in large amounts in terrestrial ecosystems. The study of this terrestrial ASi pool and its influence on watershed scale silica fluxes, remains in an absolute pioneer research stage. These Si budget studies have not included the biogenic amorphous Si stock and related fluxes. This hampers our ability to accurately quantify terrestrial cycling of Si, which is –through ocean carbon burial and CO2 uptake during terrestrial Si weathering- intricately linked to global carbon budgets.

We have studied detailed year-round concentration and flux patterns of dissolved (DSi) and amorphous Si in 60 small watersheds in the Scheldt river basin. Results show that transport of Si through the catchments is controlled by a complex set of terrestrial and aquatic processes, with land use and prominence of ecosystem types an important controlling factor.

Based on high frequency discharge measurements and concurrent analysis of ASi and DSi concentrations during intense precipitation events, we were able to attribute a percentage of yearly ASi and DSi fluxes to both base flow and precipitation event related surface run-off. Our results show ASi and DSi concentrations in upstream river basins are intricately linked to each other and to discharge, and ASi transport constitutes an important part of the total transport of Si. The ASi mainly originates from agricultural cropland soils.

We have also developed a new concept accounting for changes in silica fluxes after deforestation on different time-scales. Our concept is supported by previously collected datasets, and our new comprehensive dataset in the Scheldt River basin. The combined results indicate that immediately after deforestation, silica fluxes increase as a result of a recycling pulse of DSi from forest soil ASi, as well as increased ASi efflux. When the soil ASi pool is depleted, a new equilibrium is reached, where DSi fluxes are low compared to the pristine forest equilibrium phase. The timeframes associated with all these stages are currently unknown. Our results emphasize the potential interference between changes in vegetation, either natural or though human intervention, and the silica-carbon pump in the ocean. Reduced Si fluxes as a result of deforestation could eventually lead to reduced carbon burial in the ocean.

We can safely say that research on the silica cycle is currently on the verge of a new research era. The biological Si buffer is currently not incorporated in biogeochemical models. There are still major gaps in our fundamental understanding, and the integration of processes at different spatial and temporal scales is lacking. Addressing these knowledge gaps is essential and urgent. Their incorporation in future biogeochemical models might alter fundamental knowledge of the global silica cycle and all associated biogeochemical cycles. Our results show that land use is important to consider in models of continental silica fluxes, in addition to the traditionally studied effects of precipitation and bedrock lithology.