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Bioavailability of Si in natural and perturbed soils

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Silicon is a major element in the dissolved and solid fractions of the critical zone. Dissolved Si in the soil solution originates from chemical weathering. It is only during the 3 last decades that the role of the terrestrial vegetation has been evidenced in the biogeochemical cycle of silica through the uptake, storage and recycling of Si. In order to improve the models of Si transfers at a global scale, we need to better evidence the fundamental mechanisms that drive the biogeochemical behavior of Si.

In plants, silica is mostly present in the shoots where it accumulates as amorphous silica particles called phytoliths. The silicon concentration in plants depends primarily on the concentration of silicic acid in the soil solution and is not correlated to the total Si concentration of the soil. However, correlations were observed between the Si concentration in rice and the percentage of clay in soils and between the Si concentration in rice or banana and the stock of weatherable minerals. The weatherability of silicate minerals depends on environmental factors such as temperature and pH as well as the physico-chemical characteristics of the minerals, which can be evaluated by thermodynamical and kinetical data.

Laboratory experiments have shown that the dissolution of phytoliths is minimum at pH=3 and increases with pH. Their dissolution is one order of magnitude faster than that of primary clays or silicates especially in the pH range of most soil types indicating that plant Si biocycling may be the most important source of available Si to plants. Pot experiments confirmed this finding where durum wheat was grown in pots containing various proportions of quartz, vermiculite and amorphous silica. The highest concentration of Si is observed in the shoots of plants grown in pots containing the highest proportion of amorphous silica particles.

In natural ecosystems most of Si taken up by plants returns to the soil as phytoliths through litterfall. The distribution of phytoliths along the soil profile is similar to that of carbon and shows a rapid decrease with depth. In order to test the hypothesis that the stock of phytoliths, and more generally plant-available Si, is decreasing in cultivated soils, analysis of amorphous silica contents is required on contrasting agrosystems, i.e. with low and high Si exports where biomass outputs have been quantified on the long term. Our analysis of the phytolith concentration in several European cultivated soils support the hypothesis that intensive cultivation of Si-accumulated crops leads to a decrease in bioavailable Si.

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