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Experimental quantification of silicon pools and fluxes in a controlled soil-solution plant device

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The continental cycle of silicon (Si) chiefly relies on the Si soil-to-plant cycle where the primary source of Si is the reserve of weatherable lithogenic silicates (LSi). LSi weathering releases dissolved Si (DSi) that may take four routes: (i) leaching and export to watersheds; (ii) synthesis of pedogenic silicates (PSi) through the formation of clay minerals and/or amorphous silica; (iii) adsorption on Fe and Al oxides; (iv) uptake by plant roots. We define the mineral Si feedback loop within the soil-to-plant cycle as encompassing the first three processes. On the other hand, the biological Si feedback loop of the Si soil-to-plant cycle involves the plant uptake of DSi, formation of phytolith in plant tissues, return of phytolith to soil and further dissolution refilling the pool of plant available Si.
Literature data suggest an interpretative model supporting that the mineral Si feedback loop is largely dominant in soils at early stage of weathering whereas the biological Si feedback loop takes over with increasing weathering stage. At ultimate desilication stage, the soil-to-plant cycle of Si would entirely rely on that biological Si feedback loop.
We set up an experiment upgrading the reserve of weatherable minerals starting from a bleached E horizon of a podzol exhausted in plant nutrients and plant available silica. We followed the different pools of Si in a soil:solution:plant device using two rice cropping periods of 12 weeks each.
Our results show that the mineral and biological Si feedback loops were mutually competitive. The weatherable minerals rapidly dissolved and released Si and Al that recombined to form allophanic substances of imogolite type. The amounts of these inorganic amorphous silicates were similar in the presence or absence of rice plants. Rice cropping, however, promoted mineral weathering and produced phytoliths the amount of which increased with increasing supply of weatherable minerals.
Our data indicate that the increase in weatherable minerals supply increases the relative amount of allophanic substances whereas it decreases the relative amount of phytoliths produced by rice plants during the experiment. Our data thus support the interpretative model described here above.