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Release of organic carbon, silica, major and trace elements from degrading plant litter under microbial activity in laboratory experiments

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Quantification of major and trace elements recycling by plants is hampered by the lack of physico-chemical data on chemical elements release from degrading plant litter in soil and model laboratory environments. In this study, we applied a laboratory experimental approach for determining the organic carbon and approx. 30 chemical elements release rates from litter of typical temperate and boreal plants: larch (Larix gmelinii), elm (Ulmus laevis Pall.), tree fern (Dicksonia squarrosa), in 0.01 M NaCl solutions, circumneutral pH and temperature equals to 25°C.

Methods

Open system, mixed-flow reactors equipped with dialysis compartment (1 KDa, or approximately 1 nm pore size) and batch reactors were used. Comparative measurements were performed under sterile and non-sterile conditions with evaluation of the number of active heterotrophic bacteria via counting the number of colony-forming units (CFU) on the agar plates.

Element release rates from plant litter

![Element release rates from plant litter](image)

Litter degradation in batch experiments under microbial activity

![Litter degradation in batch experiments under microbial activity](image)

There is five time more of dissolved organic carbon for litter degradation experiments of larch compared to fern. There is a 30-40% decrease of DOC concentration in the course of biotic experiments but gradual increase after 1st day of exposure in sterile runs. This strongly implies the consumption of DOC by bacteria.

Conclusions

Litter degradation results suggest that many chemical elements release rate is independent on dissolved organic carbon release (cellulose hydrolysis). In the open-system mixed flow experiments, most elements are released at the very first stage of litter dissolution. In the closed-system (batch) experiments over 1 month observation time, the sterile biomass of larch needles liberates similar amount of organic carbon and trace metals (Al, Ti, Fe, Mn, Cu, Sr, Y, Zr, Mo, Pb) as in biotic experiment with the presence of soil bacteria. At the same time, Si release rate in sterile condition (0.74 mol/d) is an order of magnitude lower than in the presence of bacteria (6.2 mol/d). The abiotic release rate of Ti in experiments with dialysis compartment (< 1 nm) is at least an order of magnitude lower than that in conventional batch experiments (< 0.22 µm) for many trace elements (Al, Fe, Cu, Ni, Zn, Pb…). The abiotic release rate of Ca is at least an order of magnitude lower than that in conventional batch experiments (< 0.22 µm) for many trace elements (Al, Fe, Cu, Ni, Zn, Pb…).