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Halogen (F, Cl, Br, I) contents in silt and clay fractions of a Cambisol from a temperate forest

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Abstract

In spite of considerable efforts to understand the role of halogens (F, Cl, Br, I) in soil, concentration data for different soil size fractions is still sparse and information on the sorption behavior of halogens in natural soils is limited. We determined total halogen concentrations in different soil horizons and particle size fractions (i.e., coarse silt with 20–63 μm, medium and fine silt with 2–20 μm, coarse clay with 0.2 to <2 μm and medium clay with 0.02–0.2 μm) of a Cambisol from a temperate forest ecosystem in SW Germany. Furthermore, we estimated the minimum proportions of sorbed halogens onto clay minerals and pedogenic oxides for different soil horizons and different particle size fractions.

Vertical depth profiles of halogens in the individual soil particle size fractions matched with the bulk soil vertical patterns. The lack of vertical differences of total halogens concentrations (F_{tot}, Br_{tot}, and I_{tot}) in the mineral soil during soil development may be due to steady state or equilibrium conditions between weathering, sorption processes, and surface input. In contrast, the vertical depth pattern of Cl_{tot} tended to decrease, suggesting the process of Cl accumulation in the topsoil and nutrient uplift. While F was likely mainly incorporated into the crystal lattice of clay minerals and gibbsite occupying OH-sites, significant amounts of the halogens with larger ionic radii (Cl, Br, and I) were sorbed. The largest amounts (around 90% Cl and 70% Br and I, respectively) were sorbed on the smallest particle size fraction investigated (medium clay fraction; 0.02–0.2 μm), although this fraction only contributed about 1 wt% to the bulk soil. This is probably related to the highest sorption capacity of small particles due to their large surface area.

Our study provides new data on sorption behavior of the various halogens in soils of forest ecosystems, which is different between F and the heavier halogens (Cl, Br, I) and further depends on soil particle sizes. The understanding of the chemical behavior of halogens in soils has implications for the retention processes of pollutants in landfills or radioactive waste disposal.

Keywords: Sorption processes, particle size fractions, Cambisol, fluorine, chlorine, bromine, iodine