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Revealing the soil properties that affect selenium ageing in soils using a stable isotope tracer

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The radioactive ^{79}Se isotope is a fission product of ^{238}U with a long half-life; if such an isotope ends up in groundwater, it may be transferred rather efficiently into our food chain if this groundwater is used for irrigation. To evaluate this risks, a profound understanding of the fate of Se in soils is required. The objective of our study was, therefore, to evaluate the fate of selenate (Se(VI)) added to soil and to relate the rate and extent of its immobilisation (ageing) to soil properties. The hypothesis is that Se can be immobilised by incorporation in the microbial biomass and by pH dependent adsorption to oxyhydroxides.

Ageing of Se was studied in 14 contrasting soils after a fresh stable isotope $^{77}Se(VI)$ spike. Subsamples were collected at various time intervals throughout six months of incubation, and extracted with either $CaCl_2$ or NaOH to monitor the native Se and tracer ^{77}Se concentrations in solution or associated with soil organic matter, respectively. After 182 days, the concentration of the ^{77}Se spike in the $CaCl_2$ extract had decreased by 40% to >99% compared to that at day 0. This decrease in availability with time was described by a two-pool system, which allowed to derive a rate and extent of Se ageing. The resulting half-lives of added ^{77}Se in the soluble pool ranged between 1 and an infinite number of days, with a median of 29 days. Distinct but gradual Se ageing was mainly promoted by high pH, whereas Se immobilisation in low pH soils was less pronounced but more rapid. Earlier speculations of Se fixation by $CaCO_3$ at high pH were discouraged by significant ageing in non-calcareous soils, and only marginal immobilisation in tests with $CaCO_3$ amended sand. Amendment of five soils with a readily available carbon source enhanced microbial activity, thereby increasing the rate and extent of Se ageing. However, across all soils, ageing parameters were not significantly correlated with soil respiration rates. Our study showed that soil pH significantly affects the time-dependent solid:liquid distribution of Se in soils, which should be considered in risk assessments of $^{(79)}Se$ in agriculture.