Potassium isotope fractionation during plant uptake in Hawaii

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Potassium (K) is an essential nutrient but biogeochemical research lacks effective tracers of its sources and fates in terrestrial ecosystems. Stable K isotopes emerge as a potential tracer to decipher the cycles of K in soil-plant systems and to illustrate the processes controlling its biogeochemical fate. Here we focus on the isotopic signals and speciation of K in a whole soil-plant system by investigating two soil profiles developed in contrasting climates on the Island of Hawaii. Soils in the arid site (~300 mm annual rainfall) supports primarily introduced pasture grasses with occasional introduced mesquite trees, and the humid site (~1700 mm annual rainfall) supports introduced pasture grasses and macadamia nut trees. A combination of high-precision K isotope analysis, synchrotron K X-ray adsorption spectroscopy and chemical extraction has been utilized to understand the K isotopic fractionation mediated by biological reactions. The K abundance and isotopic composition have been measured for bulk soils, CaCl2-extractions, and plant parts including roots, stems/branches, shoots (stems + leaves), seeds, flowers and leaves (both living and dead) of woody and herbaceous plants. The results reveal that: (i) δ41K in vegetative materials ranges from -1.06 to +1.15‰ dependent on plant types and climate; (ii) potential K phases as ionic K+ and organic-K associations of variable proportions in plants. Compared to the bioavailable pool of K in soil, we find the direction of K isotope fractionation in plant tissues depends on K translocation pathways. Specifically, stems, barks and dying leaves are normally enriched in isotopically lighter K compared to roots and living leaves. This is potentially caused by: (i) high-/low-affinity uptake of K at the root-soil interface and (ii) chromatographic processes during intra-plant circulation. In sum, our results indicate that biological cycling of K leads to significant K isotope fractionation that should be considered in its global budgets.