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Transfers of rare-earth elements from two types of soils to two species of plants

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Presently, much information is available about the transfer of major elements from soils to plants, but much less is known about the behavior of rare-earth elements (REEs) in the same conditions. The results reported in the literature about the mobility of these elements to plants consider divergent and even opposite hypotheses and interpretations to explain the REE fractionation induced by the transfer. Understanding of the mobility of these elements in plants can be of importance, because they may provide complementary information on plant-soil interactions. This investigation deals with the fractionation of REEs in two types of plants (radish and spinach) grown on two types of clay-rich soils (illite and smectite) under a controlled laboratory condition at room temperature. The experiment on radish consisted in determining the REE concentrations of two parts (the stems+roots and the leaves), while that on spinach consisted in studying the entire plant 4 times over a 3-month period of growth. On the illitic soil, radish yields a slight difference in the REEs contents of the stems+roots and the leaves. The former concentrate about 1.90 mg. kg-1 (of the dry plant material for all values) and the latter about 1.65 mg. kg-1. On the smectitic soil, the REE concentrations are slightly lower at 1.41 mg. kg-1 for the stems+roots, and at 1.59 mg. kg-1 for the leaves. In the case of the experiment on spinach, the total REE contents decrease from 2 mg/g measured 13 days after seeding, to 0.47 mg/g one month after seeding, to 2.5 mg/g two months after seeding and finally to 4.7 mg/g three months after seeding. The REE distribution patterns of the different parts from radish grown on illitic soil were normalized to the REE content of the soil. They show that the leaves yield a pattern slightly enriched in the middle REEs. By comparison, the stems+roots from radish on the same illitic soil provide a significant enrichment in the heavy REEs,

which may be attributed to bacterial complexation in the soil. By contrast, the radish leaves and the stems+roots from smectitic soil have nearly flat REE distribution patterns for all REEs except Eu, relative to their concentrations in the soil. Similarly, the REE distribution patterns of spinash were similar at the different growth stages, except for Eu when normalized to the composition of REE in the soil. The only visible difference is again an Eu anomaly occurring at all stages of harvesting. The variation is especially significant three months after seeding, probably due to a preferential uptake of Eu^{2+} rather than Eu^{3+} by the plant, which did not fractionate the heavy and the light rare-earth elements. This study outlines that (1) the amount of REEs taken by plants and their fractionation action depend on the species of plants, (2) the amounts of REEs taken by the plants and their induced fractionation depend on the type of soil, and (3) the plants do not fractionate uniformly the REEs: differences in the mobility and fractionation of the REEs relate to different parts of the same plant.