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Fractionation of rare earth elements in plants: a study of radish plants grown in separate soils of calcium smectite and illite clay minerals under a laboratory condition

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Two different species of radish plants, Raphanus sativus and Raphanus raphanistrum, were grown in separate soils of illite and calcium smectite clay mineral compositions under a laboratory condition to determine the REE (rare earth element) concentrations of organs of the plants and the quality of their REE distributions normalized to the REE values of respective soil media which served as sources of the REE for the individual plants. The results indicated that the REE fractionation in these plants were highly species dependent and not particularly soil mineral composition dependent. No particular order existed for the REE concentration of leaves relative to the concentration of corresponding stems. The distribution patterns of REE of plant organs, which may be defined by trends in changes in the soil normalized REE concentration values along increasing atomic number of the elements for the plant organs, have both a broad aspect with a general measure of the relative difference between values of the soil-normalized heavy rare earth elements (HREE) and the light rare earth elements (LREE) and a specific aspect that reflects anomalous shifts of one or more lanthanide elements from the general distribution trend of the lanthanide elements. The broad aspect of the soil-normalized broad distribution patterns of the REE for the plant organs falls into one of two categories. One of these is characterized by enrichments in the HREE relative to LREE, and the other by a nearly flat pattern with no preference between the HREE and the LREE. The soil-normalized distribution patterns for leaves and stems may include anomalous concentrations for either one or more of the REEs. The anomalies include enrichments of Gd, Eu, Er, and Lu and depletion of Ce relative

to their neighbors. The leaves and the corresponding stems of individual plants often differed from each other in their REE distribution patterns. Although clay minerals in the soils are the primary sources of the REEs for these plants, the specific anomalous enrichments within the general REE distributions in these plants strongly reflect complexation effects with organic ligands and not with any inorganic ligands. This study suggests that dissolved organic compounds and very fine colloidal organic matter can have a major influence on the ultimate REE distribution characteristics of many river waters.