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Phytostabilization of actinide-contaminated soils (East Carpathians, Romania)

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Uranium deposits are known on all continents, and it's the unusual country that does not show signs of uranium in anomalous amounts. Natural radioactive metals leach off mine wastes and contaminate surrounding groundwater, soil and biota. Phytoremediation is a very promising technique for rehabilitation of the radioactive contaminated lands. Unfortunately, the main disadvantage of the phytoremediation techniques is the long time required for cleanup of metal contaminated soils. Phytostabilization is attractive to reduce bioavailability and offsite migration of contaminants. Unlike other phytoremediative techniques, the goal of phytostabilization is not to remove metal contaminants from a site, but rather to stabilize them and reduce the risk to human health and the environment. In the present paper, we give additional data for the U, Th and Sr transfer to vegetation grown within a uranium ore deposit. We also study the relationship between U and Th and the macronutrients Ca and P searching for analogies with essential elements for plants. The bioaccumulation of U, Th and Sr in the vegetation resulted in the removal of these metals from the soil and reduces the risk to the environment.

Conifers accumulate natural actinides to different extent. Uptake of U is greater than that Th. One reason for this is that the elements similar to nutrients (such as U and Sr being similar with Ca) follow the same path as the nutrients they are similar to.

The fir Abies alba and the spruce Picea excelsa were found to have a high uptake capacities of U. The highest concentration was achieved in Abies alba roots and twigs. We found that U concentration in plant tissues follow the order: roots » stems > twigs > needles. Apparently, U is absorbed through the roots system and limited translocation to other plant parts occurs; most U taken up by the conifers remained in the roots.

For the behavior of Th and Sr, we noticed that the first concentrate mainly in the roots, that is just like in the case of U. The levels of thorium concentration in conifers are usually low. We suggested that due to ability of solid phase of soil to absorb Th4+ ions, the bioavailability of Th in soils might be rather low. On the other hand, it is known that tetravalent thorium is able to form complexes with organic molecules that roots produce into the rhizosphere; these complexes seem to be more soluble and mobile than the ions themselves. Therefore, the Th-organic complexes may be easily absorbed by roots and translocated to other parts of conifers. Strontium has a different behavior. In conifers Sr is found to be more concentrated in needles and twigs than in roots and stems.

Since the plants do not need U, Th and Sr neither for their metabolism, nor for their structure, it follows that the assimilation of these elements is being done through passive processes (non-metabolic ones). The passive absorption implies the diffusion of uranyl ions and organically bound Th4+ from the soils in the endodermis of the roots, does to their imperfect selectivity and increased of permeability of cell membranes. However, there is more translocation of Sr than of U and Th within the plant.

We consider Abies alba and Picea excelsa behaviors very interesting because they can reach and accumulate U, Th and Sr over very long periods of time. Those plants are tolerant to the radionuclide contamination. It apparently blocked and/or "stored" efficiently the heavy metals particularly in root cells and diminishing the quantity of mobile natural heavy radionuclides. It could be used for the regreening of sites with moderate radioactive/heavy metal pollution. Consequently, planting conifers on U waste slopes may decrease the U, Th and Sr migration.