TRANSFORMATION OF CLAY MINERALS IN SOILS AND ITS EFFECT ON METAL ADSORPTION

NÉMETH, T. (Department of Mineralogy, Eötvös Loránd University; Pázmány stny 1/C, Budapest, Hungary; Institute for Geological and Geochemical Research, HAS RCAES, Budaörsi út 45, Budapest, Hungary), SIPOS, P., BALÁZS, R. (Institute for Geological and Geochemical Research, HAS RCAES, Budaörsi út 45, Budapest, Hungary), KÁTAY, Z. (Duna-Ipoly National Park, Pbox. 86, Budapest, Hungary)
nemethtibor.spanyol@gmail.com

In soils, clay minerals play an indispensable role in chemical and biological processes involving heavy metals by their significant cation adsorption and exchange capacity. The bioavaibility of these trace elements by plants decreases with the clay mineral content in brown forest soils, referring to the strong retention capacity of clay minerals to heavy metals (Sipos, 2003). It has been proved by many studies that among soil clay minerals smectites have the greatest adsorption affinity to metal ions. However, the possible transformation of clay minerals in pedogenic environment and its effect on their sorption properties is unadvisedly disregarded.

Cobalt and lead adsorption on clay minerals from brown forest soils (Luvisols) were studied. Clay mineralogy and clay mineral alteration pathways, as well as metal sorption were characterized by XRD and TEM-EDS.

Regarding their dominant clay mineral character, two kind of soil profile was studied: smectitic and vermiculitic. In the studied soil profiles typical clay mineral transformation processes may occur depending on the dominant swelling clay minerals: change of the layer charge of smectites, hydroxy-interlayering of vermiculite, chlorite vermiculitization, and iron oxidation and precipitation. Potassium fixation and illitization occur also, its effect was investigated in laboratory wetting and drying (WD) experiments on soil smectite with different interlayer cations.

The smectitic soil contains low layer charged ferruginous montmorillonite as dominant clay mineral. Alkyl amine exchange revealed the heterogeneous layer charge distribution of the montmorillonite which is very typical feature of soil smectites. The clay fraction of the soil adsorbed 12970 mg/kg cobalt at slightly acidic pH, which does not reach the sorption capacity of Na-montmorillonites from bentonite. However, significant differences of sorption capacity have been revealed by TEM-EDS between individual smectite particles. Cobalt sorption was found to increase as total layer charge of the smectite increased, or octahedral aluminium content decreased. Potassium content diminishes cobalt uptake due to K-fixation, whereas iron content promote it. Linear relationship between Fe and Co suggests the presence of fine iron oxide coating on smectite particles, which are excellent cobalt adsorbents. Hydroxy interlayering in the A and E horizons decreases the lead uptake of vermiculitic soil.

Experimental potassium fixation due to cyclic wetting and drying remarkably decreases the lead adsorption capacity of this smectite from 22800 to 14500 mg/kg. On the other hand, lead uptake does not change due to subsequent WD cycles when the interlayer cation Ca^{2+}.

Results suggest that clay mineral transformation processes have considerable effect on the heavy metal adsorption capacity of soils, and its consequences must be taken into account when fate of heavy metals in soils is studied.

NT is grateful to Bolyai János Postdoctoral Fellowship of the Hungarian Academy of Sciences for financial support. This study was in part financially supported by Hungarian Research Found (OTKA K105009) and the European Union and the State of Hungary, co-financed by the European Social Fund in the framework of TÁMOP 4.2.4. A/1-11-1-2012-0001 'National Excellence Program' (NT).

References

SIPOS, P. (2004): Acta Geologica Hungarica, 47: 411–429.