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Heat-treated serpentine-reached materials: application for sorption of heavy metals and remediation of industrially polluted peat soil

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Serpentine minerals are widely distributed in the Earth's crust, forming in some provinces with specific vegetation. Like clay minerals, serpentine minerals can be referred to as eco-friendly materials and can be used for the sorption of heavy metals in contaminated soil. The sorption of metals by serpentine minerals can occur by adsorption on the surface, entering into the mineral's structure, and the precipitation of low-soluble compounds in an alkaline environment. It is possible to intensify these processes by modifying serpentines, namely by heat treatment. Our study used two types of serpentine-reached materials from mining wastes: ortho-chrysotile from overburden rocks of Khalilovsky magnesite deposit (Cht) and lizardite from host rocks of Khabozersky olivine deposit (Lt) (Russia), thermally activated in a tube furnace at 650-750 °C.

The process of hydration occurs in the field conditions when serpentine interacts with soil solutions. Therefore, the process of nickel sorption by Cht and hydrated Cht was studied. Results indicated the formation of magnesium silicates during hydration. These chemical compounds were found to be more stable than components of initial Cht (test for leaching in 1N ammonium acetate solution, pH 4.68). Hydration of Cht reduced the activity of nickel sorption processes in the initial period of interaction. However, the nickel sorption value of hydrated Cht eventually was similar to the initial Cht when reactive phases' contact increased up to 30 days.

In the field experiment, the topsoil (0-5 cm) of industrially polluted peat near the active Cu/Ni plant (Murmansk region, Russia) was mixed with Cht and Lt in 3:1 proportion. Initial polluted peat contained more than 500 mg/kg of exchangeable Ni and 6300 mg/kg of Cu. After eight years of the experiment in conditions of continuing aerial metal emissions, the concentration of exchangeable metal fractions in soil mixtures was lower than in peat soil by 3-5 times for Cu and by 1.3 times for Ni. Simultaneously, the concentration of immobile metal fractions (bound by organic matter, Fe/Mn (hydr)oxides, and included in other insoluble compounds) was 1.5 times higher than in peat soil. The lack of nutrients (mostly Mg and Ca) in the polluted soil causes vegetation degradation in the smelter's impact zone. Soil mixed with heat-treated serpentine minerals led to increased plant-available Mg compounds (by 11-42 times) and Ca (by 2.6-4.4 times). These findings indicate the fixation of metal pollutants by heat-treated serpentine minerals and soil enrichment in essential elements. The use of the heat-treated serpentine-reached materials is promising for the long-term

decrease of metal mobility and remediation of industrially polluted soils.

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