The effect of different level and type of pollution on the heavy metals accumulation and distribution in soil-plant system

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Chemical pollution of the environment is one of the most serious problems for mankind in the modern time. The main sources of pollutants entering the environment are atmospheric emissions of industrial enterprises, ore dumps and wastes released by the chemical industry. However, regardless of the source of the pollutants, the main function in reducing environmental risk is performed by the soil. With the increasing anthropogenic load on natural landscapes and agricultural lands, reliable data on the toxicity of heavy metals (HM) as well as the mechanisms of their entry into the plants are needed to carry out environmental monitoring and quality control of grown products.

The accumulation and transformation of Ni, Mn, Zn, Cu, Cr, Cd, and Pb in soils of steppe zone of southern Russia were studied under different sources of pollution: aerotechnogenic emissions by Novocherkassk power station and industrial effluents of the chemical plant near Kamensk-Shakhtinskii city. The author’s method for determining the HM compounds composition in the soil (Minkina et al., 2008) was used to assess the ecological situation of the impacted territory. It was found that the total content of HM in the soils of the impacted territories exceeded Clarke value, especially for Zn (up to 796 times).

The patterns of accumulation and distribution of Ni, Mn, Zn, Cu, Cr, Cd, and Pb were determined for the most common species of wild-growing and agricultural herbaceous plants of the Poaceae (Triticum aestivum, Hordeum sativum, Poa pratensis L.), and Asteraceae (Ambrosia artemisiifolia, Achillea nobilis, Tanacetum vulgare) that grew in the impacted territory. Agricultural and wild herbaceous plants growing 1.5–2.2 km from the power station are polluted with Pb, Zn, Ni and Cd.

It was shown that even in conditions of extreme soil pollution by industrial effluents, the root system of the plants successfully performed its protective function: the HM content in roots significantly exceeded it in above-ground part. At the same time, the pollutants concentration ratio in the above-ground part and in the roots was higher under aerotechnogenic pollution due to the additional receipt of the HM through the surface of the leaves. The dependence between HM accumulation and distribution in plants and the content of mobile metal compounds in the soil was established (correlation coefficient=0.79).
The extreme HM contamination effect on the anatomical and morphological characteristics and ultrastructure of the cultivated and wild plants was studied by transmission electron microscopy. The differences in adaptation of the plants to the effects of a stressful environmental factor were manifested not only in the external structure but also at the anatomical and intracellular levels of organization. In the samples contaminated with HM, parenchyma cell vacuoles contained electron-dense inclusions grouped in the center of the vacuole which were probably the deposits of metal compounds. Cultivated herbaceous plants of Poaceae family were found to be more susceptible to anthropogenic pollution with HMs compared to the wild plants of the same family.

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