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# Accumulation and hyperaccumulation of copper in plants

V. Adam (1,2), L. Trnkova (1,3), D. Huska (2), P. Babula (4), R. Kizek (2,3)

(1) Masaryk University, Department of Chemistry, Brno, Czech Republic (kizek@sci.muni.cz), (2) Mendel University of Agriculture and Forestry, Department of Chemistry and Biochemistry, Brno, Czech Republic, (3) Masaryk University, RECETOX, Brno, Czech Republic , (4) University of Veterinary and Pharmaceutical Sciences, Department of Natural Drugs, Brno, Czech Republic

Copper is natural component of our environment. Flow of copper(II) ions in the environment depends on solubility of compounds containing this metal. Mobile ion coming from soil and rocks due to volcanic activity, rains and others are then distributed to water. Bio-availability of copper is substantially lower than its concentration in the aquatic environment. Copper present in the water reacts with other compounds and creates a complex, not available for organisms. The availability of copper varies depending on the environment, but moving around within the range from 5 to 25 % of total copper. Thus copper is stored in the sediments and the rest is transported to the seas and oceans. It is common knowledge that copper is essential element for most living organisms. For this reason this element is actively accumulated in the tissues.

The total quantity of copper in soil ranges from 2 to 250 mg / kg, the average concentration is 30 mg / kg. Certain activities related to agriculture (the use of fungicides), possibly with the metallurgical industry and mining, tend to increase the total quantity of copper in the soil. This amount of copper in the soil is a problem particularly for agricultural production of food. The lack of copper causes a decrease in revenue and reduction in quality of production. In Europe, shows the low level of copper in total 18 million hectares of farmland. To remedy this adverse situation is the increasing use of copper fertilizers in agricultural soils. It is known that copper compounds are used in plant protection against various illnesses and pests.

Mining of minerals is for the development of human society a key economic activity. An important site where the copper is mined in the Slovakia is nearby Smolníka. Due to long time mining in his area (more than 700 years) there are places with extremely high concentrations of various metals including copper. Besides copper, there are also detected iron, zinc and arsenic. Various plant species have adapted on such stress. The aim of this study is to investigate the behaviour of copper in plants and to assess its potential effect on the surrounding environment. To detect copper in biological samples electrochemical methods were employed particularly differential pulse voltammetry (DPV). Copper gave signals at 0.02 V measured by DPV. The obtained calibration dependence was linear (R2 = 0.995). Further, this method was utilized for determination of copper in real soil samples obtained from previously mentioned heavy-metal-polluted mining area. The content varied within range from tens to hundreds of mg of copper per kg of the soil. Moreover, we focused on investigation of copper influence on seedlings of Norway spruce. The seedlings were treated with copper (0, 0.1, 10 and 100 mM) for four weeks. We observed anatomical-morphological changes and other biochemical parameters in plants. We determined that seedlings synthesized more than 48 % protective thiols (glutathione and phytochelatins) compared to control ones. We investigated copper distribution in plant tissues by diphenylcarbazide staining. We found out that copper is highly accumulated in parenchymal stalk cells. In needles, change in auto-fluorescence of parenchymal cells of mesoderm similarly to endodermis cells. Besides, we analyzed samples of plants from the polluted area (spruce, pin, birch). The data obtained well correlated with previously mentioned.

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