Dr inż. **Monika Mierzwa-Hersztek**
[1]University of Agriculture in Krakow, Department of Agricultural and Environmental Chemistry, al. Mickiewicza 21, 31-120 Krakow, Poland,
email: monika6_mierzwa@wp.pl

Prof. dr hab. inż. **Krzysztof Gondek**
[1]University of Agriculture in Krakow, Department of Agricultural and Environmental Chemistry, al. Mickiewicza 21, 31-120 Krakow, Poland,

Dr inż. **Krzysztof Dziedzic**
[2]Department of Mechanical Engineering and Agrophysics, University of Agriculture in Krakow, Balicka 120, 30-149 Krakow, Poland

EFFECT OF LOW-TEMPERATURE CONVERSION OF WHEAT AND MISCANTHUS STRAW ON THE CONTENT OF CU, CD, PB AND ZN IN MOBILE FORMS AND IN ORGANIC MATTER-BOUND FORMS IN SANDY SOIL

Mobility and bioavailability of heavy metals, especially in sandy and acid soils are an important problem in terms of biological value that is obtained from these sites of biomass. Heavy metals are a heterogeneous group of elements that has different chemical properties and different impact on the biosphere. Due to their high toxicity and bioaccumulation capacity, these elements constitute a serious threat to living organisms, including to health and human life [Monachese et al. 2012]. Total or at least partial detoxification of heavy metal ions can be obtained by introducing biochar to soil [Beesley et al. 2010a, 2010b]. Thanks to specific properties and capacity for the exchange sorption of cations, this material more and more often finds application as a sorbent and reservoir of mineral substances [Ahmad et al. 2014]. Functional groups which are present on the surface of biochar “control” the content of mobile forms of heavy metals in soil by forming specific complexes [Han et al.

2013]. Mechanisms of forming chelate compounds with heavy metals as well as their stability in soil depend on numerous factors. What is primarily important is the quantity and type of biochar introduced to soil, soil reaction, and also type and content of an element in soil. The nature of organic-mineral compounds, degree of saturation with a metallic ion, complex adsorption on a mineral soil particle, and also biodegradation of the organic component of the complex will thus decide on the mobility of metallic ions in soil, including their uptake by plants and translocation in the soil profile. Research results obtained by Beesley et al. [2010a] and Beesley and Dickinson [2011] prove that efficiency of immobilization of heavy metal ions in soil after application of biochar is varied. When considering biochar as a substance that binds pollutants, research was conducted in which determined the effect of application of biochar produced from whest and miscanthus straw to soil on Cu, Cd, Pb and Zn content (in mobile forms and in organic matter-bound forms). The pot experiment was carried out in the greenhouse of the University of Agriculture on soil with a loamy sand texture collected from 0-20 cm layer. The experiment consisted of 6 treatments carried out in 3 replications: 0 – control soil (soil without additives), MF - soil with addition of chemically pure mineral salts, WSB - soil with addition of mineral salts (MF) and wheat straw biochar of 1% (WSB 1%) and 2% (WSB 2%), and MSB - soil with addition of mineral salts (MF) and miscanthus straw biochar of 1% (MSB 1%) and 2% (MSB 2%). The nutrients were introduced into the soil as mineral salts at the following doses: 0.10, 0.04 and 0.12 g kg-1 DM of soil, for N, P and K, respectively. After the application of biochars and mineral salts and mixing them with the soil, the seeds of perennial ryegrass were sown. During the experiment, the humidity of soils was maintained at a constant level of 45% of the WHC. Soil for chemical analyses was collected after the plant vegetation is over. Mobile forms of Cu, Cd, Pb and Zn were extracted from the soil with 1M NH_4NO_3 solution (soil : solution = 1 : 2.5) for 2 hours [Park et al. 2011]. Content of the studied metals in bonds with organic matter was determined using sequential chemical extraction developed by Zeien and Brümmer [1989] in which forms joined in bonds with organic matter were extracted with 0.025 M $C_{10}H_{22}N_4O_8$ solution, pH = 4.6 (soil :

solution = 1 : 25) for 90 minutes. The studied elements were determined in the obtained extracts by inductively coupled plasma optical emission spectrometry (ICP-OES, Perkin Elmer Optima 7300 DV). Application of organic materials caused considerable reduction of soil acidification. A larger addition of organic material to the soil caused greater increases in pH, determined both in the soil and water suspension and in the suspension of the soil and KCl solutionApplication of wheat and miscanthus straw biochar, depending on the quantity added, caused a decrease in mobility of copper, cadmium,lead, and zinc. Cu, Cd, Pb and Zn content extracted with 0.025 mol C10H22N4O8 was higher than the content of these elements determined after extraction with 1 M NH4NO3, mainly due to different extraction force of the used solutions. The obtained results indicate that, compared with the content determined in soil from the control treatment, the 2% amendment of organic materials to the soil had a greater effect on the content of Cu, Pb and Zn in the organic fraction than the 1% amendment. The applied organic materials did not affect content of cadmium in the fraction bound to organic matter of the soil.

References

1. Monachese, M., Burton, J.P., Reid, G. (2012). Bioremediation and tolerance of humus to heavy metals through microbial processes: a potential role for probiotics. App. Environ. Microbiol., 78, 18, 6397-6404.

2. Ahmad, M., Rajapaksha, A.U., Lim, J.E., Zhang, M., Bolan, D.M., Vithanage, M., Lee, S.S., Ok., S.Y. (2014). Biochar as a sorbent for contaminant management in soil and water: A review. Chemosphere, 99, 19–33.

3. Beesley, L., Moreno-Jiménez, E., Gomez-Eyles, J.L. (2010b). Effects of biochar and greenwaste compost amendments on mobility, bioavailability and toxicity of inorganic and organic contaminants in a multi-element polluted soil. Environ Pollut., 158, 2282–2287.

4. Beesley, L., Moreno-Jimenez, E., Clemente, R., Lepp, N., Dickinson, N. (2010a). Mobility of arsenic, cadmium and zinc in a multi-element contaminated soil profile

assessed by in-situ soil pore water sampling, column leaching and sequential extraction. Environ Pollut, 158:155–160.

5. Han, Y, Boateng, A.A., Qi, P.X., Lima, I.M., Chang, J. (2013) Heavy metal and phenol adsorptive properties of biochars from pyrolyzed swithgrass and woody biomass in correlation with surface properties. J Environ Manage 118:196 – 204.

6. Beesley, L., Dickinson, N. (2011). Carbon and trace element fluxes in the pore water of an urban soil following green waste compost, woody and biochar amendments, inoculated with the earthworm Lumbricus terrestris. Soil Biol Biochem, 43:188–196.

7. Park, J.H., Choppala, G.K., Bolan, N.S., Chung, J.W., Chusavathi, T. (2011). Biochar reduces the bioavailability and phytotoxicity of heavy metals. Plant Soil 348,439–451.

8. Zenie, H., Brümmer, G.W. (1989). Chemische extraction zur bestimung vin schwermetallbindungsformen in böden. Mitteilg. Dtsch. Bodenkundl. Gesellsch. 59, 505-510.

ACKNOWLEDGMENTS

Research carried out under the project named "Research on forming a model of biochar changes in soil based on quantitative and qualitative parameters of humus"financed by the National Science Centre (project no.: 2015/17/N/NZ9/01132).