EFFECTS OF SELENIUM ON THE UPTAKE AND SPECIATION OF MERCURY IN PLANTS AND FURTHER IN THE FOOD CHAINS

Anja Kavcic[1], Tanja Murn[1,2], Bojan Budic[3], Katarina Vogel-Mikus[1,2]

[1] *University of Ljubljana, Biotechnical faculty, Dept. of Biology, Ljubljana, Slovenia*
[2] *Josef Stefan Institute, Ljubljana, Slovenia*
[3] *National Institute of Chemistry, Ljubljana, Slovenia*
anja.kavcic@bf.uni-lj.si

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Introduction

Mercury (Hg) is a potentially toxic metal. By replacing the essential elements in biological molecules Hg interferes with their function and causes oxidative stress, which leads to functional disturbances of the organism and the development of various diseases, such as cancer (Jarüp, 2003). Contamination with Hg is mostly the result of mining and smelting activities, industry, traffic and use of phosphate fertilizers. In Slovenia, wider area of Idrija is highly contaminated with Hg due to more than 500 year long cinnabar mining in the past. Today the concentration of Hg in the soil at the near vicinity of Idrija's mine still exceeds the legal limits (0.05 mg kg^{-1} of dry matter), but is lower than during the mining period (Kocman et al., 2004). Mercury is uptaken from the soil by the plants. In this way it enters the food webs posing threats to the health of humans and animals.

Selenium is a microelement, which is essential in human and animal nutrition, as it is a cofactor of many enzymes. Selenoproteins act as antioxidants and thus have a direct anticancer and protective effect. In Europe the majority of human population lack selenium in their nutrition so in recent years biofortification of crops, especially cereals, with selenium is becoming a regular practice (Broadley et al., 2006).

The complexes between Hg and Se are less generally known, although Hg selectively binds with Se to form insoluble complexes - mercury selenides (Moller-Madsen, 1999), thereby reducing their bioavailability and toxicity in the environment. Measuring the amount of mercury present in the environment or food sources may provide an inadequate reflection of the potential of health risks if the protective effects of selenium (Se) are not also considered (Raymond et al., 2004).

Our aim was to study the impact of Se-biofortification of the plants on the transfer of Hg from the plants to the food chain and to estimate the potential protective role of Se against Hg induced stress in animals. Since slug snails are good indicators for metal pollution and there are no ethical objections for experiments with molluscs (Berger et al., 1993), the slugs *(Arion sp.)* were used as model animals.

Methods

Lettuce was planted in naturally (soil from the vicinity of Idrija mine) or artificially Hg contaminated soils and grown in growth chambers for three weeks. For additional three weeks, lettuce was foliarly sprayed with a selenium solution (5 microM) once per week. The rate of uptake of Hg and Se in plant organs (roots and shoots) was determined. The level of stress was assessed by monitoring of photochemical efficiency of photosystem II and some biochemical parameters (chlorophyll and carotenoids content, level of lipid peroxidation, elemental fingerprints).

Slugs were fed with Hg and Se treated lettuce for 14 days. Slugs were dissected and hepatopancreas gland and muscle tissues were taken for further analysis. The rate of accumulation and speciation of the elements in hepatopancreas and muscle tissue was determined by analyzing their Hg and Se concentrations. In addition, the level of lipid peroxidation was determined by malondialdehyde (MDA) test (Hodges et al. 1999). Bioavailability was calculated as the ratio between the contents of element (mg) in hepatopancreas and the contents of element (mg) in eaten food.

Results

Lettuce roots accumulate mainly Hg and shoots mainly Se (due to different exposure of organs to Hg or Se). In slugs, Hg mainly accumulates in the hepatopancreas. The overall results show that foliar spraying with Se lowers Hg concentrations in lettuce and further in the food chain.

Conclusion

Biofortification of plants with Se may contribute to reduction of Hg load in animals and humans. Hence, we propose that Se has a potential protective role against Hg induced stress in animals and humans.

References

Järup L. (2003). Hazards of heavy metal contamination. *Br. Med. Bull., 68*, 167–82.

Kocman D, Horvat M. (2004). Mercury fractionation in contaminated soils from the Idrija mercury mine region. *J. Environ. Monit., 6*, 696–703.

Broadley MR, White PJ, Bryson RJ, Meacham MC, Bowen HC, Johnson SE, et al. (2006). Biofortification of UK food crops with selenium. *Proc. Nutr. Soc., 65,* 169–81.

Moller-Madsen B, Danscher G. (1991). Localization of mercury in CNS of the rat. IV. The effect of selenium on orally administered organic and inorganic mercury. *Toxicol. Appl. Pharmacol., 108,* 457–73.

Raymond LJ, Ralston NVC. (2004). Mercury : selenium interactions and health implications. *SMDJ, 7,* 72–7.

Berger B, Dallinger R. (1993). Terrestrial snails as quantitative indicators of environmental metal pollution. *Environ. Monit. Assess., 25,* 65–84.