Uptake and Accumulation of Indium in Rice and Wheat

Hsin-Fang Chang (張馨方)[1,2], Puu-Tai Yang (楊圃臺)[1], Kuo-Chen Yeh (葉國楨)[2] and Shan-Li Wang (王尚禮)[1*]

[1]Department of Agricultural Chemistry, National Taiwan University, Taipei 10617, Taiwan
[2]Agricultural Biotechnology Research Center, Academia Sinica, Taipei 11529, Taiwan
wangsl@ntu.edu.tw

Abstract

Indium is a technology-critical element and also an emerging contaminant in the environment. The increasing use of indium in high-tech industries has inevitably caused its release into the environment. Elevated indium concentrations were detected in groundwater[1] and airborne deposition[2] near a large semiconductor industrial park in Taiwan. A recent survey showed that the average indium contents in the soils near two industrial parks in Taiwan were approximately two to seven times higher than the 0.021 mg kg^{-1} measured from 1978-1980, with the highest being 6.0 mg kg^{-1}.[3] Due to the toxicity of indium, the release of indium into the environment may pose a potential risk to public health, but indium exposure pathways of humans have not been established so far. This study reported the uptake and accumulation of indium in rice (*Oryza sativa* L.) and wheat (*Tritcum aestivum* L.), which are two leading crops of the world population. Indium bioavailability in contaminated soils was determined based on its speciation and fractionation of the soils, determined using In *K*-edge X-ray absorption spectroscopy and a sequential extraction method, respectively. The accumulations of indium in roots, shoots, and grains of rice and wheat were assessed. In soil, the predominant indium species is indium associated with iron hydroxides followed by indium hydroxide and phosphate precipitates. The results of μ-XRF mapping, in combination with μ-XANES spectroscopy, revealed that the formation of indium hydroxide precipitates occurred locally in the rhizosphere and restricted the translocation of indium from soil to plant roots. After indium was absorbed by plant roots, it was mainly accumulated there, with only a tiny portion reaching the grains. Indium accumulated in plants caused stunted growth, oxidative stress, anthocyanization, and unbalanced mineral nutrition. Due to the low translocation rate of indium from soil to grain, the consumption of rice and wheat grains may not contribute to the health risk of indium exposure to a significant extent and alternative exposure pathways will need to be considered.

Keywords – Indium, rice, wheat, bioavailability, chemical speciation.

References

[1] H.W. Chen, “Gallium, indium, and arsenic pollution of groundwater from a semiconductor manufacturing area of Taiwan,” Bull. Environ. Contam. Toxicol. 2006, 77, 289-296.
[2] H.W. Chen, “Characteristics and risk assessment of trace metals in airborne particulates from a semiconductor industrial area of northern Taiwan,” Fresenius Environ. Bull. 2007, 16, 1288-1294.
[3] Y.W. Lin, et al., Investigation on emerging metal contaminants in agricultural land around new developed industrial parks (in Chinese), Environmental Protection Administration, 2013.