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Stable isotope fractionation and enantiomer fraction of Hexachlorocyclohexane during uptake into plant in hydroponic system-application for food web studies on a catchment scale

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Hexachlorocyclohexane isomers (HCHs) are persistent organic chemicals. The globe use of Lindane (γ-HCH) and the widespread of HCH residuals caused the contamination in soil and groundwater and then accumulated in catchment and sequentially in plants. The uptake of plant is the final step that the HCHs enter into the food web. For sustainable management of contaminated catchment and health risks assessment, it is essential to understand the fate of HCHs during the reactive transport process in the catchment.

Based on the previous study, the HCHs could be transformed in soil and plant system in the field. However, it is difficult to distinguish the transformation of HCHs in plant system and in soil rhizosphere. In order to characterize the fate of HCHs in plant in water system, we designed the hydroponic experiment using wheat as the test plant and focused on the transformation of HCHs in different plant tissues during reactive uptake by wheat using the compound-specific isotope analysis (CSIA) and enantiomer fraction (EF). The results showed no differences of carbon isotope ratio (δ13C) and chlorine isotope ratio (δ37Cl) of α-HCH and β-HCH in nutrient solution during the whole growth period of wheat. The δ13C and δ37Cl of α-HCH increased in different wheat compartments but showed no difference in root surface compared to nutrient solution, indicating that the C-Cl bond cleaved during uptake processes and that the transformation of α-HCH took place in wheat. The 1,3,4,5,6-Pentachlorocyclohexene was found as the metabolism of α-HCH in wheat tissues, which supported the C-Cl bond cleavage. However, no carbon isotope enrichment of β-HCH was observed in either the root surface or the different wheat tissues compared to nutrient solution, indicating that there was no transformation of β-HCH in wheat. The evaluation of enantiomer fraction resulted in no difference of EF(-) in nutrient solution and the root surface but a decrease of EF(-) in wheat tissues, providing an evidence for the preferential biological transformation of (-) α-HCH in wheat.

Based on the present study, we could identify the biotransformation of α-HCH in wheat, and CSIA and EF have been applied to assess the biotransformation of HCHs in plant tissues for the first time. This research also gave an evidence that phytotransformation is a promising method for remediating the HCH-contaminated catchment.