

Compound-specific isotope analysis (CSIA) for assessing pesticide dynamics in soil and vadose zone

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A lysimeter facility was used to study long-term pesticide fate and transport through two different soils. The present investigation focuses on some commonly and worldwide used herbicides for weed control on corn (atrazine, acetochlor and metolachlor) and sugar beet (chlorldazon), together with their main degradation products. Since some degradation products are found more frequently and at higher concentrations than their parent compounds, there is growing environmental concern. The fate of these metabolites is, however, not well-understood.

Twelve weighing lysimeters filled with two typical arable soils in Switzerland (a well-drained sandy loam cambisol developed from a stony alluvium-“gravel soil”- and a poorly-drained loam cambisol developed from moraine deposits -“moraine soil”-) were cropped with corn in the first and third seasons, and sugar beet in the second one. Three types of experiments were performed: (1) herbicides application at the surface simulating the common application scenario, (2) herbicides injection at a depth of 40 cm for simulating high preferential transport through the topsoil and assessing the dynamics below the root zone, and (3) metabolites (2,6-dichlorobenzamide, desphenylchlorldazon and desethylatrazine) application at the surface to simulate rapid generation of transformation products from the parent compounds. Leachate was collected and the concentration of the applied substances and main degradation products was determined. Since assessing transport and fate of micropollutants in the environment is extremely difficult because transformation processes are slow and may not become evident from analysis of concentrations, multi-element (C, N, Cl) compound-specific isotope analysis (CSIA) is also being used.

With both surface application and depth injection, compound breakthrough by preferential as well as matrix flow was observed. A few days after their application, significant infiltration of the herbicides took place by preferential flow, bypassing the sorption and degradation capacity of the soil matrix. Thereafter, the main movement was through the soil matrix and thus, the longer residence time of the herbicides in the soil zone enhanced degradation and due to the high mobility of the metabolites, they were detected in the leachates. Breakthrough of the applied metabolites was also observed. For most of the cases, concentrations were higher in the leachates of the gravel soil than in the moraine soil. Preliminary results of C and N isotope signatures of the target compound in the leachates show significant isotope enrichment trends in acetochlor and metolachlor and less evident in atrazine, confirming the occurrence of degradation processes.