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Non-conservative characteristics of fluorescent tracers help to assess in-situ transport and attenuation of pesticides

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Traditionally, hydrological tracers are selected to behave as conservatively as possible, since most applications aim to investigate the transport of water or conservative solutes. Non-conservative tracer behavior is regarded as a limitation. However, the environmental behavior of organic pesticides is strictly non-conservative as their fate is affected by various processes, including sorption, photolysis and biochemical transformation in various environmental compartments. If tracers are used to study pesticides under these conditions, we believe that a paradigm shift is necessary: only a tracer that is affected by similar attenuation processes can realistically reproduce the overall behavior of a target pesticide. We present here two examples from two different environmental compartments: (i) agricultural soils and (ii) wetland systems. In both studies two organic fluorescent tracers (uranine, UR and sulforhodamine-B, SRB) and the salt tracer bromide (BR) were applied together with the chloroacetanilide herbicide S-metolachlor (S-MET).

On an agricultural field, plot experiments were conducted under artificial and natural rainfall conditions. The use of BR overestimated both slow leaching and fast preferential transport of S-MET in the unsaturated zone, while UR/SRB were more realistic markers. Under artificial conditions, recovery rates of BR in a tile drain were twice as high as UR and one order of magnitude higher than SRB. Under natural conditions, BR concentrations in surface soils (0-1 cm) displayed larger variances during wetting and drying periods than UR, SRB and S-MET. BR also leached deeper (below 5 cm) than S-MET in the soil column. After 70 days, characteristic fluorescent peaks of UR and SRB gradually decreased in soil samples, while a new peak increased in another spectrum, which suggests the production of a potential transformation product.

In two artificial wetland systems the impact of hydrological conditions (batch versus continuous-flow) on solute dissipation was studied. The solute mass budgets included plants, sediment and water phases and reflected the main dissipation pathways. Apart from plant uptake, BR was conservative under both conditions. Similar to S-MET, UR and SRB were affected by sorption, photo- and presumably biodegradation and all processes were more prominent in the batch than in the continuous flow wetland. This was in agreement with a larger overall dissipation of S-MET under batch (90%) than continuous mode (60%). Hence, only UR/SRB realistically illustrated the effect of hydrological conditions (different hydraulic residence times and alternating biogeochemical conditions) on S-MET attenuation in the wetland systems.