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Tile drained hillslopes as natural lysimeters – linking rapid transport and re-mobilisation of different pesticides with isotope signatures during controlled irrigation experiments

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Tile drained field sites combine the advantage of working in naturally structured soils, with the advantage of an at least partly controlled lower boundary condition. We performed a series of three irrigation experiments on a tile drained field site, combined with hydrometric measurements, stable isotopes and artificial tracers to better understand how soil water flows control rapid transport and re-mobilisation of two different herbicides. The first two experiments were performed on the day after the application of Isoproturon (IPU) and Flufenaced (FLU) in consecutive years. Rapid breakthrough of the applied pesticides into the tile drains occurred during both experiments with almost no retardation compared to the bromide tracer. Particle bound transport of the pesticides was quantified and contributed with approximately 20% to the total pesticide leaching. We finally conducted a third irrigation three weeks after the second experiment to investigate possible re-mobilisation of the pesticides that leached into the subsoil.

Depending on the initial saturation of the site different amounts of accumulated irrigation were necessary to elevate tile drain discharge above the base flow level. Hydrograph separation based on stable isotope data revealed that on average 4.95% and 6.15% of the irrigation water contributed to tile drain discharge, at the discharge peak it was 20%. Oxygen-18 and deuterium data suggested that pre- event soil water contributed significantly to the tile drain event flow. However, the isotopic composition of soil water converged towards the isotopic composition of irrigation water in course of the experiment. Mixing calculations revealed that at the end of the experiment 20% of the soil water in the entire profile was irrigation water. However, as moisture in the deeper soil was only slightly larger as the initial value, we concluded that part 20% of the soil water has been replaced by irrigation water. The soil isotopic composition corroborated furthermore that mainly the upper 40 cm of the soil water contributed to the tile drain event flow. During the third irrigation experiment we observed a rapid remobilisation of bromide and both pesticides from the soil matrix, again with was almost no retardation.

We conclude that pesticide transport at this tile drained field site is a soil moisture controlled threshold process. When the soil moisture threshold is crossed pre-event soil water, bromide and pesticides from the soil matrix are transported into nearby preferential flow paths and subsequently into to the tile drain or the shallow groundwater body. This mechanism might facilitate remobilisation and leaching of “old” pesticides, which entered the topsoil matrix during previous rainfall events, either into tile drains or shallow ground water bodies