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Comparison of environmental tracer to characterize wastewater mass fluxes into the hyporheic zone

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Groundwater and surface water are in many cases closely linked components of the water cycle with respect to both quantity and quality. Bank filtrates may eventually be impacted by the infiltration of wastewater-derived pollutants from surface waters. To study the fate of wastewater-derived substances (e.g. X-ray contrast media) in groundwater, different environmental tracers (temperature, stable isotopes, and the artificial sweetener acesulfame) were evaluated in a model-based analysis of a field experiment within the hyporheic and riparian zone of a highly polluted stream in Germany [1,2].

The suitability of acesulfame to trace wastewater-related surface water fluxes from streams into the hyporheic and riparian zone was compared with the transport of water stable isotopes (δ18O and δ2H), temperature, and hydraulic heads via analytical and numerical approaches. A calibrated conservative transport model based on a joint inversion of temperature, acesulfame, and piezometric pressure heads was employed in a model validation using additional data sets of acesulfame and water stable isotopes collected over 5 months in a stream and groundwater.

Surface water ratios calculated with a mixing equation from water stable isotopes and simulated acesulfame mass fluxes were investigated for their ability to estimate the contribution of wastewater-related surface water inflow within groundwater. The results of this study point to limitations for the application of acesulfame to trace surface water–groundwater interactions properly. Acesulfame completely missed to indicate wastewater-related surface water volumes that remain in the hyporheic zone even under stream-gaining conditions. In contrast, under stream-losing conditions, acesulfame based predictions lead to an overestimation of the surface water volume of up to 25% in the riparian zone [2]. A model sensitivity analysis revealed temperature as the best indicator in terms of mass flux prediction beneath the stream bed. Removing temperature data from the model calibration increased the uncertainty significantly, whereas the influence of acesulfame data was low [1]. However, the data worth of temperature fluctuations was limited at some distance from the stream bank. In summary, acesulfame can be a less-ideal tracer in the hyporheic and riparian zones and additional monitoring with other environmental tracers such as water stable isotopes is highly recommended to obtain reliable wastewater mass fluxes, especially at some distance from the stream bank and under alternating hydraulic conditions with longer stream-gaining periods.

References

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[2] Engelhardt, I., Barth, J.A.C., Bol, R., Schulz, M., Ternes, T.A., Schüth, C., and van Geldern, R. (2014): Quantification of long-term wastewater fluxes at the surface water/groundwater-interface: An integrative model perspective using stable isotopes and acesulfame. - Science of the Total Environment, 466-467, 16-25, [doi:10.1016/j.scitotenv.2013.06.092].