Geophysical Research Abstracts
Vol. 18, EGU2016-13250, 2016
EGU General Assembly 2016

Column experiments on organic micropollutants – applications and limitations

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As organic micropollutants become more and more ubiquitous in the aquatic environment, a sound understanding of their fate and transport behaviour is needed. This is to assure both safe and clean drinking water supply for mankind in the future and to protect the aquatic environment from pollution and negative consequences caused by manmade contamination. Apart from countless field studies, column experiments were and are frequently used to study transport of organic micropollutants. As the transport of (organic) solutes in groundwater is controlled by the chemical and physical properties of the compounds, the solvent (the groundwater including all solutes), and the substrate (the aquifer material), the adjustment and control of these boundary conditions allow to study a multitude of different experimental setups and to address specific research questions. The main purpose, however, remains to study the transport of a specific compound and its sorption and degradation behaviour in a specific sediment or substrate. Apart from the effective control of the individual boundary conditions, the main advantage of columns studies compared to other experimental setups (such as field studies, batch/microcosm studies), is that conservative and reactive solute breakthrough curves are obtained, which represent the sum of the transport processes. The analysis of these curves is well-developed and established. Additionally, limitations of this experimental method are presented here: the effects observed in column studies are often a result of dynamic, non-equilibrium processes. Time (or flow velocity) plays a major role in contrast to batch experiments, in which all processes will be observed until equilibrium is reached in the substrate-solution-system. Slightly modifying boundary conditions in different experiments have a strong influence on transport and degradation behaviour of organic micropollutants. This is a significant severe issue when it comes to general findings on the transport behaviour of a specific organic compound that are transferable to any given hydrogeochemical environment. Unfortunately, results of most column experiments therefore remain restricted to their specific setup.
Column experiments can provide good estimates of all relevant transport parameters. However, the obtained results will almost always be limited to the scale they were obtained from. This means that direct application to field scale studies is infeasible as too many parameters are exclusive for the laboratory column setup. The remaining future challenge is to develop standard column experiments on organic micropollutants that overcome this issue. Here, we present a review of column experiments on organic micropollutants. We present different setups and discuss weaknesses, problems and advantages and provide ideas how to obtain more comparable results on the transport of organic micropollutants in the future.