



## Tracing down Pharmaceuticals in the unsaturated Zone

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Pharmaceutically active substances and metabolites are found at concentrations up to the microgram/L-level in groundwater samples from the Berlin (Germany) area and from several other locations world wide. Among the compounds detected in groundwater are clofibrac acid (blood lipid regulator), propyphenazone (analgesic), diclofenac (anti-inflammatory), ibuprofen (anti-inflammatory), and carbamazepine (antiepileptic). Pharmaceuticals are measured up to the  $\mu\text{g/L}$  range in surface and groundwater. However, concentrations detected in groundwater are generally much lower.

Among the most important input paths of drugs are excretion and disposal into the sewage system. Groundwater contamination is likely to be due to leaky sewage systems, influent streams, bank filtration, and irrigation with effluent water from sewage treatment plants. There are no known natural sources of the above mentioned pharmaceuticals.

The use of pharmaceuticals as tracers is limited by variations in input. These variations depend on the amount of drugs prescribed and used in the study area, the social structure of the community, the amount of hospital discharge, and temporal concentration variations.

Furthermore, the analysis of trace amounts of pharmaceuticals is sophisticated and expensive and may therefore limit the applicability of pharmaceuticals as tracers.

Finally, the transport and degradation behavior of pharmaceuticals is not fully understood.

Experiments in the laboratory were conducted using sediment material from the Berlin

area and artificial sewage effluent to evaluate the transport and sorption behavior of selected drugs in the unsaturated zone under conditions comparable to waste water reuse conditions. Results of the column experiments show that clofibric acid exhibits no degradation and almost no retardation ( $R_f = 1.1$ ) whereas ibuprofen is almost completely biodegraded under aerobic conditions. Carbamazepine shows no degradation in the soil column experiments but significant retardation under the prevailing conditions. We conclude that clofibric acid will show the transport behavior of a conservative tracer, whereas ibuprofen may be used to characterize the biodegradation potential in the unsaturated zone.