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Spatial relationships between sources of micropollutants and drinking water supply in the Rhine basin – consequences for water management

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The contamination of rivers with micropollutants (MPs) like pesticides or pharmaceuticals from various sources is an important environmental issue. Depreciation of surface water quality not only affects the natural system, but also the human community. Drinking water production, as one of the basic needs of every community, is very sensitive to surface water quality in the case of bank filtration, artificial groundwater recharge or lake water purification. Water suppliers are therefore directly affected by pollution originating upstream. Accordingly, efficient water management and policy regulation must incorporate this spatial dependence between areas where pollution occurs and the locations where water is abstracted for further use.

In this study, we explicitly investigate these spatial dependencies. To that end, we combine a spatially distributed mass flow analysis with georeferenced analysis of actor networks within the water sector in the Rhine basin. The model is calibrated at a number of catchments in Switzerland and comparison of pollutant loads within the Rhine catchment yield plausible results. The mass flow analysis provides information regarding (1) the spatial distribution of potential sources (source areas for MPs) and their distance to the water suppliers; and (2) the parts of the catchment contributing most to the pollution at the location of the suppliers. The spatial extent and location of these source areas depend on the spatial distribution of land use types that are associated with the use of the MPs and the possibly region-specific use of a compound. In this study, we focus on agricultural herbicides, biocides from material protection on buildings and pharmaceuticals from households. On the basis of GIS data of agricultural land, buildings and wastewater treatment plants, respectively, statistical data is downscaled to identify the potential mass available for release to the aquatic system. The transfer to streams is calculated with empirical loss rates related to site-specific discharge for agricultural herbicides and precipitation for biocides. For the pharmaceuticals the release is coupled to the metabolism rates and elimination rates in WWTP. The subsequent routing along the river network accounts for degradation processes.

The resulting spatial information on the origin of MP discharge into the stream network is used to analyse the source areas for water supply in Basel and Düsseldorf and their affectedness by MPs as two exemplary test cases. These cases help to understand to which degree and to what extent managing water quality is a transboundary issue for water suppliers. The analysis provides quantitative information on how many political entities at different levels (municipalities, countries, states) need to be involved in managing the respective water resources.