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Micropollutants as indicators for groundwater recharge sources in the human environment

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Understanding groundwater dynamics around cities and other areas of human influence is of crucial importance for water resource management and protection, especially in a time of elevated environmental and societal change. The human environment – whether it be cities, industrial parks, or agricultural zones – presents a unique challenge in terms of hydrological characterization due to the alteration of natural conditions. In these areas, the water cycle is artificialized to some degree, and emissions of treated wastewater and chemical products into the surface- and groundwater system tend to disrupt the quality and quantity of water in nature. This alteration of the water cycle can be a powerful tool for identifying sources of groundwater recharge. As part of this project, we make use of certain organic micropollutants in an attempt to delineate these sources and pathways of groundwater recharge for a small alluvial aquifer in an urban area that is subject to multiple types of. Groundwater recharge is often a difficult parameter to estimate in the natural environment, and is even more difficult in a human environment. There exist many methods to estimate the quantity of recharge in a given timeframe at a given point, and numerical modeling has offered a powerful tool for ameliorating these efforts. However, significant uncertainties still exist, due in part to the fact that not all sources of recharge in the human environment can be properly identified. Micropollutants are persistent organic compounds that are regularly emitted into the environment by nearly every human activity, and most are not fully removed in current wastewater treatment plants. Despite the concern over their impact on the natural environment and particularly on water quality, micropollutants pose as a useful tool for tracing groundwater to its source. For example, recharge from cultivated fields may be identified by measuring the amount of agricultural pesticides in groundwater, while recharge from sewer leakages may be identified by measuring certain pharmaceutical products in groundwater. Micropollutant concentrations in groundwater can be measured alongside basic chemical parameters such as pH, electrical conductivity (EC), dissolved organic carbon (DOC), oxidation/reduction potential (ORP), to differentiate between compounds which recharge directly from the source, which are coming from upslope, or which are infiltrating from surface waters. The concentrations of specific micropollutants are measured and used to gain qualitative information on groundwater recharge, and this information is then compared to recharge estimates derived from established methods such as the empirical water balance as well as the water table fluctuation method, in order to complement qualitative information with quantitative information. This approach illustrates the relations between land use, climate, rainfall dynamics, and the groundwater signature through time. At its conclusion, insights gained from this study can be used to assess the risk factors of specific land use types at a given geographical location, to assess the need for infrastructure updates, and to refine protective zones around pumping wells.