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Assessment of groundwater contamination impacting stream ecosystems

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Streams are significantly impacted by a large number of micropollutants and their transformation products (e.g. pharmaceuticals, chlorinated solvents, pesticides/biocides, nutrients, heavy metals), leading to a severe degradation of essential ecological functions and services. The large diversity of compounds and their sources makes the quantification of their occurrence and toxicity a challenging task. Conventionally, chemical impacts to ecosystems are assessed one compound/group of compounds or one source type at a time. We presume this will give us a good indication of the impact of a particular stressor. Our hypothesis, however, is that this will underestimate the combined impact caused by chemical cocktail effects, and interactions between stressors. Moreover, a stream system impacted by multiple stressors has a high chronic stress level, so even small perturbations on top of changes in water flow or additional chemical stressors may be detrimental to the stream health.

To address this issue, we identified contaminant sources and chemical stressors along a 16-km groundwater-fed stream corridor (Grindsted, Denmark) to quantify the contaminant discharges, and potentially link the chemical impact and stream water quality. Potential pollution sources include two contaminated sites, aquaculture, wastewater discharges, and diffuse sources from agriculture and urban areas. Data for xenobiotic organic groundwater contaminants, pesticides, heavy metals, general water chemistry, physical conditions and stream flow from three campaigns in 2012 and 2014 were assessed. Ecological status was determined by monitoring meiobenthic (e.g. nematodes) and macrobenthic invertebrate communities.

The results show a substantial impact on Grindsted stream from multiple sources of many origins. The groundwater plume from the Grindsted factory site caused elevated concentrations of chlorinated ethenes, benzene and pharmaceuticals in both the hyporheic zone and the stream water persisting for several km downstream of the discharge area. Heavy metal concentrations were found around or above the threshold values for barium, copper, lead, nickel and zinc in the stream water, hyporheic zone and streambed sediment. The calculated TU was generally similar along the stream, but for arsenic and nickel higher values were observed where the groundwater plume discharges into the stream. Thus, the overall chemical stress in the main discharge area is much higher than upstream, while it gradually decreases downstream.

The ecological results indicate a change in community composition for both meio- and macrobenthic fauna, pointing towards the presence of a local impact resulting from the discharging contaminated groundwater. Ecological impacts could be related to xenobiotic compounds coming from groundwater, as well as to the presence of trace metals of diffuse and/or biogenic origin in the same area, but linkage to one specific factor was not possible. This work highlights the importance of a holistic assessment of stream water quality to identify and quantify the main contaminant sources and resulting chemical stream stressors leading to potential ecological impacts.