Field methods for determining point source pollution impacts in rivers: A case study of the Grindsted stream - DTU Orbit (28/07/2019)

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Well-known organic contaminants such as chlorinated solvents, as well as new classes of compounds or emerging micropollutants (e.g., pharmaceuticals) are extensively produced, utilized and then discarded in society and subsequently released to streams from multiple sources. To address this, the EU Water Framework Directive requires member states to evaluate all types of contamination sources within a watershed in order to assess their direct impact on water quality. Understanding and accurately characterizing groundwater-surface water interactions (GSI) and groundwater discharge is thus becoming an increasingly important activity for the hydrogeological investigations of rivers and streams. In cases where groundwater contaminant plumes are discharging to streams, determination of flow paths and groundwater fluxes are essential for evaluating the transport, fate and potential impact of the plume. This implies that investigators have the tools to easily and accurately evaluate the governing parameters, including an appreciation of the scale of variability, as well as conceptual models that incorporate the various mechanisms affecting flow.

An in-depth field investigation of the Grindsted stream was carried out in 2012, to develop the theoretical basis for conducting risk assessments for contaminated sites impacting surface waters. Grindsted stream was chosen, as groundwater flow is known to comprise an important part of the total water supply to the stream. It is also a well-studied site, affected by two major polluting point sources, Grindsted factory and Grindsted landfill, representing two of the 43 large-scale contaminated sites in Denmark. Our overall aim was therefore to (i) test the applicability of different methods for mapping groundwater pollution as it enters streams at a complex site, and (ii) perform a risk assessment of the stream’s chemical status, including documentation of emerging contaminants. A secondary aim was to identify and ideally separate the entry point for the two plumes to Grindsted stream.

We successfully detected six significant local-scale GSI “contact” zones along a 5 km stream stretch, which were not visible at the regional scale, using systematic temperature measurements. We then correlated the two highly contaminated contact zones, using piezometers placed where streambed temperature measurements were <10°C, to concentrations in downstream surface waters. Transects placed perpendicular to stream flow in the contact zones allowed us to effectively localize the Grindsted factory plume using samples containing a unique compositional footprint consisting of chlorinated solvents, barbiturates, sulfonamides, sulfanilic acid and bromide specific for the contaminated site. Notably, the highly volatile and toxic compound vinyl chloride was found to exceed the surface water quality criterion (0.05 µg/L) for a ca. 5 km stretch, to our knowledge the only documented study of its kind. Additionally, the sum of sulfonamides was also shown to exceed the recommended criterion (4.6 µg/L) twice along the same stream stretch. Further investigations will be necessary to finalize the location of the Grindsted landfill plume where it enters the stream; specifically we recommend that two-dimensional cross-sectional characterization be conducted to identify the direction and width of this groundwater plume.

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