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Risk Assessment of stream water: linking mass discharge from contaminated sites in groundwater with water health

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1. Introduction

Streams are impacted by significant contamination at the catchment scale, in particular as they are often locations of multiple stress, including for example xenobiotic compounds in groundwater originating from contaminated sites, diffuse source pollution (e.g. surface run-off, tile drains) and water abstraction[1]. With the enactment of the European Water Framework Directive (WFD) in 2000 and the corresponding Groundwater Daughter Directive (GDD) in 2006, all Member States are required to ensure the good chemical and ecological status/quality of both groundwater (GW) and surface waters (SW) by 2027[2]. The chemical status in surface water is defined in part by a set of environmental quality standards (EQS) on priority substances (EQS Directive (2008/105/EC) and in part by the individual Member States (e.g. Danish EPA, 2010, BEK nr. 1022). However the relationships between the quality elements used for the classification of ecological status (biological, hydromorphological and physicochemical) is defined in a more holistic manner leaving the Member States free to define the details of their own assessment tools[3]. In this study we evaluate biological methods/tools for risk assessing the impact of xenobiotic contaminated groundwater entering a stream. We focus specifically on the use of invertebrate fauna for quantifying the link between chemical and ecological status.

2. Methods and study site

The study was conducted in Grindsted stream which is impacted by e.g. agriculture, fish farms as well as two of Denmark's "mega-sites" located within 2 km of the stream (Grindsted Factory and the old Grindsted Landfill). We sampled meio- and macrobenthic invertebrates at 6 locations strategically placed in order to isolate and evaluate the impacts from a known groundwater contaminant plume entering the stream[4]. For each location, a minimum of four surber samples were collected at each of the three most dominant substrate types identified (sand, gravel and depositional areas with high content of organic matter). **Long term effects** of GW pollutants were quantified studying meio- and macrobenthic invertebrate community structure, and **short term** effects were assessed using *in-situ* chambers with *Gammarus pulex* deployed for one week in the stream at the same 6 locations.

The chemical concentrations of xenobiotic groundwater contaminants as well as the most commonly used pesticides and their degradation products in Denmark were monitored in Grindsted stream at each of the 6 ecological stations respectively in water collected from well mixed areas of the stream, the hyporheic zone and the top 5 cm of bed sediment.The measured chemical concentrations were converted to toxic units (TU) based on the 48h acute toxicity tests with *D. magna*. We used two macroinvertebrate indices (DSFI[5] and the SPEcies At Risk (SPEAR) index[6]) to characterize the ecological quality of macrobenthic fauna. The nematode community is expected to be used as the meiobenthic fauna indicator (NemaSPEAR[7]).

3. Results and discussion

For the locations in Grindsted stream where the concentration of the xenobiotic groundwater contaminants were below detection limit in both the surface water and in the hyporheic zone both the benthic meio- and macroinvertebrate communities were characterized by having the highest species richness and diversity as well as the highest ecological index scores (DSFI, SPEARpesticides and NemaSPEAR). At the sites containing the highest pollutant concentrations in the hyporheic zone (not highest TU) – which have been linked as coming from GW - the meio- and macroinvertebrate communities were significantly reduced in both species richness and diversity. The strongest effect though was seen in areas where the highest concentrations of the xenobiotic compounds were detected in the surface water and in the water from the hyporheic zone. The benthic communities showed a general trend throughout the different habitats at each station a significant absence of individuals. The most dominating xenobiotic compounds found in the GW and subsequently downstream in the SW were the chlorinated solvents (tetrachloroethylene, PCE, trichloroethylene, TCE, cis-1, 2-dichloroethylene, cis-DCE, vinyl chloride, VC), site-specific pharmaceutical compounds (e.g. barbiturates and sulfonamides) and benzene. We are additionally evaluating whether species habitat preferences for both the meio- and macrobenthic communities changes between un-impacted and impacted sites.

Almost all the xenobiotic compounds found in the SW of Grindsted stream on the investigated stretch were first detected in the groundwater surface water interaction (GSI) zones. Notably, inclusion of these compounds in the TU sum calculations significantly increased the overall toxicity for the affected sampling locations. Our findings indicate the seepage of contaminated groundwater could be important for both the chemical as well as the ecological status in the stream.

4. Conclusions

Our results show the presence of both a local and downstream impact resulting from the contaminated groundwater entering Grindsted stream for both the meio- and macrobenthic fauna. This indicates that this type of stressor affecting water bodies are of a significant importance and must therefore be included when conducting risk assessments of contaminated sites.

The toxic potential ($TU_{D.magna}$) of the identified xenobiotic contaminants was generally very low suggesting that long term exposure may generate un expected strong effects in the field.

The best estimate, for toxicological stress of the ecological status (species richness and diversity) in the stream based on the chemical data, was achieved by calculating TU for all three phases (SW, GW and pore water) from each of the investigated locations in order to assess whether the ecological status was affected.

5. References

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