Increasing ecological relevance of chemical risk assessments using geospatial approaches: results from two case studies

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1. Introduction

A key rationale for making geo-referenced chemical risk assessment is that it provides assessments that can be tailored to local landscape/watershed abiotic characteristics and ecology to account for spatial heterogeneity within river basins. Since heterogeneity is often reflected in localised specific environmental objectives and protection goals, spatially explicit assessments can better relate to landscape/watershed scale environmental management objectives than can current generic chemical environmental risk assessment, ERA, frameworks.

In 2017 the European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC) initiated a Task Force to investigate current capabilities in making spatially explicit chemical ERA (from both an exposure and effects perspective). After research for applicable data, we investigated techniques for combining disparate data sets using 2 case studies and identified some of the challenges of using different levels of taxonomic, spatial and temporal resolution in geo-referenced ERA.

2. Materials and methods

The case studies explored the integration of exposure and ecological receptor data in Hessen (Germany) based on the exposure of freshwaters to i) a surfactant used in cleaning products and ii) 3 Plant Protection Products (PPPs) (herbicide, insecticide and fungicide) applied to winter wheat, oil-seed rape and barley.

Surfactant concentrations in rivers resulting from 350 WWTP discharges were conventionally modelled and converted to Exposure:Toxicity Ratios, ETRs, using ecotoxicity data. ETRs were compared to the ecological status of 794 Water Framework Directive, WFD, biomonitoring sites in Hessen based on data for fish, diatoms, macrophytes and macroinvertebrates (provided by the Hessian State Office for Nature Conservation, Environment and Geology, Wiesbaden) to identify sites of relatively higher risk.

Environmental exposures of PPP were modelled with SYNOPS [1] using surveyed usage data randomly applied to >80,000 individual fields. 1- and 7-day time weighted average concentrations in surface water were estimated for each spatially referenced field based on many factors, including soils and rainfall using standard PPP exposure models.

Daily field-level exposures in surface water were converted to ETRs for each PPP, and summed to an acute and chronic risk index for algae, macrophytes, macroinvertebrates and fish. Stream segments containing an associated biological sampling location were exported along with the sum of risk (ETR) extending 1000m upstream for analysis. The annual sum of risk (all PPPs) for all fields was compared with the WFD ecological status of river sites within 300m of exposed fields to identify exposed locations with high or low status.

3. Results and discussion

3.1. Surfactant study

Mapping PECs (Figure 1) and ETR values onto modelled rivers is one approach to indicate segments at relatively high risk. Where these risks could be of concern, targeted risk assessments could be made. This could take account of expected species assemblages derived from WFD reference conditions. There were no trends in surfactant acute or chronic maximum ETR values and ecological status indicating that ecological status was not primarilly influenced by exposure to the surfactant (Figure 2).

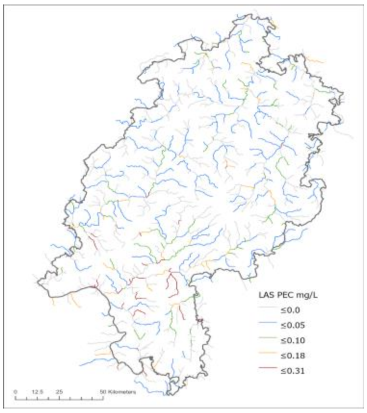

Figure 1: Distribution of surfactant PECs in Hessen rivers.

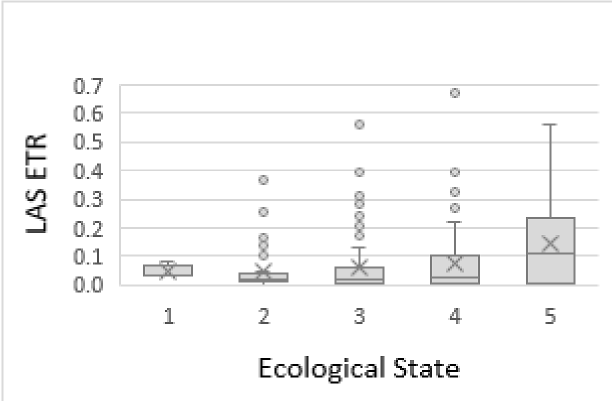

Figure 2: Ecological state and max fish chronic ETR.

3.2. PPP study

Risks to macroinvertebrates and fish were generally higher than to macrophytes and algae indicating relatively greater influence from the insecticide than from the fungicide and herbicide. However, there were no trends in PPP acute or chronic maximum ETR values and ecological status indicating that ecological status was not primarilly influenced by exposure to the 3 PPP chemicals (Figure 3).

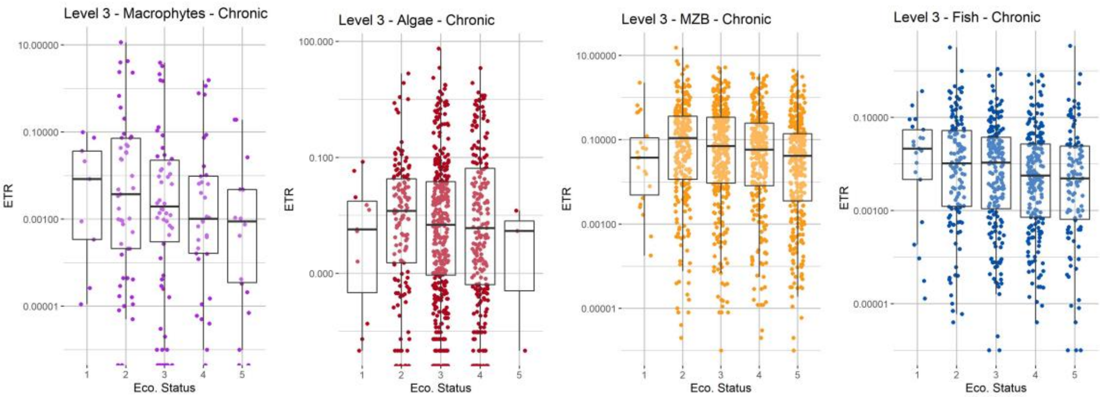

Figure 3: Chronic ETR v ecological status derived from the same taxonomic group

4. Conclusions

Our case studies demonstrated that ERA can be informed by using geospatial approaches to identify locations where species assemblages may be at relatively higher risk. However, there are few ecological data sets that are sufficiently comprehensive, consistent, locationally-specific and that span large geographic areas, e.g. pan-European, for use in risk assessment. The WFD biomonitoring of diatoms, macrophytes, benthic macroinvertebrates, fish is a useful and available European data set for freshwater ecosystems representing a broad range of structural and functional traits useful for chemical ERA.

Greater realism in assessing chemical effects could be achieved if environmental typologies and their constituent biological communities were mapped and described. Developing scenarios could provide an intermediate level of resolution between current regulatory frameworks and site-specific assessments and could form the basis for achieving a pragmatic approach to framing assessments of individual chemicals. Framing of landscape-scale risk assessment is a critical step that requires clear statement of the question to be addressed and must consider data handling, e.g. aggregation, required resolution, methods for integrating data layers.

5. References

[1] Julius Kühn Institute (JKI), Kleinmachnow , Germany. Strassemeyer J. https://www.julius-kuehn.de/

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