Heterogeneity in Biological Assemblages and Exposure in Chemical Risk Assessment: Exploring Capabilities and Challenges in Methodology with Landscape-Scale Case Studies

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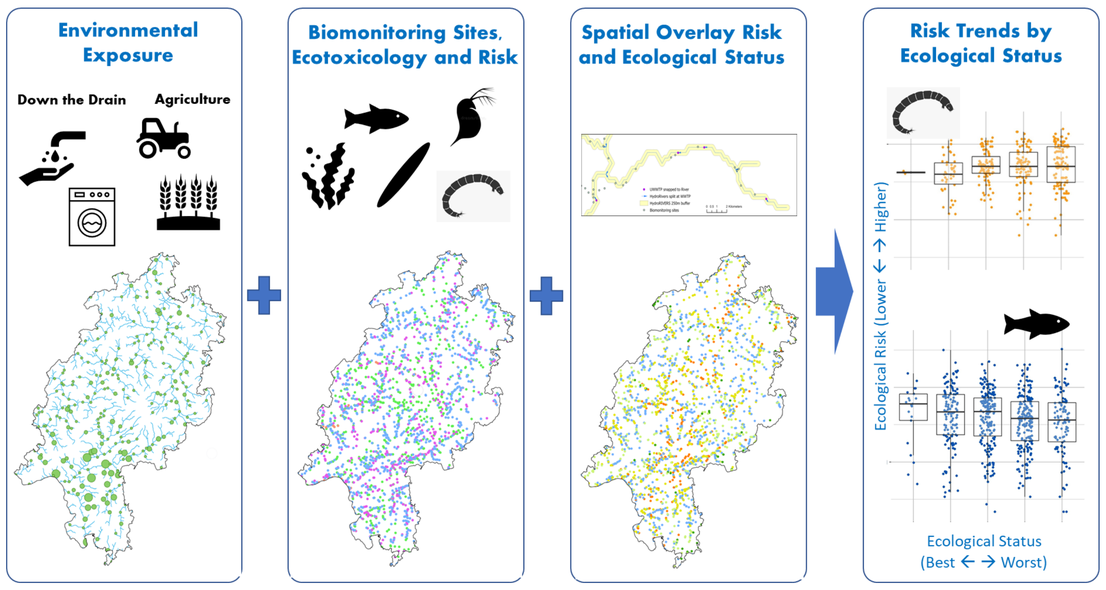


Introduction

The prospective risk assessment of chemicals across all regulatory jurisdictions follows a generic approach, comparing estimated exposures to toxic thresholds designed to be protective of all species. This approach does not directly recognise geographic patterns of species distributions or acknowledge that particularly sensitive species may not occupy potentially exposed habitats.

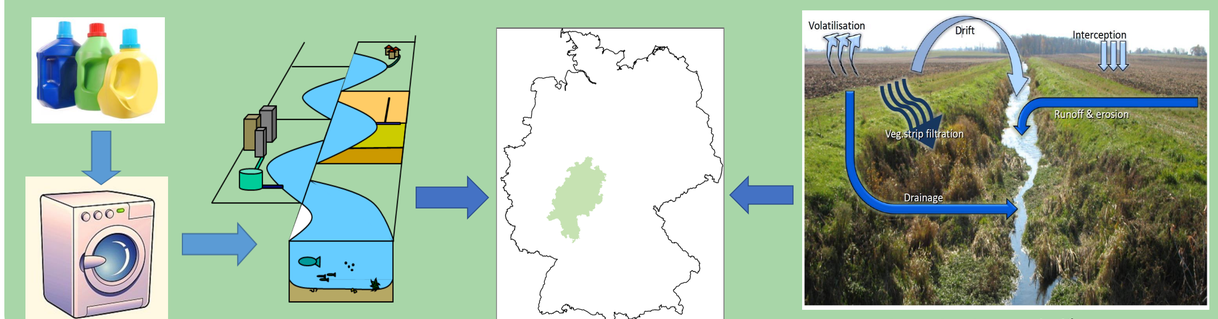
Our ECETOC Task Force investigated current capabilities in making spatially explicit chemical risk assessment (from both an exposure and effects perspective). We investigated techniques and methods for combining disparate data sets using case studies and identified some of the challenges of using different levels of taxonomic, spatial and temporal resolution in spatially explicit risk assessments. Our focus was on exploring methodology, not on providing definitive risk assessment outcomes.

Case studies

Two “proof of principle” studies were investigated in Hessen, Germany with biomonitoring data from almost 4000 locations

Exposure of freshwaters to a surfactant used in domestic cleaning products

The aggregate risk of three Plant Protection Products (PPPs) (herbicide, insecticide and fungicide) used on three crops

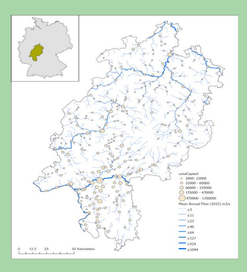


SYNOPS model[1]

PEC estimation

Surfactant

Spatial distribution of WWTPs and river network



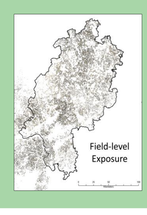
$$PEC = \frac{Conc_{influent} * (1 - Removalsurfactant)}{(River\ Flow + WWTP\ Flow) / (River\ Flow)}$$

$$Conc_{influent} = \frac{per\ capita\ surfactant\ usage}{per\ capita\ water\ usage}$$

PPP

SYNOPS model[1]
134,183 applications
81,822 fields
18,142 streams

Aquatic PECs within 300m of field & up to 1000 m upstream



Ecological receptors

Water Framework Directive ecological monitoring data for fish, diatoms, macrophytes and macroinvertebrates were kindly provided by Federal State of Hessen[2]. Attributes for the 3970 sites used in this analysis included location, abundance, evaluation of ecological state, as well as other scoring values.

Risk: Exposure Toxicity Ratios (ETR)

Surfactant

Annual mean PEC
Acute EC50 fish ; *Daphnia*

Annual mean PEC
Chronic NOEC fish; *Daphnia*; algae; *Lemna*

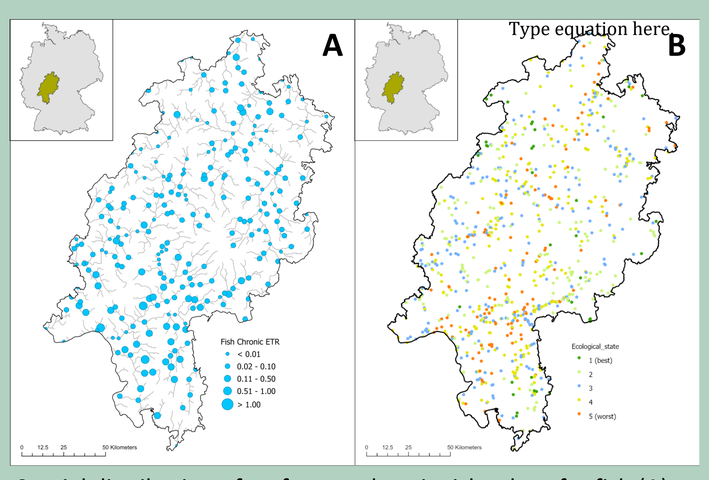
Plant Protection Products

90th %ile daily PEC
Acute EC50 fish; Daphnia

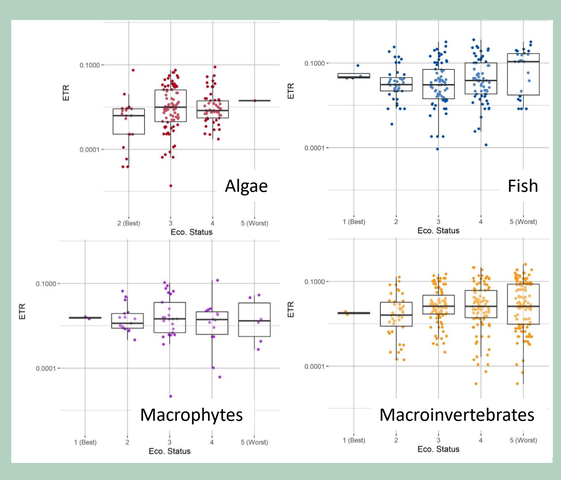
7d-TWA PEC
Chronic NOEC fish; Daphnia; algae; lemna

Chemical risk v ecological status

Surfactant



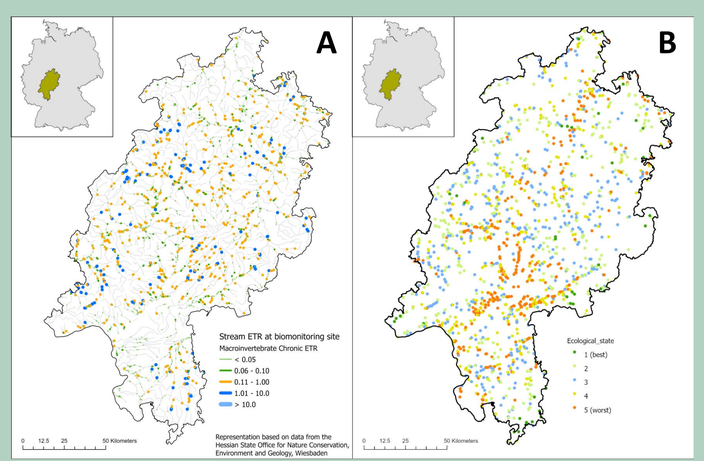
Spatial distribution of surfactant chronic risk values for fish (A) and fish ecological status of biomonitoring locations (B)



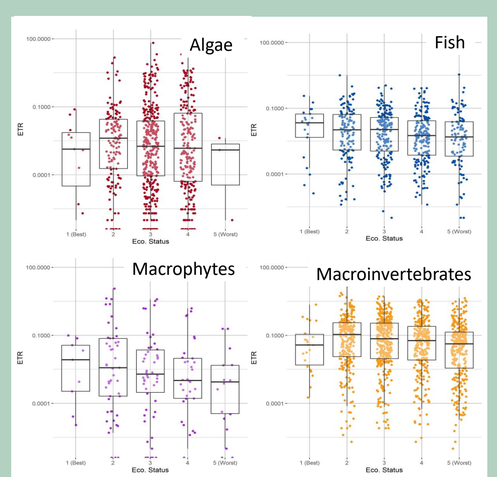
Surfactant chronic ETR v ecological status derived from the same taxonomic group

- Fish have higher ETR values due to higher sensitivity to surfactant
- No relationship between chronic ETR and ecological status for any biological quality element (BQE) was observed
- Evaluated chronic risk based on constant emissions from WWTP
- All eco monitoring locations had acute ETR < 0.1

Plant Protection Products



Spatial distribution of PPP chronic risk values for macroinvertebrates (A) and ecological status of spatially associated biomonitoring locations (B)



PPP chronic ETR v ecological status derived from the same taxonomic group

- Algal risk values related to herbicide sensitivity
- Macroinvertebrate risk values due to insecticide sensitivity
- No relationship observed between acute or chronic risk and ecological status for any of the Water Framework Directive BQEs

Thanks to Inka Marie Spyridonov (BASF SF) for help with results visualization

Conclusions

- Capability for geo-referenced analyses of relationships between ecological status and chemical risk at large spatial scales.
- Case studies demonstrated that ecological risk assessment and any subsequent remediation or conservation measures can be informed by using GIS approaches to identify locations where aquatic species assemblages may be at relatively higher risk.
- 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.
- There are few ecological data sets that are sufficiently comprehensive, consistent and that span large geographic areas, e.g., EU-wide, for use in risk assessment.
- The range of species with measured ecotoxicity data will always be limited and therefore needs assumptions about chemical sensitivity when extrapolating to in-field ecological data sets.

An Open Source publication of this work is available at:

https://doi.org/10.1016/j.ecoenv.2022.114143

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References

1. Strassemeyer, J., Daehmlow, D., Dominic, A.R., Lorenz, S., Golla, B., 2017. SYNOPSWEB, an online tool for environmental risk assessment to evaluate pesticide strategies on field level. Crop Prot. 97, 28–44. https://doi.org/10.1016/j.cropro.2016.11.036
2. Hessian State Office for Nature Conservation, Environment and Geology, Wiesbaden, Germany (Biologie der Fliessgewässer)

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