

Cumulative Risks of Pesticides for Invertebrates in Agricultural Soils

Judith Klein¹, Karlheinz Weinfurter¹, Fabian Essfeld¹, Cecilia Diaz¹, Bernd Gökener¹, Udo Hommen¹, Michael Hüben¹, Benedikt Ringbeck¹, Marie Winter¹, Dimitrios Skodras¹, Nina Lohmann², Kai Thomas³, Daniela Gildemeister⁴, Lisa Noll⁴, Ricardo Schöps⁴, Pia Kotschik⁴

¹ Fraunhofer Institute for Molecular Biology and Applied Ecology (IME), Schmallenberg, Germany

² Eurofins GfA Lab Service, Germany

³ RLP AgroScience, Institute for Agroecology, Germany

⁴ German Environment Agency, Dessau, Germany

Introduction and Study Objective

Agricultural soils are exposed to complex mixtures of plant protection products (PPPs) and biocides (see poster Tu150). However, current regulatory frameworks assess single substances and do not acknowledge multiple occurrence of chemicals in the environment.

Aim: To assess cumulative ecological risks of chemical mixtures in German agricultural soils using risk indicators (RI) derived from measured concentrations of PPPs and biocides.

Sampling and chemical analysis

- See Poster TU 151
- 110 sites across Germany, sampled 2022 – 2024
- 4 land use types: arable land (60), grassland (30), orchards (10) and vineyards (10)
- 2 soil layers (0–5 cm and 5–20 cm)
- Here focus on pesticidal active substances: plant protection products (PPP) and biocides

Results - Plant Protection Products

- RI > 1 were found in ca. 25 % of arable sites and 20 % of orchards and vineyards
- RI was dominated by single substances (on average 65 % of the RI due to single RQ)
- The cumulative risk is usually driven by fungicides, especially epiconazole, boscalid, dimoxystrobin, and tebuconazole
- Insecticides and herbicides were usually less relevant for the overall risk except clothianidin, diflufenician, and (in one site) terbuthylazine
- In grassland, the RI of 90 % of the sites was very low (< 0.01), representing the low use of pesticides here. In just one site, the RI was > 0.1 (0.12)

Calculation of Risk Quotients and Risk Indicators

Risk Quotient (RQ) calculated as measured concentration / regulatory threshold

- PPPs: Use of Regulatory Acceptable Concentrations (RAC) for soil invertebrates from EFSA conclusions and additional info: Lowest NOEC for earthworms, springtails and mites divided by an assessment factor of 5 for the in-field situation
- Biocides: Use of Predicted No Effect Concentrations (PNEC) from ECHA dossiers considering also microbes and plants and an assessment factor of 10

Risk Indicator (RI) calculated assuming concentration addition: $RI = \sum RQ_i$ per sample

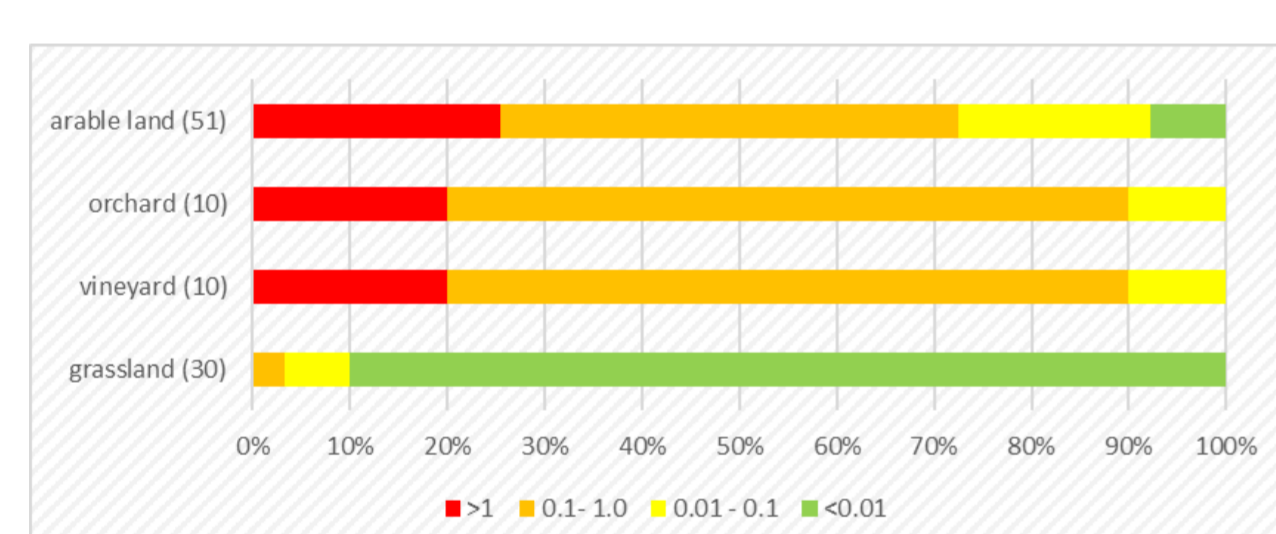
Separate RIs calculated for PPPs (using RAC) and biocides (using PNEC)

Interpretation: RQ or RI > 1 indicate exceedance of regulatory acceptable levels for single substance respectively mixture

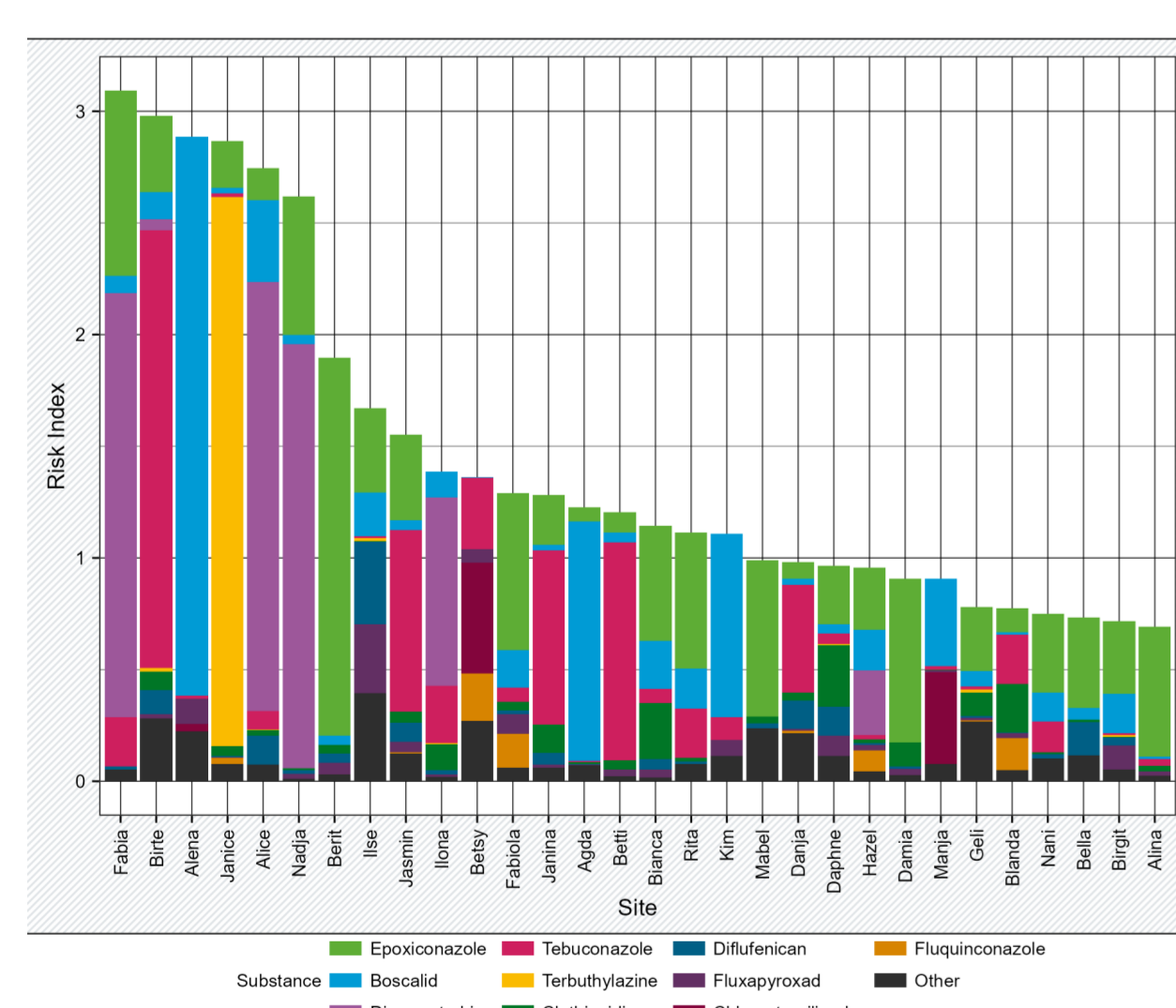
Results - Biocides

- Overall RIs were higher compared to PPPs (max. ca. 20) since PNECs for biocides are lower than RACs for PPP which allow temporary effects in-field
- For 22 % of the arable sites and 20 % of the orchards and vineyards, the RI was above 1
- The neonicotinoid clothianidin was the dominant contributor among biocidal substances, but it was also used as PPP
- RI for 80 % of grassland were < 0.01

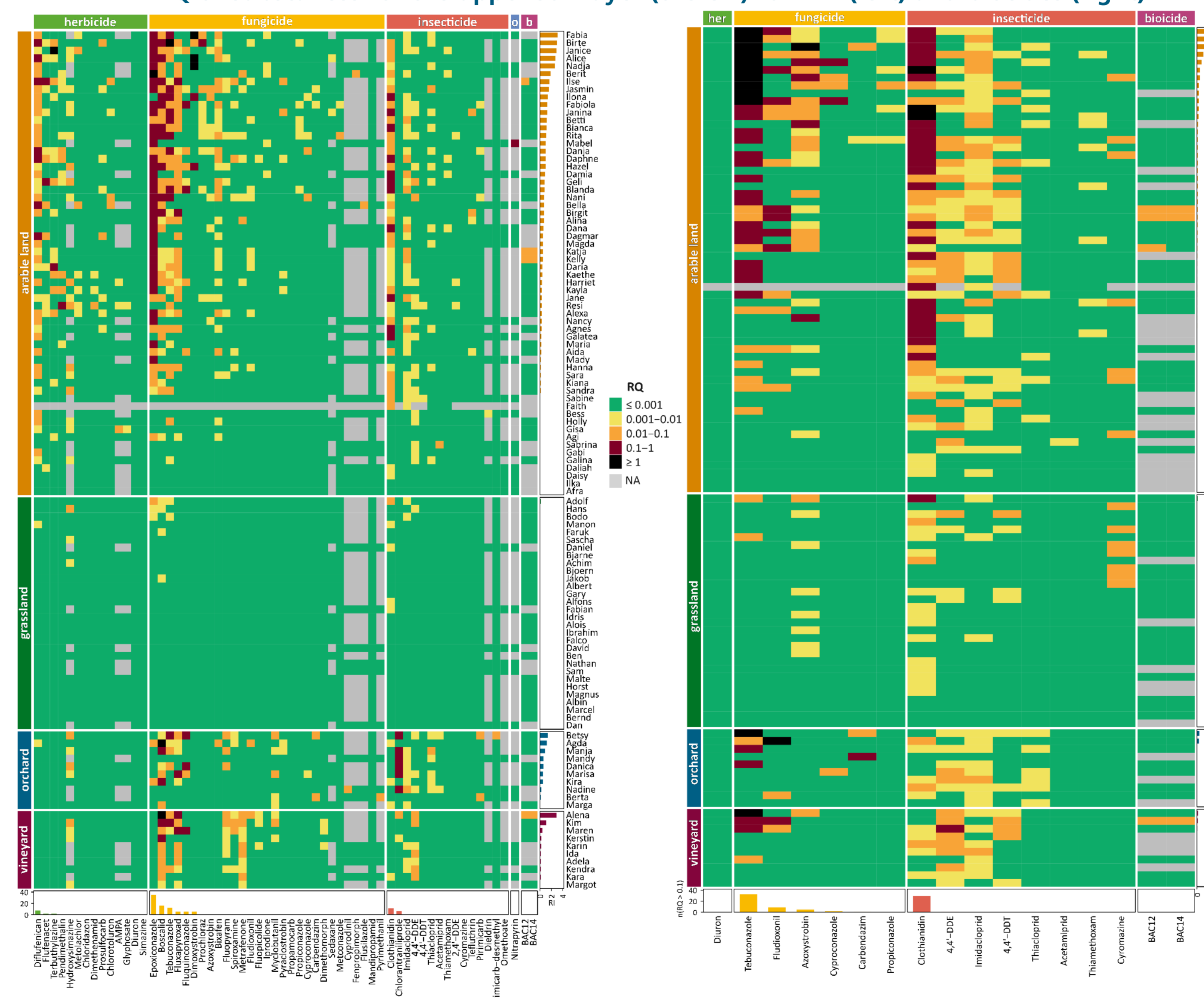
Distribution of the RI for PPP across land use types for upper soil layer (0–5 cm)



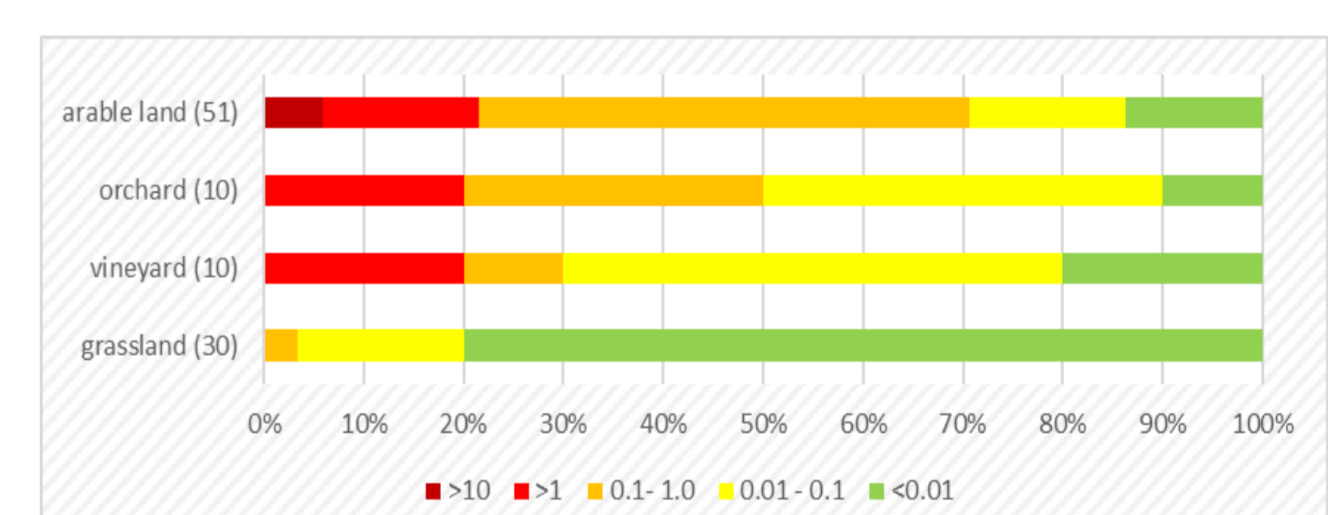
Ranking of sites by RI for PPP (top 30) based on concentrations in 0–5 cm



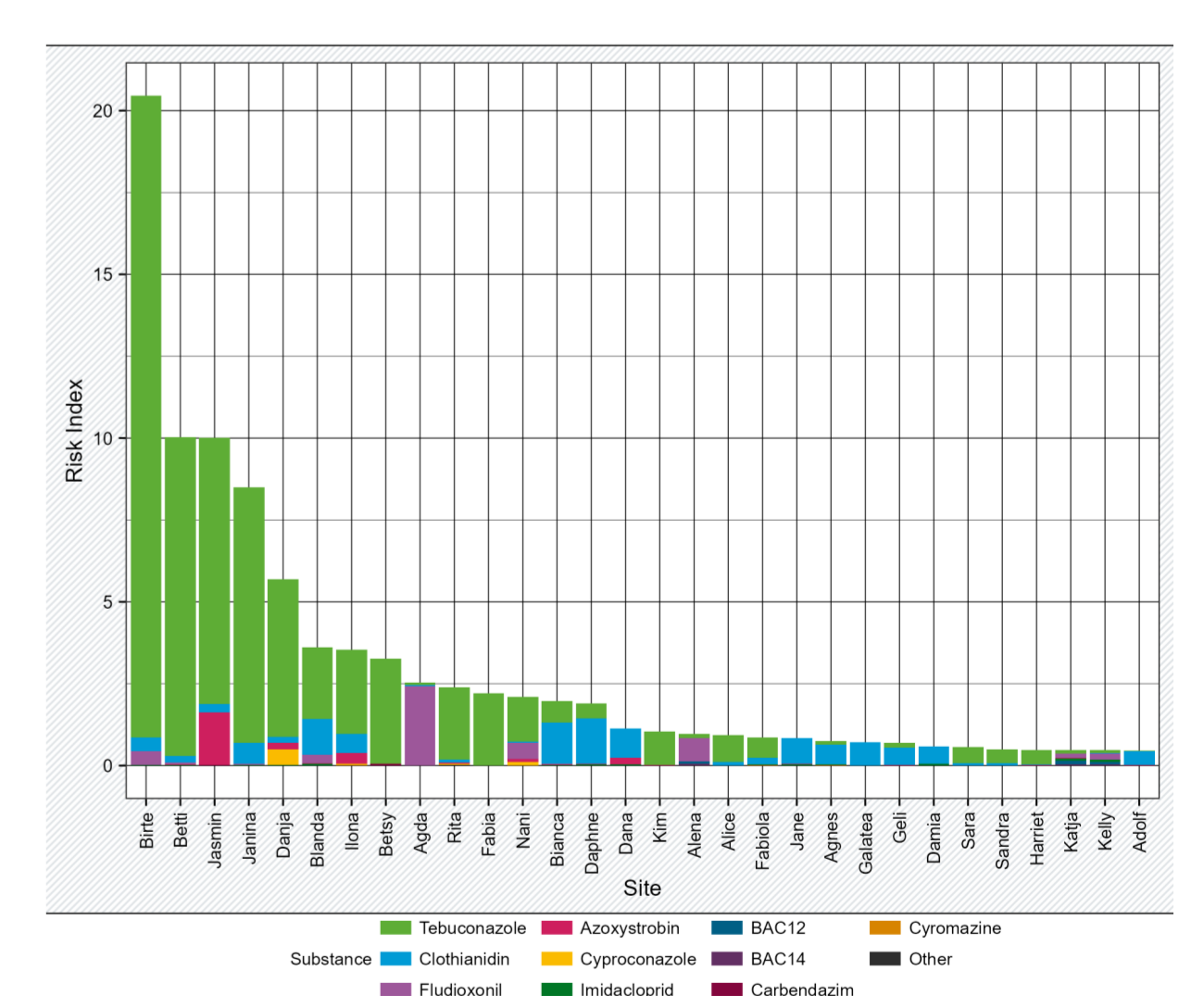
RQ of substances for the upper soil layer (0–5 cm) for PPP (left) and biocides (right)



Percentage of RI for biocides across the four land use types in the upper soil (0–5 cm)



Ranking of sites by RI for biocides (top 30) based on concentrations in 0–5 cm



Discussion

- RI depends on analytical coverage – non-analysed substances lead to underestimation
- Maximum concentrations (i.e. directly after application) cannot be determined
- Concentration addition ignores potential synergistic or antagonistic interactions but is often recommended as a conservative approach to assess mixture toxicity
- RI for PPP below 1 do not imply absence of any effects in-field since PPP are intentionally used. Thus, temporary effects on non-target organisms are accepted

Conclusion

- Monitoring-based RI complements regulatory risk assessment by better capturing real-world cumulative pressure: was
- In ca. 24 % of sites treated with PPP, the RI for PPP > 1 was usually dominated by single substances
- RI for biocides in-field are less meaningful since many substances are intentionally applied as PPP
- Integration of mixture indicators like RI can support soil protection, prioritisation of sites and substances, and future monitoring strategies

Contact:

Dr. Udo Hommen
Fraunhofer IME
Phone: +49 2972 302 255
Mail: udo.hommen@ime.fraunhofer.de

Funding:

This project was funded by Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety and supervised by the German Environment Agency (FKZ 3720 63 4020)



Download
Poster: