Using modelling approaches to transfer results of groundwater monitoring studies to other regions of interest

Nils Kehrein [1], Simon Mayer [2], and Robin Sur [2]

[1] knoell Germany GmbH | Crop Protection | Germany | Contact: **nkehrein@knoell.com**

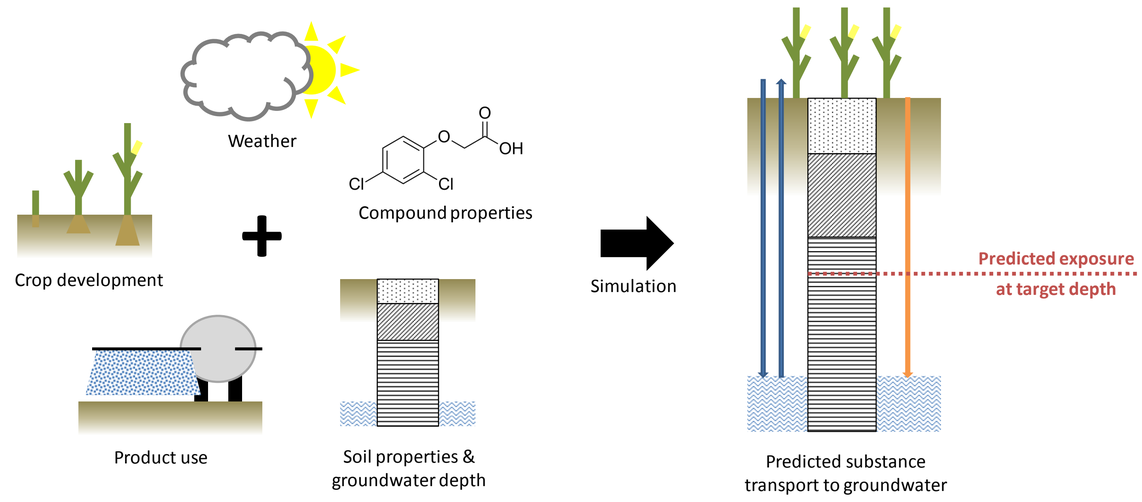
[2] Bayer AG | Crop Science Division | Germany

Introduction

Groundwater monitoring is part of the European risk assessment scheme for the (re-)authorisation of plant protection products. Monitoring is often complex, labour intensive, and usually requires several years of sample collection. The number of monitoring sites within a study is limited by the associated costs and required effort to ensure high study quality. It is therefore often necessary to focus monitoring on the main regions of product use. Spatial exposure modelling approaches can be employed to set results of monitoring studies into context and to compare them with other regions which are not covered by monitoring [1]. The concept of specific groundwater vulnerability was applied to rank and compare regions based on the likelihood of substance occurrence in leachate from the root zone. It took into account local environmental factors, such as soil and weather, as well as the properties of the evaluated substances.

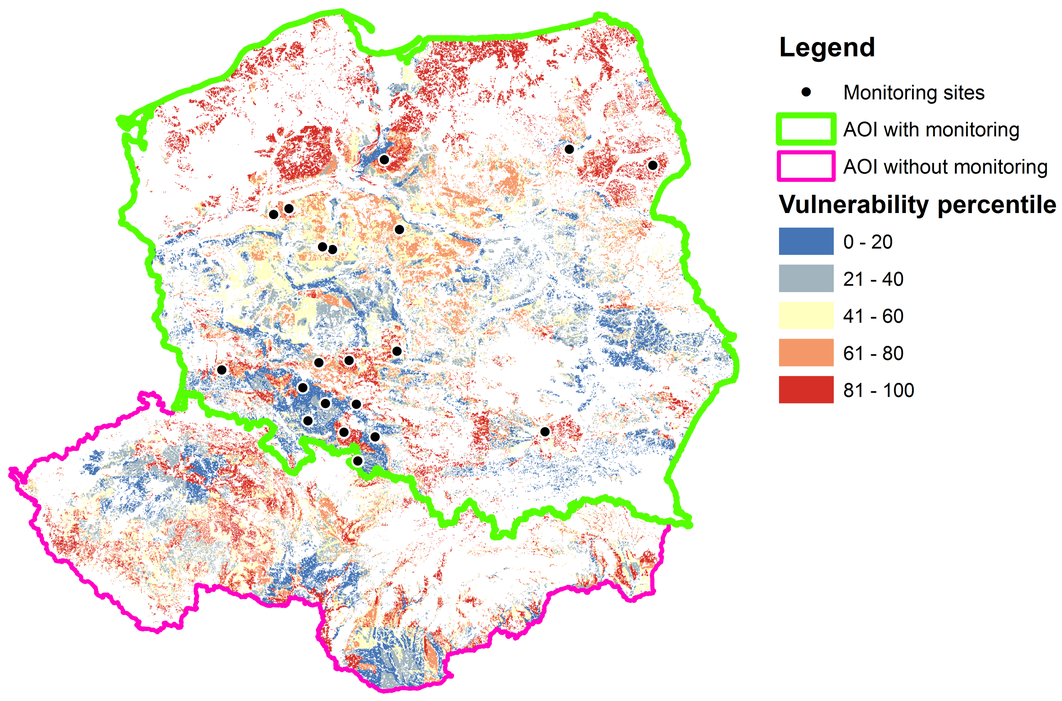
Method

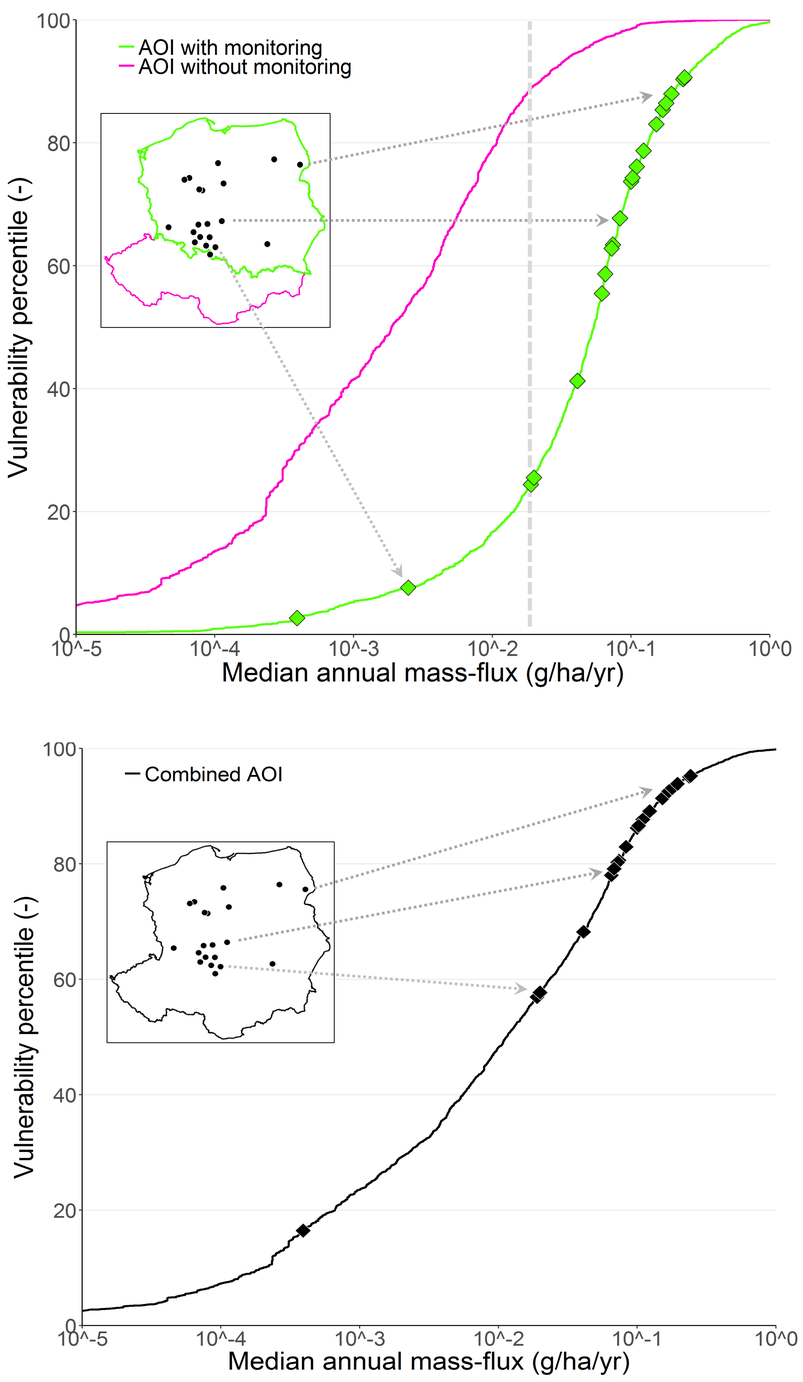
- Groundwater vulnerability was derived from exposure estimates of the process-based model PEARL 4 [2] using spatially explicit datasets of land use, weather time series, groundwater table depth, and soil properties
- Exposure estimates were calculated for all locations within the evaluated Area Of Interest (AOI); the displayed AOI represents the potential use area of a dummy plant protection product in Maize in Central Europe
- Specific groundwater vulnerability is determined by the pedo-climatic conditions occurring in the AOI and represents the risk of the dummy compound to leach to groundwater
- Vulnerabilities of hypothetical monitoring sites were compared to the rest of the AOI by their substance specific vulnerability; it was assumed that the spatial datasets properly reflected conditions at the monitoring sites



Results and discussion

- About 18,000 scenarios with unique environmental conditions were simulated
- The approach is consistent with the lower tiers of the European groundwater risk assessment scheme [3] as the risk is based on predicted exposure levels, which in turn are based on the environmental conditions appearing in the assessed area
  - Vulnerabilities occurring in a certain area can be set into context with conditions where safe use of a product was demonstrated by groundwater monitoring
- Simulations results were compiled to vulnerability maps which depict the specific vulnerability of a location to the dummy compound leaching to groundwater
  - Evaluated independently, both AOIs exhibited the full range of vulnerabilities but showed different magnitudes of exposure
  - The evaluated monitoring sites focused on regions with high crop density and included areas of low and high vulnerability
  - Large areas in the north of the green AOI were very vulnerable but were mostly irrelevant in terms of crop density





Comparison of the individual AOIs

- Vulnerabilities and their contribution to the evaluated surface area were depicted as cumulative distribution functions of the exposure estimate, i.e. median annual mass-flux at one metre depth
- Farming conditions are more vulnerable in the green AOI with monitoring sites with respect to the evaluated compound, crop, and application pattern
- A monitoring site of the 25th percentile in the green AOI reflected conditions of the 90th percentile in the pink AOI, i.e. the risk was higher than on 90% of the crop area in the pink AOI
- The monitoring sites cover a wide range of pedo-climatic conditions within the green AOI with a focus on areas of elevated vulnerability

Evaluation of the total AOI

- Combining the results of both AOI, conditions at the monitoring sites were set into context to the total evaluated area
- The monitoring sites became more vulnerable relative to the total AOI and moved up the distribution curve
- In this context, pedo-climatic conditions at the monitoring sites are focused on areas of very high vulnerability; many sites are located above the 90th vulnerability percentile
- Conditions in the total AOI are therefore sufficiently represented by the monitoring sites as they comprehensively cover areas which exhibit high risk to groundwater

Conclusions

- Vulnerability analyses based on predicted groundwater exposure provide a consistent framework to set results of monitoring campaigns into context
- It provides quantitative means to transfer results of groundwater monitoring studies to other regions of interest
- The approach enables efficient use of existing monitoring data and is consistent with the existing European risk assessment scheme
- In most cases, selecting monitoring sites will involve a trade-off between locations of high vulnerability, high crop density, and actual product use
- Vulnerability maps require carful analysis and interpretation
- It has to be ensured that the assumptions of the spatial modelling line up with actual conditions at the monitoring sites in terms of soil properties etc.

Remaining challenges

- High computational effort required to simulate all occurring combinations of input parameters
- Availability and quality of spatial datasets used as modelling inputs are diverse
- Identification and selection of the AOI requires careful consideration
- Preferential flow is generally not considered due to uncertainties and unavailability of associated soil parameters

References

[1] Gimsing et al., 2019: Conducting Groundwater monitoring studies in Europe for pesticide active substances and their metabolites. doi:10.1007/s00003-019-01211-x

[2] Leistra M. et al., 2001: PEARL model for pesticide behaviour and emissions in soil-plant systems. Alterra-rapport 013. RIVM Report 711401009; RIVM Bilthoven.

[3] European Commission, 2014: Assessing Potential for Movement of Active Substances and their Metabolites to Ground Water in the EU. Sanco/13144/2010 version 3