Sulfamethoxazole in the Vecht catchment: An application of the GREAT-ER model to assess antibiotic concentrations in whole river catchments

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Motivation

- Pharmaceuticals (i.e. antibiotics) are widely detected in the aquatic environment [1]
- Project MEDUWA (MEDicines Unwanted in WAter) aims to reduce pharmaceutical emissions into the aquatic environment
- Sewage treatment plants (STP) identified as one of the major exposure routes for pharmaceuticals into the environment [2]

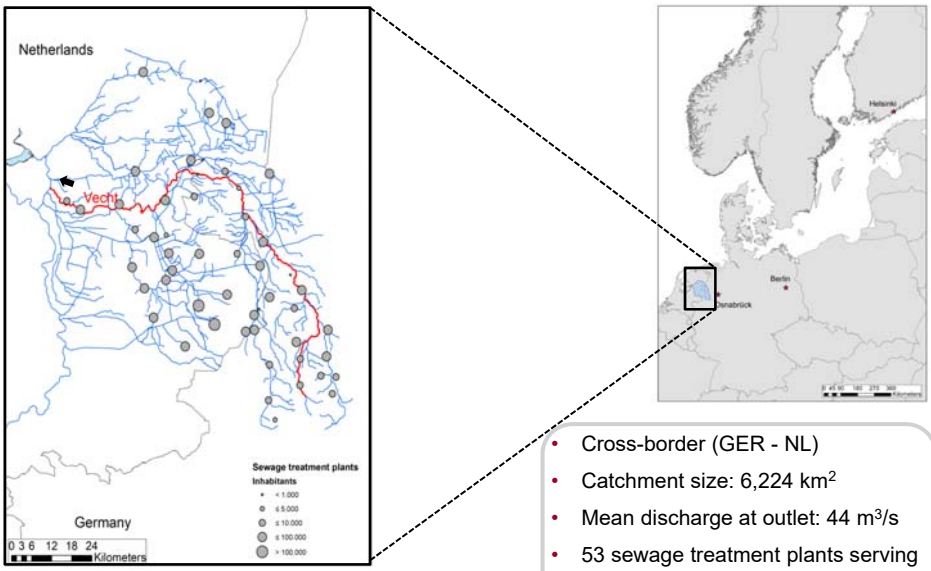
- Sulfamethoxazole (SMX) classified as one of the antibiotics of particular concern in aquatic environments [3]
- Lowest target value for SMX from literature: 100 ng/L [4]
- BUT: Limit of quantification (LOQ) for SMX in the MEDUWA project: 130 ng/L

⇨ Model simulations to close the information gap

Objectives

1. Prediction of spatially explicit concentrations of SMX in the Vecht catchment with the GREAT-ER model
2. Determine risk characterisation ratios (RCR) to frame the risk
3. Demonstrate that GREAT-ER is an appropriate tool for *a priori* evaluation of management scenarios

Vecht catchment



- Cross-border (GER - NL)
- Catchment size: 6,224 km^2
- Mean discharge at outlet: 44 m^3/s
- 53 sewage treatment plants serving 1.2 million inhabitants

The model

GREAT-ER

- Geography-referenced regional exposure assessment tool for European rivers
- Development started in 1997 for ‘down-the-drain-chemicals‘ [5,6]
- Successfully applied for pharmaceuticals: e.g. β-blocker in Glatt valley, Switzerland; Diclofenac in Ruhr basin [7,6]
- Geo-information system (GIS) application
- Steady state, mass balance model

Simulation

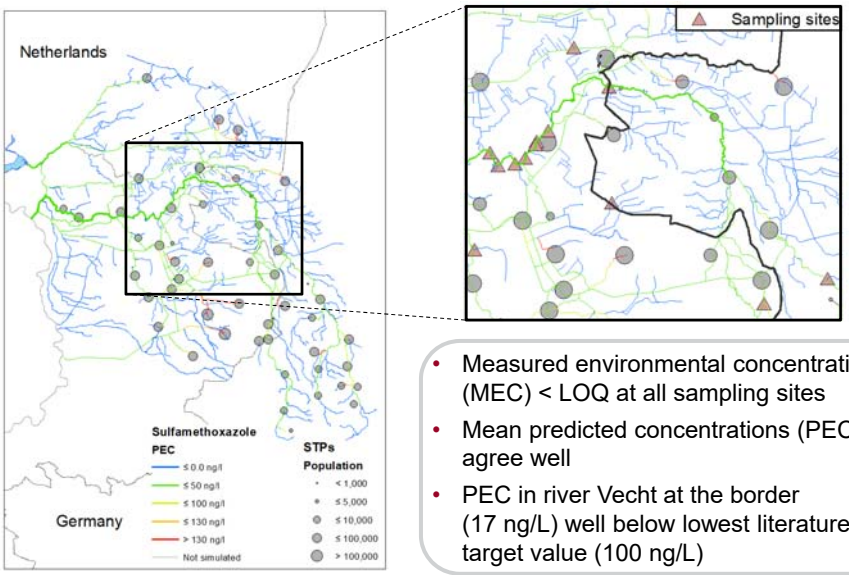
Monte-Carlo approach:

- 10,000 deterministic simulations
- Parameters for each run from defined probability distribution representing natural variability (e.g. discharge) and/or parameter uncertainty

Model parameters:

- National per capita (hospital per patient) consumption (NL, GER)
- Excretion rate
- Sewage treatment plant removal efficiencies
- Degradation (photolysis) rate

Results



- Measured environmental concentration (MEC) < LOQ at all sampling sites
- Mean predicted concentrations (PEC) agree well
- PEC in river Vecht at the border (17 ng/L) well below lowest literature target value (100 ng/L)

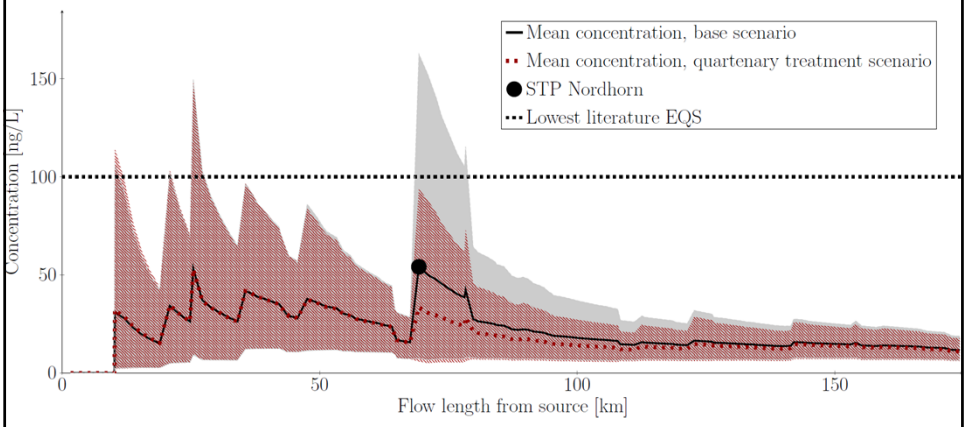
Results – Risk assessment

		Min. EQS	$PNEC_{ecotox}$ [8]	$PNEC_{resistance}$ [9]
PEC Mean	Max. RCR [a]	6.68	1.13	0.01
	Target value exceedance [km] [b]	69 (7.11%)	1 (0.10%)	0 (0.00%)
PEC 95th percentile	Max. RCR [a]	18.98	3.22	0.12
	Target value exceedance [km] [b]	206 (21.23%)	10 (1.03%)	0 (0.00%)

[a] RCR = PEC/EQS or PEC/PNEC
RCR = Risk Characterisation Ratio, PEC = Predicted Environmental Concentration, EQS = Environmental Qulality Standard, PNEC = Predicted No Effect Concentration

[b] Cumulated flow length where the target value is exceeded; percentages apply for the contaminated flow length

Results – Measures



Shaded area spans the range of 5th and 95th percentile of base scenario (grey) and quartenary treatment scenario (red)

Conclusion

GREAT-ER is a valuable tool to

- characterize the risk of the antibiotic Sulfamethoxazole in a whole river catchment
- identify important emission sources
- evaluate different mitigation measures

Outlook

- Summer scenarios
  → water in the Netherlands is pumped via canals into different tributaries
- Simulations for other pharmaceuticals (e.g. Carbamazepine, macrolides)
- Simulations for (multiresistant) E. coli
- Evaluation by comparison with data from monitoring campaign

References & Acknowledgements

References

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Removal efficiencies obtained by the project *Removal efficiencies of micropollutants at STP in the region Rijn-Oost*