GEO-REFERENCED MODELING OF ZINC IN THE RUHR RIVER BASIN EMISSIONS AND IMMISSION

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Abstract

We applied the georeferenced model GREAT-ER (Geo-referenced Regional Exposure Assessment Tool for European Rivers) to simulate spatially explicit zinc concentrations in the Ruhr river basin. For each emission pathway from point sources (household, industry, urban runoff) and non-point sources (agriculture, natural background) zinc loads were independently estimated from correlations with identified reference parameters (number of inhabitants, surface area drained, agricultural area, zinc ore regions) or from existing data and information (industry emissions). Simulated concentrations showed good agreement with monitoring data. The model explicitly links emission (loads) to the observed immission (concentrations on the local and regional scale) and thus allows for evaluating the relative importance of emission sources. For the Ruhr catchment a regionally characteristic large impact of natural and historical zinc loads is shown that is due to the fact that some regions in the river basin are relatively rich in zinc ore that has been exploited over a long period.

Introduction

- European Water Framework Directive demands a good ecological and chemical state of surface waters implying adequate concentrations of heavy metals [1].
- Zinc is an ubiquitous heavy metal which in too high doses may exhibit adverse health effects. It is used in many products such as cosmetics, roofs, gutters, tires, brakes, paving or pipes.
- Zinc emissions to the environment occur from manufacturing or application of these products, but also from other sources such as agriculture [2]. Emissions may enter surface waters via different pathways (sewer system, WWTP, surface runoff, infiltration).
- The geo-referenced software tool GREAT-ER [3] creates a direct link between the several emission sources and the immission observed in surface waters to enable identification of important sources.

Materials & Methods

- Identification of important emission sources
- Geo-referenced quantification of average loads
- Simulation of spatially explicit mean concentrations with GREAT-ER [3]
- Comparison of results with monitoring data

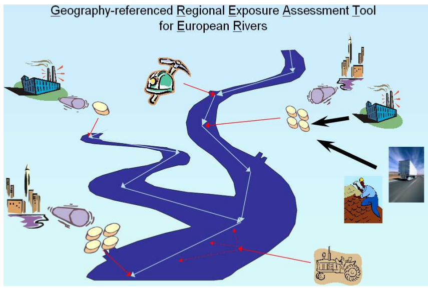

Fig. 1: GREAT-ER flow chart with extended input pathways

GREAT-ER Model assumptions

- River system is subdivided into single river reaches of a maximum length of 2 km.
- Concentration of each river reach is calculated assuming steady-state conditions (Fig. 1).
- GREAT-ER was expanded to consider the following emission pathways.
  - ➢point sources (WWTP effluent collecting roof and street runoff, domestic wastewater and industrial indirect emissions, direct emissions)
  - ➢non-point sources (e.g. runoff from agriculture, groundwater infiltration)
- Emitted loads are calculated based on spatially resolved data such as total roof area drained to WWTP.
- Temporal variations of input parameters (e.g. discharge) are considered by probabilistic simulations applying distribution functions for certain parameters.

Results & Discussions

Simulated mean concentrations are displayed as color-coded maps (Figure 2). Categories represent concentration ranges with increasing values from light blue to red. This allows for easy identification of local "hot spots".

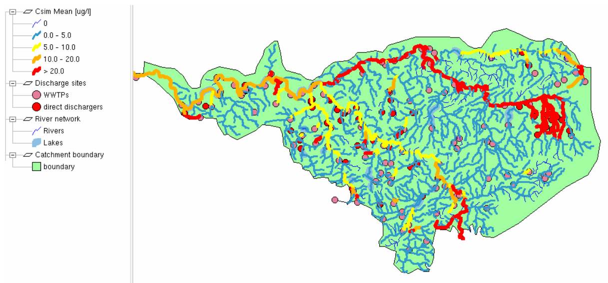

Fig. 2: GREAT-ER simulation results for average concentrations

1. Upstream parts of Ruhr River (including some small headwaters) and the largest tributary Lenne River are strongly affected by emissions from former mining activities exhibiting highest zinc concentrations in the catchment.
2. Simulated concentration profiles agree well with monitoring data from the Ruhrverband (Figure 3).

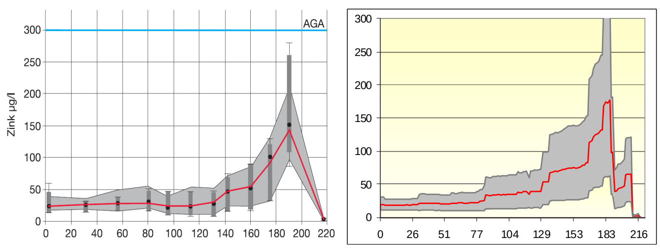

Fig. 3: Zinc concentration profiles in the Ruhr river: monitoring data for 2005 (left) [4] and simulated values (right)
Red line – mean values, grey areas 10th and 90th percentile

3. GREAT-ER provides higher spatial resolution compared to monitoring. Step-wise increase and dilution of concentrations can be clearly identified (Fig. 3).
4. Scenario analyses considering only one single emission pathway or source allows for relative evaluation of their importance. Figure 4 points out the high impact of emissions from mining activities (4a) compared to domestic wastewater (4b).

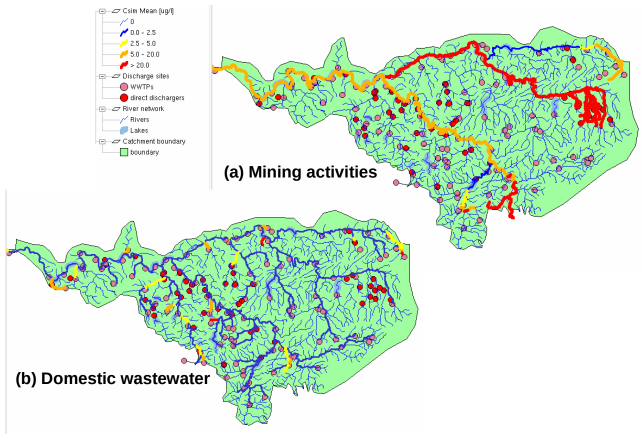

Fig. 4: Comparison of two emission sources

Conclusions / Outlook

- GREAT-ER simulation results yield reasonable zinc concentrations which agree well with monitoring data.
- A direct link between emission and immission is established that allows for identification of important sources and appropriate reduction strategies.

Literature:

[1] Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy (EU Water Framework Directive).

[2] T. Hillenbrand, D. Toussaint, E. Böhm, S. Fuchs, U. Scherer, A. Rudolphi, M. Hoffmann. Report 202 242 20/02. Federal Environment Agency, Berlin, 2005.

[3] M. Matthies, J. Berlekamp, F. Koormann, J.-O. Wagner, Georeferenced Regional Simulation and Aquatic Exposure Assessment, *Wat. Sci. Technol.* 43(7), 231-238, 2001.

[4] Ruhrverband. Ruhrgütebericht 2005, Essen, 2006.

Acknowledgements

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