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European River Basins at Risk

Werner Brack,† Leo Posthuma,‡ Michaela Hein,† and Peter von der Ohe†*

†UFZ Helmholtz-Centre for Environmental Research, Department Effect-Directed Analysis, Permoserstraße 15, D 04318 Leipzig, Germany
‡Laboratory for Ecological Risk Assessment, National Institute for Public Health and the Environment, van Leeuwenhoeklaan 9, 3720 HA Bilthoven, The Netherlands

Sustaining goods and services for human development and wellbeing provided by European freshwater ecosystems are a main objective of European Union environmental policy. These goods and services include, inter alia, the supply with pristine drinking water in sufficient quantities, fish production, nutrient cycling, degradation of wastes and pollutants, flood control, as well as human recreation in natural environments. The European Union Water Framework Directive (EU WFD) and its strong focus on the conservation or restoration of a good ecological status in European rivers is driven by this understanding and demands for integrated scientific views and practical approaches and thus for close collaboration between water managers and scientists from different disciplines.

The conference on Risk Assessment in European River Basins—State of the Art and Future Challenges at the Helmholtz Centre for Environmental Research—UFZ in Leipzig (Germany) in November 2007 was designed to promote this collaboration by bringing together science and stakeholders for a discussion of major risks to European river basins and of concepts to identify, quantify, and assess these risks. This conference was organized within the frame of the European projects MODELKEY (511237-GOCE) and RISKBASE (036938-GOCE). Key contributors to major European projects on risk assessment and water management such as MODELKEY (Brack et al. 2005), AQUATERRA (Barth et al. 2007), NoMiracle (Løkke 2005), ALARM (Settele et al. 2005), and EURO-limpacs (Birol et al. 2006) exchanged their results and shared them with policy makers and water managers.

One of the outcomes of this conference is a series of technical papers published in the January 2009 issue of IEAM addressing the range of discussions at the meeting. This series is opened by a general recommendation paper for management and research (Brack et al. 2009) followed by 2 papers dealing with water quantity issues (Iglesias et al. 2009, Meyer et al. 2009). Subsequently, the focus is shifted to ecological quality starting with 2 overarching papers on uncertainty and multiple impact assessment (Ragas et al. 2009, de Zwart et al. 2009). The following papers provide concepts and approaches to deal with specific stressors in a multiple stress context including toxic pollution (von der Ohe et al. 2009, Altenburger and Greco 2009, Schulz et al. 2009, van Gils et al. 2009), hydromorphology (Friberg et al. 2009, Verdonschot et al. 2009) and invasive species (Panov et al. 2009).

The recommendation paper was drafted by almost 20 scientists and stakeholders who attempted to point the way towards a holistic and risk-based management of European river basins (Brack et al. 2009). Multiple stress situations are predominating and provide a major challenge to water managers. Major stresses include, for example, droughts and floods, hydromorphological changes, eutrophication, invasive species, and anthropogenic pollution. Appropriate tools to identify dominant pressures and to predict multi-stressor effects are limited and among the strategic research needs claimed in this paper.

* To whom correspondence may be addressed: werner.brack@ufz.de

As a result of climate change, water quantity problems are an increasing issue for river basin management. Thus, risk assessment of droughts and floods is increasingly required, particularly since both do not only depend on temporary precipitation deficits or excesses, but to a great degree on management (Iglesias et al. 2009; Meyer et al. 2009). Socioeconomic interaction among different users of water, the spatial distribution of risks, but also uncertainties associated with flood and drought risk assessment, are addressed in these papers.

Uncertainty is a key issue in risk assessment in general, regardless whether we focus on quantitative or on qualitative water problems. In this special series Ragas et al. (2009) provide a systematic overview of the implications of uncertainty for risk-based management of river basins. The authors show how additional scientific results may reduce the uncertainties embedded in the concept and use of environmental quality standards, which may result in significantly reduced costs of management activities, as is illustrated.

In European river basins several key stressors were identified to impact the ecological status, among them agriculture including nutrient load, hydromorphological degradation, the organic load, water chemistry, toxic pollution, and invasive species (CEC 2007; de Zwart et al. 2009; Panov et al. 2009). The examples show that different combinations of stressors play their roles on different spatial scales. Within the last years, promising diagnostic tools for the quantification of local ecosystem impairment and the identification of factors causing these local impacts have been developed and tested for specific river basins, such as the Scheldt basin (de Zwart et al. 2009). The results show significant ecological effects in terms of taxa loss at most study sites as well as highly variable contributions of different stress factor contributions among sites. High losses were found due to nutrients, water chemistry, and organic load. Acute toxic pressure of contaminant mixtures was found to likely cause significant loss of taxa for 35% of the monitoring sites. The high relevance of toxic pressure of mixtures for the loss of sensitive species could be confirmed by von der Ohe et al. (2009) by demonstrating a high correlation between the reduction of SPecies At Risk (SPEAR) and the local contamination levels expressed as toxic units (relative to the toxicity for the water flea, *Daphnia magna*) in the Llobregat river basin (Spain). Moreover, although considering only a very limited number of priority pollutants (currently 41), exposure levels of these compounds in European rivers indicate an insufficient chemical status at more than 90% of the monitoring sites in the 3 river basins Elbe, Scheldt, and Llobregat that were assessed in this study.

Although it is evident that aquatic ecosystems typically experience exposure to mixtures of toxicants, risk management often still focuses on the assessment of individual toxicants. This may result in an underestimation of risks

according to current practices, while validated models for estimating joint effects due to simultaneous exposure to multiple toxicants have been formulated recently (Altenburger and Greco 2009). Nevertheless, scientific and practical gaps remain, like the issue of impacts of pulsed exposure (e.g., to pesticides due to application in agriculture), and joint effects between toxicant mixtures with non-chemical stressors. A geodata-based probabilistic risk assessment of pesticides was presented by Schulz et al. (2009). The main objective of this approach is to base exposure estimation on a realistic representation of local landscape characteristics and on empirical results for the different factors affecting the drift of compounds into surface waters. For the improved risk assessment of toxic pressures on a river basin scale, it is required to improve on the issue of exposure models, to enable establishing spatial relations between pollution sources and ecological risks. An example of such a model was presented by van Gils et al. (2009) setting a specific focus on compounds interacting with fine sediment particles. Geometry, hydrology, and fine sediment dynamics but also bioavailability and bioaccumulation are included in this assessment.

Hydrology and stream morphology do not only play an important role in pollutant transport, but they are also key factors for the composition of freshwater communities and thus for the ecological status of a river (CEC 2007). Two papers in this special series specifically focus on hydromorphological degradation impacting macroinvertebrate assemblage composition (Friberg et al. 2009; Verdonschot et al. 2009). However, in a study based on more than 1000 sites from 3 countries, Friberg et al. (2009) found relatively weak relationships between macroinvertebrate communities and hydromorphological stress. They attributed this finding to 1) the multiple stress situation, 2) the scope of commonly used macroinvertebrate assessment systems that mainly focus on eutrophication and acidification only, and 3) scaling issues. The latter are also in the focus of the second paper dealing with the question "At which scale and to what extent do hydrology and/or morphology along with physico-chemistry explain stream macroinvertebrate distribution?" (Verdonschot et al. 2009).

The potential of aquatic species to invade other river basins has been very much enhanced over the past century. This is a result of the construction of a complex network of inland waterways, connecting previously isolated catchments, and increased international trade. The associated risk of invasive species for the ecological status of European river basins is, however, slowly gaining the awareness of water managers. Panov et al. (2009) now developed risk assessment protocols for invasive alien species, and recommend the application of those protocols as part of the Common Implementation Strategy of the EU WFD.

There is increasing evidence that the holistic EU WFD approach, which consists of a focus on the ecological status in multiply stressed aquatic ecosystems on a basin scale, is preferable as an addition to the more isolated approaches based on single-site evaluations and on evaluations looking at individual pressures. Although it is well acknowledged that managements based on many of the latter approaches yield good improvements, such methods alone are not sufficient. It appeared to be one of the biggest challenges to start unraveling the complicated network of pressures and interactions thereof that cause the insufficient ecological status we often observe. The mitigation of, for example, the apparently dominating pressure, may only result in an unsuccessful recovery when there are limitations posed by other factors immediately underneath the dominant factor—there is always the possibility of a "weakest link" that unexpectedly prevents recovery of the ecological status. Future research is needed to develop tools to identify key stressors and stressor combinations, to derive effective programs of measures, and to predict ecosystem responses to these programs of measures. We hope that the Leipzig conference and this special series give important impulses to 1) further enhance our efforts to gain a better understanding of multiple stress situations in European river basins, 2) use his understanding for practically supporting water management by providing sound and practicable approaches, and 3) help achieve the final policy goals of the sustainable current use of our freshwater resources and ecosystems, while protecting their beauty and their goods and services for the next generations.

REFERENCES

Altenburger R, Greco WR. 2009. Extrapolation concepts for dealing with multiple contamination in environmental risk assessment. *Integr Environ Assess Manag* 5:62–68.

Løkke H. 2005. NoMiracle Newsletter 1. http://nomiracle.jrc.ec.europa.eu/Newsletters/NoMiracle_Newsletter_no_1.pdf. Accessed 23 October 2008.

Barth JAC, Grathwohl P, Jones KC. 2007. Special issue: AquaTerra: Pollutant behavior in the soil, sediment, ground, and surface water system—Introduction. *Environ Pollut* 148:693–694.

Birol E, Karousakis K, Koundouri P. 2006. Using economic valuation techniques to inform water resources management: A survey and critical appraisal of available techniques and an application. *Sci Total Environ* 365:105–122.

Brack W, Bakker J, de Deckere E, Deerenberg C, van Gils J, Hein M, Jurajda P, Kooijman B, Lamoree M, Lek S, López de Alda MJ, Marcomini A, Munoz I, Rattei S, Segner H, Thomas K, von der Ohe PC, Westrich B, de Zwart D, Schmitt-Jansen M. 2005. MODELKEY. Models for assessing and forecasting the impact of environmental key pollutants on freshwater and marine ecosystems and biodiversity. *Environ Sci Pollut Res* 12:252–256.

Brack W, Apitz SE, Borchardt D, Brils J, Cardoso AC, Foekema EM, van Gils J, Jansen S, Harris B, Hein M, Heise S, Hellsten S, de Maagd G-J, Müller D, Panov VE, Posthuma L, Quevauviller P, Verdonschot PFM, von der Ohe PC. 2009. Toward a holistic and risk-based management of European river basins. *Integr Environ Assess Manag* 5:5–10.

[CEC] Commission of the European Communities. 2007. Commission staff working document. Accompanying document to the communication forum from the commission to the European Parliament and the council: "Towards sustainable water management in the European Union". First stage in the implementation of the Water Framework Directive 2000/60/EC. COM (2007) 128 final.

De Zwart D, Posthuma L, Gevrey M, von der Ohe PC, de Deckere E. 2009. Diagnosis of ecosystem impairement in a multiple stress context—How to formulate effective river basin management plans. *Integr Environ Assess Manag* 5:38–49.

Friberg N, Sandin L, Pedersen ML. 2009. Assessing impacts of hydromorphological degradation on macroinvertebrate indicators in rivers: Examples, constraints and outlook. *Integr Environ Assess Manag* 5:86–96.

Iglesias A, Garrote L, Martin-Carrasco F. 2009. Drought risk management in Mediterranean river basins. *Integr Environ Assess Manag* 5:11–16.

Meyer V, Haase D, Scheuer S. 2009. Flood risk assessment in European river basins—Concept, methods, and challenges, exemplified at the Mulde River. *Integr Environ Assess Manag* 5:17–26.

Panov VE, Alexandrov B, Arbačiauskas K, Binimelis R, Copp GH, Grabowski M, Lucy F, Leuven RSEW, Nehring S, Paunovic M, Semenchenko V, Son MO. 2009. Assessing the risks of aquatic species invasions via European inland waterways: From concepts to environmental indicators. *Integr Environ Assess Manag* 5:110–126.

Ragas AMJ, Huijbregts MAJ, Henning-de Jong I, Leuven RSEW. 2009. Uncertainty in environmental risk assessment: Implications for risk-based management of river basins. *Integr Environ Assess Manag* 5:27–37.

Schulz R, Stehle S, Elsaesser D, Matezki S, Müller A, Neumann M, Ohlinger R, Wogram J, Zenker K. 2009. Geodata-based probabilistic risk assessment and management of pesticides in Germany, a conceptual framework. *Integr Environ Assess Manag* 5:69–79.

Settele J, Hammen V, Hulme P, Karlson U, Klotz S, Kotarac M, Kunin W, Marion G, O'Connor M, Petanidou T, Peterson K, Potts S, Pritchard H, Pysek P, Rounsevell M, Spangenberg J, Steffan-Dewenter I, Sykes M, Vighi M, Zobel M, Kuhn I. 2005. ALARM: Assessing large-scale environmental risks for biodiversity with tested methods. *Gaia-Ecological Perspectives for Science and Society* 14:69–72.

van Gils J, van Hattum B, Westrich B. 2009. Exposure modelling on a river basin scale in support to risk assessment for chemicals in European river basins. *Integr Environ Assess Manag* 5:80–85.

Verdonschot PFM. 2009. Impact of hydromorphology and spatial scale on macroinvertebrate assemblage composition in streams. *Integr Environ Assess Manag* 5:97–109.

von der Ohe PC, de Deckere E, Prüß A, Muñoz I, Wolfram G, Villagrasa M, Ginebreda A, Hein M, Brack W. 2009. Towards an integrated assessment of the ecological and chemical status of European river basins. *Integr Environ Assess Manag* 5:50–61.