511237 (GOCE)

MODELKEY

Models for Assessing and Forecasting the Impact of Environmental Key Pollutants on Marine and Freshwater Ecosystems and Biodiversity

Integrated Project in "Sustainable Development, Global Change and Ecosystems"

Publishable Executive Summary

Period covered: from 1st February 2005 to 31st January 2006
Date of preparation: 1st March 2006

Start date of project: 1st February 2005
Duration: 5 years

Werner Brack & Michaela Hein
MODELKEY coordination
UFZ Centre for Environmental Research Leipzig-Halle
Department of Effect-Directed Analysis
Permoserstr. 15
04318 Leipzig
Germany
www.modelkey.org

Publishable executive summary

MODELKEY: **Models** for Assessing and Forecasting the Impact of Environmental **Key** Pollutants on Freshwater and Marine Ecosystems and Biodiversity

Summary of the project

The European Water Framework Directive demands for a good ecological status in European waters. In order to support European water managers to meet this challenging goal MODELKEY is designed to provide modelling and experimental tools for the establishment of reliable cause-effect relationships between chemical pollution and the ecological status and for the assessment of risks to aquatic ecosystem health and biodiversity. This is done by the following two closely interlinked approaches: In a mechanistic and site-specific approach effect-directed analysis of key toxicants is combined with in depth effect and exposure analysis and modelling on the whole range of degrees of biological complexity (from cell to ecosystem) and on the whole range of trophic levels (from attached primary producers (biofilms) to fish community as top predator). In a basin-wide approach tools for exposure, effect, and risk modelling in the three river basins selected as case studies (Elbe (Czech Republic and Germany), Scheldt (France, Belgium and the Netherlands), and Llobregat (Spain)) are developed on the basis of existing monitoring data that are made available in one central MODELKEY database. The site-specific approach provides knowledge rules, key toxicants and measured input data for basin-scale modelling and is designed to allow a strong linkage to models at selected sites. The basin-scale approach helps to select sites of interests and provides basic information for site-specific assessment. For toxicant, risk and hot spots prioritisation and thus for a better river basin management MODELKEY provides an end-user friendly decision support system that integrates, visualises and operationalise MODELKEY results for policy makers and water managers.

The MODELKEY consortium is coordinated by the German Helmholtz-Centre UFZ Centre for Environmental Research in Leipzig. It combines the expertise of 26 partners from 14 European countries including three small or medium sized enterprises and four end-users involved in water management.

Contractors are: UFZ, UA, CEFAS, DELFT, CVR, VUA, CNRS, CSIC, UdG, UB, VRI, IVB, UJOE, ARGE Elbe, RIKZ, RIVO, SZU, RIVM, UoS, SPbU, ACA, UdB, ECT, XEN, DW/OH, NIVA.

1. Introduction

Efficient river basin management requires a reliable scientific knowledge base on driving forces of insufficient ecological status and tools to assess and predict effects and risks on impacted ecosystems including biodiversity. To provide this knowledge the Integrated Project MODELKEY (http://www.MODELKEY.org/) as funded within the 6th Framework Programme of the European Commission (511237 (GOCE)) started in February 2005 within sub-priority 6.3 – Sustainable Development, Global Change and Ecosystems.

2. MODELKEY general objectives

Triggered by the requirement of the European Water Framework Directive for a good ecological status in European rivers till 2015 MODELKEY aims to provide the scientific tools for the identification of toxic effects that are required to meet this challenging goal. Thus, MODELKEY comprises a multidisciplinary approach aimed at developing interlinked and verified diagnostic and predictive modelling tools as well as state-of-the-art effect-assessment and analytical methods generally applicable to European freshwater and marine ecosystems:

- to assess, forecast, and mitigate the risks of traditional and recently evolving pollutants on fresh water and marine ecosystems and their biodiversity at a river basin and adjacent marine environment scale,
- to identify site- and basin-specific key toxicants, which are not necessarily currently monitored “priority pollutants”,
- to provide a better understanding of cause-effect relationships between the impact of environmental pollution as a causative factor and changes in biodiversity and the ecological status, as addressed by the Water Framework Directive (WFD),
- to provide early warning strategies on the basis of sub-lethal effects measured in vitro and in vivo and provide links to effects on community health and biodiversity,
- to provide methods for state-of-the-art risk assessment and decision support systems for the selection of the most efficient management options to prevent adverse effects on biodiversity and to prioritise contamination sources and contaminated sites,
- to strengthen the scientific knowledge on an European level in the field of impact assessment of environmental pollution in aquatic ecosystems and biodiversity by extensive training activities and knowledge dissemination to stakeholders and the scientific community.

3. MODELKEY research approach

MODELKEY combines and interlinks two general approaches towards the establishment of cause-effect relationships and the assessment and prediction of effects and risks to aquatic ecosystems.

A mechanistic site-specific approach focuses on the mechanistic analysis, understanding and modelling of effects and exposure considering different levels of biological complexity as well as different trophic levels. Major issues are effect-directed identification of key toxicants, the assessment and modelling of bioavailability e.g. of sediment-associated toxicants, and effect propagation from a cellular level via biomarker responses in laboratory and field organisms towards effects on biodiversity and community structure. For a better understanding of community effects the impact of toxicants on simplified communities is modelled and simulated in laboratory experiments.

A basin-scale approach focuses on diagnostic and predictive modelling of exposure, effects, and risks in river basins based on monitoring data that are frequently collected by water agencies. Combining stochastic and deterministic elements generic exposure models are developed to predict concentrations in sediments, water, and biota of different trophic levels. Ecosystem effect models are developed to diagnose deviations of communities from those at reference conditions, to assign effects to possible causes and to predict changes of the ecological status according to different pollution and management scenarios. Exposure and effect models are integrated and form the basis of a user-friendly decision support system for risk assessment and prioritisation. Close links between the site-specific and the basin-scale approach ensure a permanent optimisation of basin-scale modelling by including new data and mechanistic understanding and by model verification at the sites of interest. Basin-scale monitoring data and modelling results help to select and pre-characterise sites of interests for mechanistic investigations.

4. General project structure

MODELKEY is organised in 7 scientific subprojects (figure 1) that are performed in the three case studies in the river basins of Elbe (Czech Republic and Germany), Scheldt (France, Belgium, and The Netherlands), and Llobregat (Spain). The scientific subprojects focus on key toxicant identification (KEYTOX), the establishment of a database for all three river basins (BASIN), exposure modelling of contaminants (EXPO), effect modelling of contaminants (EFFECT), site assessment and model verification (SITE), decision making (DECIS) and training (TRAIN).

5. Scientific content and progress achieved

5.1 Subproject KEYTOX

KEYTOX aims at the development of novel tools for effect-directed analysis of key toxicants, at their validation and inter-comparison, at their application for toxicant identification at the sites of interest, and at the establishment of a key toxicant database. Method development successfully started with focus on exhaustive and bioavailability-directed extraction methods, powerful fractionation procedures and novel in vitro tools for effect detection. Reference materials including, sediments, water and fish tissue for method validation were prepared. Thorough literature reviewing of former studies on effect-directed analysis (EDA) provided a first collection of possible key toxicants. A first demonstration version of the key toxicant database suggests this tool as a promising approach to promote and network EDA in Europe.

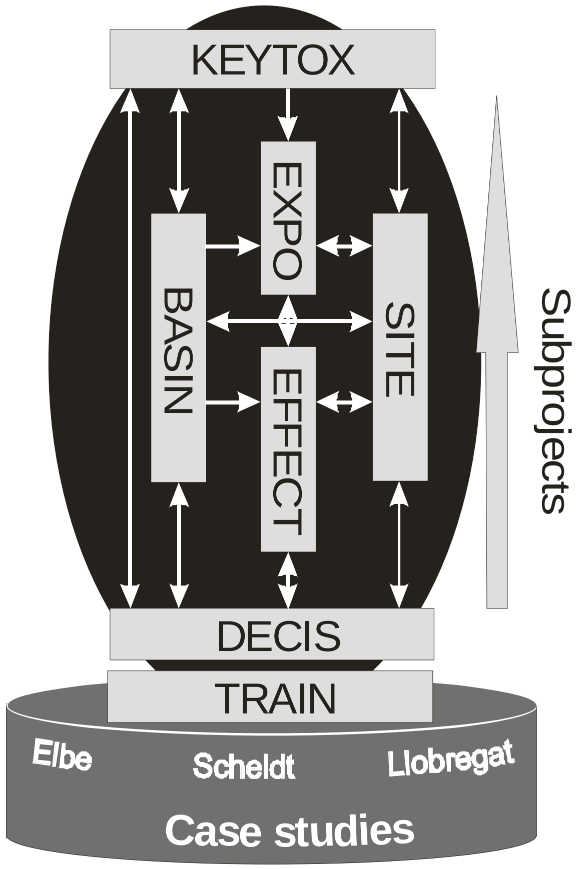

Figure 1: Overview of the structure of the project

5.2 Subproject BASIN

In close collaboration with numerous water agencies from six different countries an inventory of so far scattered monitoring data from three river basins was compiled in an easy-to-use meta-database, while in parallel MODELKEY started to integrate the original data on contamination, toxicity, ecology, habitat quality, and hydraulic conditions in a database for modelling purposes that now contains about 1.5 Mio individual data.

5.3 Subproject EXPO

EXPO focuses on basin-scale exposure modelling using a generic model that integrates models on erosion and sedimentation of contaminated sediments, transport and fate of contaminants in rivers and estuaries, and models on bioavailability and food chain accumulation. With extensive literature reviews, the identification of required and available data and concept creation the basis for successful modelling was laid. First versions of transport models have been provided and tested at selected river stretches for agreement with former experimental studies.

5.4 Subproject EFFECT

Effect modelling in MODELKEY includes a mechanistic approach on the basis of Dynamic Energy Budgets for a better understanding and prediction of effects in simplified communities as well as basin-scale diagnostic modelling for the identification of ecosystem effects and for attributing them to probable causes, and predictive modelling on the basis of artificial neural networks for predicting the impact of pollution and management scenarios. Mechanistic modelling is supported and validated by experimental approaches that are based on simple laboratory communities.

5.5 Subproject SITE

Figure 2: Common sampling campaign at the River Elbe

The major focus of SITE is on the development of tools for a causal analysis of site-specific risks to biodiversity. The assessment includes the risk of remobilisation of contaminated sediments, bioavailability and food chain accumulation, and effects to biofilm communities, the benthic invertebrate communities and the fish community. A diagnostic toolbox is developed that links in vitro and in vivo toxicity testing and biomarkers in laboratory- and field-exposed organisms as early warning tools with community effects in the field under thorough consideration of the specific exposure conditions. A comprehensive literature review on site-specific effect assessment tools was started. Method development started based on field samples from the case studies collected in common sampling campaigns (figure 2).

5.6 Subproject DECIS

DECIS is designed to develop integrated risk indexes and a decision support system (DSS) for risk and hot spots prioritisation allowing the exploitation of MODELKEY results by water managers and policy makers for scientifically based river basin management and a facilitated implementation of the Water Framework Directive. In addition to risks on biodiversity, socio-economic criteria are implemented in the DSS. A general agreement on the concept and structure of the DSS, its major objectives, and the integration of models and databases was achieved in intensive communication of all partners involved.

5.7 Subproject TRAIN

Despite major training activities that particularly focus on young researchers, end-users, and scientists from associated and new member states are scheduled for the second half of the project, first training activities were performed. A major highlight was a course on Dynamic Energy Budget theory and modelling by the University of Amsterdam.

6. Dissemination and integration of end-users

The integration of end-users at an early stage into the performance of MODELKEY and the dissemination of MODELKEY concepts, approaches and results was a major concern of this project. Thus, key end users were either integrated as full partners into the MODELKEY consortium or they were invited to join the MODELKEY end-user communication board as associated end-users. A specific end-user intranet and a newsletter sent to about 600 policy makers, water managers and scientists from all over Europe working in the field of river basin management and risk assessment promote the dissemination of MODELKEY results the communication with external experts. This is supplemented by several presentations at scientific conferences, papers in national and international journals, trade fair presentations, and press releases and a radio interview in order to make the general and the scientific public aware of MODELKEY.

7. MODELKEY links to other projects

MODELKEY is closely linked to other national and European projects that focus on risk assessment, pollution research in aquatic ecosystems, monitoring, and river basin management via internet links, common participants, and mutual participation in project meetings. Examples are the European IPs ALARM, NoMiracle, and Aquaterra, and the STREP SWIFT-WFD. The coordinator of MODELKEY will be involved as a work package leader in the CA RISKBASE that aims to integrate European risk-directed projects. On a case study level an intensive communication of MODELKEY with other national and international projects is also established, e.g. by the joint conference on environmental scientific activities in the Elbe basin held in Leipzig in November 2005.

8. The future of MODELKEY

MODELKEY is scheduled to continue until January 2010. After one year, the project has already made significant scientific progress, achieved a high degree of integration and a high awareness in the scientific community, among end-users and in the public. Further progress is to be expected and further collaborations with external scientists and end-users are aimed at.