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NoMiracle Newsletter No. 6

NOvel Methods for Integrated Risk Assessment of CumuLative stressors in Europe

NoMiracle Annual Progress Meeting 2006 in Antwerp

By Hans Løkke and Claire Mays

The NoMiracle Annual Progress Meeting was held at University of Antwerp in Belgium 11-15th of September 2006. The organising Committee chaired by Prof. Wim de Coen from Antwerp University, and a Scientific Committee including NoMiracle Pillar Leaders organized a full program which still left time to enjoy the warm weather and good beer of the Flemish capital.

NoMiracle referenced in video news release about Pesticides

NoMiracle coordinator Hans Lokke was interviewed for European video release illustrating the way bad pesticide use can threaten human health and the environment, and highlighting the key aspects of the new EU Thematic Strategy on the Sustainable Use of Pesticides. The film can be viewed at http://www.tvlink.org/vnr.cfm?vidID=195

The video news release focuses on Denmark where a National Action Plan is being implemented in collaboration with the National Environmental Research Institute in Silkeborg. The Danish plan involves all relevant actors. It ensures that farmers are trained and encourages scientific research on new ways of controlling and reducing the use of pesticides. In France, also showcased by the film, the national plan focuses on monitoring pesticides residues in food, visiting farmers in the field, providing education and advice to pesticide users and carrying out research on how to optimize pesticide dosage.

The aims of the Annual Progress Meeting include communication of scientific results and planning for the next period of the NoMiracle project as well as communication and exchange of ideas between partners.

In this issue

The meeting was preceded by Ph.D. training courses on:

1. Selection of scenarios for risk assessment, by Dr. Peter Borgen Sørensen
2. Separation of uncertainty and variability in spreadsheet models, by Dr. Ad Ragas and Ph.D. Femke Brouwer
3. Fate and exposure modelling, by Dr. Ian Cousins and Ph.D. James Armitage
4. Toxicogenomics by Prof. Wim de Coen and Dr. Karlijn Van der Ven
5. Mixture toxicity, response characterisation, experimental design and data analysis by Dr. Claus Svendsen

All teachers are from the NoMiracle Consortium. The courses were attended by 41 students.

Articles by	Science & technology objectives	
Münier; Holmstrup; Jones & Griffin; Baas et al.	**1.**	To develop new methods for assessing the cumulative risks from combined exposures to several stressors including mixtures of chemical and physical/biological agents
Schlink et al.	**2.**	To achieve more effective integration of the risk analysis of environmental and human health effects
Mayer et al.	**3.**	To improve our understanding of complex exposure situations and develop adequate tools for sound exposure assessment
Baas et al.; Holmstrup	**4.**	To develop a research framework for the description and interpretation of cumulative exposure and effect
	5.	To quantify, characterise and reduce uncertainty in current risk assessment methodologies, e.g. by improvement of the scientific basis for setting safety factors
Schlink et al.; Pistocchi; Münier	**6.**	To develop assessment methods which take into account geographical, ecological, social and cultural differences in risk concepts and risk perceptions across Europe
	7.	To improve the provisions for the application of the precautionary principle and to promote its operational integration with evidence-based assessment methodologies

This issue of the NoMiracle Newsletter furnishes a panorama of project results to date. The following texts reflect the oral contributions at the Antwerp meeting plenary, and illustrate how each scientific task addresses NoMiracle's major science and technology objectives as shown in the Table below.

Münier, Holmstrup, and Jones & Griffin participate in the development of new methods for assessing the cumulative risks from combined exposures to several stressors including mixtures of chemical and physical/biological agents (Objective No 1). To cope with the complexity of cumulative risks, two main approaches are explored. The first deals with the complexity of real-life exposure situations, applying Geographical Information Systems (GIS) technologies and spatial modelling to identify most likely combinations, and 'hot spots' of stressors. The other approach is broadly based on a bottom up philosophy.

Understanding and predicting cumulative stress is the ultimate goal that needs to be addressed in order to guarantee human and ecosystem health. It requires solid knowledge about (individual and combined) chemicals, non-chemical stressors, and their combined action. Furthermore, NoMiracle will explore potential mechanistic explanations for the deviations of existing mixture toxicity models. A new theory for the derivation of compounds toxicity as a function of their chemical properties has been developed as described by Baas et al. (objective No 4).

In the following text, Münier demonstrates how hot spot areas of mixtures of chemicals, *in casu* pharmaceuticals, can be assessed by developing GIS methods, emphasising the importance of assessing spatial release patterns and their relation to potential vulnerable ecosystems. Holmstrup and Jones & Griffin work on complex experimental data produced within the project. Holmstrup focuses on the cumulative effect of chemicals in combination with natural stressors, and Jones & Griffin apply metabolomics to give a 'snapshot' of the physiology of a cell or tissue, and assess how it has changed from normal as a response to exposure to chemical mixtures or to disease.

The integration of the risk analysis of environmental and human health effects is a general theme of the project, involving many scientists (objective No 2). Schlink describes a model to disentangle the cumulative effect of the variety of environmental stressors which can be observed in epidemiological studies. Mayer et al. have launched chemical activity as a theoretical and practical improvement of the concept of bioavailability (objective No 3).

The text of Schlink elucidates how to take into account geographical, ecological, social and cultural differencies across Europe (objektive No 6). This topic is also dealt with by Pistocchi and Münier.

The remaining main objectives (No 5 and 7) will be illustrated in coming newsletters.

Map analysis for visualizing risk scenarios

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Cumulative risk assessments cover analysis, characterisation and possible quantification of the combined risk to health or the environment for multiple agents or stressors. Common risk scenario selection procedures consider amounts of production and usage of chemicals and their toxicity, including the occurrence of mixtures and other stressors. It is well known that there is a considerable geographical variation throughout Europe in human activities and health as well as in ecosystems, their function and vulnerability, and in the occurrence of stressors. Inclusion of map data and spatial modelling may therefore often turn out to contribute valuable knowledge when selecting high risk scenario situations. Our work focussed on adding a geographical dimension to the term 'hot spot' by using Geographical Information Systems (GIS) technologies.

Pharmaceuticals in the environment

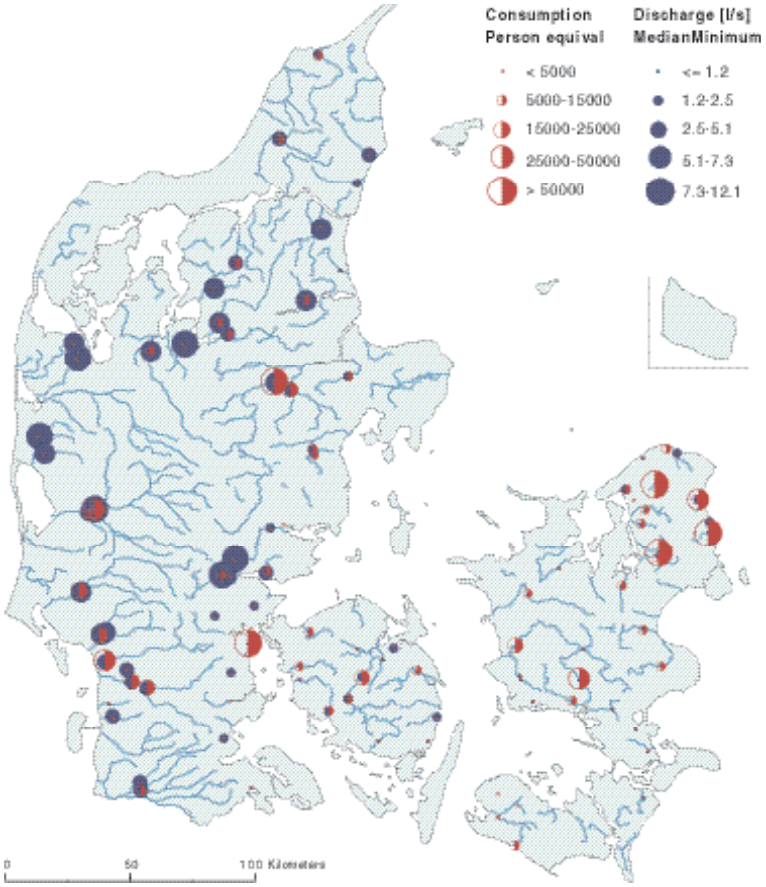
An emerging environmental and health problem is the unintended release and thus increasing detection of pharmaceuticals in the environment. Entry routes for pharmaceuticals to the environment are manifold. We consider the routes offered by household and hospital sewage, industrial production and waste, and from veterinary applications in agriculture and aquaculture.

Case study of pharmaceuticals

In a Danish case, the release of pharmaceuticals from human and veterinary consumption to the surface water environment has been examined.

Emissions from these sector activities have been mapped, using GIS-data on waste water treatment plants, agricultural production and aquaculture.

Releases of pharmaceuticals have been related to data from surface water monitoring stations and catchments adjoined. For example, the release of pharmaceuticals from human consumption has been calculated for each catchment by aggregating the number of persons attached to all waste water treatment plants within a catchment. These person equivalents (PE) may be used as a proxy for human consumption of pharmaceuticals, anticipating a uniform consumption profile for the entire Danish population.



Modelled human consumption of pharmaceuticals as person equivalents (PE) allocated to wastewater treatment plants within catchments. Hot spots may be identified by comparison to low discharge situations for selected freshwater monitoring stations.

Environmental sensitivity

An important parameter characterising effects on the aquatic environment depends upon environmental sensitivity regarding pharmaceuticals concentration in freshwater streams, i.e. dilution of the outlet from wastewater treatment plants. A widely accepted expression for a high risk situation is described by the median minimum discharge for a 30 year period.

The map in Figure 1 displays an example from this study: Indications of potential hot spot areas are catchments with high consumption and low discharge. The map suggests a tendency mainly in the eastern part of Denmark, where consumption is high and discharge low. The approach may be further developed to include metabolism, modelling of fate and transport and ecotoxicological data.

Information on types of waste water treatment exist for all plants and consumption profiles may be refined by including age, sex, place of residence and social status. The analysis demonstrated and the inclusion of the future perspectives requires knowledge about 'what is going on where' and is feasible only using a spatially explicit GIS-based approach.

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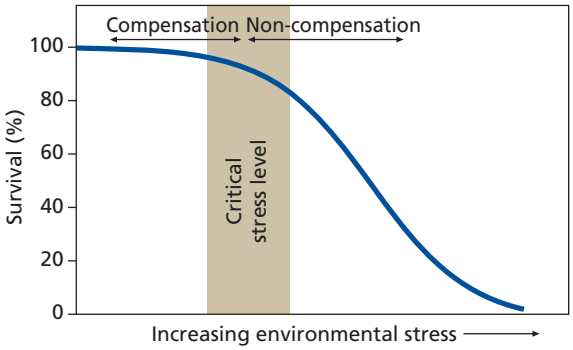
Natural stressors and toxicants

Why study interactions between natural stressors and environmental chemicals?

In our terminology we define 'a stressor' as a physical, biological or chemical condition that influences an organism in a negative way. Examples could be the exposure to temperatures that are beyond the normal limits experienced by the organism, or a toxic compound brought into the environment of the organism. Such 'stressors' can, if harsh enough, cause molecular and biochemical perturbations in the organism, which may result, for example, in impeded growth, reproduction, or ultimately in death of the organism. This state of the organism is termed 'stress', and we say that the organism is 'stressed'. Organisms experiencing 'stress' usually display what we call 'a stress response'. This term covers the counter measures or defence mechanisms that the organism may or may not have developed through evolution.



Typical response curve of an organism exposed to increasing levels of an environmental stressor (or in fact any stressor). The organism is able to compensate for the resulting stress until the intensity of the stressor reaches a critical level. At higher levels of the stressor the organism is no longer able to compensate. The overall aim of Workpackage 3.2 is to investigate if, and at what levels, toxic chemicals can/will shift this curve to the left, i.e. make the organism more susceptible to natural (non-chemical) stressors.

Several simultaneous stressors

In natural environments it is not unusual for an organism to be exposed to several stressors at the same time. For example, an organism could be exposed to climatic stressors (desiccation or high temperature) at the same time as it is exposed to environmental toxicants, i.e. a pesticide sprayed onto agricultural fields. Likewise, when considering human health aspects it seems important to include 'natural' stressors when assessing the effects of environmental pollutants, for instance in indoor air. Examples of such non-chemical stressors could be pathogens such as aggressive bacteria, or allergens such as the spores of certain fungi.

How does natural and chemical stressors interact

In traditional toxicological and ecotoxicological studies, organisms are usually exposed to a single chemical at increasing concentrations, while factors such as temperature, moisture, or oxygen are held at a constant optimum.

These traditional laboratory tests can therefore lead to an underestimation of the toxicity of the chemical in natural environments where the organism will periodically encounter several physical and chemical stressors simultaneously. It is the ultimate aim of NOMIRACLE WP3.2 to provide a broad understanding of how environmental chemicals interact with natural stressors, and how this may challenge the current risk assessment of chemicals.

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Metabolomics as a tool for cross species assessment in ecotoxicology

Advances in analytical technology in recent years have revealed that many organisms in the environment are exposed to an incredibly large variety of pollutants during their lifetime. For instance, many people will have heard of the concern over the effects of endocrine disrupting compounds (EDCs) on fish populations. Other anthropogenic contaminants include groups such as poly brominated flame retardants, pharmaceuticals and pesticides. Metabolomics can be used to give a 'snapshot' of the physiology of a cell or tissue and to assess how it has changed from normal as a response to disease or exposure to pollution.

Need for methods to assess cumulative risk

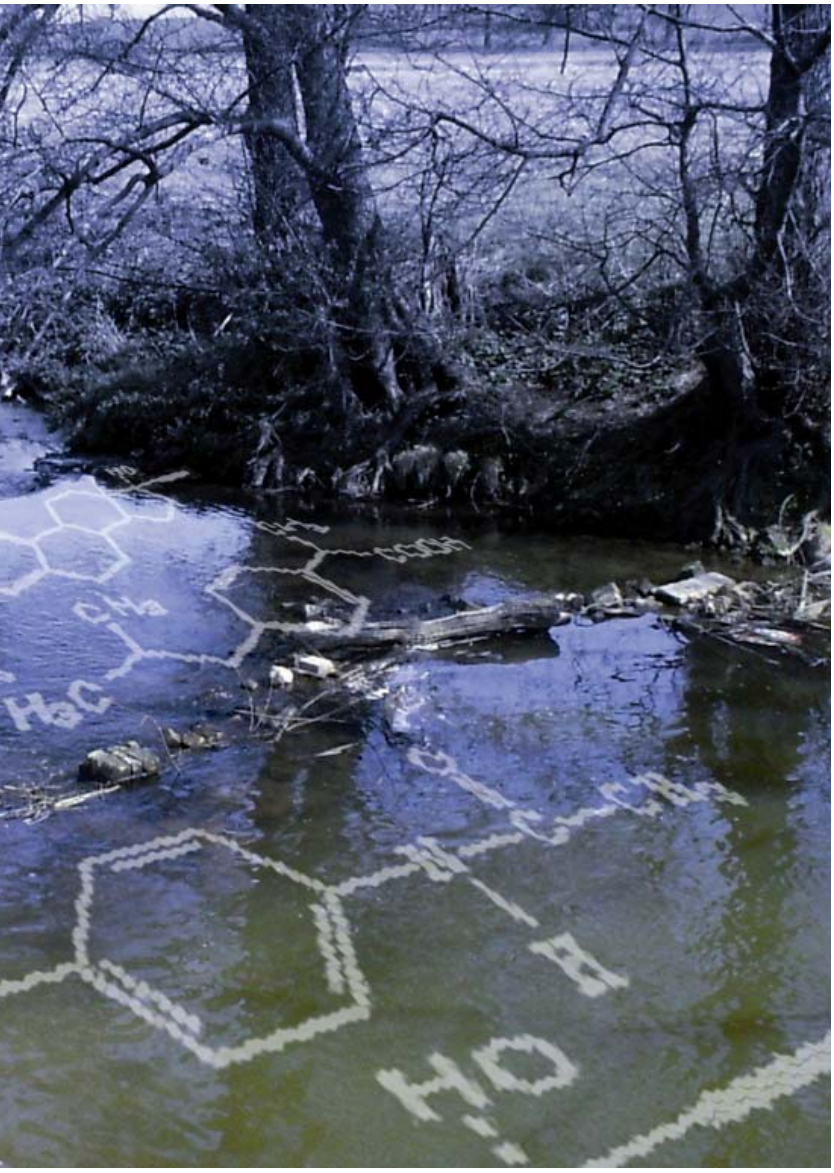
However, the majority of these pollutants are present at extremely low concentrations and so it is difficult to ascertain whether or not they have an overall effect on ecosystem health, especially if outward effects are minimal. There is therefore a need to develop methods for assessing, for a range of species, the cumulative risks from exposure to multiple pollutants at non lethal dose levels. One technique which offers a great deal of promise in this area is metabolomics.

Metabolomics methods integrate mixture responses

Metabolomics can be defined as the analysis of thousands of naturally occurring small molecules

Many environments are contaminated with a multitude of pollutants.

(metabolites) that are the products of cellular metabolism. These include things like sugars, fats and amino acids. It can be used to give a 'snapshot' of the physiology of a cell or tissue and to assess how it has changed from normal as a response to disease or exposure to pollution.



The primary analytical technique for metabolomic studies is Nuclear Magnetic Resonance Spectroscopy (NMR). This has a number of advantages in that it requires minimal sample preparation and is fast and robust technique, which allows a wide range of small molecule metabolite to be measured simultaneously. The disadvantage is a lack of sensitivity. For this reason many metabolomic-based studies now also use Gas and/or Liquid Chromatography Mass Spectrometry, which have the advantage of greatly enhanced sensitivity compared to NMR but with a trade-off of increased sample preparation time.

Metabolic profiles

Within the auspices of the NoMiracle project the University of Cambridge has established collaboration with the Center for Ecology and Hydrology, part of the UK Natural Environment Research Council and the University of Piemonte Orientale in Italy. We are running long term studies to establish a basal metabolic profile for the earthworm *Lumbricus rubellus*, the mussel, *Mytilus galloprovincialis* and the slime mold, *Dictyostelium discoideum* and how these change in response to exposure to a variety of both single compounds and mixtures. Initial baseline studies have been performed using nickel and chlorpyrifos.

There will subsequently be further single toxicity studies on at least two more compounds (imidachloprid and thiachloprid) after which work will begin on the mixture tests.

The work to date on this section of the NoMiracle project demonstrates the suitability of NMR and GC-MS (combined with multivariate data analysis) to recognise the normal biochemistry of a number of organisms, as well as their metabolic responses to toxic insult. The ultimate aim is to help develop a framework for the assessment of the effects of complex mixtures of pollutants, which it is hoped will offer great improvements in the understanding of the effects of cumulative pollution exposure on ecosystem health.

Bas Kooijman and Hans Løkke

Modelling effects of mixtures of compounds

After reviewing physiology-based toxico-kinetic models [1], we modelled the effects of mixtures of compounds on the survival of organisms. We used biology-based methods [5] to relate effects of compounds on the hazard rate of organisms to their internal concentrations. The interaction of compounds is taken to be proportional to the product of their internal concentrations.

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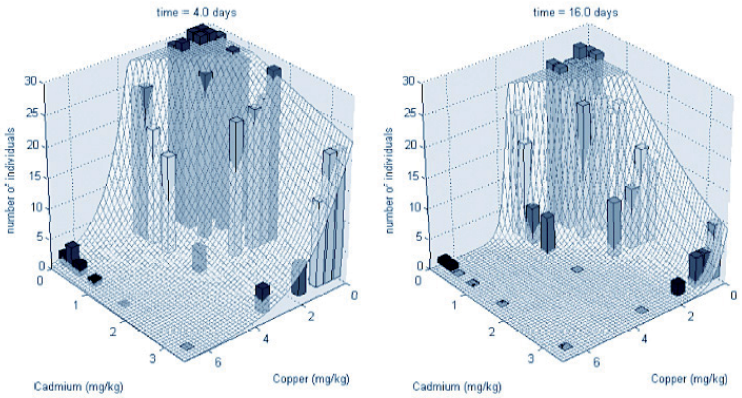
Code

We wrote code to apply the model as part of the DEBtool software package[1]. This code also provides estimates for the variance-covariance matrix of the parameter values, and allows a variety of algorithms for the calculation of the ML estimates (scoring, simplex, genetic algorithms), varying from fast to robust. The use of these procedures, however, does require some experience.



The survival frequency of *Folsomia candida* in a mixture of Cu & Cd at 4 (left) and 16 (right) day of exposure. All daily data are fitted simultaneously for the full period of 21 days of exposure.

Exclusive model

Our extension of the biology-based methods is exposure-time explicit, and is still the only such method handling lethal and sublethal effects in a single framework.

Investigating binary mixtures of metals by DEBtool

Using DEBtool we applied the model to data on the binary mixture of metals (Cu, Cd, Pb & Zn) on the survival of the springtail *Folsomia candida*. The irreversible-binding variant of the model fitted the data best and to a very good degree. We concluded that none of these metals showed interactions, except the mixture Cu & Pb, which showed a slightly antagonistic interaction. The results are submitted for publication. [3]

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New theory

We developed theory for the derivation of compounds toxicity as a function of their chemical properties. This theory has close links with other theory that we developed for the co-variation of parameter values across species.

A paper [4] discusses the interrelationships between the two bodies of theory, which may help fill gaps in our knowledge in anticipation of risk assessment applications.

No Effect Concentrations robust

We also did research on the effects of variation of parameter values among individuals, focusing on the statistical consequences for such a variation on the No Effect Concentration (NEC) [2].

We showed that NEC-estimates are really robust for such changes, and, therefore, the NEC can take the place of the No-Observed Effect Concentration (a misleading but still widely used concept which both OECD and ISO have recommended phasing out).

[1]Download from http://www.bio.vu.nl/thb/deb/deblab/

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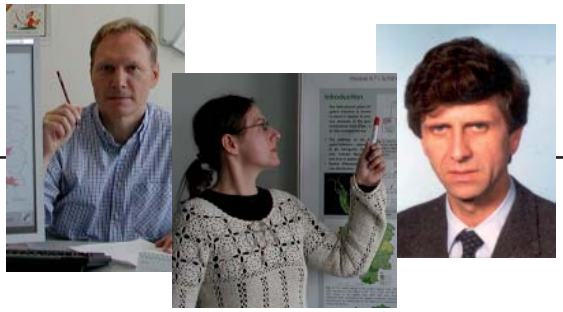

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Modelling, assessing and ranking of spatial and individual risks for human health

Humans – half of whom today are living in urban areas – face a variety of environmental stressors that pose a risk to their health. The NoMiracle project seeks novel methods for integrated risk assessment, of cumulative stressors in particular. For human health, this requires appropriate modelling approaches able to disentangle the cumulative effect of the variety of stressors that can be observed, for example, in epidemiological studies with children. Our research aims at delivering such a modelling approach. It can then be used to rank stressors and other risk factors according to their importance, thereby helping to put preventive measures into practice.

Infection with *Helicobacter pylori*

Helicobacter pylori bacterium was discovered in 1982 by the Australian scientists Robin Warren and Barry Marshall who won the Nobel Prize in 2005. *Helicobacter pylori* can cause gastric complaints and even stomach cancer. The infection path of this disease is not yet fully clear, but researchers know the epidemic process is multifactorial. We decided to develop a statistical model for the assessment of environmental risks for children starting school to be infected with *Helicobacter pylori*.

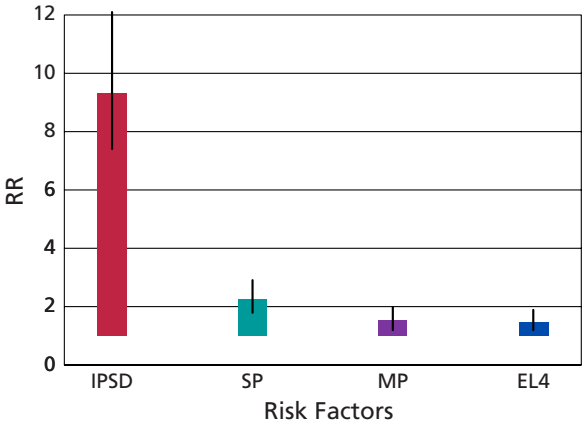
Risks

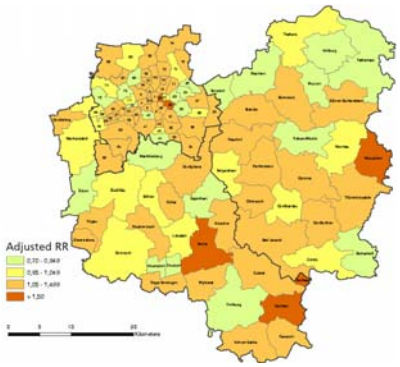
The total risk for an individual to get an *H. pylori* infection is a composite of risks that can be attributed to several different factors, such as the individual's constitution, living and social conditions, and environmental conditions. The latter may be narrowly associated with the living area of the individual and, thus, can be geo-referenced. For example, water supply, including the use of private wells, is a location-specific risk factor. While these factors can vary in space (heterogeneity) they may also be similar across short distances, i.e., they are auto-correlated. Furthermore, spatial changes in risks can be an indicator of risk factors that change across the area and are not yet known.

The NoMiracle risk model

There are three major components of health risks: individual risks, risks attributable to spatial conditions, and temporal changes in risks. Up to now, only the first two have been included in a statistical model for the assessment of environmental risks for children starting school to be infected with *Helicobacter pylori*. The NoMiracle risk model innovates by taking into account individual- and family-specific factors as well as the conditions in the urban neighbourhood (Figure). All significant factors are ranked according to their adverse health effect, and the spatial risk components are mapped together with their statistical significance.

	At least 1 of the parents has stomach complaints	Single mother/ father	Persons per m^2 > avarage (0.045 pers/m^2)	Low educational index	District
$\log(RR_{ij}) =$	$a_0 - 2.23\ x_{1j} -$	$0.80\ x_{2j} -$	$0.43\ x_{3j} -$	$0.39\ x_{4j} -$	b_i
$RR_{ij} =$	$e^{a_0} \cdot$	$9.30 \cdot$	$2.27 \cdot$	$1.54 \cdot$	$1.48 \cdot$ e^{b_i}





Spatially explicit modelling of the relative risk (RR) for *Helicobacter pylori* infection in school starters in the districts of Leipzig city and two adjacent rural areas. This figure demonstrates the splitting of the risk into risks attributable to individual specific factors and/or exposure to environmental stressors and into risks attributable to the urban district. The latter are adjusted for heterogeneities in spatial distribution of individual and environmental stressors (Adjusted Relative Risk). The approach accounts for spatial correlations between neighbouring districts, provides confidence intervals (not shown here) and enables comparisons between the risks in small areas. Note the ranking of individual-specific risk factors.

The latter facilitates the identification of significant 'hot spot' areas.

The benefits of the suggested modelling technique are: disentanglement of risk factors, inclusion of different sources of randomness (individual predisposition, spatial area, etc.), splitting and ranking of risks attributable to specified stressors. Furthermore, the capture of district-specific risks is improved because the algorithm 'borrows' statistical power from existing neighbourhood data: the model predicts health data for districts where, by chance, no cases were observed. Characteristics of spatial data (spatial autocorrelation, heterogeneous distribution of stressors, etc.) are taken into account.

Future research work will apply this algorithm to allergic ailments and include more geo-reference and individual-specific risk factors. Moreover, the NoMiracle algorithm opens the door to future applications in the assessment of eco-toxicological risks.

Availability and exposure of hydrophobic organics

New findings based on chemical activity

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Research in the last decade has led to several bioavailability concepts and to many more methods to measure bioavailability [1]. One reason for disagreement is the confusion of two fundamentally different parameters A. *accessible quantity* and B. *chemical activity*.

A. The accessible quantity describes a mass of contaminants, which can become available to e.g. biodegradation and bioouptake. The accessible quantity can be determined with mild extraction schemes or depletive sampling techniques.

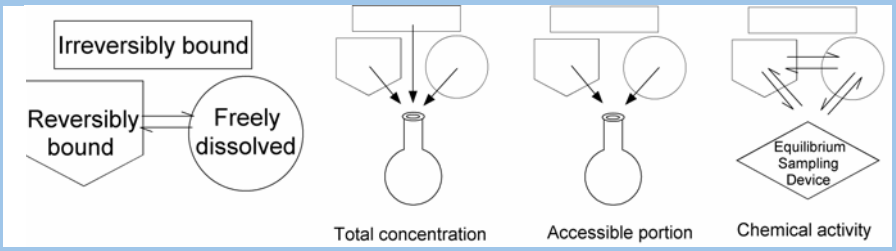
B. *The chemical activity* quantifies the potential for spontaneous physico-chemical processes such as diffusion, sorption and partitioning. For instance, the chemical activity of a sediment contaminant determines its equilibrium partitioning concentration in sediment organisms and differences in chemical activity determine the direction and extent of diffusion between environmental compartments. Chemical activity can be measured with equilibrium sampling devices and is theoretically closely linked to fugacity and freely dissolved concentration.

Can highly hydrophobic organic substances cause aquatic baseline toxicity and can they contribute to mixture toxicity? [2]

Effect concentrations for aquatic baseline toxicity generally decrease with increasing Log K_{OW} values of up to 5-6, whereas less is known about the baseline toxicity of organic chemicals with Log K_{OW} values above 6. A physico-chemical analysis of the dissolution process for organic chemicals was combined with reported baseline toxicity data, which lead to the following conclusions. Firstly, there is no absolute hydrophobicity cut-off for baseline toxicity at a Log K_{OW} of 6, since aquatic baseline toxicity for fish and algae was observed for chemicals with Log K_{OW} values above 6.5 and with effect concentrations below 10 µg/L. Secondly, the baseline toxicity was exerted at a relatively constant chemical activity of 0.01 to 0.1. Finally, organic chemicals with high melting points cannot provide a sufficient chemical activity to exert baseline toxicity as individual pure chemicals, whereas they still contribute to the baseline toxicity of complex mixtures.

Diffusive mass transfer of PAHs through different exposure media

The biological uptake of hydrophobic organic compounds is often limited by the diffusive transport through a thin boundary layer. Therefore, a new technique [3] was applied to determine the diffusive mass transfer of 12 PAHs through different exposure media at a given gradient in chemical activity. The diffusive flux of PAHs increased significantly in the presence of humic acids, surfactants, cyclodextrin and through the digestive fluid of a sediment worm. Further, the observed enhancement factors increased generally with increasing hydrophobicity of the PAHs. These results demonstrate that medium constituents that normally are believed to reduce 'bioavailability' actually can increase exposure and uptake.



Bioavailability parameterization: A contamination is divided into the pools irreversibly bound, reversibly bound and freely dissolved. The reversibly bound and the freely dissolved are accessible. Equilibrium sampling devices brought into equilibrium with the freely dissolved pool and the reversibly bound pool provide chemical activity. The distinction between reversibly and irreversibly bound contaminants is not required for the definition and the determination of chemical activity.

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Quantifying the effect of medium composition on the diffusive mass transfer of hydrophobic organic chemicals through unstirred boundary layers. Environ. Sci. Technol. 2005, 39, 6123-6129.

Towards geographically based chemical fate models for Europe

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The objective 6 of NoMiracle is to assess region-specific environmental fate of chemicals through a novel multimedia fate and exposure model with regionalised spatial resolutions at the European level, capable of accounting for different temperate zones and periods.

Mapping strategy

We thought a new model was needed to meet this objective, but early work resulted in the idea that developing a mapping strategy was more urgent. This means a method to combine as many spatial data (maps) as possible in order to understand and quantitatively predict chemical distribution in Europe. Representing a great variety of features—layering information on maps—is feasible. Simple but spatially explicit models can give us screening-level evaluations of the risks present in a given geographical zone. Complex models both for site-specific (catchment- to field-scale) assessment and for specific issues are not surrogable by this approach, and are still required if one wants to simulate process dynamics. However, the simple models are 'good enough' for screening. Spatial patterns of long-term (e.g. monthly, annual) means of chemical concentrations/fluxes are rather stable: very complex environmental processes tend to produce geographically 'simple' patterns according to e.g. temperature, precipitation, wind, vegetation cover…

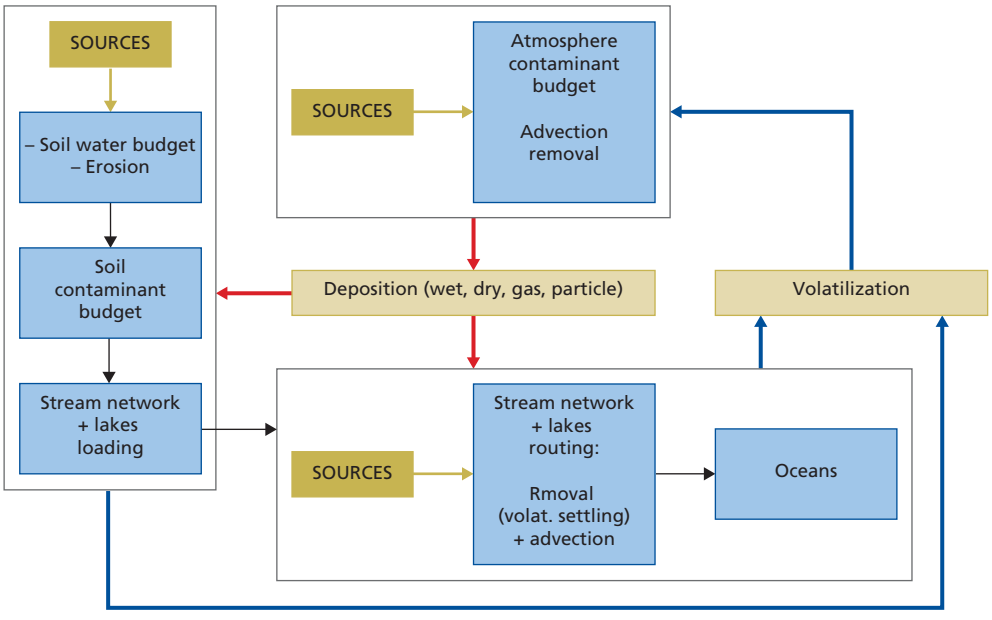

Figure 1 – Block diagram showing the environmental compartments presently considered in the MAPPE model, and the linkages among them provided by stream network loading, volatilisation and atmospheric deposition.

MAPPE – a GIS-based tool for policy decisions

In this spirit a Geographic Information System (GIS)-based model was developed at the JRC, under the acronym MAPPE (Multimedia Assessment of Pollutant Pathways in Europe), which is also the Italian word to denote 'maps'. This provides a tool for screening-level modeling of the fate and transport of chemicals over large regions such as continental Europe. It is a generic, scale-independent method rather than a closed-form model software, and is implementable in any GIS package.

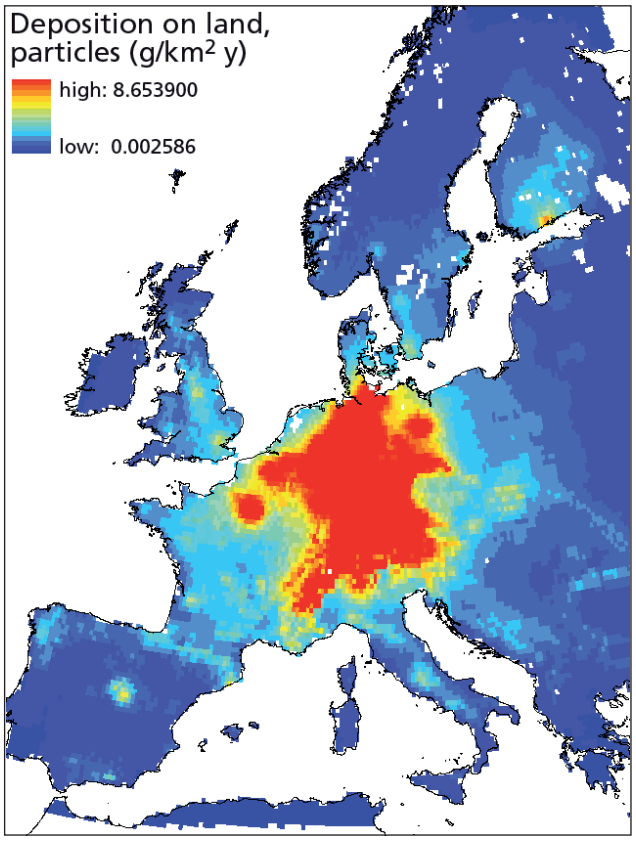

Figure 2 – example of an output of the MAPPE model (atmospheric particle-attached deposition of PCBs in Europe; emission data referred to year 1995).

Users can quickly incorporate feedback from experimental evidence at the level e.g. of landscape and climate parameters (characterised with finer and finer spatial resolution, like that from remote sensing) or physico-chemical properties such as chemical partition coefficients between two environmental phases. The mapping strategy is potentially useful in addressing spatial screening issues, such as ranking priority areas at the continental level starting from actually available information for most chemicals. Such a tool has definite value for policy making and decisions.

As suggested by Figures 1 and 2, the model retains the simplicity of box models, while mapping spatial patterns. It requires limited input parameters, and capitalizes on spatial variability of climate, soil properties, hydrology, etc. So far the method has been tuned to provide results in agreement with benchmark models (SimpleBox, MSCE-POP of EMEP) within one order of magnitude, and reasonable preservation of ranking for decision-making. Discrepancies in soil concentration are mainly related to the memory effect of this medium, while for ocean concentration a main source of discrepancies might be at the level of gas exchange between water and atmosphere.

Future developments will improve land/ocean parameterisation (volatilisation, deposition; pooled sediment flux), emission estimates (time-slicing for long memory media such as soil), and partitioning algorithms (ppLFERS). As well, in spatially-explicit model verification 'experimental' spatial pattern descriptions are needed; these might allow us to capture new types of data, e.g. from passive samplers or food lipid sampling.

A new application of the model is forthcoming for pesticides (main advection medium: inland waters), other polar chemicals such as pharmaceuticals, and emerging pollutants such as PBDEs.

Second Open Workshop in Stuttgart 2007

Communicating Chemical Risks

The role of risk perception and communication for characterizing and managing Cumulative Stressors
12th and 13th of April 2007

Communicating about chemicals is a challenging task risk managers in companies and regulatory authorities. This workshop focuses on good practice in risk communication and 'What determines success in risk communication?'. Various case studies examining the perception and management of risks, from the chemical as well as from other sectors, will give insights of the wide range of how risks could be handled and communicated.

The workshop will put up the following issues:

- Complexity, uncertainty and ambiguity in risk assessment and management
- Major Insights from risk perception studies and their relevance for regulating cumulative stressors
- Aspects of risk governance: an integrative perspective of risk
- The role of assessment and perception for risk management
- The crucial function of risk communication at all stages of the risk governance process
- Models of stakeholder involvement and participation

Who could participate?

Partners of the NoMiracle Consortium, experts from companies, NGOs, EU-representatives, scientists.

Venue:

International Meeting Centre of the University of Stuttgart
Robert-Leicht-Straße 161
70569 Stuttgart, Germany

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*Articles in the NoMiracle Newsletter do not necessarily reflect the attitude of the NoMiracle Newsletter.