FROM RISK ASSESSMENT TO RISK RESPONSE

Communicating Complex Risks to Concerned Stakeholders

WORKSHOP

2-4 April 2008

"Aristotle" Conference Centre
National & Kapodistrian University of Athens
University Campus (Panepistimiopolis) Zographou
Athens, Hellas

Programme

Day 1 (2nd April 2008) Field Trip to Lavrion (54 km SE of Athens)

Leaders: Euro Geol Alecos Demetriades (IGME) and Ass. Prof. N. Skarpelis (University of Athens)

This gives participants an opportunity to investigate a case study on the assessment, perception and communication of risks of lead and arsenic poisoning of residents by exposure to ancient and recent mining and smelting wastes. The following documents give some information on the Lavrion case study:

(1) Risk perception and communication in Lavrion

(2) Spatially resolved hazard and exposure assessment in Lavrion

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Day 2 (3rd April 2008) Workshop

8-50 – 9.00	*Welcome*
	Session 1 - Chair: Mike Ramsey
9.00 – 9.25	**David Briggs (Imperial College London, UK)** Risk assessment and risk communication in the context of complexity
9.25 – 9.50	**Cindy Jardine (University of Alberta, Canada)** Stakeholder Participation and Risk Governance: Bringing Together Different Risk Perspectives
9.50 – 10.15	**Timo Assmuth (SYKE, Finland)** Expert and regulator perceptions of mapping, assessing and managing multiple cumulative risks
10.15 – 10.40	**Marco Martuzzi (WHO-Europe)** Assessing and managing complex risk factors: lessons from WHO's experience
10.40 – 11.00	*Coffee*

Session 2 Chair: - Alecos Demetriades

11.00 – 11.25	**Mike Ramsey (University of Sussex, UK)** Effects of measurement strategies on both the assessed and the perceived risk of exposure in human health risk assessment
11.25 – 11.50	**Roel Smolders (Vlammse Instelling voor Technologisch Onderzoek, NV)** Do's and don'ts of biomonitoring in integrated risk assessment
11.50 – 12.15	**Hans Keune (University of Antwerp, Belgium)** Communication and policy uptake of human biomonitoring research results in Belgium; risk communication and policy interpretation in cooperation with experts, policy makers and stakeholders
12.15 – 12.40	**Leendert van Bree (Netherlands Environmental Assessment Agency)** Dealing sensibly with risks - A Dutch approach toward risk management and communication
12.40 – 13.05	**David Gee (EEA)** Towards Common Terminology and Approaches to Evaluating Scientific Evidence
13.05 – 14.00	*Lunch*
14.00 – 15.45	**Parallel Breakout Sessions** 1. Risk or reassurance - what should the community be told? **Alex Stewart (Health Protection Agency, UK)** 2. Public Role and Responsibility in the Risk Management of Emerging Scientific Knowledge: A Case Study of Disinfection By-Products (DBPs) in Drinking Water **Cindy Jardine (University of Alberta, Canada)** 3. Pesticide Air pollution in the Athens urban area **Polyxeni Nicolopoulou-Stamati (University of Athens, Greece)** 4. Informed consumers? – first pragmatic steps **Loredana Ghinea (European Chemical Industry Council)**
15.45 – 16.15	*Coffee*
16.15 – 16.45	**Breakout session reports**
16.45 – 18.00	**Plenary discussion**

Day 3 (4th April 2008) Workshop

	Session 3 - Chair: David Briggs
9.00 – 9.25	**Denis Sarigiannis (JRC)** New directions for risk assessment of environmental chemical mixtures
9.25 – 9.50	**Olf Herbarth (University of Leipzig, Germany)** Influence of indoor exposure on eczema in early childhood
9.50 – 10.15	**David Broday (Technion, Israel)** Towards an integrated Environmental health informatics system
10.15 – 10.40	**Matti Jantunen (Finnish Public Health Insitute, Finland)** Integrating risk perception into the [environmental] health risk model
10.40 – 11.00	*Coffee*
	Session 4 – Chair: Denis Sarigiannis
11.00 – 11.25	**Brian Miller (Institute of Occupational Medicine, UK)** Mortality impacts of air pollution and other environmental factors
11.25 – 11.50	**Joost Lahr (Alterra, Wageningen UR, The Netherlands)** Risk mapping of environmental pollutants: state-of-the-art, possibilities and limitations
11.50 – 12.15	**Tomas Trnovec (Slovak Medical University)** PCB Exposures in Eastern Slovakia: Health Effects, Remediation, and "Safe" Levels
12.15 – 13.00	**Final discussion and departure**

ABSTRACTS

Workshop Session 1

Risk assessment and risk communication in the context of complexity

David Briggs, Department of Epidemiology and Public Health, Imperial College London

Modern risks to human health are characterised by complexity. Few environmental hazards, today, are singular or immediate, operating directly to produce high relative risks of acute health effects within well-defined populations. Instead, the main concerns relate to more subtle yet intricate problems, often involving many different hazards acting in combination and via different pathways, and over the long-term – and creating major threats to public health occurs not because of the magnitude of the risk at the individual level, but because of the large numbers of people involved.

In the face of these complex problems, policies on environmental health need to be more inclusive and collaborative in approach, and inevitably have to rely on the involvement of many more actors, and impact upon the lives of many more people. Policy-making, in turn, requires comprehensive and balanced information, not only on the risks and their causes, but also on the impacts (both adverse and beneficial) of existing or future policies. Traditional forms of risk assessment, focusing on individual and proximal hazards, have been found wanting in these circumstances. Instead, more integrated approaches to assessment become necessary, capable of analysing many-to-many relationships in long and complex causal chains. In recent years methods of integrated assessment have been developed for this purpose. Though primarily used, so far, to assess environmental problems (e.g. climate change, air pollution) at broad regional or global scale, these clearly offer the potential (and could readily be extended) to analyse these impacts of environmental hazards and policies on human health.

Integrated environmental health assessment poses many scientific and technical challenges, not least in terms of the availability of suitable data and models. These are compounded by the existence of multi-causality, non-linearity and adaptive responses to change, which characterise the majority of the systems of interest. In many ways, however, the biggest uncertainties derive from the difficulties of framing assessments for such complex problems, and in communicating the results of assessments (and their inherent uncertainties) to the many different stakeholders concerned. In the face of these complexities, simple point estimates of risk or impact are far from adequate; if these estimates are to be understood, and sensible action devised, information also needs to be provided on the uncertainties in the results of the assessment, and their sensitivity to the methods of assessment used. Nor are traditional forms of risk communication, which see users as the passive recipients of technical information, sufficient if stakeholders are going to be encouraged to accept the implications of the assessment, and take sensible actions of their own to address them. Instead, stakeholders need to be involved in the whole process of analysis: from issue framing and selection of the scenarios used for assessment, through design of the assessment protocols, to appraisal and interpretation of the results.

Achieving such participation in the context of complexity is itself a major challenge. Many different stakeholders may potentially need to be involved, not all of whom are readily identifiable. Differences in interest, knowledge, power and articulacy have to be overcome, often in the face of suspicion and limited resources and time. Different priorities and value systems need to be balanced so that the implications of different actions can be sensibly compared, and consensus achieved. Based on thinking and practical examples from two current EU-funded projects on integrated assessment of environmental health risks and impacts in Europe (INTARESE and HEIMTSA), and drawing on results from previous studies, this paper outlines a framework for assessment, highlights the importance within this of issue-framing and communication, and discusses some of the methods that can be used to ensure successful stakeholder participation in the assessment process.

Stakeholder Participation and Risk Governance: Bringing Together Different Risk Perspectives

Cindy Jardine, Dept. of Rural Economy, University of Alberta, Canada

Over the past 30 years of formalized risk decision-making, the value of stakeholder participation in risk governance has become increasingly evident. Involving stakeholders produces decisions that are responsive to varying interests and values, including those of the community. Stakeholder participation has also helped to prevent or resolve conflicts, build trust between various parties, and inform all parties about different aspects of the risk. However, many risk professionals and decision-makers are not yet 'sold' on the value and feasibility of stakeholder participation. So what can be done to improve the process so that it is more successful (and therefore more appealing) for everyone involved? How can we reconcile different perspectives on the risk to reach more consensual and accepted decisions? How can we better recognize the respective roles of "risk as analysis" and "risk as feelings" (Slovic et al. 2004) in risk deliberations, and improve the integration of these into risk governance and rational decision making? Some "lessons learned" from past stakeholder participation efforts will be explored, and general guidance for successful participation presented. Evaluation criteria for assessing the success of stakeholder participation will also be discussed.

Findings from studies of views on cumulative risks of multiple stressors and from other work on assessment-management interfaces in project NoMiracle

Timo Assmuth*, Mikael Hildén, Jari Lyytimäki, Finnish Environment Institute (SYKE)

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The interactions between risk assessment and 'risk responses' are obviously key to whether understanding of risks leads to desirable action. The importance of these relationships is matched by their complexity. This is partly due to the ambiguity of these areas of activity. Their links are also multi-directional: assessment not only

transfers data and findings to management responses, but the latter in turn influence assessment. We thus do not only go *from* assessment *to* response but also vice versa. Complexities in these relationships stem also from the multitude of socio-political influences and tensions which in the case of risks are especially strong.

In such contexts, uncertainties pose key challenges e.g. when balancing precautionary and evidence-based assessment and management. It will be discussed how integrated treatment of multiple risks from chemicals and other stressors adds to uncertainties and to challenges in responding to risks, but also how attention to assessment-response interfaces and to the use of information therein may improve this integration.

We will present theoretical and empirical findings and questions about cumulative risks from multiple stressors in assessment-management interfaces, focusing on risk perception and communication. The presentation is based chiefly on the NoMiracle (Novel Methods for Risk Assessment of Cumulative Stressors in Europe) project, and thus emphasizes integrated assessment of risks in connection with chemicals.

We clarify conceptually how also the effects of risk agents and stressors constitute 'responses', as described e.g. by dose-response models. These responses are conceptually different from deliberate management responses; nevertheless, there is a continuum between the two that does not allow sharp boundaries. Secondly, interfaces between risk assessment and risk management between conventions developed in different disciplines and used in different cases. This variation in risk assessment and in its boundaries with management is often seen as problematic and combated by 'harmonization'. Both of these dynamic continua are related to the multi-dimensionality of risks and to their limited objectivity. It will be discussed how this plays a key role in risk assessment and management and in controversies around these.

The NoMiracle project is centered on natural scientific research, development of measurement and modeling methods and researcher training in assessment of exposures to and effects of chemical mixtures. The project includes explicit R&D in risk assessment-management links mainly in the part 'Dealing with multiple risks and uncertainties in a policy context'. The project also includes R&D indirectly addressing these interfaces, e.g. in relation to safety factors, and practical work in dissemination and exploitation of results. There is thus a continuum of R&D and other work at various level of proximity to the assessment-response interface (http://nomiracle.jrc.it/webapp/ViewPublicDeliverables.aspx).

In a theoretical analysis we focused on frameworks of information for integrated risk assessment and management, specifically in chemicals regulation at EU level (Assmuth & Hildén 2008). We examined different aspects of integrated risk information in frameworks in proximity to policy, emphasizing areas of integration that are less developed in 'scientific' risk assessment, e.g. comparative risk-benefit analyses. We showed how the policy level influences the information frameworks and hence the conduct and use of integrated assessments. We applied models of the policy-driven information frameworks and of their interaction with new information and scientific frameworks on EU chemicals control. We concluded that by paying attention to the nature of the framework it is possible to resolve the most crucial aspects of integration, and to develop assessments that focus on key complexities and issues. We discuss how information constitutes a key aspect of both reflection and response on risks especially in connection with expert activities.

A web-based survey was conducted among experts and stakeholders of views on integrated risk assessment of cumulative stressors, and opportunities and obstacles for development (Assmuth & al. 2007). A key finding was the pronounced variability of views on risks and uncertainties and the use of information, only partly explained by the methodology, unfamiliarity with issues or other background factors. However, co-variations of responses

suggest regularities in opinion patterns and mental constructs, including overall views like optimism or pessimism with regard to (integrated) knowledge and control of risks. Potential for specific risk maps in integrating information was found, but there were doubts of their role in communication. Views on the interaction and integration of risk assessment and risk management also varied greatly. A key conclusion was that views on risks and risk assessment cannot be reduced to any simple model, and cannot (and need not) be dispelled in a forced manner. This should be taken into account in developing novel and integrated methods for risk assessment and in linking them with management. As the methods cannot deliver generally valid normative results that would be unambiguously understood, assessment methods should be transparent with respect to assumptions and data treatment processes and to inherent interpretations and value judgments.

Ongoing analysis of interviews among EU-level experts and stakeholders likewise revealed profound variation in thinking about risks and uncertainties, (integrated) risk assessment, and its links with management, and added to insights in arguments and motivations (Assmuth & Craye, in progress). Different interpretations of precaution and participation also surfaced. Some stressed a division of assessment and policy, others felt needs for more holistic approaches to (chemical) risks also in the policy interface, e.g. with risk-benefit considerations. Among obstacles to integration, tensions were noted between a broader assessment and management scope and structural, e.g. legal and administrative divides. These tensions were also interpreted in terms of limited ability to cope with information, and to balance breadth with detail and routines with new information and methods. It was felt that despite increasing integration of some aspects of risk, REACH as single substance based is inherently limited, but further moves toward multi-stressor, inter-sector and assessment-management linkages may disturb consensual implementation, thus being a longer-term goal.

The team conducted studies about risk perception and communication and about the potential of conceptual modeling in the NoMiracle domain, i.e. integrated assessment of risks from multiple stressors (Renn & Benighaus 2006). This work focuses on the importance of framing for risk perception and managing, examines risks as a dual phenomenon representing mental constructs and their manifestations in the experience of harm, investigates aspects and factors of risk perception, including the social and cultural context, and draws conclusion about risk communication that is designed to mediate between risk analysis and perception. It was discussed in which way scientific information on perceptions can be integrated in normative judgments on risk acceptability and how analytical risk assessment results interact with risk perception and ethical concerns. The goal of risk communication should not be persuasion but deliberation on multiple views.

The prospects and limitations of risk communication were addressed in a workshop involving experts from other EU IPs, social science experts, stakeholders and students (Renn & Benighaus, Eds. 2007). Needs, constraints and tasks in risk and uncertainty communication were identified in general and specified for implementation in the context of NoMiracle. The participants stressed the importance of framing, social context and audience-sensitivity of communication, in particular in connection with the need to make and justify risk-benefit trade-off considerations. Structured, dynamic (iterative), multi-stakeholder and pluralistic approaches to communication and participation in integrated risk governance were further discussed during the workshop and will be included in the recommended design for risk governance of multiple stressors.

References

Assmuth T, Hildén M. 2008. The significance of information frameworks in integrated risk assessment and management. Environ. Sci. & Pol. 11;71-86. doi:10.1016/j.envsci.2007.07.006.

Assmuth T, Lyytimäki J, Hildén M, Lindholm M, Münier B. 2007. What do experts and stakeholders think about chemical risks and uncertainties? - An Internet survey. The Finnish Environment 22/2007. Finnish Environment Institute, Helsinki. http://www.ymparisto.fi/default.asp?contentid=241573&lan=en
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http://nomiracle.jrc.it/Documents/PublicDeliverables/D.4.3.14%20Report%20from%20the%20Stuttgart%20Workshop%20on%20Risk%20Communication.pdf

Assessing and managing complex risk factors: lessons from WHO's experience

Marco Martuzzi, World Health Organization, Regional Office for Europe, Rome Office

The World Health Organization, like several other health agencies, is engaged in providing advice to governments over matters of environment and health. The goal is that such advice should contribute to adopting policies that: are based on scientific evidence, give health the highest priority; be equitable and sustainable. This goal is increasingly challenging, due to increasing uncertainty brought about by fast technological development and by complexity of societal organization. In addition, questions asked about health and environment tend to address broad determinants (e.g., transport policies) as well as specific risk factors (air quality). This tendency is very visible in WHO's work: Member States increasingly require that not only technical information is made available on degree of scientific evidence on a given exposure – disease association, but also on the health implications of strategic policy choices. From waste management to nanotechnology, from energy policy to water systems, governments (and other stakeholders) often ask *trans-scientific* questions, i.e., questions addressed to science that cannot be answered by science alone.

This challenge is being approached by several angles. Integrated risk assessment is one of those. With reference to the recurring debate over whether or not a new paradigm (in the Khunian sense) is needed, integrated assessment may be regarded as an attempt to expand the current paradigm to accommodate larger complexity, by pursuing a holistic approach of risk assessment/risk management (very clear, for example, in the full chain approach). There are a number of points in the traditional risk assessment / risk management paradigm (some authors describe this as the *modern* model) that can be modified in order to make it more realistic, more relevant to real life policy questions, in short more reliable and informative:

- some restrictive assumptions can be relaxed (for example, proportional hazards in multiplicative models);
- multiple distribution mixing, analytically intractable, can be modeled through computing simulation;
- uncertainty can be characterized more appropriately distinguishing its location and its level;
- quality of the underlying evidence based can be assessed against the actual needs of the exercise;
- formal processing of expert opinion can be added;

- common metrics such as burden of disease or monetary value can be used for comparative purposes;
- different value systems and competing ethical frameworks can be made explicit, with their implications on the outcome of the assessment.

All of these elements, and certainly many more, require the development of methodology and tools; they also require the provision of human and cultural resources to design, conduct and interpret complex assessments in multidisciplinary settings, involving tasks stretching from gathering of the evidence base, to engage in consultation with stakeholders, to identifying communication strategies. Experience in projects such as INTARESE and HENVINET has been showing the degree of complexity of such exercises, at least given the current configuration of science, research and policy in the EU. It is likely that this work will give further ammunition to various practitioners, including WHO, to respond to the challenging questions mentioned above.

This avenue is however not the only one being explored. Integrated risk assessment does upgrade radically the traditional risk assessment / risk management scheme, but some systemic features are maintained, including:

- the role of the expert risk assessors, who avail themselves of enhanced tools to carry out an complex estimation;
- the guiding value or the aspiration towards scientific rigour (sometimes also of methodological elegance);
- a Mertonian view of research (i.e. motivated by disinterestedness, originality and skepticism);
- a tendency to favour specificity rather than sensitivity in assessing the scientific evidence (i.e., penalize false positives more heavily than false negatives);
- an overall view that regards integrated assessment as a *product*.

In essence, while the technical tools for integrated assessment evolve substantially, the underlying role of science in society and *vis à vis* the political power is unchanged. Other approaches question this state of affairs (explicitly or more often implicitly) and seem to focus on risk governance, rather than on risk assessment, representing perhaps a more radical departure from the current paradigm. Activities in the domain of health impact assessment (HIA) may be examples of models proposed as alternative to the modern model, such as those based on involving stakeholders in the capacity of peers.

Approaches such as HIA often share some characteristics:

- the *super partes* status of scientific experts is eroded, as they tend to become part of the extended peer community of stakeholders; objectivity is not a strict requirement, and may actually be unattainable as the values of the assessment are exposed;
- the work is conducted by operating deliberately within imperfections;
- emphasis is on the *process* rather than on the product.

While it is difficult to discuss and judge these models in the abstract, applications exist that may qualify as concrete attempts to turn them into practice. Even though these applications are not necessarily motivated by the need to respond to the limitations of risk assessment, some systematic review of key examples may shed more light on pros and cons of various models of risk assessment and its alternatives.

Workshop Session 2

Effects of measurement strategies on both the assessed and the perceived risk of exposure in human health risk assessment

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Direct estimates of the concentration of contaminants in the environment, are often required to make assessments of hazard, exposure and risk. The measurement strategy that is selected will have an effect on both the assessed risk, and potentially upon the risk perceived by stakeholders, such as local residents. The measurement of toxic compounds in gases derived from landfill sites to assess a possible causal link to reported birth defects in local areas, can be used to exemplify these general issues.

Measurements made from such strategies are never true values, and always have uncertainty. This includes contributions from both systematic and random effects, and from the sampling procedure. This uncertainty can be estimated by recently published methodologies[1]. A balance can be made between the uncertainty and the cost of any investigation[2]. These costs can include not only those for the measurements, but also those for the consequences of the measurements, such as those for the management and the communication of risk.

Two measurement strategies will be compared for the case study. One uses a plume dispersion model to estimate the human exposure from a distant source measurement, which generates a large uncertainty. A second measurement strategy, which reduces this uncertainty, requires samples to be taken in close proximity to people (e.g. in their houses). This, however, has the potential disadvantage of potentially changing the people's perception of the risk of exposure. It may alert them to the possibility of previously unsuspected risk, or confirm the presence of previously suspected risk. Quantifying the extent of a previously suspected risk may reveal it to be negligible, and thereby reduce perceived risk. Alternatively it may reveal the exposure to be significant, but this may also identify way in which the risk can be reduced to a safe level. The opposite effect is also possible, in which an awareness of the risk perceived by people can also affect the strategy that is selected by the investigator. In that case, aiming to avoid changing the perceived risk can distort the measurement strategy, and cause bias (and increased uncertainty) in the estimates of exposure.

The generic case study on estimating the exposure to gaseous emissions of people living around landfill sites, will be used to examine these issues and to draw conclusions on how optimal measurement strategies can be designed that address both the assessment and the perception of risk.

[1]Ramsey M.H., and Ellison S. L. R.,(eds.) (2007) Eurachem/EUROLAB/ CITAC/Nordtest/ AMC Guide: *Measurement uncertainty arising from sampling: a guide to methods and approaches. Eurachem* ISBN 978 0 948926 26 6. (http://www.eurachem.org/guides/UfS_2007.pdf)
[2]Ramsey M.H., Taylor P. D. and Lee J.C. (2002) Optimized contaminated land investigation at minimum overall cost to achieve fitness-for-purpose, Journal of Environmental Monitoring, 4, 5, 809 - 814

The Do's and Don'ts of Human Biomonitoring in Integrated Risk Assessment

Roel Smolders, Greet Schoeters, VITO, Environmental Toxicology, Boerentang 200, B-2400 Mol

Human biomonitoring (HBM) is defined as the analytical measurement of any substance, structure, or process in human matrices (blood, urine, etc.) that indicate an exposure or susceptibility towards stressors or that predict the incidence or outcome of disease. HBM offers a measure of the internal dose of a chemical substance in a person's body or its fate, taking into account often poorly understood processes such as bioavailability, accumulation, excretion and metabolism, and therefore has a rightful place in any integrated risk assessment.

HBM offers excellent opportunities for integration of exposure routes of pollutants, individual time-activity patterns, mixture effects of environmentally relevant exposure scenarios, and non-biological factors such as lifestyle or socio-economic context. Hence, HBM data generally are more relevant for integrated risk assessment than mere extrapolations from chemical concentrations in soil, air, and water.

However, the presence of a contaminant in a human matrix such as urine, blood or hair is not necessarily equal to the presence of risk, and alarming reports on the widespread presence of e.g. brominated flame retardants in breast milk or POPs in the Arctic have often confused the popular media and the general audience, fueling the controversy on the use and misuse of human biomonitoring data. If HBM data is to be incorporated into an integrated risk assessment paradigm, additional aspects such as toxicological data, environment and health information and an appropriate weight-of-evidence approach should be included, and a proper communication strategy is needed. This presentation aims at highlighting some of the advantages of using HBM for integrated risk assessment, but also wants to warn for some of the existing pitfalls. Additionally, we will be reporting from the INTARESE Workshop "The use of biomarkers for risk assessment" that was held in November 2007 at the second annual INTARESE Meeting in Prague, where these do's and don'ts of human biomonitoring were extensively discussed.

Communication and policy uptake of human biomonitoring research results in Belgium; risk communication and policy interpretation in cooperation with experts, policy makers and stakeholders.

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Complexity not only is dependent of problem characteristics, but also of the ambition one chooses to realize. Reducing ambition because of known complexities only solves part of real world problems. The 'ambitious real world scientist' however should be aware of unforeseen, emerging and partly unsolvable complexities. Furthermore, the 'ambitious real world scientist' has problems of public relations to solve: the promise of traditional science is 'to make things easier in life' or 'to solve problems', whereas the 'ambitious real world scientist' confronts her or his extended peer community with complexities unheard of in specialized scientific disciplines or policy environments.

We present work of the Flemish Centre for Health and Environment, working directly for the Flemish government. From 2001 to 2006 the Centre investigated the relation between environmental pollution and human health by measuring pollutants and health effects in (over 4000) Flemish inhabitants. A major challenge concerns the translation of these human biomonitoring data to policy priorities and measures. Medical, environmental and social scientific experts and policymakers cooperatively developed an action-plan for interpretation and policy uptake with regard to the human biomonitoring results. In the beginning the discussions in the action-plan steering group mainly focussed on environmental and medical scientific interpretation of the monitoring data. Consultation of scientific experts as well as the literature was considered sufficient to produce the necessary knowledge and answers. While trying to build bridges towards policy interpretation the limitations of an exclusively scientific endeavour became clear. Setting policy priorities when also other than (medical and environmental) scientific factors had to be taken into account proved to be problematic. The social scientists introduced other relevant assessment criteria (e.g. social preferences, feasibility of policy measures) and proposed the formation of a stakeholder jury that would judge relevant data and knowledge from a broader perspective in order to give advice to the government. The government will make a decision informed by both expert and jury advice. Furthermore the need for development of a procedure 'from data-interpretation to decision making' proved to be useful. In 2007 the action plan was used in practice in order to give advice on priority setting for the ministers of environment and health, based on the human biomonitoring results. We used a multi criteria analysis method for structuring information and discussion. We will also focus on issues of risk communication in general.

Dealing sensibly with risks – A Dutch approach toward risk management and communication

Leendert van Bree, Netherlands Environmental Assessment Agency, Bilthoven

Desirability and fairness of (equal) protection of civilians from health risks of environmental exposures is increasingly balanced against efficient use of (limited) public expenditure to reduce these health risks. Various risk aspects play a role in assessments of policies for risk management, including size and nature of health effects, cost efficiency, cost benefit ratios, and public perception and acceptance of risks.

In response to and in line with the Agency's first scoping report on this issue – 'Dealing sensibly with risks (De Hollander and Hanemaaijer, 2003)', the Dutch cabinet has adopted this new human health risk policy concept and has agreed to apply it to important issues at all policy domains dealing with human health risks.

Currently, the Agency is preparing a second report, including a further inventory of a large number of environmental and non-environmental risk factors and a detailed analysis on a triptych of risk metrics: 1) quantified physical health risk, 2) quantified perceived health risk, and abatement costs of control (i.e. risk reduction) measures.. Special attention is given to cross-analyses of cost-effectivity ratios and of similarities in ranking of risks. Risk and industrial safety examples that are analyzed in detail are: air pollution/PM_{10}, aviation and airports, noise, soil pollution and sanitation, industrial and transport safety, risks of flooding, and substances. The report also includes a brief analysis of issues surrounding dealing sensibly with risks and policy options.

The results of all these analyses will be presented. Furthermore, the 'dealing sensibly with risk' concept will be considered in a wider perspective of transitions in risk assessment and risk management and decision making evaluations.

On Preventing Harm: the Importance of Terminology, Timing, and Transparency in Evaluating "Evidence for Action".

David Gee, Strategic Knowledge and Innovation, European Environment Agency

Developmental, reproductive and other harm that results in lifelong or late onset serious disease and dysfunction can be initiated in the early life stages of human beings, and other species, by a variety of toxicants. It is often the timing of the dose more than the dose itself that distinguishes harmful from harmless exposures to such toxicants. As much of the harm is irreversible, and sometimes multi-generational, the timing of actions to prevent such harm is also critical, as it is for exposures that occur at other vulnerable times to vulnerable groups.

Reaching agreement between stakeholders on a sufficiency of evidence for early action to prevent harm requires transparency and consistency in the terminology used to both describe cause/effect relationships and to

characterise the different strengths of evidence that may be appropriate for different precautionary and preventive actions.

It is also necessary to identify and make transparent the frequently implicit rules and argumentation used by Risk Assessment committees as they turn scientific knowledge into conclusions about evidence of hazards and risks. Some of these rules, including the widely used Bradford Hill causal 'criteria', are briefly reviewed in light of multi-causality and the methodological biases within environmental sciences.

Proposals are made to improve terminology, transparency and the timing of actions to prevent harm.

Workshop Session 3

NEW DIRECTIONS FOR RISK ASSESSMENT OF ENVIRONMENTAL CHEMICAL MIXTURES

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Present salient problems in assessing the health risk to chemical stressors include the multitude and complexity of pathways, lack of data and explicit mechanistic understanding for identical dose-response assessment, and the diversity of phenotypic consequences of exposure among others. Joint interaction of modifying factors including genetics, diet and age window of exposure makes the articulation of an effective framework for integrated human health risk assessment even more challenging.

The current orientation in chemicals risk assessment is to tackle them as single substances affecting individual health endpoints while, in reality, human exposure occurs to mixtures of chemicals as they are present in the environment and consumer products. The possibility to address the human exposure to mixtures of chemicals and the associated health risk beyond the sheer additivity paradigm is what is needed to adequately tackle public and consumer health risk assessment. A multi-layered integrated approach supported by an extensive knowledge base would enable rapid advances in this quest. Combining the information from environmental fate analysis, epidemiological data and toxicokinetic/dynamic models for the estimation of internal exposure can give powerful support to advanced human health risk assessment. Coupling these data with gene and protein expression profiles as signatures of exposure to classes of toxicants to derive biologically-based dose-response estimates would open the way towards adopting a biological connectivity approach to risk assessment. A transcriptome-wide overview of gene expression patterns supports the mechanistic understanding of underlying biological changes induced by chemical mixtures even at sub-toxic doses. This information is essential for the derivation of dose-response functions relevant from the low, environmentally relevant doses, up to doses of

toxicological concern and occupational exposure levels. In this way, the need for extrapolations that induce uncertainty in the final risk estimate can be alleviated.

Through the combined use of toxicogenomics data together with biology-based dose-response models that take into account the individual substance biokinetics and the mixture biodynamics it is possible to derive health risk values coupled with the associated uncertainty estimations. Hierarchical modeling based on Bayesian statistics and Markov chain Monte Carlo using experientially-derived prior distributions of the most critical parameters in the modeling chain allows us to estimate population health risk from exposure to environmental chemical mixtures. Health risk uncertainty is then explicitly accounted for and reported hand-in-hand with the risk values, resulting thus in a both transparent and scientifically robust method for mixture risk assessment.

This work will give examples of applications of the connectivity approach outlined above in the following areas:

(a) combined exposure to mixtures of volatile organic chemicals in the indoor and outdoor environment

(b) estimation of body burden from chronic (life-long) exposure to mixtures of chemicals and of the associated health risk

The experience obtained from these examples leads us to the identification of the current knowledge and methodological gaps for full implementation of this approach for regulatory purposes. Useful conclusions may thus be drawn as to the future needs for scientific developments that will meet the requirements of integrated health risk assessment, geared to protect adequately public health from environmental and consumption-related stressors.

Influence of indoor exposure on eczema in early childhood

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NoMiracle

At the outset the NoMiracle (project co-ordinator: Dr. Hans Lokke, Denmark) will be presented shortly:

To support current and future European strategies, in particular for environment and health, there is an urgent need for development of methods for assessing the cumulative risks from combined exposures including complex mixtures of chemical, physical, and biological agents integrating the risk analysis approaches of environmental and human health.

NoMiracle will deliver understanding and tools for sound risk assessment, including the identification of biomarkers and other indicators of cumulative impacts.

This will facilitate the link information concerning the condition of air, water, soil and the built environment with human and ecosystem health monitoring data. It includes also human toxicology and epidemiology, aquatic and terrestrial ecotoxicology, environmental chemistry/biochemistry, toxicogenomics, physics, mathematical modelling, geographic informatics, and socio-economic science.

Epidemiological study

Background.

Other factors besides a genetic disposition seem to play a role in the development of allergic disorders. Exposure to risk factors such as indoor air pollution is becoming increasingly interesting, especially during early childhood.

Methods.

Within epidemiological studies, involving approximately 2500 children, the effect of indoor exposure on physician-confirmed eczema and allergic symptoms has been investigated. The exposure situation has been characterised on hand of measurements and the description of redecoration activities (painting, floor covering and new furniture) before birth and in the first years of life.

Results.

Highly exposed children showed a significant effect on allergic disorders compared with the control group of not exposed children. The lifetime prevalences without any vs. all three redecoration activities were for allergic symptoms 9.3 vs. 17.2 % and for eczema 11.5 vs. 20.4 %. Adjusted for confounders, the redecoration associated burden led to odds ratios of 1.8 (95%CI: 1.3-2.6) for allergic symptoms and 1.9 (95%CI: 1.4-2.7) for eczema.

Conclusion.

The comparison of an exposed and not exposed vulnerable group shows that exposure emissions due to redecoration activities seem to be associated with the risk of eczema and allergic symptoms. Thus, prevention of allergic disorders should include the avoidance of such activities around birth and in the first year of life.

Link to NoMiracle

In case of the health part of the NoMiracle project the above cited results and conclusions are both the basis for some parts and an essential element of the NoMiracle project. To support the (health relevant) hypotheses the NoMiracle project looks for exposure pattern (considering indoor VOC), the prognosis of expected health effects (using cell models and results of epidemiological studies and modelling of exposure and health effect pattern.

Towards an Integrated Environmental Health Informatics System

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http://envexp.technion.ac.il

In many regions worldwide, enormous amounts of environmental observations, monitoring and sampling data, and medical, behavioral, and epidemiological records keep accumulating in numerous independent archives. These datasets contain much unexploited information that can shed light on various key questions regarding possible associations between pollutant emissions, environmental concentrations, compound toxicity, epidemiology and human health. Methodical scrutiny of comprehensive environmental and medical databases can reveal previously undetected relationships, enhance the extent to which we understand known ones, and point towards new directions where answers to environmental health problems may be found. To date, use of this exponentially increasing amount of data is oftentimes inefficient and results in waste of the resources put in their acquisition.

In order to profitably mine the existing databases they must first be acquired and collated. Obtaining the data along with all the relevant documentation and meta-data and organizing them in an orderly manner and readable formats is a tedious but indispensable initial step. The data must then pass through rigorous quality assurance procedures to uproot erroneous records and ensure their consistency and correctness, and to estimate the levels of the residual uncertainty. Whereas software for visual inspection and routine preliminary data analysis is available, to work efficiently in an interconnected and hierarchical environmental health information system the architecture of these tools must be general and flexible, affording the implementation of future modifications and adjustments. Sometimes, this means borrowing advanced technologies and algorithms from different research fields not directly related. Often however, development of exclusively tailored methods and algorithms that best suit the problem at hand are inevitable. Understanding the intricacy of environmental health problems is a prerequisite to avoid pitfalls encountered in the statistical inference process and to increase the confidence level of the results.

In our presentation we will describe some steps towards the development of an integrated environmental health informatics system in Israel that, combining various methodologies, will make it possible to effectively tackle the masses of accumulated data and harness them to the purpose of better studying and understanding environmentally-related health concerns. We are in the process of collecting and organizing the data from the extensive air pollution monitoring network in Israel. These data, originally designed for tracking concentrations of criteria pollutants and in case of standard exceedances issuing warnings to the public and professional personnel, proved to be a gold mine for enhancing our understanding of relationships among different pollutants as well as for providing different ways for analyzing their sources. Specifically, using only common monitoring data we could allocate the shares of observed pollutant concentrations to their respective specific and categorical sources. Our work improved the process of delineating spatial features from a scarcely distributed spatial data by optimizing the mapping procedure and by developing tools for map comparison. This enabled revealing simultaneous synergistic or antagonistic trends among different pollutants, integrate them across distinct georeferenced layers, assess the combined (multi-route) exposure to pollutants present is different environmental media, and estimate the risk from these exposures. Studying relationships among records that

have "long memory" attributes may improve our understanding of the temporal variability of chronic exposure and of their health markers.

Using only available archived monitoring data, we developed methods for identification of pollution sources and for estimation of their shares in the observed pollutant levels. Ratios of pollutant concentrations and correlations among them proved to be powerful tools for this purpose. These methods were adapted and applied to different data sets and shown to be common across pollutants. Recently, using these methods, background pollutant levels and daily pollutant recirculation due to the alternating sea and land breezes were identified. These insights are expected to impact on future policy to reduce environmentally-related health hazards.

The difficulties in managing and efficiently using environmental data are mirrored and usually enhanced for health data. Medical, clinical, and epidemiological data tend to arrive from many different sources, using distinct observation methodologies and classification schemes. Moreover, the nature of medical data oftentimes makes them more difficult for analysis, partly because they tend to be limited in scope due to privacy and release policy issues. Retrieval of data from diverse public health and medical records and implementation of quality assurance procedures must be followed by a pre-processing stage that includes matching and geo-aligning data from various sources within a GIS platform. We found that a trained human eye was needed in many cases to intervene and make modifications to routinely used tools. Namely, refinements of the subtleties of health data standardization and normalization proved to be both important and non-trivial, since the selection of data appropriate for each analysis was found to bear important implications for the following statistical analyses and inference. Assessing the spatial randomness of georeferenced parameters (both health indices and exposure metrics) and accounting for multiple testing were found crucial in developing sound statistical methods for testing possible relationships between environmental attributes and health markers.

In conclusion, a complete integrated framework for combined analysis of environmental and health data is yet to be developed. For both environmental and health data, the insights gained from basic yet rigorous analysis are indispensable. Incorporation of more sophisticated algorithms and versatile analysis tools enables the extraction of hidden attributes and interconnections among the available data. Integration of diverse tools pays dividends in terms of clarity of the results and sharpening of the conclusions. Such analysis tools are the heart of an integrated informatics system for environmental health inference.

Integrating risk perception into the [environmental] health risk model

Matti Jantunen, Finnish Public Health Institute, Department of Environmental Health, Unit of Environmental Epidemiology, Kuopio, Finland

Workshop Session 4

Mortality impacts of air pollution and other environmental factors

Brian Miller
Principal Epidemiologist, Institute of Occupational Medicine, Research Avenue North, Riccarton, Edinburgh, EH14 4AP, UK

Health Impact Assessment involves predicting future changes in population health following interventions, e.g. the reduction of air pollution. In practice, to do this for mortality outcomes presents particular technical problems, since a change in mortality rates affects the size and shape of subsequent populations at risk.

The solution is to use life-table methodology, which provides a framework for a consistent treatment of mortality impacts. We have developed IOMLIFET, a system of spreadsheets that allows maximum flexibility in both the input assumptions and the summary outputs. Impacts on mortality hazard rates may differ across both age and (future) calendar time; outputs, expressed either as numbers of deaths or life-years experienced, can also be summarised in any subsets or combinations of these two time axes.

We've applied our method to a variety of HIA topics. We'll show some results and demonstrate why we prefer life-years as an output over attributable deaths, and how some commonly-used simplifications may mislead as longer-term projections. We'll discuss the problems of communicating results, and show results from comparing the impacts of different sorts of risks – air pollution, passive smoking and deaths from traffic accidents. We'll also describe common approaches to weighting predicted gains in life years, either by applying monetary values, or by making adjustments for depleted quality of life due to illness or disability in the years before death.

Risk mapping of environmental pollutants: state-of-the-art, possibilities and limitations

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NOMIRACLE is an integrated research project under the 6th Framework Programme of the European Union. NOMIRACLE stands for Novel Methods for Integrated Risk Assessment of cumuLative stressors in Europe (http://nomiracle.jrc.it/). The project focuses on environmental pollutants but also looks at other stress factors. Cumulative stress may include:

- multiple sources of emission;
- behaviour and fate in multiple compartments (multimedia fate);
- multiple pathways of exposure;
- multiple receptors (notably integration of ecological & human RA);
- multistress (with as a special case combitox, the combined effects of toxicants).

NOMIRACLE includes a work package on risk presentation and visualisation that mainly deals with methods for ecological and human health risk mapping.

In a literature survey of current risk mapping methods was conducted in 2005 to assess the state-of the-art of risk mapping methods for toxic substances. The results indicated that risk mapping is a rapidly developing field of expertise. However, published maps differed considerably with regard to risk assessment methods, assessment level, indicators, scale, type of underlying data and spatial operations applied. Some examples of this will be shown. Many maps had shortcomings from the NOMIRACLE point of view:

- very little attention was being paid to communication and to the target audience;
- human and ecological risk assessment were hardly assessed simultaneously, let alone integrated;
- there were few maps of cumulative stressors;
- there were few maps of stressors at larger scales (catchment areas, pan-European, etc.).

Some of these gaps are currently being filled by ongoing work in the field of risk mapping, also by partners in the NOMIRACLE project. Examples of these newer methods will be shown. Among the novelties are:

- cumulative stress maps;
- self organising maps (SOM);
- risk maps at the continental scale;
- and multimedia fate maps.

Risk maps are often made to communicate the results of environmental risk assessment to stakeholders and to the general audience. However, this should be done with great care. Geographical maps are a very powerful tool for communication and the wrong use can easily lead to misconception and public unrest. This is illustrated with some experiences from the past.

In 2006 the NOMIRACLE project organised a workshop on complex chemical risk assessment in Verbania-Intra, Italy. Some of the recommendations provided for making sound (cumulative) risk maps were:

- Identify the target audience and stakeholders for the map (be aware that risk perception of the general public is different from that of the specialists!).

- Provide a clear objective of the map.
- Use the appropriate risk assessment methods and clearly describe these.
- Apply appropriate cartography and spatial operations.
- Get the visualisation right (scale, colours, etc.), most notably avoid suggestive use of symbols and colours.
- Always provide complete and accurate legends with the maps.
- Provide guidance for the interpretation of the maps.
- Provide information about any uncertainties associated with the methods and results.
- Use the right communication channels and techniques.

More about this workshop can be found at:

http://nomiracle.jrc.it/Pageslib/IntraWorkshop.aspx, and

http://nomiracle.jrc.it/Lists/Events/Attachments/2/proceedings.pdf.

PCB Exposures in Eastern Slovakia: Health Effects, Remediation, and "Safe" Levels

Tomas Trnovec, Slovak Medical University, Bratislava, Slovakia, and Todd A. Jusko, University of Washington, Seattle, WA 98195, USA

A risk assessment is an analysis that gathers information about toxic substances at a site to estimate a theoretical level of risk for people who might be exposed to these substances. Data for the assessment comes from both scientific studies of the potential toxin and environmental data collected from the site of exposure. As a result, a risk assessment provides a comprehensive scientific estimate of risk to persons who may be exposed to these hazardous substances.

Eastern Slovakia is generally acknowledged to be one of the most heavily polluted sites by polychlorinated biphenyls (PCBs) in the world. Through international research collaborations over the last two decades, large amounts of data have been collected on 1) environmental exposure to PCBs and 2) related health outcomes. In spite of the magnitude of the anticipated and evidenced health effects, until now, no formal risk assessment process has been conducted by National health and environmental authorities.

Here, we describe the pieces of conducting a formal risk assessment in the Eastern Slovak population using the World Health Organization (WHO) model. This model is comprised of: (1) issue identification; (2) hazard identification; (3) dose–response assessment; (4) exposure assessment for the relevant population; and (5) risk characterization. Such an assessment is imperative for this region since to date, few changes with regard to public health—in a fairly large population—have taken place. Below, we describe the five stages of the WHO risk assessment model in terms of the Eastern Slovak experience:

Issue Identification and Hazard Identification (# 1 & 2)

There is ample evidence that PCBs and other organochlorine compounds are present at high concentrations in the population of eastern Slovakia. Further, published data have demonstrated possible neurotoxic, immunotoxic, and ototoxic effects of PCB exposure in human and animal studies.

Dose–Response Assessment (# 3): State of PCBs and Human Health Endpoints

This stage is of crucial importance to the risk assessment process. It evaluates both qualitative and quantitative toxicity information to estimate the incidence of adverse effects occurring in humans at different exposure levels. To be sure, two important bodies on both sides of the Atlantic have reviewed the available data on toxicology of PCBs in the last decade: the Agency for Toxic Substances and Disease Registry (ATSDR) in USA and the European Food Safety Authority (EFSA). Relevant documents do not contain conclusive data on dose-response relationship on any of the most important health outcomes. Too few congeners have been studied (in animals!), on enough endpoints, with enough studies for each congener, to draw much in the way of conclusions regarding either relative potency of the congeners or the relative sensitivity of the organ systems. Cited experimental studies assessed different endpoints, using different doses, dosing duration, and life stage of exposure. Lowest observed adverse effect levels (LOAELs) and/or no-observed adverse effect levels (NOAELs) for a congener/endpoint were very often identified on the basis of a single study. The human data on exposure to environmental mixtures containing PCBs did also not allow for distinguishing between effects of NDL- and DL-PCBs and PCDDs/PCDFs either, one reason why risk assessment in connection with PCB exposures relies mainly on animal data. Even though the potential effects of PCBs have been insufficiently assessed so far in epidemiological studies, accumulating evidence suggests that clinically-important deficits in neurobehavioral and immune functions may occur at widely prevalent exposure levels. Due to criticism, as a complement to traditional methods for assessing risks of non-cancer endpoints, the Environmental Protection Agency (EPA) Science Advisory Board has challenged the regulatory scientific community to develop improved methods for RfD calculation. Development of benchmark dose (BMD) methods is one approach that has been taken to address the challenge.

Two sets of BMD calculations on PCBs currently exist. One on neurobehavioral effects, the other on immunotoxic effects, both in regard to children exposed perinatally. To develop a BMD calculation for ototoxic effects of PCB exposure, flexible software was developed with cooperation from colleagues at the Slovak Technical University in Bratislava. We will present BMD data for the following outcomes in PCB-exposed populations in eastern Slovakia: Thyroid volume and hormones in adults, various parameters of neurobehavioral performance in children, hearing threshold in children, and amplitude of otoacoustic emissions in children. We consider the assessment of the BMDs for various health outcomes related to PCBs exposure in eastern Slovakia a significant contribution to public health decision making in eastern Slovakia.

Exposure Assessment (# 4) The frequency, magnitude, and duration of exposures to PCBs and their major metabolites has already been identified and published in a series of papers from several studies. Our most recent data show that over time, the PCB body burden in children gradually decreases, but surprisingly, in approximately one-fifth of children from our cohort, PCB levels increase.

Risk Characterization (#5) In the absence of reliable human data on dose–response assessment (item 3), the last stage, i.e. the risk characterization detailing the nature and potential incidence of effects for the exposure conditions described in the exposure assessment cannot be successfully completed. Thus, it is important that, for the most sensitive health outcomes, more studies assessing the dose–response relation be carried out. Lastly it has to be admitted that the risk communication process, though largely neglected, was recently induced mainly with regard to implementation of the non-combustion technologies for destroying persistent organic pollutants (POPs) in Slovakia.

Speaker Profiles

David Briggs is Professor of Environment and Health Science in the Department of Epidemiology and Public Health at Imperial College London. A geographer by background, his research focuses on the use of GIS methods for exposure modelling and spatial analysis of environmental health effects. As leader of the GIS Group in the Small Area Health Statistics Unit, he is involved in a wide range of national studies including investigations of landfill sites, multiple deprivation, and urban air pollution. He has been a principal investigator on many EU-funded projects, including several studies focusing on traffic-related pollution and health (SAVIAH 1 and 2, HEARTS), a study aimed at mapping air pollution and atmospheric emissions across the EU (APMoSPHERE), a study on data limitations for EU environmental policy support (BICEPS) and two studies on the use of satellite data for environmental monitoring and policy support (MANTLE, GEMS). He currently leads a 33-instution project on Integrated Assessment of Health Risks from Environmental Stressors (INTARESE), funded under the EU 6th Framework Programme, and is a member of the large HEIMTSA IP, which is exploring the use of integrated assessments to analyse policy scenarios in Europe. He is also a partner in the EU-wide ESCAPE project which is integrating analysis of air pollution cohorts across Europe (currently at negotiation stage). Other current projects include two cohort studies on air pollution and health in Bradford (NERC-funded) and Bristol (MRC-funded), and studies of mobile phone base stations (DH/MTHR), powerlines (MTHR) and air pollution modelling (RGI), and a major study of health risks in Scotland (for the Scottish Executive). Two other EU-funded projects on air pollution (MACC, GENESIS) are at negotiation stage. He has published over 100 research papers, and about 40 research reports and books, and has presented invited papers to more than 150 conferences and symposia, world-wide.

Cindy Jardine is an Assistant Professor in the Department of Rural Economy at the University of Alberta. She is also an Adjunct Professor in the Centre of Health Promotion Studies and the Dept. of Human Ecology. Cindy has a diverse academic background, with a PhD in Medical Sciences (Public Health Sciences - Environmental Health), MSc in Environmental Science/Engineering (both from the University of Alberta), and BSc (Honours) in Zoology from the University of Manitoba. She has recently been awarded tenure and promotion to Associate Professor, effective July 1, 2008.

Cindy's research interests are in the areas of environmental health risk communication, risk perception and risk assessment. Her research involves looking at the role of risk communication as a part of a comprehensive risk management strategy, including incorporating pubic perspectives into risk decision making. Much of her research has done with Indigenous communities in northern Canada to better understand their risk perspectives and risk communication needs.

Prior to joining academic, Cindy had a diverse career in environmental and health management, working with various provincial health and environment departments. She also spent 3 years working in Jakarta, Indonesia as an environmental advisor to the Indonesian Environmental Impact Management Agency.

Cindy was recently been appointed Editor of the *International Journal of Qualitative Methodology*. She has

been a member of the National Advisory Panel on Responsible Care® for the Canadian Chemical Producers Association since 2000. She is also a Professional Biologist in the province of Alberta, and a member of the Society for Risk Analysis.

Timo Assmuth earned a BA degree at the University of Turku in Geology and Chemistry, then a MA majoring in Environmental Science and Limnology at the University of Helsinki where he defended his PhD thesis on risk assessment on contaminated sites. He has worked for 23 years as researcher at the Finnish Environmental Institute (SYKE) and its predecessors, mainly on wastes, soil protection, environmental technology, chemicals, environmental health, and risk analysis, and has participated in various national international projects, networks, societies, committees and other activities and bodies in these areas. He is presently engaged in the EU integrated project NoMiracle (Novel Methods for Risk Assessment of Cumulative Stressors in Europe). He was a visiting Fulbright scientist at Tufts University Department of Urban and Environmental Policy and Planning during fall 2007. His current research interests include comparative risk analysis, history of ideas, socio-psychology of environmental risk and uncertainty, philosophy of science and science policy, and cultural studies related to environmental issues. Timo Assmuth is Adjunct professor at the University of Helsinki.

Marco Martuzzi is an epidemiologist with experience in environmental and occupational studies. He has worked at the Italian Institute of Health, the London School of Hygiene and Tropical Medicine, the Imperial College School of Medicine, before moving to WHO, first at the International Agency for Research on Cancer (Lyon) and over the last eight years at the European Centre for Environment and Health, Rome Division. He has experience in methods and applications of descriptive and geographical studies in non-communicable disease epidemiology, which were the subject of his PhD obtained from the University of London in 1996. His recent areas of work is on the health effects and the health impact of several environmental factors including air pollution, asbestos, waste, electromagnetic fields and socio-economic determinants. He is responsible for the programme Health Impact Assessment Methods and Strategies, which contributes to supporting WHO's European Member States in decision making on environment and health matters.

Mike Ramsey is Professor of Environmental Science at the University of Sussex, and Chair of the European Committee of the Society of Environmental Geochemistry and Health (SEGH). After degrees in Chemistry & Geology, and Analytical Geochemistry, he worked for 3 years in the Mining Industry in Zambia, and then spent 20 years in various research and lecturing posts at Imperial College London.
He has published over 100 scientific papers, mainly in environmental geochemistry, including estimation of measurement uncertainty from field sampling, and the effects of heterogeneity (and the uncertainty it causes) on plant uptake of heavy metals and on human health risk assessment. Current research projects include investigation of uncertainty from sampling of contaminated land (DTI/CLAIRE funded) and contaminated food

(FSA funded). He is also Chair of both the Eurachem/Eurolab/Citac/Nordtest Working Group on Uncertainty from Sampling, and the Royal Society of Chemistry Sub-committee on Sampling Uncertainty and Quality.

Roel Smolders graduated as an Engineer in Applied Biological Sciences (BSc. University of Antwerp, 1994; MSc. University of Louvain, 1997), majoring in forestry and nature conservation. After spending some time at two different engineering firms as a consultant on water and soil pollution, he returned to his Alma Mater to pursue a PhD in Environmental Toxicology (University of Antwerp, 2002). He is (co-) author of about 30 papers and book chapters, and has presented almost 40 presentations at a variety of national and international conferences.

After spending almost ten years studying different aspects of ecotoxicology and risk assessment, he has expanded his line of work towards the human side of environmental toxicology. Since the beginning of 2006, Dr. Smolders is working as an Expert on Environment and Health at the Flemish Institute for Technological Research (VITO) in Mol, Belgium, with a specific focus on human biomonitoring.

Recently, his work has been focusing on the support of two major and exciting programs funded by the European Commission under the 6th Framework Program for Research and Technological Development, the ESBIO project (Expert team to Support BIOmonitoring in Europe) and the INTARESE project (INTegrated Assessment of health Risks of Environmental Stressors in Europe). Both programs aim at promoting and incorporating human biomonitoring as a tool for environmental risk assessment and human and environmental health policy support. In the INTARESE project, Roel Smolders is Deputy Workpackage leader for WP2.2 (human biomonitoring).

Hans Keune graduated in 1999 as a Political Scientist (*International Relations* and *Technology Assessment*) at the University of Amsterdam on: *Thermonuclear fusion between laboratory and society. The decision making process on thermonuclear fusion research in the European Community for Atomic energy 1976-1998*. From February 1999 till May 2000 he worked as a researcher at the *Research Institute on International Industrial Relations* in Amsterdam. In May 2000 he moved to Belgium where he started working at the University of Antwerp. Until 2002 he worked on a research project concerning the Work - Life Balance (*the development of an instrument of social audit*) at the Faculty of Applied Economics.

From the beginning of 2002 he started working at the Research Department for Technology, Energy, Environment (STEM) (University of Antwerp, Faculty of Applied Economics, Department of Environment, Technology & Technology Assessment) on the project *The Centre of Expertise for Environment and Health*, financed by the Flemish Government for the period 2001 – 2006. In January 2007 he moved to the Sociology Department at the Faculty of Political and Social Sciences (University of Antwerp) to work on the extended project *The Centre of Expertise for Environment and Health* (2007 – 2011).

His expertise is mainly related to *environment & health* (science, social issues and policymaking), *risk* (perception, communication and assessment), *knowledge* (production, integration, interpretation and

application), *complexity*, *inter- and transdisciplinarity* (boundary work science – government – society and participation), *action research*, *group assessment/decision support methods* (e.g. multi-criteria decision analysis, Delphi method, focus group). He has published in a number of national and international peer reviewed journals and books on his work.

Leendert van Bree has 20 years experience in inhalation toxicology of air pollutants, health risk and impact assessment of air pollution, and science-policy interface activities regarding air pollution research and control strategies. He has successfully coordinated a large number of studies on the health effects of air pollutants, funded by Dutch scientific organizations and the Dutch ministry of Environment. He has been a contractor in the EU funded HEPMEAP study linking exposure, toxicology, and epidemiology data to assess the contribution of traffic emissions to health effects associated with Particulate Matter. In addition, he has been one of the initiators of AIRNET, a Thematic Network on Air Pollution and Health in the European Union and acted as a coordinator in the management team. He is involved in studies and advisory tasks for national and international bodies and agencies (VROM, EEA, US-EPA, UN ECE, IIASA, WHO, Harvard University) in the field of (1) research programmes and health risk assessment of air pollution and (2) impact assessment and abatement strategies. His professional interests are quality of the environment, health impact and benefit analyses, and risk-based and effective environmental policy. Dr. Van Bree is currently programme director 'Health Risks, Well-being, and Quality of Life' at the Netherlands Environmental Assessment Agency (L.van.Bree@mnp.nl).

David Gee was educated in politics and economics and has worked for over 30 years at the science/policy interface of occupational and environmental risk assessment & reduction, with UK Trade Unions: with the Environmental Group, Friends of the Earth, where he was Director; and, since December 1995, with the European Environment Agency, an EU information providing body in Copenhagen, where he is responsible for "Emerging Issues and Scientific Liaison" and Group leader for Science ,Policy and Innovation.

He has published reports and lectured on many issues, including *Scientific Uncertainty; the Precautionary Principle; Environmental Health; Environmental Taxes and Ecological Tax Reform; and Clean production/ Eco-efficiency.*

He is initiator, co-editor and contributor to the widely cited and used EEA report, *"Late Lessons from Early Warnings: the Precautionary Principle 1898-2000" (2001) which is now going into vols 2, 3 and 4.*

He is married with four daughters.

Dimosthenis Sarigiannis is a Chemical Engineer from the Technical University of Athens and the Ecole Centrale of Paris. He received his MSc and PhD at the University of California, Berkeley and he currently leads the work on Consumer Product Safety and Quality at the Institute for Health and Consumer Protection of the European Commission's Joint Research Centre (JRC). Prior to that he led the activities on Human Exposure to

Environmental Stressors and Health Effects and on Risk Assessment of Chemicals at the European Chemicals Bureau, and has been Scientific Assistant to the JRC Director General, Strategy Manager of the Institute for Health and Consumer Protection, and Head of the Complex Systems Modelling Sector at the JRC Institute for Systems, Informatics and Safety.

Since 2003 he has been elected Associate Professor of Environmental Engineering at the Aristotle University of Thessaloniki in Greece, and since 2006 he is visiting professor at the Master of Science program on Toxicological Risk Assessment and Management of Environmental Pollutants at the University of Pavia in Italy. Since 2005 he is the Secretary General of the Mediterranean Scientific Association for Environmental Protection. In 2002-2004 he was the Secretary of the Joint Research Centre Scientific Committee, and during the period 2006-2009 he serves on the Scientific Committee on Chronic Risks of the National Institute for Environmental and Industrial Risk of France (INERIS).

His research focuses on the evaluation of the health and environmental impact of industrial and environmental toxicants, uncertainty associated with human health risk assessment, data/model fusion for environmental health monitoring. Over the last 4 years, he has focused on the set-up and use of biology-based computational models toxicogenomics techniques for better informed risk assessment of chemical mixtures in the environment and consumer products. He is the author or co-author of more than 80 scientific papers published in the peer-reviewed literature and has led over 15 international research projects in the USA and the EU in the above areas.

Olf Herbarth is Managing Director of the Centre for Environmental Medicine at the University of Leipzig. His research interests include:

- environmental medicine, hygiene (focused on environmental hygiene), epidemiology (including molecular epidemiology)
- exposure research: internal and external (close to human) exposure
- effect research (health and well-being), pathology, mechanisms of action of exposures
- development of non-invasive methods for medical diagnosis
- risk analysis, threshold values, dose-response-relationship; prevention measures
- modelling of epidemiologic processes and time series modelling , including forecasting

He is adjunct Professor at the Wessex Institute of Technology, involved as a PI/co-PI in a considerable number of national and international research projects including epidemiological studies. He has published more than 200 articles, most of them in peer reviewed journals, has been appointed member of several commissions and the editorial boards of four international scientific journals.

David Broday is Assistant Professor of Environmental, Water and Agricultural Engineering in the Faculty of Civil & Environmental Engineering at the Technion, Israel Institute of Technology. Dr. Broday received his M.Sc.

degree in Agricultural Engineering and his D.Sc. Degrees in Mechanical Engineering from the Technion. Then, he expanded his training in environmental sciences and exposure and risk assessment. During the past ten years, Dr. Broday served as an advisor and researcher for several government agencies, international firms and non-profit environmental organizations in Israel and the U.S. His research interests involve the development and application of new methods for diagnostic and mechanistic studies of multipathway physicochemical transport and fate processes that take place in different environmental media. The long term goal of his work is to develop a consistent framework for source-to-dose-to-risk modeling and estimation.

He teaches and conducts research in a variety of environmental health topics including interpretation of urban air pollution data, indoor and microenvironmental air quality, personal and population multi-pathway exposure, dosimetry of inhalable pollutants and risk assessment. He was the organizer of the workshop on Urban Exposure to air pollutants in the Haifa bay area, and participated in many projects that involved estimation of chronic exposures to hazardous agents both outdoors and in occupational settings. He has over 25 publications in leading scientific journals and more than 60 conference presentations on relevant topics. He serves as a peer reviewer for several scientific journals and government documents, and has been a member of several national advisory committees in Israel on environmental issues. Over the years, Dr. Broday received as Principal or co-Principal Investigator more than €3 million as funding of environmental health research from various international, national and private sector agencies and organizations.

Brian Miller has a BSc(Hons) in Mathematics and Statistics from Strathclyde University, Glasgow and a PhD in Epidemiology from the University of Edinburgh.

He worked at the Forestry Commission Northern Research Station, Roslin, Scotland from 1975 to 1979, in which year he joined the Institute of Occupational Medicine in Edinburgh, Scotland. He is now Principal Epidemiologist there.

His publications list attests to his extensive experience in applying statistical principles and techniques in many fields of application, including occupational and environmental epidemiology, risk quantification, impact assessment, exposure assessment, toxicological testing, instrument design, and quality assurance schemes. He is an experienced project leader and has a special interest in studies of the health effects of inhaled particles and vapours. Recent work has included studies of the mortality patterns of workers once employed in the British coal industry, and contributions to various projects on quantifying the health impacts of air pollution reduction strategies in the UK and in Europe.

In April 2005 he was appointed to the UK government's Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment (COC).

Joost Lahr (1962) began his study Environmental Science at the Wageningen Agricultural University in The Netherlands in 1980 and specialized in ecotoxicology and water purification/water quality control. In 1988 he obtained his M.Sc. degree.

From 1988 to 1991 he worked short terms for various Dutch and international organizations on the subject of side-effects of pesticide use in locust and vector disease control: with the WHO in Ivory Coast, Wageningen University/FAO in Senegal and for the Ministries of Public Works and Foreign Affairs in The Netherlands.

In the period 1991-1997 Joost lived and worked as an expert for the FAO at the LOCUSTOX-project in Senegal, West-Africa. He was responsible for the project's research concerning the assessment and prevention of side-effects in surface waters caused by locust combat operations. His work focused on the impact of insecticides on some groups of very peculiar invertebrate species that live in temporary ponds in the Sahel region. In January 2000 he obtained a PhD on the subject of this research from the "Vrije Universiteit" in Amsterdam.

After migrating back to The Netherlands, Joost worked for the private consultancy AquaSense in Amsterdam from 1998 to 2003 where he was a senior consultant and project leader in the field of ecological risk assessment of pollution (AquaSense was later acquired by the larger company Grontmij). One of the highlights during this period was his active involvement in the Dutch national investigation of estrogenic substances in the aquatic environment (the 'LOES' programme). His work for AquaSense has resulted in a large number of technical reports and several international publications in the area of risk assessment of estrogenic compounds and of polluted sediments.

Since the end of 2003 Joost works at the Centre for Ecosystem Studies of the institute Alterra as a research scientist specialized in environmental risk assessment of pollutants. Alterra is part of the Environmental Sciences Group of the Wageningen University and Research Centre (WUR) in The Netherlands. He is, among others, involved in eco(toxico)logical projects in the field of veterinary pharmaceuticals, heavy metals, biomarkers, soil functioning, agrobiodiversity and risk mapping. He acts as coordinator of the work package on risk presentation and visualisation in the EU project NOMIRACLE on novel methods for integrated risk assessment of cumulative stressors in Europe.

Tomas Trnovec was Director of the Institute of Preventive and Clinical Medicine in Bratislava, Slovakia. His distinguished background in the evaluation of the risks of organochlorinated substances to human health includes the coordination of the FP5 project 'Evaluating human health risks from low-dose and long-term PCB exposure, and a NIH, National Cancer Institute project (PCBs and early childhood development in Slovakia) as well as being a principal investigator in a large number of projects involved with the effect of PCB exposure on health. He is a Faculty member of the International Institute for Rural and Environmental Health, University of Iowa-IPCM Bratislava and has published more than 150 articles mostly in peer-reviewed publications. He was awarded the Gold Medal of Jan Jesenius by the Slovak Academy of Science in 1991.