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Contents

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EDITORIAL

Integrating environmental risk assessment in the real world

Environmental risk assessment is notoriously difficult. In assessing risks, we are dealing with the likelihood of events that – crucially – have not happened yet. Environmental risks are particularly challenging because of the complexity of the physical and ecological systems around us and the range of events that might happen. These include, for example, natural disasters, the spread of dangerous substances, and ecosystem changes leading to food and health security issues. Added to that, the constant emergence of new materials, new events and new knowledge makes it essential to update our understanding continually, to be able to identify threats that actually matter, as well as opportunities for timely action.

Preparing for the possible effects of what has not happened yet is even more complex at the scale of transnational ecosystems, over lengthy time periods, or when dealing with hazardous substances, whose pathways through the environment can generate multiple impacts. Improving our capacity to assess combined effects and identify environmental risks effectively is crucial. Yet, over recent years, risk assessment has not been highlighted as a priority.

Policymakers have the complex task of defining which impact they want to assess, how to evaluate it, and what is a tolerable level of risk. When making these difficult decisions, they must also decide on whether and how to reflect public and expert attitudes. Environmental risks are often considered public planning's 'wicked' problems — those, such as climate change, natural hazards and pandemics, where there is little or no opportunity to learn by trial and error, and every attempt to solve the problem counts significantly, with uncertain outcomes.

A number of challenges in this field remain. One important outstanding challenge lies in predicting combinations of risks that can impact on a range of different environmental dimensions (e.g. climate, eutrophication, acidification, land use, etc.) to enable effective priority-setting. Another challenge is to include socio-economic aspects when assessing environmental risks, which will require the potentially difficult integration of scientific, social and economic disciplines. Yet another challenge is to integrate product policies and territorial policies within '**Life-Cycle Approaches**', which attempt to allow policymakers to balance trade-offs within a whole system.

With these challenges in mind, are the current structures fit for the practical purposes of policymakers? And, beyond that, are they fit for a public which might understand and approach the same issues differently? There seems to be a broad academic consensus that more consistency, greater openness, transparency and documentation, and ongoing evaluation in light of new scientific data are necessary and desirable. However, communication challenges between sectors may still occur because of the increasing specialisation of the data being produced. Sectors therefore need to develop common metrics, terminology, and methodologies (thus creating shared knowledge areas). Otherwise, there is a danger that one sector's risk assessment mechanisms will become increasingly irrelevant to other sectors.

In the EU, most environmental policies are risk-based. However, the understanding of what constitutes a risk, the way in which policymakers use knowledge to address risks, and strategies for dealing with uncertainty differ from sector to sector. The European Union's 7th Environment Action Programme, 'Living well within the limits of our planet', calls for an improvement in our understanding and ability to manage "emerging environmental and climate risk", and the adoption of a systemic and integrated approach to managing environmental risk.

This Thematic Issue outlines some next steps towards an integrated environmental risk assessment. The studies presented here bring together overlapping knowledge areas and insights into new applications or significant gaps in risk assessment processes; each makes a valuable contribution towards integration.

In '**A vision and roadmap for integrated environmental modelling**', the researchers outline an 'organised' approach to transferring information from its research sources to its application in real-world problem-solving. The article suggests using interdisciplinary science to solve or address complex, multifaceted problems, such as climate change and pollution. Based on discussions at five international workshops held between 2000 and 2010, the researchers propose methods to achieve greater convergence between practitioners such as maintaining high standards for community participation from a wide range of scientific approaches; introducing standardisation between different computer programmes; and visualisation tools, such as geographic information systems.

In '**Risk management: a dynamic approach with real-time assessment of new hazards**', methods are proposed to integrate quantitative risk assessments, to form 'dynamic' approaches to risk management. The researchers identify a failure to account for new information in many environmental risk-assessment processes — which can lead to grave misunderstandings. Many risk assessments are static, one-time processes, or use older or generic data — for example, to determine potential failure rates of equipment and processes. Therefore the authors propose exploiting an overlap in two separate risk-assessment techniques to allow for continuously improving, repeated risk analyses. Using the examples of three serious metal dust accidents in a plant producing steel and iron powders in the US in 2011, they illustrate how a real-time approach, constant monitoring and record-keeping could also contribute to increased risk awareness and a better-developed organisational safety culture. These lessons are transferable to other, wider scales of human activity.

The case of '**Chemical risk governance in the EU: limits and opportunities to integration and harmonisation**' suggests that, while decision makers may have good intentions to integrate different areas of knowledge, significant challenges can remain. The authors highlight how and where social and political obstacles can crop up — for example, when chemical controls overlap with other areas of regulation, such as GMOs, water, soil and air pollution, energy, health or waste management. Alignment of opinion is not simple to achieve between groups of people with different cultures, roles and spheres of influence. As new cross-sectorial risks, problems and innovations emerge — such as diseases or nanotechnology — existing regulatory structures may find it challenging to keep up. The authors suggest an inclusive, self-aware and sensitive approach would allow risk-related regulations to become more flexible and responsive in future. However, they found that it is not feasible — or even desirable — to integrate all risks fully, and trade-offs will continue to be necessary.

Ecological risk assessment is a way of evaluating how an environment might be badly affected by a hazard, such as chemical pollution or an introduced alien species — and how likely it is to happen. As discussed in, '**A more comprehensive ecological risk assessment combines existing models**', researchers have explored the idea that the use of an individual risk assessment method could under- or over-represent the ecological risks of a hazard, or misrepresent them in the context of a larger system. To counteract this, the researchers propose a framework that uses the overlaps between food-web-based, ecosystem-based and social ecology-based models. This achieves a 'nested' structure, in which the information gained from one level of analysis can be shared with other levels.

In '**Bridging life cycle assessments and planetary boundaries: a cross-EU chemical emissions footprint**', researchers developed a new 'footprint' methodology for chemical emissions. Their first step — an analysis of chemicals in freshwater systems in the EU27 (in the year 2005) — finds impacts from domestic consumption were mainly driven by pesticide and metal emissions. The second step links the chemicals released into the environment with the ability of affected ecosystems to recover from the potential impact caused. A definition of what 'safe' limits are for chemical pollution is as yet undefined and an appropriate metric to link step one with step two has not yet been identified, although the researchers suggest that the Marine Directive's 'Good Environmental Status' might act as an initial yardstick.

There is a growing need to assess the effects of multiple chemicals and mixtures. The article '**Prospects for integrating chemical risk assessment**' outlines the gaps in chemicals regulation in Europe, and how these could be broached. The authors recommend possible steps to integrate the assessment of hazards with risk assessments, noting that the lack of suitable platforms for sharing, and, crucially, the confidentiality of many hazard-related data, form obstacles to successful risk assessment. They also suggest that a computer program that models exposure risks would be of benefit, as well as the development of a common language between socio-economic assessments and risk assessments — for example, linking 'cancer risk indicators' with cancer's socio-economic effects.

In the article '**Geodiversity should be better integrated into ecosystem assessments**', the researchers make a case for the better use of geodiversity information in environmental management. Understanding the makeup of rocks, minerals, fossils, soils, waters, landforms and processes in a local area is an essential step in understanding the ecosystem services it provides. Yet this information is poorly integrated — or even acknowledged — in current sustainable land management. The authors highlight key areas and methods where geoscience knowledge can be used better, to inform adaptive ecosystem management. They emphasise that a lack of good information about past ranges, rates and types of earth system changes will compromise effective planning and prioritisation of limited resources.

Hopefully these examples together show some collaborative and integrated paths towards forward-thinking assessment and management of environmental risks.

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Theme(s): Environmental information services, Water

A vision and roadmap for integrated environmental modelling

Integrated environmental modelling (IEM) is an organised approach to streamlining the movement of scientific information from its research sources to its application in problem solving, according to a study that envisions a global-scale IEM community. The researchers present a roadmap for the future of IEM, describing issues that could be addressed to develop its potential even further, such as how best to integrate diverse stakeholder perspectives and appropriate guidelines for 'problem statements'.

"Integrated environmental modelling is inspired by the need to solve increasingly complex real-world issues, such as climate change and pollution"

IEM uses interdisciplinary science to develop models that address specific environmental problems at varying scales. It is inspired by the need to solve increasingly complex real-world issues, such as climate change and pollution, which involve not just ecological concerns, but also social and economic concerns. It is used by national and international organisations, senior and mid-level managers, environmental assessors and policy developers, who need to understand the full range of impacts of proposed policies and management plans.

The roadmap is based upon discussions held at five international IEM workshops between 2000 and 2010 attended by delegates from government, academia and the private sector. It covers an extensive range of issues relating to IEM, organised into four elements: applications, science, technology and community. Some of the actions recommended by the roadmap under each of these elements are highlighted below.

IEM applications

IEM applications are stakeholders' methods for defining, selecting, integrating and processing the full range of environmental, social and economic information needed to inform decisions and policies.

While the importance of stakeholder involvement in IEM is recognised, the roadmap proposes that new guidelines are needed to manage, facilitate and report the interactions between stakeholders. Social science expertise is needed to help develop the processes for merging different views, priorities and values.

IEM science

The science of IEM provides knowledge and strategies to support decision processes. The concept of holistic thinking — which addresses and describes a problem in the context of a larger picture or system — is central to IEM science.

The roadmap highlights holistic thinking issues that should be addressed. For instance, it is challenging to merge knowledge from different domains in a way that is coherent and represents a complex system appropriately. This challenge needs to be addressed at each step of the modelling process, beginning with the 'problem statement' which, in essence, reflects a question that needs to be solved using a structured approach; its purpose is to provide the information needed to guide the subsequent steps of an IEM application.

It should define, for example, the specific issue or concern, context, objectives and available resources. Currently there are no widely accepted procedures for developing problem statements, and so the authors suggest that guidelines would also be useful for this.

Source: Laniak, G. F., Olchin, G., Goodall, J., Voinov, A., Hill, M., Glynn, P., Whelan, G., Geller, G., Quinn, N., Blind, M., Peckham, S., Reaney, S., Gaber, N., Kennedy, R. & Hughes, A. (2013). Integrated environmental modeling: A vision and roadmap for the future. *Environmental Modelling & Software*. 39: 3–23. DOI:10.1016/j.envsoft.2012.09.006.

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A vision and roadmap for integrated environmental modelling (continued)

"The roadmap's implementation depends on community participation and acceptance..."

IEM technology
IEM technology enables science to be expressed, integrated and shared. Examples include computer models and visualisation tools, such as geographic information systems (GIS).

A key challenge recognised by the IEM community is that it is difficult to efficiently and effectively transfer data between different models. The roadmap's authors suggest that this problem would be partly solved by introducing new computing standards that standardise syntax (concerned with the grammatical structure of language) and semantics (concerned with meaning of words and sentences) related to exchanging data and knowledge among models.

IEM community
The IEM community consists of practitioners and organisations involved in integrated environmental science and related computer technologies.

The roadmap suggests that organisations should collaborate in developing and promoting best practices and standards of IEM. Although this is challenging on such a large scale, it will enable valuable IEM information to be efficiently shared and applied to inform environmental decisions.

The roadmap's implementation depends on community participation and acceptance, its authors say. They encourage all IEM practitioners and stakeholders to contribute to global awareness and efforts to pursue solutions to problems which affect the entire community.

Source: Laniak, G. F., Olchin, G., Goodall, J., Voinov, A., Hill, M., Glynn, P., Whelan, G., Geller, G., Quinn, N., Blind, M., Peckham, S., Reaney, S., Gaber, N., Kennedy, R. & Hughes, A. (2013). Integrated environmental modeling: A vision and roadmap for the future. *Environmental Modelling & Software*. 39: 3–23. DOI: 10.1016/j.envsoft.2012.09.006.

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Theme(s): Risk assessment, Chemicals

Risk management: a dynamic approach with real-time assessment of new hazards

New research has combined two different techniques for identifying hazards and assessing risks into a single dynamic risk assessment process. The new approach fills a gap in many current risk assessment techniques as it can be applied throughout the lifetime of a process, not just during its design phase, taking into account new information to update risk assessments and calculations systematically.

"...while many risk assessment methods have proven extremely effective in managing major accident hazards, they are often limited by being static, one-time processes performed during the design phase of chemical plants or industrial processes"

Quantitative risk assessment (QRA) and management is one of the most common approaches to hazard identification and accident prevention in the chemical and process industries. QRA, a project management technique which pinpoints the probability of a risk event occurring and the impact the risk will have if it does occur, can be used in this particular context to determine the potential loss of life caused by undesired events. Software can be used to model the effects of such an event and even to calculate the potential loss of life.

However, while many risk assessment methods have proven extremely effective in managing major accident hazards, they are often limited by being static, one-time processes performed during the design phase of chemical plants or industrial processes.

As such they often use older data or generic data on potential hazards and failure rates of equipment and processes and cannot be easily updated in order to take into account new information, giving a more complete view of the related risks. New information may take the form of, for example, 'early warnings' (i.e. near-miss accidents) or other events which may occur during the operational phase of a process.

This failure to account for new information can lead to unrecognised hazards, or misunderstanding about the real probability of their occurrence under current management and safety precautions.

This research aimed to develop and demonstrate a more dynamic approach to risk management, allowing new information to be taken account of more easily.

The researchers identified two different hazard identification and risk assessment techniques, which both used a 'Bow-Tie analysis' as part of their hazard identification processes. This overlap allowed the models to be integrated under a single approach ('framework') for continuously improving, iterative risk analysis.

The first technique, the Dynamic Procedure for Atypical Scenarios Identification (DyPASI)[1], is a systematic process which screens for and identifies possible accident scenarios related to the equipment or process.

The second technique, Dynamic Risk Assessment (DRA), estimates the frequency of different accident scenarios, using a statistical technique called 'Bayesian inference', which updates the probability of an accident on the basis of abnormal situations or incident data as they occur in real time.

Source: Paltrinieri, N., Khan, F., Amyotte, P. & Cozzani, V. (2013). Dynamic approach to risk management: Application to the Hoeganaes metal dust accidents. *Process Safety and Environmental Protection*, 92(6), 669–679. DOI:10.1016/j.psep.2013.11.008

1. Developed as part of the EC iNTeg-Risk project, funded under Framework Programme 7: http://integrisk.eu-vri.eu/home.aspx?lan=230&tab=2316&pag=196

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Risk management: a dynamic approach with real-time assessment of new hazards (continued)

"...the accidents at the Hoeganaes Gallatin facility would both have been predictable and preventable if a dynamic risk approach had been used."

The researchers tested the effectiveness of this approach using a case study of metal dust accidents at the Hoeganaes Gallatin facility in Tennessee (USA) where atomised steel and iron powders are produced. The facility experienced three serious accidents in 2011 relating to metal dust which, the authors say, are examples of a lack of hazard identification and laxity in the management of safety.

According to the authors, the accidents at the Hoeganaes Gallatin facility would both have been predictable and preventable if a dynamic risk approach had been used. A number of specific measures for prevention, mitigation and control were identified which would have helped prevent the accidents. These measures included eliminating or mitigating escaping dust at the source, as well as administrative controls such as worker training and operating procedures.

The authors conclude that the dynamic approach to risk assessment outlined in this study could allow for more complete and precise hazard identification, triggering real-time risk assessments to raise general risk awareness in the company.

However, the authors highlight that no matter how good risk assessments may be they are only effective if used in association with a proper learning safety culture, and constant monitoring and recording of performance and incidents in order to respond to emerging risk issues.

Source: Paltrinieri, N., Khan, F., Amyotte, P. & Cozzani, V. (2013). Dynamic approach to risk management: Application to the Hoeganaes metal dust accidents. *Process Safety and Environmental Protection*, 92(6), 669–679. DOI:10.1016/j.psep.2013.11.008

For more information on DyPASI, read Paltrinieri, N., Tugnoli, A., Buston, *et al.* (2013). Dynamic Procedure for Atypical Scenarios Identification (DyPASI): A new systematic HAZID tool. *Journal of Loss Prevention in the Process Industries*, 26(4), 683-695. DOI:10.1016/j.jlp.2013.01.006 http://www.sciencedirect.com/science/article/pii/S0950423013000223

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Theme(s): Risk assessment, Chemicals

Chemical risk governance in the EU: limits and opportunities to integration and harmonisation

Chemical risk assessment and governance can be integrated and harmonised, but only up to a limit, albeit a variable limit, finds new research. The study's authors examined the socio-political processes and factors surrounding integrated risk assessment and governance associated with chemicals in the EU. The research suggests there are opportunities for improvement if different views and implications of risk integration are considered through open communication and negotiations.

"Risk governance brings together a wide range of actors – nations, political groups, institutions, industry and so on – which often have different areas of focus (e.g. environment or health) and roles in risk governance."

There are many types of governance involved in the assessment and response to risks. For example, the governance and regulation of chemicals may overlap with that of environment, health and waste management. As such, integration in the governance of risks is also seen as a good idea, yet many social and political obstacles may exist before this can be achieved. This research reviewed, analysed and combined existing research on the socio-political aspects of risks and risk integration in order to explore five aspects of EU governance and risk integration, focusing on the management of environmental and health risks from chemicals in the EU, aiming to identify limits and opportunities.

These aspects and their findings in brief were as follows.

The actors and activities in multi-level and multi-sectorial governance.
Risk governance brings together a wide range of actors — nations, political groups, institutions, industry and so on — who often have different areas of focus (e.g. environment or health) and roles in risk governance.

The cultures of different groups of actors in risk governance.
The authors roughly grouped these groups into 'prototypes', such as 'egalitarians' and 'bureaucrats'. Prototypes see the needs and opportunities for integrated risk assessment and management in different ways. For example, bureaucrats may prioritise needs within the confines of their institutional structures and hierarchies, while egalitarians may emphasise the democratic treatment of risks to all groups, and be concerned with how trade-offs between risks are defined, for example, does the benefit of a risk rise as the level of risk increases, or can the same benefit be achieved from accepting a smaller, different, risk?

Horizontal integration
'Horizontal' refers to co-operation between different EU sectors or organisations on the same governmental level. In the EU the types of risks addressed and integrated vary by sectors, which are loosely defined by their economic activities or areas of protection (e.g. environment, energy or health).

However, there are often overlaps between sectors, which provide opportunities for convergence. For example chemicals control, which includes classification and labelling, registration, evaluation and authorisation of industrial and consumer chemicals, pesticides and biocides, can overlap with other regulative areas that focus on chemicals, such as regulation of pharmaceuticals, cosmetics, food additives, radionuclides and nanomaterials. Other fields close to and even overlapping chemicals control include GMOs; water, soil, and air pollution; waste and product policy; public and occupational health; consumer and citizen safety; and energy. The authors emphasise that approaches are variable and changeable between sectors, and note that any integration between sectors also requires the alignment of risk governance.

Source: Assmuth, T., Hildén, M. & Benighaus, C. (2010). Integrated risk assessment and risk governance as socio-political phenomena: a synthetic view of the challenges. The Science of the Total Environment 408(18), 3943–53. DOI:10.1016/j.scitotenv.2009.11.034

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Chemical risk governance in the EU: limits and opportunities to integration and harmonisation (continued)

"....opportunities could also be identified to develop forms of risk regulation to become more flexible and responsive to new risks and to accommodate new knowledge of risks."

Vertical integration

'Vertical' refers to the links between higher and lower levels of governing bodies or scientific committees; vertical integration also involves the contrasting directions of globalisation and localisation. The EU is increasingly part of regional and global political and economic systems, as well as being comprised of diverse Member States, adding a level of complexity which may be challenging to risk assessment and governance, presenting both problems and opportunities for integrated treatment of risks in increasingly connected socio-economic and political systems. There is a question about the appropriate level of Member State influence in the interpretation of cumulative risks, and in the procedures for assessing these. The appropriate level may depend on the circumstance; for example, a weak harmonisation for land-use planning allows specific, contextualised approaches. However, for chemicals, the tendency is towards harmonisation across Member States, and the authors highlight the lack of political and legal mechanisms in the governance of global flows of chemicals above the EU level as a potential problem.

Change and innovation in integrated risk governance

Social, political, technological and environmental changes can all influence risk governance. However, new risks and problems, such as emerging animal or plant diseases or previously unknown consequences of innovations, such as nanotechnology, can appear quickly and regulatory systems may be slow to react or respond to them.

The authors found that due to barriers of knowledge or complexity, in both the risks themselves and governance structures, not all risk considerations can be fully integrated, at least in detail, formally or extensively, due to the fact that there is no common measure (resulting from qualitative differences), and trade-offs are needed. For example, it is not feasible to treat all health risks and long-term ecological risks in a single process. This also means that simplifying governance by removing hierarchies may make some integration easier by cutting back bureaucracy; but, in other circumstances, it may make integration harder, by removing co-ordinating functions or regulatory oversight.

Overall, the authors believe that there are limits — such as barriers in vertical relations between the EU, its members and regions, and the global community — to the amount that the governance of risk assessment can be integrated; however, opportunities could also be identified to develop forms of risk regulation to become more flexible and responsive to new risks and to accommodate new knowledge of risks. The authors hypothesise that to do so will require identification of overlaps and a transparent, inclusive and self-aware approach to integrating risk, which is sensitive to the different types of socio-political contexts, values and decision structures involved.

Source: Assmuth, T., Hildén, M. & Benighaus, C. (2010). Integrated risk assessment and risk governance as socio-political phenomena: a synthetic view of the challenges. The Science of the Total Environment 408(18), 3943–53. DOI:10.1016/j.scitotenv.2009.11.034

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A more comprehensive ecological risk assessment combines existing models

Integrated environmental modelling (IEM) is an organised approach to streamlining the movement of scientific New New research has examined three different categories of Ecological Risk Assessment (ERA), each with different goals. The researchers find that overlaps between the three assessments could be combined to create a more comprehensive form of ERA, usable by regulators and environmental decision makers.

"Ecological Risk Assessment is a way of evaluating how and how likely the environment is to be adversely affected by a 'stressor', or hazard, such as chemical pollution or an introduced alien species."

Assessing the risks of human activities to the environment can help to avoid irreparable damage to the ecosystems which provide for human needs. ERA is a way of evaluating how and how likely the environment is to be adversely affected by a 'stressor', or hazard, such as chemical pollution or an introduced alien species. The researchers assert that ERA has been highly recommended for environmental decision making, helping to expose potential immediate and long-term effects of a stressor and to deal with some ecological hazards before they actually occur.

It is typically performed using complex mathematical and statistical models which emulate the effects of a single stressor. However, a number of different ERA methods have been developed, each focusing on different levels of an ecosystem's response.

As such, it is possible that use of an individual assessment method could under (or over) estimate the ecological risks of a stressor, or misrepresent them in the context of a larger system.

This research aimed to identify overlaps between the different models, which would allow them to be integrated into a more holistic model for risk evaluation in environmental management. This was done by reviewing examples of ERA models from published scientific literature across three broad categories of ERA, classified according to the scale and focus of the models (food-web-based, ecosystem-based and socio-ecological).

'Food-web-based' models are used to analyse the complex relationships between species in an ecosystem, based on food-web analysis, focusing on the bioaccumulation of toxic chemicals and determining the ecological significance of risk.

'Ecosystem-based' models focus on changes to interactions among communities of organisms and environmental factors, such as sunlight and temperature, and are useful for evaluating how an ecosystem's structure and the functioning of its combined parts may change in response to a stressor or a number of stresses at the same time.

'Socio-ecological' models focus on the social effects (e.g. changes in ecosystem services, and their derived human benefit) of environmental changes. Such socio-ecological changes are, according to the authors, the main focus of risk evaluation processes in legal and regulatory decision-making contexts.

There were other differences between the cases as well, since the individual risk assessments assessed the types of stressor, the things affected by the stressor, or, for example, the effects of nutrient flows, in different ways.

Source: Chen, S., Chen, B. & Fath, B. D. (2013). Ecological risk assessment on the system scale: A review of state-of-the-art models and future perspectives. Ecological Modelling 250(19), 25–33. DOI:10.1016/j.ecolmodel.2012.10.015

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A more comprehensive ecological risk assessment combines existing models (continued)

"The identification of network relationships of material and energy flow between species, habitats and society may be a good basis on which to collate the merits from the three types of ERA models."

The researchers placed each ERA model along a scale of organisational levels, allowing them to determine at what scales different models overlapped. These organisational levels ranged from individual organisms, to populations, communities, habitats and ecosystems, up to economic and socio-ecological systems. The identification of network relationships of material and energy flow between species, habitats and society may be a good basis on which to collate the merits from the three types of ERA models.

The researchers identified frequent overlaps or synergies in the types of data they used or produced which could be shared between models for more comprehensive, integrated risk assessment and communication.

For example, the data output from species-level and food-web investigations can be an important part of ecosystem and socio-economic models, while data from these larger scales can provide background and explanation for the effects of a stressor at smaller scales.

The authors outlined a 'framework' for achieving such an integrated model. This consists of three main steps: problem formulation, risk characterisation and risk assessment. The researchers propose using all of the different ERA model groupings (food-web, ecosystem and socio-economic) while characterising the risks — using the outputs of each process to feed information into each other model — before going on to determine a final risk estimation during the risk assessment step.

Source: Chen, S., Chen, B. & Fath, B. D. (2013). Ecological risk assessment on the system scale: A review of state-of-the-art models and future perspectives. Ecological Modelling 250(19), 25–33. DOI:10.1016/j.ecolmodel.2012.10.015

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Theme(s): Chemicals, Water, Risk assessment, Sustainable consumption and production

Bridging the gap between life-cycle assessments and planetary boundaries: a cross-EU chemical footprint

A methodology for assessing 'chemical footprints' has been developed by researchers to evaluate human pressures on the environment and the impact of chemicals released by the production and consumption of goods. The study integrates a life-cycle approach with different methodologies, such as those developed in the context of environmental risk assessment and sustainability science, with the aim of assessing the extent to which chemicals impact on ecosystems beyond their ability to recover (i.e. surpass planetary boundaries).

"The researchers anticipate that a comprehensive approach like LCA would prevent shifting the burden of responsibility for chemical emissions from one product life cycle stage to another."

Environmental 'footprints' can be used to assess human pressures on the environment and environmental sustainability. They enable a quantitative understanding of the use of natural resources by humans, and integrate several different modelling approaches under one methodology. Carbon and water footprints are widely used to assess human impacts; however, despite the widespread use of chemicals in many products and services, these methods do not normally include assessment of chemicals emissions and potential impacts.

In this study, researchers from the European Commission's Joint Research Centre[1] developed a conceptual framework for assessing chemical footprints, capitalising on knowledge in sustainable chemical management, namely, in the context of life cycle assessment (LCA) and ecological risk assessment.

The researchers anticipate that a comprehensive approach like LCA would prevent shifting the burden of responsibility for chemical emissions from one product life cycle stage to another; on the other hand, risk assessments and the underpinning precautionary principle are desirable inclusions since many chemicals' physical properties, as well as direct and indirect effects, are still barely known.

The researchers posit that these factors should sit in the context of a sustainability assessment approach, which takes account of the current situation and future scenarios in terms of 'planetary boundaries': earth's limits, which could not be surpassed without triggering abrupt environmental change on the planetary scale.

Based on these concepts, the chemical footprint is assessed via two steps. The first step, based on LCA, assesses the intensity of chemical pressure in terms of emission into the environment from all sources and the potential impact of these. This can be calculated using impacts within a single country (production-based), or the overall impact of a product, taking into account trade impacts (consumption-based), or a more comprehensive global understanding, including all the environmental impacts that occur abroad, but which are driven by a national or a European demand for imported goods.

To illustrate a consumption-based approach, the researchers present a case study at the macroscale — across the then EU-27, using domestic, import and export data — in which the first step is calculated for the year 2005 to assess the impacts on freshwater ecosystems.

Their preliminary analysis, based on some representative products, revealed that impacts on freshwater ecosystems from domestic consumption in the EU-27 were mainly driven by pesticide and metal emissions. Further work is ongoing to refine the assessment, expanding the number of representative products and improving the impact assessment of chemicals.

Based on the first step, the second step links the chemicals released into the environment with the capacity

Source: Sala, S. & Goralczyk, M. (2013). Chemical Footprint: A Methodological Framework for Bridging Life Cycle Assessment and Planetary Boundaries for Chemical Pollution. Integrated Environmental Assessment and Management. 9 (4): 623–632. DOI: 10.1002/ieam.1471.

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Theme(s): Chemicals, Water, Risk assessment, Sustainable consumption and production

Bridging the gap between life-cycle assessments and planetary boundaries: a cross-EU chemical footprint (continued)

"There are a range of policy decisions that could be supported by an economy-wide chemical footprint calculation for Europe; it could be useful for evaluating the decoupling of economic growth from environmental impact..."

of affected ecosystems to recover from the potential impact caused (the 'carrying capacity' of the ecosystem). The definition of what the planetary or 'safe' boundaries are for chemical pollution — and how the boundaries should be identified — is an ongoing scientific challenge. However, the researchers posit that 'Good Ecological Status' (GES) and the associated chemical and biological conditions to be achieved by EU rivers, as stipulated in the Water Framework Directive, could be seen as a preliminary policy–based definition of such boundaries — especially since GES was built to integrate as much evidence as possible.

The study highlights a number of issues that must be resolved to develop the chemical footprint concept further. These include identification of which chemicals to evaluate and from what source; identifying priority chemical compounds; as well as dealing with emerging contaminants.

There are a range of policy decisions that could be supported by an economy-wide chemical footprint calculation for Europe; it could be useful for evaluating the decoupling of economic growth from environmental impact, for example.

A suitable methodology to link step one with step two is critical, but yet to be identified. The conventional conversion (of a footprint measurement into a land area value or to a dilution volume in water) would be based on a variety of assumptions very distant from realistic impacts, say the researchers. They say it is essential to find a system that allows comparison between the chemical footprint value and the boundary limit values for chemical pollution.

The researchers finally suggest that establishing planetary limits that support progress against measurable targets is a crucial step, as are further efforts in knowledge integration across scientific, technical and regulatory information across disciplines, to enable sustainable chemicals management. They say chemical footprints could be used as a policy tool supporting consistency of product policies and territorial policies, aimed at improving environmental quality at a macro scale.

1. http://ec.europa.eu/dgs/jrc/

Source: Sala, S. & Goralczyk, M. (2013). Chemical Footprint: A Methodological Framework for Bridging Life Cycle Assessment and Planetary Boundaries for Chemical Pollution. Integrated Environmental Assessment and Management. 9 (4): 623–632. DOI: 10.1002/ieam.1471.

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Theme(s): Chemicals, Risk assessment

Prospects for integrating chemical risk assessment

Chemicals regulation in Europe could be improved through integrated risk assessment, says an EU project. The project team presents a range of perspectives on how the integration of hazard, exposure and socio-economic assessments can be promoted and implemented.

"Integrated hazard assessment has an important role to play in integrated risk assessments. In this context the hazard is the property of the chemical that may cause harm..."

Risk assessment in the chemicals industry is facing increasing challenges. A rising number of substances need their risks assessing, owing to revised legislation: for example, the EU's REACH has the potential to substantially increase the demand for safety testing in the next few years.

The growing need to assess multiple stressors and the toxicity of mixtures adds further complexity to risk assessment. Non-scientific considerations, such as budget restrictions or political and public preferences (e.g. to reduce animal testing), also drive the field.

The project, HEROIC[1], says that these developments highlight the need for a more integrated approach to risk assessments under chemical regulations, such as REACH, the Plant Protection Products Regulation and the Biocides Regulation. Such an approach makes use of existing data and pulls together hazard, exposure and socio-economic information.

Integrated hazard assessment has an important role to play in integrated risk assessments. In this context the hazard is the property of the chemical that may cause harm, and the risk is the chance of the harm being done – both in terms of likelihood and extent.

Integrated hazard assessment can combine data from tests with non-test data, which include, for instance, predictions of a chemical's toxicity based on information from tests on a similar chemical or a similar target species, or the extrapolation (i.e. the estimation of a value that falls outside a range of known values) from environmental toxicity data to humans and vice versa — i.e. using human safety data for assessing environmental toxicity assessments.

The success of integrated hazard assessment partly depends on the availability of hazard data, the paper says. However, importantly, intellectual property issues mean that most data of this kind are confidential. Furthermore, there are currently no suitable platforms for sharing these data.

Success also depends on the use of a suitable framework for integrating information and appropriate tools to integrate data (e.g. models). In addition, new methods to assess the inherent uncertainty and variability of these data need to be developed.

Exposure assessment — which establishes the link between a chemical emitted to the environment and the exposure of actual people, animals or plants to that chemical — is an equally important part of integrated risk assessments. Exposure assessment considers all the interacting physical, biological and chemical phenomena that lead to exposure. This includes how a chemical is transported through the environment through air, water, soil or other mediums, how it accumulates in the food chain and how the body reacts to it upon contact.

A computer model which integrates information on all these phenomena and effects would be useful for better assessing exposure, the researchers say. However, such integrated models are not yet available.

Source: Péry, A. R. R., Schüürmann, G., Ciffroy, P., Faust M., Backhaus T., Aicher L., Mombelli E., Tebby C., Cronin M. T. D., Tissot S., Andres S., Brignon J. M., Frewer L., Georgiou S., Mattas K., Vergnaud J. C., Peijnenburg W., Capri E., Marchis A. & Wilks M. F. (2013). Perspectives for integrating human and environmental risk assessment and synergies with socio-economic analysis. Science of the Total Environment 456-457: 307-16. DOI:10.1016/j.scitotenv.2013.03.099.

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Prospects for integrating chemical risk assessment (continued)

"...socio-economic assessment can provide an overall view of the benefits and negative impacts of either continuing to use or ban a chemical. These include the chemical's value to society, as well as its health and environmental risks."

Finally, socio-economic assessment can provide an overall view of the benefits and negative impacts of either continuing to use or ban a chemical. These include the chemical's value to society, as well as its health and environmental risks. However, there are challenges to overcome before socio-economic assessment can be fully utilised to support risk assessment. Better connections and a common language between the two fields are needed, for instance. 'Intermediate indicators', which connect the indicators used in risk assessment and socio-economic assessment, would be useful in this respect; risk assessment talks of 'cancer risk indicators', whereas socio-economic assessments are concerned with the socio-economic effects of cancer, to give an example.

1. HEROIC (Health and Environmental Risks: Organisation, Integration and Cross-fertilisation of Scientific Knowledge) is supported by the European Commission under the Seventh Framework Project. See: www.heroic-fp7.eu

Source: Péry, A. R. R., Schüürmann, G., Ciffroy, P., Faust M., Backhaus T., Aicher L., Mombelli E., Tebby C., Cronin M. T. D., Tissot S., Andres S., Brignon J. M., Frewer L., Georgiou S., Mattas K., Vergnaud J. C., Peijnenburg W., Capri E., Marchis A. & Wilks M. F. (2013). Perspectives for integrating human and environmental risk assessment and synergies with socio-economic analysis. Science of the Total Environment 456-457: 307-16. DOI:10.1016/j.scitotenv.2013.03.099.

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Geodiversity should be better integrated into ecosystem assessments

Information about geodiversity — i.e. the variety of the material, non-biological parts of the natural world — could be better used and more integrated in environmental management in the UK, finds new research. The authors examined the inclusion of geodiversity information in UK assessments and identified a number of areas where geoscience knowledge is vital for informing ecosystem management.

"Geodiversity information can provide a view of how environments and life (by the study of fossils, for example) have adapted to a changing climate or environmental conditions over a geological timescale. This can be used to help understand possible future environmental changes..."

Ecosystem-level assessments, such as the Millennium Ecosystem Assessment and the UK National Ecosystem Assessment (UKNEA), review the ecosystem services — such as food, fuel or recreation — that society gains from the natural environment. Valuing ecosystem services is an important part of an 'ecosystem approach' to environmental management, which aims to promote the conservation of nature and the sustainable use of resources.

Many ecosystem services are either underpinned or delivered by 'geodiversity', the variety of rocks, minerals, fossils, soils, waters, natural landforms and processes which shape them over time.

However, despite geodiversity's importance to ecosystem services and functioning, its recognition at a policy level, according to the authors, remains low and is poorly integrated in the development of ecosystem approaches.

Geodiversity information can provide a view of how environments and life (by the study of fossils, for example) have adapted to a changing climate or environmental conditions over a geological timescale. This can be used to help understand possible future environmental changes, their effects on life and how we might prepare for or adapt to them.

This research first examined how geodiversity information fits into the ecosystem approach and ecosystem assessment at a conceptual level, and used this to examine the degree to which this is recognised within the UKNEA. They then reviewed published scientific literature to select examples of how geoscience can help inform the management and delivery of ecosystem services, with a focus on climate change adaptation.

The researchers found that the UKNEA did contain many elements of geodiversity, both alone and integrated within parts of environmental systems, such as soil formation nutrient cycles and natural coastal protection. However, the authors found that these were rarely presented in a systematic fashion nor generally acknowledged as an essential part of sustainable land management.

Four main geodiversity-related gaps in the UKNEA process were identified. These were the omission of non-renewable resources, a lack of long-term perspectives both in the past and the future, an uneven treatment of geomorphological processes (physical processes, such as erosion, at or near the Earth's surface) and a general lack of integration of the dynamic links between geodiversity and biodiversity.

The authors also highlight areas where they feel other geodiversity-related evidence could be better integrated into the UKNEA, focusing on areas where geoscience knowledge can be used to inform adaptive ecosystem management.

Source: Gray, M., Gordon, J. E. & Brown, E. J. (2013). Geodiversity and the ecosystem approach: the contribution of geoscience in delivering integrated environmental management. Proceedings of the Geologists' Association 124(4), 659–673. DOI:10.1016/j.pgeola.2013.01.003

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Geodiversity should be better integrated into ecosystem assessments (continued)

"...geodiversity is relevant across a broad range of policy agendas including nature conservation, planning, landscape, environment, education, sustainable rural development, health and quality of life..."

For example, they highlight that understanding of past ranges of natural variability, rates and types of geomorphological processes (i.e. earth surface processes, such as air, water and ice, which can mould the landscape) is important for anticipating and planning for change, as well as for validating conservation management decisions and allowing prioritisation of limited resources.

A real-world example is the use of records of sea-level change, over the last 10,000 years, to inform future sea-level rise scenarios and their impacts on coastal biodiversity. In Scotland, sea-level rise is overtaking the final phase of land uplift, following melting of the last Scottish ice-sheet, with the result that coastal retreat and squeeze will have a widespread impact on ecosystem services (e.g. loss of habitats, loss of beaches for recreation). The record of past processes, landforms and sediments helps us understand how the coastal system works. This can then be used to inform adaptive coastal management and bring multiple benefits for people and nature conservation.

Finally, the authors identified a number of future challenges and opportunities for the further integration of geodiversity into ecosystem approaches. These include encouraging the greater participation of geoscientists in interdisciplinary networks and delivering new geoscience research to help support the ecosystem approach and climate change adaptation.

The authors conclude that geodiversity is relevant across a broad range of policy agendas including nature conservation, planning, landscape, environment, education, sustainable rural development, health and quality of life; and that geodiversity information was underrepresented in the ecosystem assessments examined. For ecosystem assessments to be fully successful they must also integrate the best geodiversity information available.

Source: Gray, M., Gordon, J. E.,& Brown, E. J. (2013). Geodiversity and the ecosystem approach: the contribution of geoscience in delivering integrated environmental management. Proceedings of the Geologists' Association 124(4), 659–673. DOI:10.1016/j.pgeola.2013.01.003

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Flood strategies could improve with the help of socio demographic data

Flood management could be improved by including socio-demographic information in the assessment of flood risk, suggests new research. The research combined traditional flood risk assessment with information on the 'social vulnerability' of people living in flood risk areas. The results show that there are almost twice as many people of high social vulnerability (e.g. low-income or elderly) in flood risk areas of Rotterdam as low social vulnerability people.
http://ec.europa.eu/environment/integration/research/newsalert/pdf/flood_strategies_could_improve_with_help_of_socio_economic_data_408na2_en.pdf

How to communicate the risks of population growth

We need a better understanding of how the public perceive the risks of population growth, a new discussion paper argues. Research into public perceptions of the environmental and social challenges of population growth could guide behavioural-change communications to help limit growth and manage the difficulties. Specific communication issues include how to convey statistical information and the complex impacts of population growth.
http://ec.europa.eu/environment/integration/research/newsalert/pdf/communicating_population_growth_risks_393na2_en.pdf

Bathing water disease risk may increase under climate change

Climate change may increase the amount of pathogens entering bathing waters in some areas, finds a new study. The research, carried out in a lagoon in the Baltic Sea, found that, although higher temperatures can reduce microorganism populations, this is likely to be outweighed by contamination due to runoff caused by increased rainfall. The authors are currently developing a system for alerting local authorities and the public to potentially hazardous bathing water.
http://ec.europa.eu/environment/integration/research/newsalert/pdf/374na1_en.pdf

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