



Department
for Environment
Food & Rural Affairs

Chemicals in the Environment scoping workshop – 20 February 2017

Broadway House Conference Centre, Tothill Street, London, SW1H 9NQ

Workshop report

Summary

NERC and Defra co-hosted a workshop on 20 February 2017 to scope priority research questions around management of chemicals in the environment with a view to developing collaborative research activity.

Thirty-nine attendees with perspectives from government policy and regulation, industry, civil society and a range of research disciplines prioritised the following areas as most important to improve fundamental understanding of the issues:

- Translating effects from individuals to populations and beyond (ecosystems and ecosystem services)
- Assessment of the risks from chemical mixtures
- Identifying the significance of chemical stressors in a world of multiple stressors
- Environmentally sustainable chemicals in a changing world
- Human exposure to chemicals and impacts on health and wellbeing

Research questions were identified in each of the areas above along with consideration of the beneficiaries and users of the research and any translation steps needed.

A consensus of the workshop was that an aspirational goal is needed to direct future research effort in this field. One idea was a community model that can draw together data to help industry, regulators and society prospectively assess risks and make decisions about chemical use. Such a model would allow the capture of complexities and future scenarios of environmental and socio-economic systems. The areas of research prioritised at the workshop are a step towards this goal.

The workshop attendees made a strong case for training of the next generation of ecotoxicologists, skilled in experimental, modelling and statistical techniques, to rebuild capacity for research and industry. A focal point to bring together multidisciplinary teams and facilitate learning across disciplines and nations was recommended.

NERC, Defra and other potential partners will consider the outputs of the workshop and develop a case for a collaborative research programme.

Background

The Defra's Hazardous Substance Advisory Committee (HSAC) provides expert advice to government on protection of the environment, and human health via the environment, from potentially hazardous substances. Within the last few years the Committee has discussed ecotoxicology research and concluded that much more research is required to understand the mechanisms by which the adverse effects of anthropogenic chemicals, singly and in combination, arise in biota and humans.

Discussions between NERC and Defra resulted in recognition that to manage chemicals effectively, there are still fundamental research questions to answer about if and how broad, low-level chemical exposure harms populations, ecosystem functioning, and humans and how these effects are influenced by other environmental factors. It was felt timely to determine whether new research concepts, approaches and techniques can be applied to this problem and it was agreed to jointly organise a workshop to explore this.

Some further information about HSAC's discussions in this area is provided in annex A.

Workshop aims

The aim of this workshop was to identify the key environmental research priorities needed to underpin management of chemicals in the environment relevant to the UK, with a view to potentially developing new collaborative research activity. The workshop brought together experts from Government policy and regulation, industry, civil society and environmental science perspectives to:

- scope priority challenges in chemicals management with regards to the natural environment;
- identify emerging research questions and opportunities to apply new techniques and approaches to address the issues, considering novelty and timeliness;
- determine approaches and partnerships needed to effectively translate research into practice e.g. enable risk-based decision making and uptake into policy measures; and
- determine future UK research capacity needed to support management of chemical impacts in the natural environment.

A full programme and list of workshop participants are provided in annex B and C, respectively.

Preparation for the workshop

In advance of the workshop each participant was asked to provide their top three challenges for this area. A "challenge" was defined as an unmet ecological or human health issues associated with chemicals in the environment, now and in the future. Challenges could also include innovative solutions to address, mitigate and manage chemicals differently to better protect the environment. Participants were asked to think broadly about different kinds of chemicals, environments and potential interactions with ecosystems and/or human populations via the environment. Challenges could be policy, practice or science-led and should be stretching. Following submission, the challenges were collated and then circulated for scoring according to impact if resolved/urgency to be addressed on a 0-1000 scale (where 1000 was highest impact/most urgent). The median scores were then calculated and challenges were placed in order, and those appearing above 500 were reviewed and duplicate areas were pragmatically grouped. This gave a list of 16 challenges as a starting point for discussions at the workshop. This list of 16 is provided in annex D.

Introductory presentations

There were a number of introductory presentations at the workshop to set the scene for the day.

Dr Ned Garnett, NERC Associate Director Research

Dr Ned Garnett laid out the NERC remit and specifics as relevant to the workshop, NERC science budget and other research funds (such as the Global Challenges Research Fund, Newton Fund and Industrial Strategy), existing investments in this area and what NERC would like to achieve from the workshop. Further details of the presentation are provided in annex E.

Professor Ian Boyd, Defra Chief Scientific Adviser

Professor Ian Boyd spoke about evidence in Defra. He outlined how, although not welcome, cuts in Defra capacity to directly fund science provides an opportunity to look for other ways of working, resulting in workshops such as this. This allows Defra a role in co-designing science needs for policy delivery whilst also utilising Research Council expertise in commissioning research and engaging the science community to identify and frame the science questions. Defra as a whole organisation has produced some high level statements of need for evidence, of which three questions are relevant to this workshop:

- How can industrial pollution be controlled and effectively and efficiently managed?
- How can we manage existing, new and emerging chemical pollutants to reduce damage to the environment and human health?
- How can we better understand the nature and extent (at local and national levels) of all forms of pollution including chemical and air?

Research in the area of chemicals in the environment in the past has often been post hoc; once pollution events have already happened or impacts have already occurred. Chemicals in the environment arise from human use and we need to consider how we can build the messages about the challenges of chemicals in the environment so that people are able to understand why they need to make changes in behaviour.

Without advancing the science in this area, will we have to rely on hazard based assessments, which are very restrictive. We need sufficient information to put colour around the assessment of chemicals in the environment, so we can use a better risk based approach on how to use both new and existing chemicals in the future.

Professor Boyd noted that this workshop is focussed on the environment but human health is important. The interaction between the environment and health is key in unlocking the political and social elements and the human impact of a reduction in the quality of the environment should be the general message from a workshop like this and from any research proposals in this area.

Dr Oliver Price, Unilever

Dr Oliver Price provided an industry perspective for this area. He talked about the innovation pipeline and responsible and sustainable by design innovation, how new science is needed to input into this and guide and improve prospective risk-based assessments to ensure ecological relevance, and the importance of having the right expertise in the UK to deliver and translate on this topic. Further information on his presentation is provided in annex F.

Dr David Santillo, Greenpeace

Dr David Santillo gave a civil society perspective. He spoke about what he thought of as the seven key challenges for this topic, which included chemical mixtures, chemicals of emerging concern, pathways in soil and sediment, implications of climate change, the importance of maintaining a broad research agenda, improving regulatory approaches, and involving and engaging society. Further information on his presentation is provided in annex G.

Challenges

The workshop participants discussed the challenges submitted and where to merge and prioritise challenges. Five challenges were taken forward for further discussion but it was recognised that these broad areas were related and could incorporate some of the more specific challenges submitted:

1. Translating effects from individuals to populations and beyond (ecosystems and ecosystem services)
2. Assessment of the risks from chemical mixtures
3. Identifying the significance of chemical stressors in a world of multiple stressors
4. Scenarios to predict future chemical hazards and risks in a changing world
5. Human exposure to chemicals and impacts on health and wellbeing

The participants agreed that there were benefits in considering 2 and 3 as one challenge but for logistics on the day decided to discuss them separately at this stage. The following sub-sections summarise the discussion (as recorded on the day) of breakout groups around identifying research and translation questions for these five challenges.

1. Translating effects from individuals to populations and beyond (ecosystems and ecosystem services)

- Does routine use of chemicals harm wildlife populations/ecosystems?
 - Novelty: No coordinated research activity in this space is ongoing and it would be a radical reappraisal of ecotoxicology and regulation.
 - The use of very large under-utilised monitoring datasets, new exposure models and new statistical approaches and their integration would be novel science.
 - Impact on the structure, function, dynamics and connections within ecosystems (relevance of impacts on microorganisms and this leads to a better assessment of resilience of the environment).
 - Impact would be for regulators, water industries and chemical industry.
- Can we obtain diagnostic information on causes of effects on field populations that can aid in both diagnosis and prediction of population-level effects?
 - Novelty: new measures for attributing biological effects to specific chemicals/chemical groups.
 - Beneficiaries: regulators, industry.
- Can we go beyond current laboratory endpoints to predict population-level effects based on life histories, species traits/vulnerabilities, etc.
 - Novelty: seeks to develop the existing paradigm of risk assessment to consider higher level impacts of chemicals.
 - Beneficiaries: industry, regulators.
- Validating Environmental Quality Standards.

2. Assessment of the risks from chemical mixtures

- There has been little progress in this challenge in last 10 years. Research questions:
 - Do mixtures really matter, and if so, is this at all trophic levels?
 - What drives rate of chemical degradation in the environment? If all chemicals were instantly degradable, would it simplify mixture complexity?
 - What factors determine which compounds in mixtures are important?
 - How can we model the presence of mixtures in the environment and their impacts?
- Translation needs:
 - Regulators/policy makers: development of future surveillance, future testing and interactions so as to be able to combine available datasets from regulators to make them available.
 - Engagement of industry: innovation funding.
 - Raise awareness with the public of outcomes and translate into action.

3. Identifying the significance of chemical stressors in a world of multiple stressors

- Research questions:
 - Can we build a systems based approach to address this question in which we combine retrospective (descriptive, epidemiological and field) and prospective (experimental and mechanistic studies) approaches to build a suitable framework?
 - Can we do this across spatial and temporal scales? Across levels of biological organisation?
 - Can we harness the existing big environmental datasets to enable this?

All of this would use a cohesive multi-factor approach.

- Translation needs:
 - User friendly package for assessing chemical impacts: something that combines 'not in my back yard' and relevant exposure scenarios with Toxcast; identify risk scenarios rather than just hazardous chemicals.
 - Better modelling approaches for both exposure and ecology.
 - Suitable large scale facilities for conducting the experiments to evaluate prospective approaches.
- Outputs:
 - Guidelines on what is a problem and what is not a problem.
 - Improved risk management tools, when to act and when to leave alone.
 - Guidance for more sustainable innovation. Prioritising risk and saving money through not being too precautionary.

4. Environmentally sustainable chemicals in a changing world

- Research questions:
 - Can a reliable integrated chemical model of the UK be developed for use under different scenarios? This could be used to understand changes in chemical exposure and toxicity under different climate change and demographic scenarios.
 - What are the interactions of human demographics and disease on chemical exposure and toxicity on the UK? Can we identify where are the highest exposures to chemicals for humans? Are chemical exposures associated with particular diseases and therapies?
 - How to evaluate chemical impact in the future resource management (food, energy, water, transport, IT, waste management (circular economy))? What are the chemical emissions, risks and use in 20 to 50 to 100 years in the future?
- These questions would require new ways of systems thinking in:
 - linking economics, demographics, health science and natural sciences; and
 - step change in environment, human health and economics exposure modelling and risk/impact/safety assessment.
- Translation needs:
 - Regulators and other organisations: used to make the correct chemical decisions; working towards a national chemical strategy/policy.

5. Human exposure to chemicals and impacts on health and wellbeing

It is a political and societal reality that a scientific solution to safeguarding the environment must be underpinned by impact on human health.

- Research questions:
 - What are humans actually exposed to (the exposome)? This would require data on chemical accessibility and bioavailability, both internal and external to the body.

- How are humans protected by a functioning environment? This could require mapping the ecological pathways for wellbeing. What is the ecological condition required to buffer harm caused by chemicals?
- How do we better link exposure to health? This would involve genetic mapping of disease susceptibility based on exposure using causal relationships.
- Can we distinguish points of departure from health by pathways perturbed from chemical exposure?
- Beneficiaries:
 - Targeted risk management decreasing the burden of human disease and increasing wellbeing.
 - Reduced animal testing.

Capacity requirements

The participants agreed that there was a lack of new expertise in this area and multidisciplinary training and bringing together interdisciplinary teams was a necessity. This would train the next generation of ecotoxicologists, skilled in experimental, modelling and statistical techniques, to rebuild capacity for research and industry. This is timely because the [2017 NERC Request for Evidence of Training Priority](#) was open at the time of the workshop, inviting members of the community to submit evidence highlighting and evidencing areas of training need within NERC remit to inform the NERC Training Advisory Board discussions and NERC decision making on postgraduate training investments. This evidence will principally be used to identify topics for CDT investment but may also inform the management of other training activities, such as short courses. The call closes on 12 April 2017. The workshop participants were encouraged to contribute to this.

Other capacity needs raised included:

- A community model from which to hang the topics of the workshop would draw the relevant communities together.
- A translation of expertise from human epidemiology would be beneficial in developing the thinking and processes in this area.
- Given that we are dealing with the same chemicals all over the world, opportunities for international partnership would be valuable.
- An ecotoxicology synthesis centre, as a focus for the community where people from different disciplines could co-locate to do analysis and hold workshops, would be welcome.
- A facility to do the large scale studies is currently absent.

Conclusions and next steps

The organisers felt that the sense of ambition for high quality and up to date approaches to the issues raised, coupled with their potential impact was very obvious. The positive attitude of the workshop participants demonstrated the desire of this community to come together and that there were real prospects for the field.

A consensus of the workshop was that an aspirational goal is needed to direct future research effort in this field; for instance this could be a community model that can draw together data to help industry, regulators and society prospectively assess risks and make decisions about chemical use, and that is able to capture complexities and future scenarios of environmental and socio-economic systems. The areas of research prioritised at the workshop are a step towards this goal.

NERC, Defra and other potential partners will consider the outputs of the workshop and develop a case for a collaborative research programme.

ANNEX A

HSAC PAPER ON KEY RESEARCH QUESTIONS IN ECOTOXICOLOGY

What are the consequences for individuals and populations of both humans and wildlife, of lifetime exposures to highly complex, ill-defined mixture of anthropogenic chemicals generated by today's society?

Background

Ecotoxicology is a relatively new science that emerged during the late 1960s. The term was first coined by Professor Rene Truhaut to refer to pollution investigations related to wildlife. However, by the 1980s a more sophisticated definition emerged where ecotoxicology was defined as; *“the study of the effects of anthropogenic chemicals and radiations on ecosystems and their components”*.

Although fundamental scientific investigations still proceed in this field, ecotoxicological research has tended to focus principally on the development of practical techniques to evaluate the potential toxicity of chemicals in the environment, and the likelihood that organisms will be exposed to dangerous concentrations *in situ*. In particular, a great deal of effort has been put into developing toxicity test procedures that not only use mortality as an endpoint, but also consider sub-lethal effects on growth, reproduction and viability of offspring. Similarly, attention has been paid to the chemical speciation, persistence and fate of contaminants in diverse environmental media, together with their effects on biota. Mechanistic studies have tried to unravel the ways in which chemicals are taken up, metabolised, detoxified and excreted as well as attempting to identify the damage they give rise to. Methods have also been developed to predict the potential toxicity of chemicals based on structure - activity relationships (QSARs).

While the efforts outlined above have provided useful, scientifically-based, tools and information for regulators and environmental managers to take action to protect the environment, it is difficult to assess how successful they have been. Few of the more fundamental principles that underpin ecotoxicology, and the general questions that must be addressed when trying to evaluate newly emerging threats have been answered. This in large part reflects a lack of research funding for ecotoxicology because many funding bodies have failed to recognise that ecotoxicology is indeed a legitimate area of scientific investigation, rather than simply a set of environmental management procedures. The national need for high quality science in this area is very high. This is particularly clear regarding issues such as neonicotinoid insecticides and pollinating insects, endocrine disrupters and fish populations, the safety assessment of novel substances such as nanomaterials and novel chemical formulations and how climate change will affect the fate and effects of environmental chemicals. Without underpinning science to inform decisions and actions to deal with these concerns, the cost to the UK economy will run into £billions, and our ability to influence chemicals policy in major international fora such as the European Union and the Organisation for Economic Cooperation and Development will be limited.

Key Questions

Set out below are a number of examples of extremely important ecotoxicological questions that have not been fully answered (or in some cases, not addressed at all) over the last 50 years:

Prediction of ecotoxicological effects on individuals

1) Which chemicals are of most concern?

- 2) Does the existence of non-monotonic dose-response relationships in some cases invalidate predicted no observable effect concentrations?
- 3) How do effects of pollutants in one or two target tissues give rise to toxicity in the whole organism? (This is especially relevant for the various invertebrate phyla (95% of all animal species) whose physiology and toxicology are poorly understood).
- 4) Which species are most vulnerable to which specific types of environmental pollutants?
- 5) How can pollutants be identified that are not persistent, bioaccumulative or overtly toxic, but which cause significant ecotoxicology effects?
- 6) Can pollutants produce significant ecological change by influencing the behaviour of organisms rather than through direct toxicity?
- 7) How does exposure to pollutants affect the Darwinian fitness of organisms?
- 8) Are growth rate, reproductive output, viability of offspring and mortality the most useful endpoints for assessing pollutant toxicity? Do different pollutants affect these endpoints to different extents?
- 9) Which groups of chemicals produce the most damaging, long term (chronic and trans-generational) effects on organisms? (Rank order).

Prediction of effects on populations/communities

- 10) How do environmental chemicals effects at the level of individual organisms translate into population, community and ecosystem level effects?
- 11) How do the differential effects of pollutants on populations of different species *in situ* lead to changes in ecosystem structure, function and sustainability?
- 12) What proportion on individuals within a population and which individuals (for example, juveniles, adults, males, females, starved, well-fed?) must be affected by pollution before ecologically significant effects occur?
- 13) How can we recognise a 'normally' functioning population/ecosystem, so that we can differentiate between chemically-induced perturbations (followed by rapid recovery) and more serious, longer term damage?
- 14) How do natural changes in the chemical environment arising from normal biological and ecological processes affect populations, communities and ecosystems structure and function?

Recovery from adverse impacts

- 15) How do repeated exposures to pollutants during the life course of organisms *in situ*, affect the ecology of populations or communities?
- 16) How reversible are pollution effects in ecosystems? Can organisms and populations fully recover from pollutant exposure or does the experience influence future responses to other pollutant exposures?
- 17) What do we mean when we say that a community of organisms has recovered following a pollution episode? Is the recovered population likely to be as resistant to another pollutant exposure as a pristine population would be?
- 18) What ecotoxicological information is required to help in deciding how far to proceed with clean-up procedures?

Adaptation to effects

- 19) What are the ecological consequences for populations and communities of organisms developing physiological tolerance or genetic resistance to exposure to specific pollutants?
- 20) How can wildlife species develop resistant populations following exposure to some chemicals (e.g. pesticides, metals), but not others (PCB, PAH, Dioxins) (or do they??).

21) Are chemicals in the environment causing epigenetic effects and, if so, are these effects resulting in significant damage to wildlife?

Multifactorial effects

22) Do the most polluted sites in the environment exhibit the most severe disruption of ecosystem structure and function?

23) How do mixtures of chemicals affect the toxicity of individual pollutants?

24) To what extent do impacts not related to chemical pollution (e.g. global warming, habitat loss, extreme natural events) compromise the ability of organisms to cope with chemical pollution?

Special/other effects

25) Are representatives of diverse invertebrate phyla vulnerable to endocrine disruption and genotoxicity via mechanisms different from those that operate in vertebrates?

26) Does endocrine disruption occur in the absence of any other manifestations of toxicity (genetic damage, immune dysfunction, etc.)?

27) Do endocrine disrupting chemicals transgress the general principles that pollutants possess a threshold dose or concentration, below which no adverse effects occur in particular species?

Next steps

HSAC will prioritise these questions in due course, but we conclude that many of them urgently need to be addressed. The list of questions is long, reflecting the multi-disciplinary nature of ecotoxicology. This has often led to the side-lining of research grant applications in this field. The objective of ecotoxicology is principally to facilitate an understanding of pollutant effects in ecosystems, but also to allow accurate predictions of potential pollutant effects on wildlife populations by extrapolation from experimental toxicological evidence at the molecular, cellular, physiological and whole-organism levels of biological organisation. Most of the questions listed above address this objective. Such extrapolation is still surrounded by uncertainty, and has led to the widespread use of so-called 'safety' or 'assessment' factors when regulating chemicals, an empirical practice which is probably over-protective in many cases and under-protective in other. This excessive precaution has led to significant economic consequences, such as the frequent abandoning of development of promising new chemicals. The other side of this coin is that biodiversity continues to be lost and ecosystems to degrade because we are not fully aware of all the deleterious effects of mixtures of contaminants in the environment, nor of their effects on human disease incidences. We are still unable to accurately predict effects of the complex mixtures of anthropogenic substances in sewage and other discharges.

How the questions should be addressed is a complicated issue, but it boils down to the need for ecotoxicology to resume its place as an academic discipline worthy of much more funding support than it currently receives in the United Kingdom. It will be apparent that the ecological effects of chemicals are still far from being predictable, so the issues listed above should form the basis for a new funding stream aimed *inter alia* at environmental chemists, biochemists, (eco)toxicologists, ecologists and population modellers. Although a programme of this type could be led by the Natural Environment Research Council, its multi-disciplinary nature calls for the additional involvement of other research councils such as the Biotechnology and Biological Sciences Research Council the Economic and Social Research Council and the Medical Research Council. Furthermore, some aspects of the work would be more efficiently funded direct by government departments such as Defra and DH, perhaps acting in partnership with industry organisations, so it will be important for departmental budgets to reflect this need despite the push for spending cuts.

HSAC, February 2016

ANNEX B

Workshop programme



Department
for Environment
Food & Rural Affairs

Chemicals in the Environment scoping workshop – 20th February 2017

Broadway House Conference Centre, Tothill Street, London, SW1H 9NQ

Background

There are many tens of thousands of chemicals that we use and dispose of every day and the market is growing by about 2000 new compounds per year (Daughton, 2004; Richardson and Ternes, 2014). These chemicals enter the environment through a variety of pathways where their persistence and fate is controlled by complex interactions. Organisms are exposed to combinations of chemical mixtures and other environmental stressors throughout their lifetime and the potential impacts of this exposure on individuals, communities, ecosystems and the services they provide, remain largely unknown (Holmstrup *et al.*, 2010; Johnson and Sumpter, 2014). There are well-cited examples of negative impacts e.g. the stark reduction in birds of prey populations as a result of exposure to organo-chlorine insecticides, such as DDT (Ratcliffe, 1967), which led to the establishment of regulation to mitigate similar events. However, most chemical regulations operate on a single substance basis, meaning that mixture effects can only be inferred if monitoring shows clear impacts to individuals. This raises issues for predicting and managing the impact of new and emerging chemicals.

We want to manage chemicals to make safe products and protect the environment, ensuring the right level of regulation that incorporates current science and meets societal needs. To manage chemicals effectively, there are still fundamental questions to answer about if and how broad, low-level chemical exposure harms ecosystems and humans at a population level, and how these effects are influenced by other environmental factors. It is timely to determine whether new research concepts, approaches and techniques can be applied to this problem, for example, ecological modelling to scale up effects on individuals to populations, and new 'omics and data science techniques for large scale detection of impacts.

Workshop purpose

The workshop convenors would like to identify the key environmental research priorities needed to underpin management of chemicals in the environment relevant to the UK, with a view to potentially developing new collaborative research activity. The workshop will bring together experts from Government policy and regulation, industry, civil society and environmental science perspectives to:

- scope priority challenges in chemicals management with regards to the natural environment
- identify emerging research questions and opportunities to apply new techniques and approaches to address the issues, considering novelty and timeliness
- determine approaches and partnerships needed to effectively translate research into practice e.g. enable risk-based decision making and uptake into policy measures
- determine future UK research capacity needed to support management of chemical impacts in the natural environment

Outputs

- Clarity on priority policy and industry challenges and opportunities where UK environmental science can contribute
- Understanding of the fundamental research questions, pathways to impact and translation requirements aligned with the identified priority challenges
- Identify the support needed to leverage existing strengths and capability build areas to support UK and wider needs

PROGRAMME

Time	Programme
10:00	Registration - refreshments available
10:30	Welcome and introduction Professor Stephen Holgate (HSAC and workshop Chair)
10:45	NERC perspective Dr Ned Garnett, NERC Associate Director Research
11:00	Drivers of chemicals in the environment and research needs (10 minutes each plus 5 minutes of Q&A each) <ul style="list-style-type: none">• Evidence in Defra, Professor Ian Boyd, Defra Chief Scientific Adviser• Industry perspective, Dr Oliver Price, Unilever• Civil society perspective, Dr David Santillo, Greenpeace TBC
11:45	Workshop methodology
12:00	Session 1 - Identify priority challenges
13:00	Lunch
14:00	Session 2 - Identifying research and translation questions
14:45	Session 3 - Considering capacity needs
15:30	Chairman's summary
15:45	Next steps
16:00	Close

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Richardson S.D., Ternes T.A. Water Analysis: Emerging Contaminants and Current Issues. *Analytical Chemistry* 2014; 86: 2813-2848. doi: 10.1021/ac500508t.

ANNEX C

Workshop attendees

Mohamed Abdallah	University of Birmingham
Camilla Alexander-White	Royal Society for Chemistry
Roman Ashauer	University of York
Rachel Benstead	FERA
Michelle Bloor	University of Portsmouth
Alan Boobis	Imperial College London
James Box (organising committee)	NERC
Alistair Boxall	University of York
Ian Boyd	Defra
Howard Brett	Thames Water
Elise Cartmell	Scottish Water
John Colbourne	University of Birmingham
Chris Collins	University of Reading
Tim Cullingford	MRC
Caroline Culshaw (organising committee)	NERC
Michael Depledge	University of Exeter
Tamara Galloway	University of Exeter
Ned Garnett	NERC
Lizzie Garratt (organising committee)	NERC
Jim Harris	Cranfield University
Louise Heathwaite	University of Lancaster/Scottish Government CSA
Stephen Holgate (workshop chair)	University of Southampton
Tom Hutchinson	University of Plymouth
Susan Jobling	Brunel University
Andrew Johnson	CEH
Stephen Lofts	CEH
Brett Lyons	CEFAS
Lorraine Maltby	University of Sheffield
Peter Matthiessen	Consultant Ecotox
Patrice Mongelard (organising committee)	Defra
Oliver Price (organising committee)	Unilever
David Santillo	Greenpeace
Richard Shore (organising committee)	CEH
Jason Snape	Astra Zeneca
Dave Spurgeon	CEH
John Sumpter	Brunel University
Robyn Thomas	NERC
Jim Wharfe	Independent
Paul Whitehouse	Environment Agency

ANNEX D

Challenges under discussion at the workshop

1	Translating effects from individuals to populations (and potentially ecosystems and ecosystem services)
2	Chemical mixture assessment and control
3	Integration of chemical stressors in a range of stressors
4	Human exposure to chemicals and impacts on health and wellbeing
5	Chemicals and wildlife behaviour
6	Do we see impacts on wildlife where the highest risk chemicals are present at the highest concentrations?
7	Translating back from impacts in the field to individual chemicals
8	When does a risk become an impact?
9	Identify the highest priority chemicals for research and regulation by comparative risk assessment
10	Environmental/ecological modelling and translating to the landscape scale for use in risk assessment
11	Emerging contaminants
12	New biological monitoring/assessment techniques
13	Defining an acceptable chemical environment
14	Sources of chemicals
15	Effects on the soil/water microbiome
16	Scenarios to predict future chemical hazards and risks in a changing world

ANNEX E

Presentation slides: Dr Ned Garnett, NERC Associate Director Research

**Chemicals in the environment:
NERC perspective**

Scoping Workshop
20th February 2017

Ned Garnett,
NERC Associate Director Research

Our vision

**To place
environmental
science at the
heart of
responsible
management of
our planet**

NERC remit

- NERC's remit includes terrestrial, marine, freshwater, science-based archaeology, atmospheric and polar sciences, and Earth observation; in other words we fund research based in the **natural environment**.
- Our scientists study and monitor the physical, chemical and biological processes on which our planet and life itself depends.

NERC remit in this area

- There are three specific points within our remit of relevance to this workshop:
 - Ecotoxicology:** Diagnostics, tolerance and adaption in relation to natural and anthropogenic toxic substances.
 - Environment and health:** The relationship between environmental variables and human health. Sources, sinks and pathways of potentially harmful chemicals and organisms present in the natural environment that may have an effect on human health.
 - Pollution:** Production, transport, transformation, interaction and effects of substances which are present at concentrations above those normally expected in a clean environment; understanding the long-term availability and fate of pollutants and waste materials.

NERC's science budget 16/17

Global Challenge Research Fund £1.5bn (over 5 years)

Newton Fund phase 2 £585k (over 5 years)

Industrial Strategy - Science and Innovation £4.7bn (over 4 years)

Strategic investments

- Completed programmes:
 - Environmental Nanoscience Initiative (ENI)
 - Environmental Exposures and Health Initiative (EEHI)
 - Urban Atmospheric Science (ClearFlo)
- Active investments:
 - Atmospheric Pollution and Human Health in a Developing Chinese Megacity (APHH China)
 - Atmospheric Pollution and Human Health in a Developing Indian Megacity (APHH India)
 - Antimicrobial Resistance cross-council programme
 - AMR in the real world
 - 'Omics programme
 - Highlight topic - Pathways, impacts and fate of nanomaterials
 - Soil Security Programme

APHH

- This programme has two separate activities looking at urban air pollution and its impact on health in Chinese and Indian Megacities.

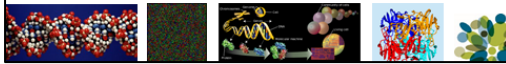
AMR

- NERC is funding grants will examine the role of the environment and host microbiome in influencing the evolution, acquisition and spread of antibacterial resistance, and as a reservoir for resistance.
- This is part of the wider Cross-Council AMR Initiative.

'Omics programme



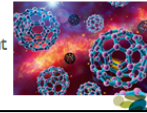
- Mathematics & Informatics for Environmental Omic Data Synthesis
 - aims to develop the fundamental knowledge needed to integrate large volumes of genomic, transcriptomic, proteomic and metabolomic data into wider environmental analyses to address new research questions
 - aims to promote the development of omic informatics as a professional niche within environmental research



Nanomaterials HT



- Environmental pathways, impacts and fate of manufactured nanomaterials. Three consortia:
 - tracking relevant nanomaterial transformations, exposure, uptake and effects in freshwater and soil systems
 - distinguishing realistic environmental risks of nanoplastics by investigating fate and toxicology in real-world scenarios
 - multimodel characterisation of nanomaterials in the environment



Soil Security Programme



DS ecotoxicology grants



- 7 current Discovery Science grants
 - Adaptation to environmental stress by evolution of non-genotypic heterogeneity within microbial populations
 - Bioavailability and biological effects of microscopic plastic debris in the ocean
 - Elucidating the potential interaction of manufactured nanoparticles with polycyclic aromatic hydrocarbons: An integrated toxicogenomics approach
 - Leveraging comparative physiology and genomics to predict species sensitivity: A novel framework for interspecies extrapolation in ecotoxicology
 - Metal/Metal Oxide Nanomaterials and Oxidative Stress- Are there Harmful Health Effects in Fish for Environmental Exposures?
 - RED FIRE: Radioactive Environment Damaged by fire: a Forest In Recovery
 - Obesogens in a naturally obese animal: An experimental approach to assess the impact of marine pollutants on fat tissue function in seals



Workshop drivers



- HSAC have concluded that this area of science has been severely neglected to date and, along with restrictions on budgets for departments, this might result in a gap in the evidence required for important policy decisions.



NERC expectations



- The workshop aims to identify the key environmental research priorities needed to underpin management of chemicals in the environment.
- The outputs of today will be used to consider the development of a new collaborative research activity.



Presentation slides: Dr Oliver Price, Unilever



CHEMICALS & ENVIRONMENT: RESEARCH NEEDS

INDUSTRY PERSPECTIVE

R&D : CORE ENGINE OF GROWTH FOR UNILEVER

Unilever

Science & Technology

Product Experience

RESPONSIBLE INNOVATION

- Safety and health of consumers and responsible innovation
- Advances in environmental sciences required to future proof innovation and protect our natural resources
- Role of prospective and retrospective risk-based assessment

Market Product

ENVIRONMENTAL ASSESSMENTS

Logos at the top: EFSA (European Food Safety Authority), ECHA (European Chemicals Agency), HSE (Health and Safety Executive), and UK Government (HM Government, Environment Agency, Defra).

Process Flow:

- Prospective Risk Assessment
- Product Launch
- Retrospective Assessment

Supporting Elements:

- Guidelines (linked to Prospective Risk Assessment)
- Guidelines (linked to Retrospective Assessment)

Bottom Section:

- HORIZON 2020
- Research Councils UK
- NERC SOURCE OF THE ENVIRONMENT
- New Science

NEW SCIENCE

Scientific Committee on Emerging and Newly Identified Health Risks
SCENIHR

Scientific Committee on Consumer Safety
SCCS

Scientific Committee on Environmental Risks
SCER

Addressing the New Challenge for Risk Assessment

Scientific Committee on Consumer Safety
SCCS

Scientific Committee on Consumer Safety
SCCS

Making Risk Assessment More Relevant for Risk Management

Scientific Committee on Consumer Safety
SCCS

Current environmental risk assessment would benefit from greater incorporation of ecological realism

... a need to better address uncertainties on the consequences of chemicals in the environment and risks to ecosystem structure and function

eceloc

MAKING RISK ASSESSMENT MORE ECOLOGICALLY RELEVANT

The diagram illustrates the integration of ecological factors into risk assessment. The central flow is:



- Exposure Tools (Measurement)** (dashed box) receives input from:
 - Interspecies/age/sex/size differences
 - Higher tier exposure
- Revised OECD Test methods** (dashed box) receives input from:
 - Time variability (seasonality)
 - Spatially heterogeneous exposure
 - Effects extrapolation
 - Higher tier testing
 - Effects of variable exposure
 - Ecological interactions (synergism, indirect effects)
- Environmental RA PEC/PNEC ratio** receives input from:
 - Exposure Tools (Measurement)
 - Revised OECD Test methods
 - Ecological modeling
- Regulatory decisions** receives input from:
 - Environmental RA PEC/PNEC ratio
 - Ecological modeling
 - New methods required for more ecologically relevant RA
 - Current EUTOX/RA research areas making input

Logos at the top: ecefc, cefic, and LRD (The European Research Institute).

Footer: ecefc, FEDERAL GOVERNMENT OF THE NETHERLANDS, www.ecefc.org

WHY UK RESEARCH?

- Environmental chemistry and ecotoxicology have been losing support, resources, and recognition at universities across the globe
- Chemicals in the environment have been described as a critical planetary boundary
- Industry needs expertise that can shape and translate new insights to inform safe and sustainable innovations



ANNEX G

Presentation slides: Dr David Santillo, Greenpeace

Drivers of chemicals in the environment and research needs

A civil society perspective
Dr David Santillo
Greenpeace Research Laboratories

20.02.17 NERC/DEFRA Chemicals in the Environment scoping workshop 1

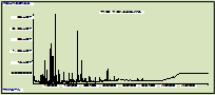



7 key challenges...

Exposure to mixtures	Contaminants of emerging concern	Soils and sediments as pathways
Implications arising from climate change	Maintaining a broad research agenda	Protecting & improving on regulation
Involving and engaging people		

20.02.17 NERC/DEFRA Chemicals in the Environment scoping workshop 2

1. Dealing with exposure to chemicals as complex mixtures

- In our environment (outdoor and indoor)
- In the workplace
- In our food and drink
- In consumer products


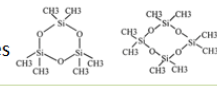





20.02.17 NERC/DEFRA Chemicals in the Environment scoping workshop 3

2. Identifying and prioritising contaminants of emerging concern

e.g.


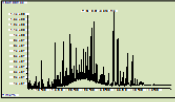
- 'new' brominated and chlorinated flame retardants
- organofluorine (including perfluorinated) compounds
- organosilicon (siloxane) compounds
- new generation pesticides

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3. Taking better account of soils and sediments as pathways of exposure



- Transfer of contaminants in sewage sludges
- Relatively poor data on toxicity of chemicals to soil or sediment organisms
- Potential for impacts on microflora, meiofauna, etc. and consequent impacts on ecosystem processes
- Long-term reservoirs of legacy contaminants

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4. Implications of climate change, & implications for resilience

- Long-term changes in climate, acidification, oxygen saturation, etc. may affect mobility and bioavailability of contaminants, e.g.
 - Higher temperatures
 - Changes in REDOX
 - Intense rainfall and flood events
- Chemical exposures might reduce resilience to such changes, whether long-term trends or shorter-term intense events

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5. Need to maintain & encourage a broad research & monitoring agenda

- Keep funding exploratory research, not just application-driven research
- Review and focus monitoring programmes, but don't lose them
- Share data more widely and more accessibly
- Maintain an effective RADAR for new & emerging chemicals and risks



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working workshop

7

6. Protect & improve on existing chemical regulations

- REACH was hard won, has broad support and is effective
- We should not seek to reinvent it after the UK leaves the EU
- Nevertheless - need for better empirical measures of effectiveness
- Issues of data gaps, data quality and blind-spots remain



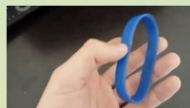
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8

7. Engaging the public in research

- Is there a role for citizen science in relation to chemicals in the environment?
 - Observation?
 - Sampling?
 - Data analysis?
- Is there value in direct attempts to monitor the human exposome?



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