

## **Current challenges in assessment of risks to human health from organic contaminants in soil and groundwater**

**Paul Nathanail**

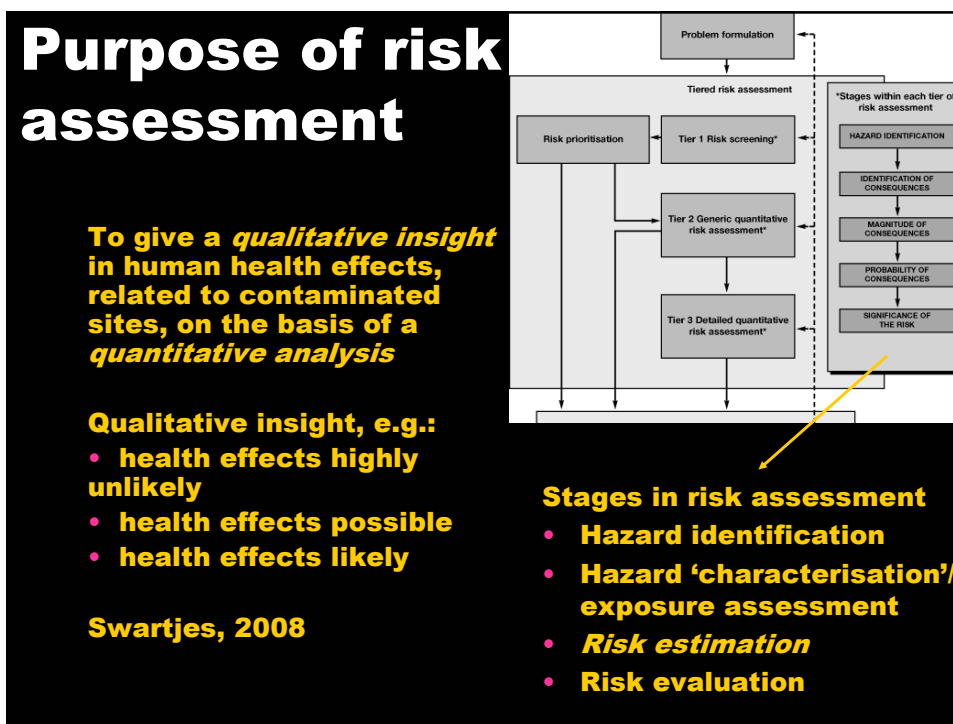
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SHE-Net Workshop 3: Risk assessment from contaminated soils to humans via the foodchain, 1 – 2 July 2008, University of Nottingham

## **Words matter**

- **“Current challenges in risk assessment modelling for organic contaminants”**



## UNOTT/ LQM activities in risk based contaminated land management

<p><b>Research</b></p> <ul style="list-style-type: none"> <li>• <b>SNIFFER method update</b></li> <li>• <b>Bioavailability in DQRA (As, Ni, Pb)</b></li> <li>• <b>GAC for 31 substances</b></li> <li>• <b>From laboratory to TDI/Index Dose</b></li> <li>• <b>Toxicology review of PAHs</b></li> <li>• <b>Sampling strategies</b></li> <li>• <b>Chemical weapons: fate, transport &amp; assessment criteria</b></li> </ul> <p><b>Education</b></p> <ul style="list-style-type: none"> <li>• <b>MRes Contaminated Land Management</b></li> <li>• <b>MSc Env Management</b></li> </ul> <p><b>Training</b></p> <ul style="list-style-type: none"> <li>• <b>CPD from introduction to advanced master classes</b></li> <li>• <b>Sector focused: regulators, house-builders, consultants</b></li> </ul>	<p><b>Practice</b></p> <ul style="list-style-type: none"> <li>• <b>Site investigation/ characterisation</b></li> <li>• <b>Exposure assessment (inc Byker)</b></li> <li>• <b>Hard G/D QRA (eg CS<sub>2</sub>, asbestos)</b></li> <li>• <b>Options appraisal</b></li> <li>• <b>Peer review</b></li> <li>• <b>Expert witness</b></li> </ul> <p><b>Disseminate</b></p> <ul style="list-style-type: none"> <li>• <b>Contaminated Land Ready Reference</b></li> <li>• <b>Generic Assessment Criteria</b></li> <li>• <b>Public speaking</b></li> <li>• <b>Peer review journal papers</b></li> <li>• <b>Conference organising (CABERNET 2005, '07 &amp; '09)</b></li> </ul>
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 <p>School of Geography <b>MRes in Contaminated Land Management</b></p> 	 <p>School of Geography <b>MRes in Contaminated Land Management</b></p>
<p><b>A two year part time industrially focused course aimed at UK, European and International consultants, regulators and land owners</b></p> <p><b>Risk Based Contaminated Land Management</b> Risk based management of historic contamination of land and groundwater has gained international acceptance. Many countries have legislative similar to Part 1A of the UK's Environmental Protection Act. The approach depends on identifying, characterising and then demonstrably breaking source-pathway-receptor pollutant linkages likely to pose an unacceptable risk.</p> <p><b>Sustainable Urban Land Management and Regeneration</b> Worldwide structural changes are creating large tracts of abandoned land that require intervention before being brought back into beneficial use. Alleviating pressure on greenfield sites, creating sustainable communities and preserving wealth requires cross-disciplinary abilities and understanding.</p> <p><b>University of Nottingham</b> Nottingham, as one of the leading UK Universities, encourages high quality curricula which are policy relevant research. The School of Geography's Land Quality Management Group are founder members of FROTH Forum, the UK's Centre for Excellence in Contaminated Land, and co-ordinator CABERNET – the EC funded network on sustainable brownfield regeneration and urban land management. We are involved in research and consultancy for regulators and industry throughout the UK and rest of Europe spanning a broad spectrum of contaminated land management and sustainable regeneration:</p> <ul style="list-style-type: none"> <li>- Site characterisation</li> <li>- Risk assessment</li> <li>- Remediation strategy selection</li> <li>- Remediation verification</li> <li>- Sustainable brownfield regeneration</li> <li>- Risk communication</li> <li>- Policy and legislation</li> <li>- Brownfield regeneration</li> <li>- Urban land management</li> </ul> <p><a href="http://www.nottingham.ac.uk/geography">www.nottingham.ac.uk/geography</a></p>	<p><b>MRes in Contaminated Land Management</b> Our 100+ delegates since 1997 have come from regulators, government, consultants and problem holders. The course comprises 4 technical modules, professional skills courses and a work related dissertation. Modules are delivered in 1 week blocks preceded by distance learning and with based training. This includes both 3 weeks attendance over 2 years, completion of distance learning and a dissertation.</p> <p><b>Practical Expertise</b> Commercial training, consultancy and contract research activities are carried out through Land Quality Management Ltd. The Course draws heavily on LQM's daily experience in writing technical guidance, in carrying out risk assessments, selecting and verifying remediation strategies and in peer reviewing third party reports.</p> <p><b>Potential Delegates</b> If you have a degree and work experience in contaminated land management then this is the course for you to develop your understanding of and abilities in a fascinating and rewarding subject area.</p> <p>While our Master's programme is geared to the needs of UK stakeholders, it is relevant and immediately applicable to other European and international contexts. Potential delegates from any country are welcome to contact us to ensure their needs will be fully met.</p> <p><b>Employers</b> Our delegates are much sought after skilled professionals. If you think you may be interested in recruiting our graduates – that's worth considering. All our delegates are in full time employment and vacancies are not brought to their attention. You could employ just one of your staff on the course though!</p> <p><b>Site Characterisation Module</b> You will learn how to characterise potentially contaminated land within a risk based framework. The intellectual framework is encapsulated in the conceptual model of contaminant sources, pathways and receptors of concern coupled with uncertainties in this information. You will become familiar with key information on site investigation and analytical methods, sources of information and legal/regulatory requirements through distance learning and guided reading of key texts or digital.</p> <p>Attendance at Nottingham will develop your skills in designing investigations, interpreting information, completing land condition records and reviewing third party reports.</p> <p><b>Risk Assessment Module</b> The module will follow the internationally accepted principles of tiered risk assessment involving qualitative followed by generic and detailed quantitative risk assessments.</p> <p><b>You will learn the principles of contaminated land risk assessment and develop your ability to use selected risk assessment models such as CLEA, SNIPPER, GASSM, CONSAL, FRCA, and RISK.</b></p> <p><b>The key skills will focus on chronic and acute human health risk assessment. Groundwater and ecological risk assessment as well as other receptors will also be covered.</b></p> <p><b>Remediation Module</b> You will learn about the range of civil engineering, physical, biological, chemical and thermal in situ and ex situ remediation technologies. You will realise the range of case studies in the UK and elsewhere and then practice the selection of remediation technologies to break pollutant linkages. You will be introduced to the operating windows of a number of commonly used remediation techniques.</p> <p><b>Attendance at Nottingham will develop your skills in selecting remediation technologies and stakeholder participation. You will encounter a range of case studies through guest speakers from industry and regulators.</b></p> <p><b>Urban Regeneration Module</b> You will explore the process of urban regeneration, in particular of previously developed/ brownfield sites and how the social, economic, environmental and institutional aspects of sustainability impinge on the redevelopment process. The module will draw heavily from experiences throughout the UK, Europe and the rest of the world that has formed part of our research and consultancy projects.</p> <p><b>International Study Tour</b> A one week study tour is an integral part of the course. Fees cover international travel and accommodation. Delegates are required to a different regulatory regime, and meet technologies allowing comparisons with current practice at home.</p> <p>Previous cohorts have visited Live Carek, Woburn, Massachusetts (U. Lowell), the University of Waterloo research facility at Brampton, and superfund sites in New York, New Jersey, California, Utah, and Idaho.</p> <p><b>Further Details</b> If you would like to know more about studying and researching contaminated land management and sustainable brownfield regeneration at the University of Nottingham's Land Quality Management Group, please write, call or email the programme director, Dr Paul Nathanail:</p> <p>Email: <a href="mailto:paul.nathanail@nottingham.ac.uk">paul.nathanail@nottingham.ac.uk</a> Tel: +44 (0)115 951 4000 Land Quality Management Group, School of Geography, University of Nottingham, Nottingham NG7 2RD, United Kingdom</p> <p><a href="http://www.nottingham.ac.uk/geography">www.nottingham.ac.uk/geography</a></p>

## Dates for the Diary

**13-15 May 2009 3<sup>rd</sup> International Conference on Managing Urban Land, St Etienne, France (CABERNET 2009)**

• **Abstracts due by 31 October 2008**

**Grazie mille!**

**Email [paul@lqm.co.uk](mailto:paul@lqm.co.uk) for more information or a copy of these slides**

NERC, EA, Defra, MOD, MRC, The Wellcome Trust,  
ESRC, BBSRC, EPSRC and HPA



## Environment & Human Health

- **The joint Environment & Human Health Programme will strengthen the UK's capacity for multidisciplinary studies into environment and human health issues.**
- **This programme is an inter-disciplinary capacity building programme that will identify and prioritise research areas where the natural environment and human health interact and strengthen the UK science community's ability to undertake multi- and inter-disciplinary research to investigate such interactions.**

## SHE-Net

- **“The aim of SHE-Net is to improve our estimates of human exposure to toxic organic chemicals in soil through the consumption of home grown and allotment produce and consequently improve the protection of public health.**
- **The largest area of concern in the risk assessment process for contaminated soils is the oral ingestion pathway, specifically the plant uptake of organic pollutants, where knowledge is currently lacking.”**

<http://www.reading.ac.uk/soilscience/Research/SHE-Net/SHE-Net-about.asp>

### **SHE-Net Workshop 1**

## **Transfer of organic pollutants from soils to plants.**

(25-26 Sept 2007, Reading University)

- **“A simple screening model to determine if there is any possible chemical transfer to crops may be enough at the stage. One order of magnitude was deemed a reasonable margin of error for a model; although two orders of magnitude maybe useful because of the high uncertainty associated with some plant processes.”**
- **“The data variability encountered across experiments was a considerable problem recognised by the workshop. It was proposed that guidelines are required before data can be used in the validation and calibration of models. Plant and chemical specialists will be required to draw up such guidelines.”**

### **SHE-Net Workshop 2**

## **Human health and organic pollutants.**

(29th – 31st January 2008, Newcastle University)

- **Social science had an important role to play in finding ways to communicate risk**
- **It was felt that different levels of trust existed depending on the source of information**
- **Terminology, especially in the case of negative media coverage, could influence reaction, for example 'contaminated' land sending a more negative message than 'brownfield'.**
- **Bioaccessibility – reliability and robustness of methods and whether these should be standardised – and whether they should be different for metals and organics. The importance of soil type and the effects of pollutant ageing in soil were also raised.**

### **SHE-Net Workshop 3**

## **Risk assessment from contaminated soils to humans via the foodchain**

(1 – 2 July 2008, University of Nottingham)

- **“Even though the rigorous methodology of QRA can establish objective 'safety' thresholds for contaminants, there are still uncertainties associated with these values resulting from an imperfect understanding of environmental pathways and mechanisms, such as plant uptake identified here, as well as the toxicology of many of the substances of concern.**
- **Workshop sessions will include:**
  - **review of existing risk assessment models,**
  - **probabilistic vs. deterministic computational approaches,**
  - **review of data availability and quality requirements.”**

## **Exclusions – topics dealt with in SHE-Net 1 & 2**

- **Bioavailability**
- **Plant uptake**
- **Toxicology**



## What is different about *organic* contaminants?

- **Biodegrade**
- **Metabolised**
- **Daughter products may be more or less toxic/ mobile/ persistent**
- **Structure 'predicts' fate and transport**
- **Mixtures are common and unavoidable**
- **'worst' ones are manufactured**

## Exposure assessment choices

- **Legal context**
  - **New/old contamination**
  - **Current/ change of land use**
- **Critical receptor**
  - **Adult/ child**
  - **Typical/ atypical**
- **Exposure scenario/ land use**
  - **Determines pathways**
- **Representative contaminant concentrations**
  - **Total, bioavailable, medium specific**
  - **Maximum, UCL, LCL, average, surrogate, equivalent,**
- **Algorithms & input parameters**
  - **Pathways**
  - **Correcting input parameters**
  - **Handling uncertainty – probabilistic vs deterministic**



## Volatiles

- **Indoor air pathway**
  - **'Measure if you can – model if you must'**
- **Sampling protocols**
- **Composite sampling protocols**
  - **SVOC**
  - **VOC !!**

## Semi Volatiles

- **PAH – BaP, Napthalene**
- **PCB, Dioxins, Furans**
- ***See workshops 1 & 2***

## **Chemical weapons: Sulphur Mustard, or “Mustard Gas”**

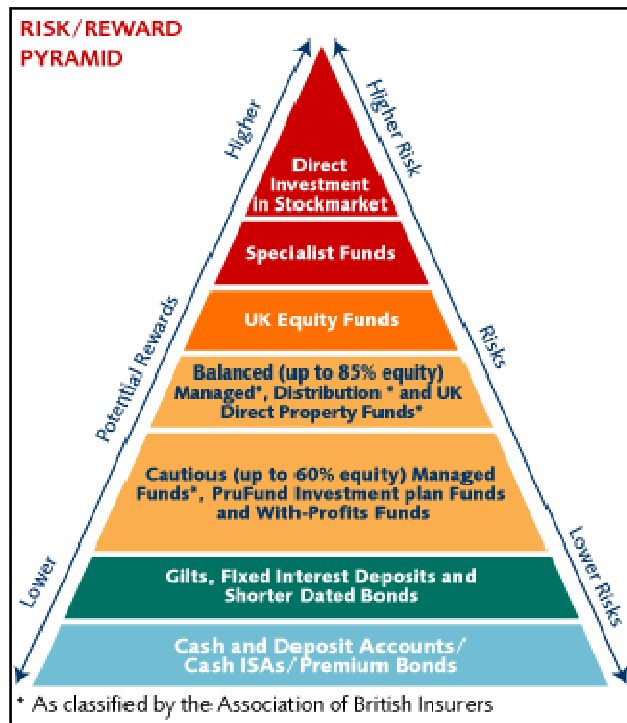
- **Oily liquid used as incapacitating CW**
- **Now recognised carcinogenic agent**
- **Contaminated soil pose acute & chronic HH risks**
- **Simple aqueous chemistry suggests it should be short lived, especially in presence of water.**
- **Causes of longevity generally assumed to be understood, precise reasons not definitively determined; evidence in support of existing theories is at best circumstantial.**
- **Prevailing view is Sulphur Mustard is somehow protected by oligomeric or polymeric sulphonium species produced during incomplete hydrolysis reactions.**
- **Poor understanding of abiotic fate of Sulphur Mustard, uncertainties remain in risk assessment and remediation**

Ashmore & Nathanail, Environ Int (2008) doi:10.1016/j.envint.2008.03.012

## **Half lives/ degradation rates**

- **Assumed persistence is over conservative**
- **Could cautious ‘half lives’ be used to inform GAC?**
- **SSAC can of course still invoke site specific measurements of degradation rates**





## The risk / reward pyramid

### Myth or truth?

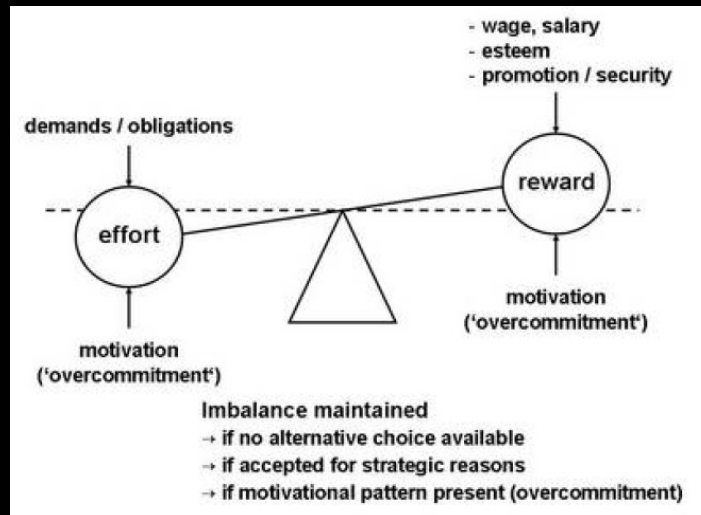
Please note that this diagram is intended to be a general indicator of relative risk and may vary in certain circumstances. It is not intended to show examples of all types of investment or savings vehicles. The investment approach may change in the future.

## Conclusions

- **T-alk *with* stakeholders in *plain* language**
- **R-aise *realistic* expectations**
- **U-nderstand *local* concerns & history**
- **S-pend *time* listening**
- **T-ake the *action* you promised to take**

Nathanail, 2008, Social dimension of sustainable remediation, SURF 10 June 2008

## Effort-reward imbalance at work

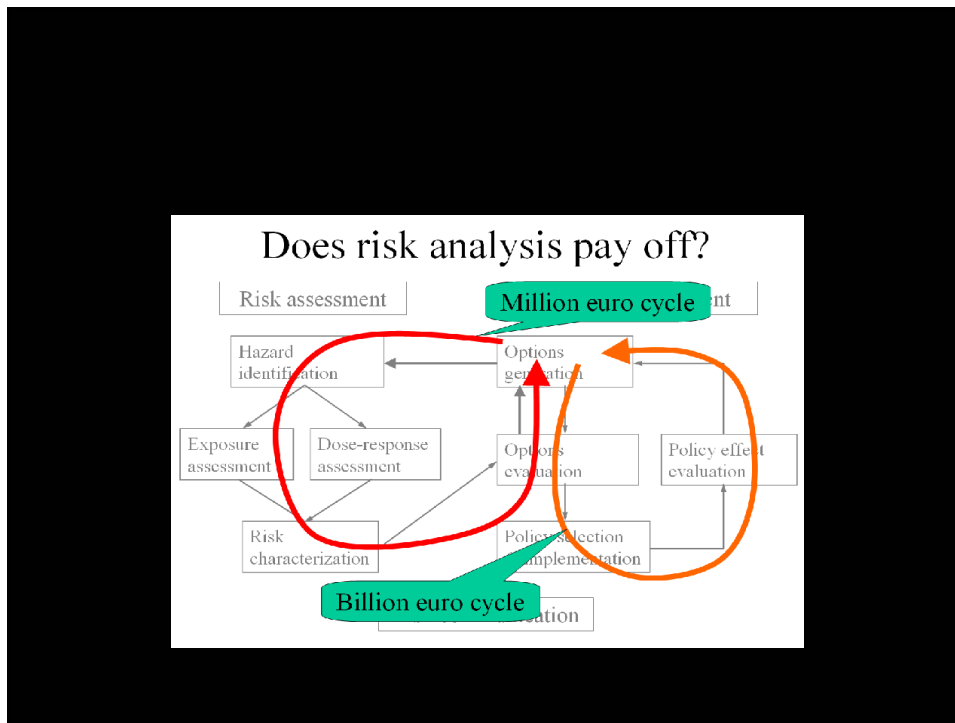


<http://www.uni-duesseldorf.de/MedicalSociology>

## Risk perception - reality



Is the glass (half) full or (half) empty?



## 'risk' Modelling

### Probabilistic

- **CLEA2002**
- **CLEA UK beta**
- **BP Risc**
- **GasSim**

### Deterministic

- **SNIFFER**
- **RBCA**
- **BP Risc**

BUT:

78 It is for consideration:

- A deterministic model is adopted for the derivation of generic assessment criteria  
 EA Appendix to DEFRA CLAN 6/2006

**“(i) The CLEA model will be changed<sup>18</sup> to a fully deterministic basis, with appropriate selection of deterministic values.”  
DEFRA CLAN 6/2006 ‘The way forward’**

- **Why probabilistic?**
  - **To account for natural variability within a parameter set (for example, body weight)**
  - **To account for parameter uncertainty (for example, average daily soil ingestion rate)**
  - **To allow decision-makers to consider the outcome from a fuller knowledge of the variation in final outputs**
- **“CLR10 criticised use of a deterministic model because of the choice of input parameters might result in “creeping conservatism”. This problem can arise where parameter values are chosen individually and without any consideration of the overall effect of several different decisions. It is not a problem that solely applies to a deterministic approach although such a framework might encourage it.”**
- **“the existing [CLEA] model “fell between two stools” and should move one way or the other”**

**71 ... Key concerns with the existing model included general understanding and communication of results (‘what does the 95th percentile tell us?’), openness in the decision-making, and the combination of a fixed percentile choice with few probabilistic variables meant that outputs were unduly dominated by the tails of these parameters.**

**The EA does not support making the existing framework more probabilistic because of the lack of scientific understanding for many input parameters to define both the range and shape of distributions.**

**72 In comparison with other countries, the UK is the only probabilistic model used for developing generic assessment criteria.**

**76 Risk practitioners have often, and incorrectly, perceived that a percentile choice from a probabilistic model is directly proportional to the real world. It has often been reported that the use of the 95th percentile of exposure estimates in CLEA for the purpose of deriving SGV is protective of “95 per cent of the UK population”.**

## **Soil Framework Directive**

- **?will seek to encourage harmonisation in risk assessment**
- **(left) levels of unacceptable risk to member states**
- **Constitutions apart, watch this space!**

## **Key question to pose to SHE-Net 3:**

- **IF the EA intent is deterministic exposure assessment for GAC determination,**
- **SHOULD SSAC be determined using probabilistic tools?**
- **IF YES, what communication and training & harmonisation issues does this raise?**
- **IF NO, how will over conservatism be avoided?**