NICOLE Meeting:

Industrial Land Contaminated by Heavy Metals

Bilbao 20-21 May 1999

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Introduction:

The meeting objectives were to review the problem of industrial land contamination by heavy metals, to progress and research findings to date, and to identify further research needs and develop new projects proposals to address them. Over 50 members from 14 different countries attended this meeting. A meeting agenda delegates list is attached at the end of this document.

The first day consisted of presentations by NICOLE members (problem holders, research performers, and facilitators). These presentations addressing the issues related to the problem of industrial land contamination by heavy metals, and were divided into three main areas:

- Human risk assessment,
- characterization,
- remediation.

During the second day, a workshop activities identified further project needs and proposals for further activities. A group contact person was nominated for each proposed area of further activity.

This information pack consists of a brief meeting outline, copies of overheads presented and a copy of the delegate list and agenda for the meeting.

NICOLE would like to thank Labein for their hospitality and help organizing this meeting, without which the meeting would not have been so successful nor enjoyable, and Jose Luis Aurrekoetxea, general manager of IHOBE welcome.

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The Problem

P.Cortesi, chairman of NICOLE, opened the workshop summarising the main technical/scientific issues related to metals contamination (from speciation to leachability to uptake etc,) and the Industry point of view.
Cortesi stressed the need, for Industry (problem owner) for cost effective use of resources. Hence the remedial targets must be based upon a correct evaluation of the risks in order not to clean more than necessary. In this regard risk assessment models need further optimisation. He concluded that only a site specific/risk based approach can ensure an optimal balance between environmental benefit and efficient use of financial resources.

Many metals are used by industry for the good of society. Some metals are micro-nutrients, essential to health, but metals are toxic in excessive quantities. Dealing with metal contaminated sites is a legacy of production of materials for use by society. The management of these sites must be carried on a risk related basis. Risks from contaminating metals depend on a linkage existing between source, pathway and receptor. This linkage is affected by the mobility and availability of metals. Hence a good knowledge of the complex biogeochemical interactions in the soil environment is needed for a sound risk management approach. Containment, solidification/stabilisation, and separation/concentration technologies are technologies that are used today to deal with heavy metals. Biological and *in situ* treatments such as electro-remediation are promising emerging technologies.

Human Risk Assessment Presentations

Two papers were presented:

- "Analysing risk for human health and ecosystem function in metal contaminated soil." (Arantzazu Urzelai, Spain)
- "(Bio)availability of metals" (Chris Zevenbergen, IWACO, NL)

Risk assessment can become very complex, so a step by step strategy was proposed: receptors at risk are defined, followed by an hazard analysis based on bioavailability of heavy metals in soil matrix, and finally the exposure risk assessment is estimated.

Zevenbergen proposed that bioavailability of heavy metals in soils/sediments should be expressed in terms of pore water concentration because of the higher toxicity and mobility of free metals ions present in pore water. Bioavailability is controlled by many factors like environmental condition (pH, Eh, salinity, DOC), buffer capacity (ANC, redox), binding capacity, mobility speciation. Total concentration of heavy metals in soil does not reflect availability.

Characterization Presentations

Four papers were presented:

- The behaviour of heavy metals in contaminated soils (Brian Alloway, University of Reading, UK)
- Geostatistics (Chantal de Fouquet, Ecole des Mines de Paris, France)

- Speciation (Ramses van Rijssen, Free University Brussels, Belgium)
- Industrial land contamination: a general overview of contamination by heavy metals in the Basque autonomous community (Ana I. Alzola Echazarra, IHOBE, Bilbao)

Mobility and bioavailability of heavy metals contaminants are complex and specific phenomena affected by a number of different factors, including: the properties of the contaminant metal, the properties of the soil or matrix, and site factors (co-contaminants, climate, land use, etc). Where uptake by plants is concerned, this also depends on factors such as genotype, rate of growth etc. The mobility and bioavailability of heavy metals, can be changed by adjusting - for example - soil pH, redox, and sorptive capacity. Nonetheless, the behaviour of metals in soils remains poorly understood.

A geostatistical study of a site in France was presented. Sampling is expensive, so it is advisable to make the most of the available data, using geostatistical tools. to avoid any risk. Redundancy is also necessary for precision. What constitutes an acceptable degree of uncertainty in risk assessment depends on the future use envisaged for the site.

The complexity of heavy metal behaviour in soil was reiterated by van Rijssen. Speciation studies can help understanding of this behaviour, but are too expensive to be useful as a general tool. It is also difficult to compare data from different speciation tests. There is a need not only for harmonisation on sampling, and preparation of the sample techniques, but also in analytical procedure. The development of soil quality criteria based on speciation was proposed to help more reliably quantify risks.

The Basque country is faces large problems of heavy metal contamination. The Basque country has particular difficulties for two reasons: its mountainous geography means that only a small proportion of its available surface s suitable for habitation and use, and that it has an extensive legacy of metal based industrial use. 3,830 metal contaminated sites have been identified in the Basque country.

Remediation Presentations

Five presentations were made:

- Design and Installation of geochemical barriers (Derk van Ree, Geodelft, NL)
- Remediation of heavy metals contaminated soils by sulphate reducing bacteria (Paolo Carrera, Ambiente S.p.A./ENI, Italy)
- Contaminated soil remediation/contaminated soil containment using electro-kinetic methods. Laboratory and pilot experiences (Alberto Bonilla, Labein, Spain)
- In situ Treatment (Joop Okx, Tauw, NL)
- Treatability studies on solvent extraction technologies in contaminated soils with organic wastes and heavy metals (Inaki Susaeta, Gaiker, Spain)

Van Ree outlined how passive reactive permeable barriers are a well-established and inexpensive technology,. Passive barriers use sorption and precipitation to trap heavy metals and metalloids within their matrix. A variety of

materials can be customised to treat specific conditions of: contaminant, soil and groundwater. Van Ree also outlined his research work investigating the formulation of "active" barriers.

Carrera suggested that use of sulphate reducing bacteria is a viable remediation option, able to transform heavy metals to less soluble / toxic forms. The effectiveness of this remediation approach is affected by factors such as: redox conditions, metal speciation, and soil texture/composition. Carrera feels that this technique still requires further laboratory and simulation testing to confirm its applicability at full scale.

Electro-kinetic methods use low intensity current between electrodes to mobilise contaminants in soils of any permeability. Laboratory results show that positive and negative species at different ranges of concentration may be mobilised across a wide range of concentrations [Bonilla]. Metal contaminant speciation is a useful predictive tool for likely effectiveness of electro-remediation.

Joop Okx reminded delegates that there is a limited number of *in situ* treatments suitable for the remediation of heavy metals. Furthemore the effectiveness of these treatments is limited by factors such as the degradability, availability and volatility of the contamiant, and the suitability of ground/soil conditions, in particular permeability and soil organic matter content. Some *ex situ* treatments such as.bioleaching could also be feasible as *in situ* techniques, but are not proven. As only a limited number of full-scale studies have been carried out, there is a need for the stimulation of further pilot scale trials.

Susaeta presented a two phase solvent extraction process for the co-extraction of heavy metals and HCH from soil. In this system the solvent used can achieve extraction of metals in excess of 50% (e.g. arsenic, zinc, cadmium, lead, nickel, chromium and copper), although not for lead. The technology was suggested to be feasible for the co-extraction of heavy metals and organic contaminants.

Short Presentations by New NICOLE Members

Three short presentations were made by new NICOLE members:

Immobilisation of heavy metals in soil and the measurement of bioavailability decrease (Ludo Diels, VITO, Belgium) *The development of cell biosensor using bacteria was introduced. These* Biomet *Test sensors are intended to quantify bioavailability of specific metals.*

Introduction of current research interest at the University of Hertfordshire (Corinne Allimann-Lecourt, University of Hertfordshire, UK) *Research carried out in the Clean Technology Research Group was introduced. Preparation of two adsorbent materials which can be used in containment barriers, and the development of two novel technologies for the extraction and recovery of heavy metals were presented along with two ex situ extraction processes for toxic metals (* SERVO *and* STEL*) .*

Hydrometallurgical purification of soil polluted with heavy metals and characterisation of metal binding forms (W. Calmano, TU-Hamburg-Harburg, Germany). Calemo presented an hydrometallurgical process, which uses electolysis to generate a leaching agent. After leaching, the leachate is treated electrolytically to deposit the metals in

the elemental form and regenerate the leaching agent for recirculation. Data suggesting 99% removals of mercury in a test system were presented.

Plenary

Following the workshops addressing future research needs nine new project areas were identified, organised in three broad themes. A contact person was nominated for each suggested project area. Any NICOLE members interested in finding out more about or collaborating in a particular project area is free to contact this individual for further information.

- *Risk assessment*
  - Bioavailability/Contact name: Vincent Druelle, email: vincent.druelle@edfgdf.fr
  - Key parameters/Contact name: Lex Oosterbaan, email: a.oosterbaan@tebodin.nl
  - Validation of models/Contact name: Chris Zevenbergen, email c.zevenbergen@rtd.iwaco.nl

- *Characterisation*
  - Triad (chem./ecotox./human)/Contact name: Ramses van Rijssen, email: rvryssen@vub.ac.be
  - Mixtures of elements/Contact name: Brian Alloway, email: b.j.alloway@reading.ac.uk
  - On-site measurements/Contact name: Stefan Godzik, email: godzik@ietu.katowice.pl

- *Remediation*
  - Barriers/Contact name: Derek van Ree, email: ree@delftgeot.nl
  - Exploring possibilities of natural attenuation/Contact name: Isabelle Hecho, email: le-hecho@cnrssp.org
  - Extraction/Contact name: Corinne Allimann-Lecourt, email: C.lecourt@herts.ac.uk