Risk based management of contamination and protection of the soil system in urban environments

JOINT Research Agenda 2005

JOINT-Workshops

- The Functioning and Management of the Water-Soil-System at River-Basin Scale: Diffuse Pollution and Point Sources. Orléans, France, 26th – 28th November 2003
- Towards an Integrated Management of Soil and Water Resources: Fate and Behaviour of Pollutants. Bonn, Germany, 7th – 9th June, 2004
- Towards a harmonised management of European soil resources: Research Agenda for Soil Protection. Vienna, Austria, 28th – 29th October 2004

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ISBN: 3-937750-01-0

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Towards an integrated approach for sustainable management of soil and groundwater resources in urban areas.

1. Foreword

International interest in research, policy and practice related to sustainable management of the soil and water system is increasing, especially due to the implementation of the Water Framework Directive and the development of an EU Thematic Strategy on Soil Protection[1]. JOINT (Joint Technical Approach for Soil and Groundwater Quality Management) contributed to these European developments with the organisation of 3 workshops dedicated to the JOINT objectives:

- Diffusion of current R&D results and connecting existing technical approaches,
- Stimulation of co-operation for applied research,
- Support of the development of upcoming soil policy.

The first workshop held in November 2003 in Orléans, France, focussed on presenting the progress of soil and groundwater related EU research projects to end-users, service providers, regulators and scientists with the aim of finding solutions on “how to bring results of EU research quicker and closer to the end-users”. To improve communication, dissemination and bringing the research closer to the market/users the JOINT team contributed to the technical digests of EUGRIS.

One explicit aim of the second workshop held in June 2004 in Bonn, Germany, was to inform about activities in the field related to funding opportunities, to illustrate the prioritary topics to be covered by future research activities and to facilitate a discussion to be used for partner search to allocate powerful consortia.

The third workshop in October 2004 in Vienna, Austria, was organised together with the Thematic Network SCAPE (Soil Conservation and Protection for Europe) to analyse and disseminate the recommendations that have been made by the Technical Working Group Research of the EU Thematic Strategy in order to group the most important, urgent and cost-effective soil research issues as “priority research areas”. A brochure introducing this research agenda for soil protection in Europe was prepared and presented at the Vital Soil EU policy conference in The Hague (November 2004).

The research agenda for soil protection in Europe describes general research needs for all soil threats, based on a DPSIR (Driving forces, Pressures, State, Impacts and Responses) approach. The present publication by JOINT gives more specific recommendations for risk based management of contaminations in the soil system, aimed at integrating the management of the soil and groundwater resources. It is focusing on the research needs for the design of adequate resource management responses in the light of changes in land use and climate changes in the European Union.

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[1] EU Communication "Towards a Thematic Strategy of Soil Protection (COM (2002)179final)

2. Introduction

European soils are under pressure by past and present non-sustainable land-use practices. In the near future land-use will change in many areas of Europe due to social and economic driving forces and climate change. These changes will provide opportunities to curb the way we use our land into a more sustainable direction. Therefore a thorough understanding of the varying properties of the soil (and water) systems that determine the opportunities for more eco-efficient land use and sustainable utilisation of soil and water resources is essential for the future.

The Environment Council of EU Ministers of Environment has already stressed the importance of eco-efficiency. If the EU wants to become" the most competitive and dynamic knowledge-based economy in the world" (Lisbon 2000 European Council), and wants to assure a high level of quality of life and social well being for citizens by providing a healthy environment (Sixth Community Environment Action Programme Article 2, Decision 1600/2002/EC), a big progress in eco-efficiency and sustainability in resource utilisation will be necessary.

The Environment needs to be considered as an important economic opportunity for Europe. Investments in new environmental technologies will strengthen Europe's competitiveness, while investments in the scientific basis of land and water resource management will maintain Europe's environment friendly profile. Focussed long-term research and development efforts are crucial to further develop the necessary innovations.

The Vital Soil conference confirmed again soil contamination as one of the priority threats to soil and its uses and functions for economy and society. It has been analysed and discussed extensively in the development of the EU thematic strategy for soil protection, using the DPSIR (Driving forces, Pressures, State, Impacts and Response) framework. The experience gained from national soil contamination policies and from discussions in EU funded networks like CARACAS, NICOLE and CLARINET led to the conclusion that the soil environment is too complex for classical command and control type of responses to solve specific soil problems. Classical instruments like "Environmental Quality Standards" limit further degradation of water and air quality and reverse negative trends towards quality improvement. However, the broad experience with contaminated land management has shown that "trend reversal" is very costly. Autonomous restoration of soil quality is too slow or not occurring at all. It requires the application of expensive technologies and civil engineering in many cases. This has led to the general conclusion that an integrated management approach is needed, which considers soil and waters as one system interacting with other compartments of the environment and with the socio-economic world through uses and functions. Integration with spatial planning, which is starting to learn to address the soil as a three dimensional system, is of utmost importance for this system oriented approach.

3. General principles: from DPSIR for soil contamination to the response - risk based management of the urban soil system

Fundamental soil research has contributed significantly to the understanding of natural and relatively undisturbed soil systems and led to insight in the behaviour of soil systems under agricultural pressure. This knowledge has been used to build the DPSIR scheme for the most common soil threats. However the design of proper management responses requires understanding of the system being managed. Whereas agricultural production systems have been studied extensively because of their economic relevance, and other more or less natural rural systems are now studied at a river basin scale in the integrated project AQUATERRA (Integrated Modelling of the river-sediment-soil-groundwater system; advanced tools for the management of catchment areas and river basins in the context of global change), the knowledge about urban systems lacks behind. Urban soils are very different from natural and agricultural soils. This is traditionally seen as a threat: urbanisation is blocking water- and geochemical cycles. However the soil system in urban environments has positive functions and it is important to understand them. Urban environment will expand very fast in the next 20 years as several EU development scenarios have shown, leading to the remediation of severely contaminated sites.

Research to guide future soil management policies and to address their needs has to start now. As far as contamination is concerned, preventive approaches in the EU policies (e.g. chemical emissions and leakages / spills at industrial facilities) will be in place. Agricultural problems will be partly solved depending on political driving forces, but will not require new basic science. However, the problems involving contamination of the soil systems in the urban environment do need input from basic sciences to develop and implement sustainable management solutions.

Strategic scientific knowledge should be developed for a better understanding of the soil system and its management, and techniques and technologies are required to put management into practice. Understanding and managing soil systems requires the contribution of many research disciplines, which can only be achieved in large trans-disciplinary projects. Such projects can build on the knowledge created by various activities under FP5, key actions “Water” on the scientific – technological side and “City of Tomorrow” on the management side, and can complement the results of research projects started under FP6 at river basin scale with urban soil system management.

Resource management or monitoring and understanding the behaviour of the soil system needs tools such as techniques and technologies. Many promising tools have already been developed but their practical implementation is still a problem. Research should give support to overcome the barriers for implementing the RTD results in a number of smaller short and medium term projects. The development of a system oriented management framework will also contribute to the implementation of promising tools. The strategic/scientific knowledge development and the development of (EU harmonised) technical tools should not take place in isolation. Some accompanying activities will be necessary that help to network within the scientific and end-users communities, to evaluate the results and up-date the state of the art, and to focus on the main needs, strategies and future perspectives in the area.

4. Core topics for research priorities

A. Soil and groundwater contamination at urban scale – understanding the system

The general conditions of urban soil and water systems are very different from the more natural soil and water systems that have been the focus of traditional scientific research. A proper understanding of the system has to be considered with the identification of key parameters for the functioning of the system and their reflection in appropriate conceptual management models. Compared with natural soil and water systems the most important characteristics of urban environments to be considered are the background pollution of soil related to air, dust, rainwater and waste and the occurrence of preferential pathways in soils and the subsoil caused by e.g. tunnels and permeable layers around sewer systems.

Management of contaminated urban environments requires a sound scientific basis for decisions about spatial planning, risk management and remediation.

Research topics:

1) **Fate and transport of pollutants** in various media (surface water, sludge, dust, vapour and water in the unsaturated zone, groundwater) and the metabolisation of organic pollutants in sediments, soil and groundwater.

2) **Detection of methods** to understand much better toxicity aspects, especially in cases of mixed pollutants; fast and cost effective screening methods; on-site detection methods with detection limits appropriate to background values or tolerable risk levels.

3) **Dynamics of urban background contamination**: contributions to soil and groundwater contamination resulting from air, dust, rainwater, waste and rubble and the effect of transport of large soil volumes from construction to be dumped elsewhere.

4) **Preferential pathways**: definition and characterisation of i.e. perched aquifers and sewer systems; modelling the contribution of preferential pathways to the total mass fluxes and their relevance for the overall impacts.

5) **Urban pathways/receptors**: clear definition of the various exposure situations that need to be accounted for in risk assessments in the urban environment.

6) **Impacts**: estimation of the impacts on houses/constructions, on ecosystems (rivers, lakes, fjords and sediments) and on human health; modelling of the fluxes of contaminants through the preferential pathways.

7) **Evaluation of impacts:** definition of indicators for the assessment of soil quality; evaluation of estimated or measured impacts (and risks); how to value the spread of contaminants to clean soil and water resources?

B. Soil and groundwater contamination at urban scale – management of the system

An increasing part of the European population lives in urban areas. The UN predicts that in 2030 2/3 of the world's population will live in Megacities. Management of the soil system in these large urban environments will become a major challenge. The most important technical management mechanisms for urban soils which have to be developed are:

Research topics:

1) **Urban land as future settlement area – conservation of natural soil functions:** related to the enlargement of settlement area, the use of soil disturbed by sealing and excavation is in conflict to natural soil functions. Management options to minimise disturbance of soil functions could be reduction of area consumption or alternative construction processes.

2) **The city and its excretions – minimisation of emergence and transfer of pollutants:** waste water, sewage sludge, sediments, waste, dust and exhausted gases are well known sources of soil pollution. Little attention has been given so far to buildings as source of soil pollution during their use and later on during demolition to rubble. The city is a source of organic and inorganic pollutants but emissions could be minimised by the consequent use of sustainable materials and improved life cycle management of buildings.

3) **Urban soil as buffer and filter – optimum functionality for the urban water-soil-system:** functionality as buffer for contaminants, storage and filter for rainfall, interaction with groundwater and surface water is reduced in urban areas. Options to enhance this functionality are urgently needed.

4) **At the end of the chain – restoration of soil functions after demolition of settlements:** due to demographic developments settlement areas will be given up and demolished. Key topics to be addressed for this reintegration into natural processes will be management of organic matter and biodiversity.

5) **Social and economic evaluation of soil – non technical management options:** the market value of soil in a service and information dominated society has to be redefined compared to agricultural and industrial societies, life cycle considerations in the context of social and urban development have to be integrated in economic models.

6) **Indicators for sustainable development** for the monitoring of long-term developments, including recycling of the sites for different uses.

7) **Integrating models** for the soil-water-system at urban scale for risk assessment and prognosis of future developments and consequences are further basic requirements for a proper management of soil and groundwater contamination at urban scale.

C. Towards harmonisation -standardisation and testing of methods

Evaluation of impacts of contamination will benefit from further harmonisation of measurements and evaluation methodologies. This will enhance scientific consistency and confidence for the managing authorities and the public. On the other hand the very diverse contaminated situations require diversity in assessment tools. Harmonisation should also be applied with caution in areas were there is uncertainty and disagreement about which approach is the best. Research to reduce these uncertainties has to be done first.

Finally, in order to perform quality assurance protocols and develop standard operational procedures (SOP), there is a continuous need of developing reference materials, especially for organic contaminants, and for interlaboratory studies on different media, including urban soils and various types of dredged material. As compared to water studies, there is still a lack of information. Standardised procedures and intercomparison studies between laboratories are required to compare monitoring data generated under various monitoring programmes.

Research topics:

1) **Leaching tests for various media:** Harmonisation of different types of leaching tests used in EU countries for media like surface covering layers, granulates, urban soil, sludges and sediments is necessary and already feasible for inorganic pollutants. Methods for organic pollutants are still in their infancy and future activities can build on the experience gathered by the network on leaching tests for inorganic substances. As compared to the analysis of metal speciation, there is a need to further develop sequential fractionation protocols in the determination of organic pollutant from soil and other relevant media.

2) **Soil vapours measurement methodologies**: Soil vapour is a very important transport route for organic pollutants, but there is large uncertainty about the resulting exposure of humans and other organisms. Appropriate sampling and measurement methods for soil vapour and indoor / outdoor air need further development. These methods are needed for improving the modelling of vapour pathways.

3) **Modelling the transport of contaminants and their transfer to humans and other environmental compartments** as water, air, biomass. Concepts and models for the transport in soils and their direct and indirect transfer to the different receptors are needed.

4) **Risk evaluations in urban areas**: A comparative study of different risk assessment methods indicated the need for a higher credibility of procedures, transparency of models, assumptions and boundary conditions. To harmonise risk assessment the relevant pathways in urban areas should be specified, in order to redefine the modelling methods and test the results against real measurements. Generic screening tools like Toxicity Identification Evaluation (TIE) should be further developed and tested in urban environment to assess impacts on urban ecosystems. Generic tools may also take into account impacts of non-regulated pollutants.

D. Technology development

The Risk Based Land Management (RBLM) concept described by the CLARINET-network[2] forms the basis for contaminated soil and groundwater management and therefore also their protection. RBLM is aiming to integrate the decisions on time-frame and choice of solution by considering fitness for use, protection of the environment, and long term care.

The steps towards a European soil strategy and the business opportunities developed from environmental requirements will act as stimulus for technology innovations. Barriers for their implementation and application will be subsequently tackled by the instruments of the Environmental Technology Action Plan (ETAP). Creative initiatives are further needed supporting existing European instruments to enhance dissemination and applicability of innovative technological solutions, commercialisation and meeting the markets needs. Research should be additionally focussed on critical limitations for bringing the technological solution to the markets.

Research topics:

1) **Fast and cost effective monitoring concepts and devices:** Reducing the cost and time needed for monitoring, i.e. by focussing on systems enhancing fast screening of the level of contamination; development of early warning systems; efficiency of remediation and control of operation during clean-up; technology development with a strong focus on limitations given by market conditions.

2) **Natural rehabilitation processes:** improvement of soil functions contributing to natural attenuation; quantification of natural rehabilitation processes and technologies to stimulate and to directly influence and control these processes.

3) **Sustainability/persistence of remediation technologies:** Limiting negative side-effects of remediation, i.e. by controlling negative environmental effects of oxygenation (by-products), enhanced bioremediation (microbiological or degradation by-products), etc.

4) **Economic models** for assessing the cost-benefit relationship for clean-up technologies, verifying cost/efficient innovative solutions to complex soil and groundwater contaminations in urban areas.

5) **Field scale testing and demonstration** of technology innovations as key activities to close the gap between research and implementation. Performance verification, assessment of technical limitations and applicability.

6) **Concepts and technologies to enable re-use of decontaminated soils and rubble** to reduce the huge masses of low to medium contaminated materials to be dumped or destroyed.

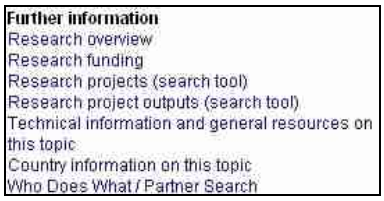
[2] http://www.clarinet.at

All information available on:

The EUGRIS portal is a web based user-friendly information platform for contaminated land and groundwater information. EUGRIS is openly available and provide a comprehensive and overarching information resource for sustainable groundwater and land management practice. EUGRIS directs any user to the most appropriate source rather than store vast amounts of information itself. The information EUGRIS provides is a series of reviews, summaries and locations for more detailed sources across Europe. EUGRIS as dissemination tool aspires to act as a **"central broker"** of information. The modular structure allows a quick integration of further technical content and new country pages.

Among others EUGRIS seeks to:
provide a high-quality platform for dissemination and extraction of existing knowledge across Europe (guidelines, case studies, methods, reviews, regulations, conferences, workshops, courses, curricula etc.)provide access to innovative research findings, products, technologies (e.g. on-going RTD projects and their objectives, new tools, demo sites, first findings, technology transfer etc.)
enhance the transfer of information between stakeholders and their networks (e.g. regulators, researchers and industry but also end-users, NGOs etc.)
support co-ordination of RTD funding across Europe (e.g. access to information about former, on-going and future research plans and their outcomes)
improve efficiency of policy and regulatory development (e.g. regulating agencies can obtain information and results on research work and strategies of neighbour countries)

Main sources are the results from European research and development programmes. The **RESEARCH** pages offer research findings by technical topics and link to a database containing research funding programmes as well as current and past projects and their available outputs and deliverables. EUGRIS' information is drawn from and linked to reliable sources. So EUGRIS tries to bridge the existing gap between researchers and potential end users and to promote the dissemination of EC funded research results.



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JOINT got funding from the European Commission in the specific programme „Energy, Environment and Sustainable Development" of 5th RTD Framework Programme. Contract No. EVK1-CT-2002-80024. The authors are solely responsible for the content of this publication which does not represent the opinion of the Community. The Community is not responsible for any use that might be made of data appearing in this publication.

Risk based management of contamination and protection of the soil system in urban environments – the 5 key messages

1. Soil is one of the most important ecosystems and a largely non-renewable resource. A vital soil provides numerous services fundamental to the welfare of society and the competitive advantages of Europe in the world. Without a sustainable use of soil, risks and insecurity will increase and economic opportunities will decrease.

2. Threats to soil are causing serious social and economic damage in Europe, amounting to billions of Euros every year. As recently identified by the member states priority threats to soil are erosion, contamination, loss of organic matter and biodiversity and sealing. They reduce the quality of life and the wellbeing of citizens and challenge the social and economic development in Europe at large.

3. Risk based management of contamination is identified as a key issue of an integrated approach for sustainable management of soil and groundwater resources. The JOINT workshops identified the expanding urban environment as a focal point for strategic research and described research priorities in the following areas:

    - Soil and groundwater contamination at the urban scale – Understanding the system and Management
    - Technology development, demonstration and implementation
    - Harmonisation, standardisation and testing of methods and risk management approaches.

4. Strategic scientific knowledge should be developed for a better understanding of the soil system and its management, which can only be achieved in large trans-disciplinary projects. Techniques and technologies are required to put management into practice. Many promising tools have already been developed. Research should give support to overcome the barriers for implementation in a number of smaller short and medium term projects. Further accompanying activities can help to network within the scientific community, to evaluate project results and to focus on the main needs, strategies and future perspectives in the area.

5. These priority research areas will lead to a better understanding of soil and its interactions with other environmental compartments. Understanding the natural capacities and restrictions of this system in line with the development of cost-effective technologies and their harmonisation at European level is essential for the development and implementation of integrated resource management policies in the near future.