Nanotechnology for contaminated land **Rem**ediation in Europe and beyond

A four year, €14 million research project funded through the European Commission FP7 called NanoRem has recently commenced.

The overarching aim of **NanoRem** is to develop, and support the appropriate use of, nanotechnology for contaminated land remediation in Europe (known as *nanoremediation* [1]).

NanoRem will focus on facilitating practical, safe, economic and exploitable nanotechnology for *insitu* remediation. This will be undertaken in parallel with developing a comprehensive understanding of the: environmental risk-benefit for the use of nanoparticles; market demand; overall sustainability; and stakeholder perceptions.

The project is designed to unlock the potential of nanoremediation processes from laboratory scale to end user applications and so support both the appropriate use of nanotechnology in restoring land and water resources and the development of the knowledge-based economy at a world leading level for the benefit of a wide range of users in the EU environmental sector. The project has 28 partners from 13 countries, including universities, research institutions and private companies. The consortium is co-ordinated by the VEGAS team (Research Facility for Subsurface Remediation) from the University of Stuttgart in Germany.

The main objectives of **NanoRem** are to:

1. Identify the most appropriate nanoremediation technological approaches to achieve a step change in remediation practice.
2. Develop lower cost production techniques and production at commercial scales of nanoparticles.
3. Determine the mobility and migration potential of nanoparticles in the subsurface, and relating these both to their potential usefulness and also their potential to cause harm.
4. Develop a comprehensive set of tools to monitor practical nanoremediation performance and determine the fate of nanoparticles.
5. Engage in dialogue with key stakeholder and interest groups to ensure that the work meets their needs, is most sustainable and appropriate whilst balancing benefits against risks.
6. Carry out a series of full scale applications in several European countries to provide realistic cost, performance, fate, and transport findings.

[1] *Nanoremediation describes the use of very small particles (called nanoparticles) to treat or even destroy contaminants in soil and groundwater. There is no accepted international definition of a "nanoparticles". However, in general it describes a particle having one or more dimensions of 100 nanometres or less. A nanometre is one thousand millionth of a metre, which can be written as* 10^{-9}*m..*

The 28 project partners and their home countries are:

Partner name	Country
University of Stuttgart, VEGAS, Research Facility for Subsurface Remediation Karlsruhe Institute for Technology, KIT Helmholtz-Zentrum für Umweltforschung GmbH – UFZ Helmholtz-Zentrum München, Deutsches Forschungszentrum für Gesundheit & Umwelt Golder Associates GmbH Industrie Anlagen Betriebsgesellschaft mbH, IABG UVR-FIA Verfahrensentwicklung – Umweltschutztechnik – Recycling GmbH	DE
r^3 environmental technology ltd Land Quality Management Ltd, LQM Contaminated Land: Applications in Real Environments, CL:AIRE University of Manchester	UK
Technical University of Liberec, TUL Aquatest AS Palacký University in Olomouc Nano Iron, s.r.o	CZ
Fundació CTM Centre Tecnològic Fundacion Tecnalia Research & Innovation, TECNALIA	ES
Centre National de la Recherche Scientifique, CNRS-CEREGE Bureau de Recherches Géologiques et Minières, BRGM	FR
Solvay (Schweiz) AG	CH
Ben-Gurion University of the Negev	IL
University of Vienna	AT
Norwegian Institute for Agricultural and Environmental Research, BIOFORSK Norwegian University of Life Sciences	NO
Politecnico di Torino	IT
Geoplano Consultores, S.A.	PT
Technical University of Denmark	DK
Stichting Deltares	NL

For further information about the project, visit the project website www.nanorem.eu

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Editors

Background Information about Nanoremediation

The 2010 projected world market for applications of environmental nanotechnologies was suggested to be approximately $6 billion Joint Research Centre (JRC) Ispra 2007) across four sectors: remediation, protection, maintenance, and enhancement, of which remediation is thought to represent the fastest growing area. These predictions portrayed a major opportunity for nanotechnology in the rapidly growing worldwide remediation sector.

Nanotechnology used for remediation, or “nanoremediation”, is primarily employed for treating soils in the saturated zone and groundwater *insitu*. They are not used for the treatment of unsaturated soils as the nano particles are rapidly inactivated or inefficient in the presence of air. Nanotechnology *could* offer a step-change in remediation capabilities as indicated by laboratory scale findings, which show that the range of treatable contaminants and the speed by which they can be degraded or stabilised can be substantially increased over *insitu* saturated zone remediation technologies (Müller and Nowack 2010). In practice this step change and the JRC predictions for nanotechnology use in remediation made in the mid-2000s have not been achieved to date.

There have been relatively few large-scale applications of nanoremediation. Bardos *et al.,* (2011) identified 58 examples of field scale applications of nanoscale zero-valent iron (nZVI) from a wide range of information sources. Only 17 of these were in Europe (Czech Republic and Germany), although bench-scale nanoremediation research is widespread across the EU. Furthermore, the practical use of nanoremediation was found to be largely confined to the treatment of chlorinated solvents *insitu*. This niche already has well established techniques (particularly *insitu* bioremediation and *insitu* chemical redox).

The reasons for this failure in market development were most recently reviewed in the UK, where nanoremediation has not been permitted at all (Anon, 2012). Costs are thought to be high compared with other technologies. In addition, in some countries, the environmental use of nanoparticles is seen as potentially hazardous or risky as an activity, leading to precautionary and conservative regulatory positions and questions have also been raised about the general sustainability of nanoparticles use in remediation. Finally, information published from field application projects is typically insufficient to draw firm conclusions about the effectiveness of the remediation. Nevertheless, the indications are that so far nanoremediation has not demonstrated a step-change in performance over existing solutions, largely because of the limited mobility and stability of the nanoparticlesused.

The current circumstances reflect an unrealised potential for nanoremediation in contaminated land restoration, both in terms of potentially facilitating a greater return of land and aquifers to a usable state, and in terms of the development of nanotechnology products and services in the environmental sector. NanoRem is designed to unlock this potential and so support both the appropriate use of nanotechnology in restoring aquifer resources and the development of the knowledge-based economy at a world leading level for the benefit of a wide range of users in the EU environmental sector.

References:

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