PRESS RELEASE

Exciting initial ecotoxicity results from the NanoRem project

No significant toxicological effects were found on soil or water organisms when ecotoxicological tests were undertaken for a range of nanoparticles that could be used for remediation projects:

- NanoFer 25S, made from nanoscale zero-valent iron, used for the remediation of chlorinated hydrocarbons in the large scale flume pilot experiment, and at Spolchemie I, Czech Republic.
- Carbo-Iron, a composite made from activated carbon and zero-valent iron, to be used for the remediation of chlorinated hydrocarbons in the large-scale flume pilot experiment, and at Balassagyarmat, Hungary.
- Fe-Oxide, nanoscale goethite, used for the remediation of toluene in the large-scale container pilot experiment, and at Spolchemie II, Czech Republic.
- Fe-Zeolites, aluminosilicate containing an iron catalyst, used in lab-scale remediation studies.
- Bionanomagnetite, (with and without 5% Pd), nanomagnetite produced by bacteria, used in lab-scale remediation studies.

These were tested for their effects on a range of organisms, mostly using standard methods published e.g. by the Organisation for Economic Co-operation and Development (OECD). These organisms were:

- *Eisenia fetida*, earthworm, used for its relevance upon ingesting soil and skin contact with contaminants in soil.
- *Lolium multiflorum* (ryegrass) and *Raphanus sativus* (radish), representing monocotyledon and dicotyledon plants, used for their relevance in contact exposure of germinating seeds and roots.
- *Daphnia magna*, aquatic crustacean, used for its relevance for ingesting suspended particles and contaminants in water.
- *Lumbriculus variegatus*, freshwater oligochaete, used for its relevance for ingesting sedimented and suspended particles and filtering freshwater.
- *Pseudokirchneriella subcapitata*, microscopic green algae, used for its relevance in contact exposure in aquatic environments.
- *Vibrio fischeri*, bioluminescent marine bacterium, used for its high sensitivity to contaminants, and relevance to marine environments.

Ecotoxicity testing will continue for any new nanoparticles or formulations developed as the NanoRem project progresses.

The project has also been looking at how nanoparticles reactivity and toxicity change with time. It is believed that as nanoparticles interact within the soil matrices they become less reactive, and therefore less toxic with time. NanoRem's findings confirm this anticipated trend which is very similar to how chemicals in general react in soil. As chemical contaminants age in the soil, their reactivity is reduced along with their bioavailability and toxicity.

There are currently widespread concerns that nanoparticles being used to treat pollutants may not fully degrade them, but transform the pollutants into more toxic compounds. NanoRem has investigated whether this phenomenon may be occurring, both in large scale pilot experiments and in the field using bioassays to investigate toxicity. These bioassays have used sensitive test organisms and have also investigated whether there are changes to the indigenous populations of microorganisms. This work is still under way, but the initial results indicate no enhancement of pollutant toxicity (or nanoparticle toxicity) even within a few metres of the injection wells and shortly after injection. On the contrary, groundwater samples from one of the field sites (Spolchemie II) were found to be highly toxic prior to injection of Fe-Oxide nanoparticles, but toxicity was significantly reduced within 3 weeks after the injection (see Figure 1 below).

Monitoring of the wells around this and other field sites injected with nanoparticles will continue for several months with additional chemical analyses being carried out by other partners within the NanoRem project, to provide detailed evidence of the different processes occurring during the treatment of the different contaminants. The results will be reported to depict the mechanisms of degradation and ecotoxicity that are occurring, but so far are very promising.

Microbial community analyses from the polluted field sites are in progress, and assays on microbial functioning are scheduled for the second half of the project.

For further information about this work and the whole NanoRem project visit www.nanorem.eu

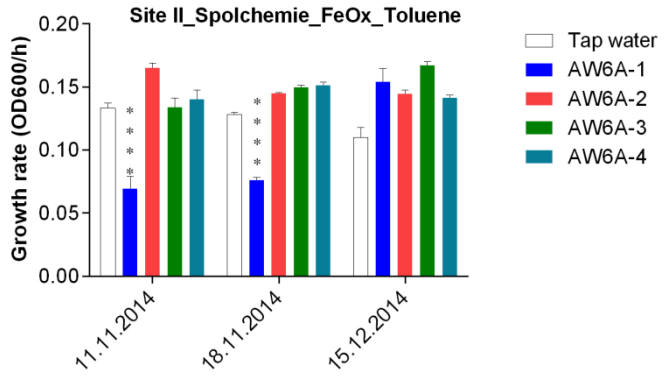

Figure 1, showing reduced toxicity of groundwater close to an injection well (monitoring well AW6A-1) at the polluted site Spolchemie II (assessed as growth rate of the bacterium *Clostridium perfringens* by the Technical University of Liberec), within three weeks after iron oxide (FeOx) nanoparticles.

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Notes to Editor:

1) Uncertainties about the environmental impact of the use of reactive nanoparticles to ecosystems is identified as a key factor to the restricted use of them in soil and groundwater remediation. The NanoRem project is addressing this issue and as part of the project, to build knowledge, confidence and provide regulators and other stakeholders evidence whether or not the technology is environmentally harmful to the natural ecosystem functions of soil and groundwater. One work package is looking specifically at this aspect and is looking to:

(1) Measure the toxicity of the nanoparticles currently used and developed during the project
(2) Assess the ecotoxicity of nanoparticles when in contact with soil and pollutants (matrix effects)
(3) Describe how toxicity of nanoparticles change with time when in contact with soil
(4) Describe how nanoparticles interact with indigenous microorganisms in soil during and after remediation treatments.

This press release addresses findings for objectives (1) to (3). Objective (4) remains work in progress.

2) Where potential ecotoxicological impacts are found in new nanoparticle developments, then this information can be used to modify particles or develop application strategies that mitigate any potential risks. For example, a newly developed milled iron nanoparticles has been developed by UVR-FIA GmbH. UVR-FIA GmbH has developed a method to produce the FerMEG 12 nanoparticles of elementary iron in a two-stage top-down process. Dry grinding to get particles < 40 μm, followed by grinding with a bivalent

alcohol as the grinding liquid. With this technology, nanostructured, flake-shaped particles with thicknesses less than 100 nm are obtained.

The material is being used for the test site in Bad Zurzach (Switzerland) which is contaminated by chlorinated compounds originating from manufacturing of tri- and tetrachloroethylene.

3) References**:** Results are so far only available in internal reports, but will be presented at the AquaConsoil meeting in Copenhagen in June 2015 and at the ICEENN 2015 conference in Vienna in September.

4) Erik Joner leads work package 5 on environmental impact. He is a senior researcher and head of the Environmental Pollution and Ecotoxicology section at Bioforsk/NIBIO and has worked on unintended environmental effects of nanoparticles since 2006. Bioforsk (Norwegian Institute for Agricultural and Environmental Research) is a public research institute with 450 employees, 50 of which work on environmental issues through European and national projects. Bioforsk is merging with two other sector institutes on the 1st of July 2015 under the name NIBIO (Norwegian Institute for Bioeconomy Research). Work within WP 5 is also conducted by the Technical University of Denmark, Technical University of Liberec and University of Manchester.

5) Nanoremediation use aqueous suspensions of very small particles (called nanoparticles) to treat and degrade contaminants in soil or groundwater. There are several definitions of the term “nanoparticle”. 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. A single human hair has a diameter of 50,000 to 100,000 nanometres. This would mean that perhaps as many as 1,000 nanoparticles made of iron could fit across a single hair.

6) A short summary of the NanoRem project is detailed below and further information can be found on the project website www.nanorem.eu

NanoRem 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. NanoRem uniquely takes a holistic approach to examining how the potential for nanoremediation can be developed and applied in practice, to enhance a stronger development of nanoremediation markets and applications in the EU. NanoRem’s ambitious objectives are:

i. Identification of the most appropriate nanoremediation technological approaches to achieve a step change in practical remediation performance. Development of lower cost production techniques and production at commercially relevant scales, also for large scale applications.
ii. Determination of the mobility and migration potential of nanoparticles in the subsurface, and their potential to cause harm, focusing on the nanoparticle types most likely to be adopted into practical use in the EU.
iii. Development of a comprehensive tool box for field scale observation of nanoremediation performance and determination of the fate of nanoparticles in the subsurface, including analytical methods, field measurement devices, decision support and numerical tools.
iv. Dissemination and dialogue with key stakeholder interests to ensure that research, development and demonstration meets end-user and regulatory requirements and information and knowledge is shared widely across the EU.
v. Provide applications at representative scales including field sites to validate cost, performance, fate, and transport findings. The NanoRem consortium is multidisciplinary, cross-sectoral and transnational. It includes 28 partners from 13 countries organized in 11 work packages. The consortium includes 18 of the leading nanoremediation research groups in the EU, 10 industry and service providers (8 small and medium-sized enterprises) and one organisation with policy and regulatory interest.

The NanoRem project has a value of approximately €14 million. It started in February 2013 and will continue to January 2017. It 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 University of Stuttgart in Germany, which has more than 17 years of relevant experience in research and development of remediation technologies and is also involved in running this European FP7 project dealing with nanoremediation technology development.

29 project partners and their web sites are as follows.

Partner name	**Country**	**Web link**
University of Stuttgart (VEGAS)	DE	www.vegas.uni-stuttgart.de
Karlsruhe Institute for Technology	DE	www.kit.edu
Solvay (Schweiz) AG	CH	www.solvay.com
Helmholtz-Zentrum für Umweltforschung GmbH - UFZ	DE	www.ufz.de
Ben-Gurion University of the Negev	IL	in.bgu.ac.il
Fundació CTM Centre Tecnològic	ES	www.ctm.com.es
University of Vienna	AT	www.univie.ac.at
University of Manchester	UK	www.manchester.ac.uk
Fundacion Tecnalia Research & Innovation	ES	www.tecnalia.com
Helmholtz Zentrum München	DE	www.helmholtz-muenchen.de
Bioforsk	NO	www.bioforsk.no
Technical University of Liberec	CZ	www.tul.cz
Norwegian University of Life Sciences	NO	www.nmbu.no
Aquatest	CZ	www.aquatest.cz
Palacký University in Olomouc	CZ	www.upol.cz
Centre National de la Recherche Scientifique	FR	www.cnrs.fr
Politecnico di Torino	IT	www.polito.it
Geoplano Consultores, S.A.	PT	www.geoplano.pt
Technical University of Denmark	DK	www.dtu.dk
Stichting Deltares	NL	www.deltares.nl
r^3 environmental technology Ltd	UK	www.r3environmental.com
LQM, Land Quality Management Ltd	UK	www.lqm.co.uk
Contaminated Land: Applications in Real Environments (CL:AIRE)	UK	www.claire.co.uk
Nano Iron, s.r.o.	CZ	www.nanoiron.cz
Golder Associates GmbH	DE	www.golder.com
Bureau de Recherches Géologiques et Minières	FR	www.brgm.fr
UVR-FIA GmbH	DE	www.uvr-fia.de
Scientific Instruments Dresden GmbH	DE	www.scidre.de
University of Duisburg-Essen	DE	www.uni-due.de