Nanotechnology for contaminated land Remediation

University of Stuttgart, USTUTT – VEGAS
Hans-Peter Koschitzky

NanoRem

What does „nano“ means ?

Small size ➔ higher surface area ➔ more reactive
NPs (in a carrier fluid) injected into saturated zone via wells
Focus on source treatment
Applicable below buildings
“independent” of application depth
„semi-passive“ technology
particles e.g. nZVI
innovative technology

Overall Goals (1)
“NanoRem - Taking Nanotechnological Remediation Processes from Lab Scale to End User Applications for the Restoration of a Clean Environment”

Identification of the most appropriate nanoremediation technological approaches that could 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.

Determination of the mobility and migration potential of nanoparticles in the subsurface, and their potential to cause harm, focusing on the NP types most likely to be adopted into practical use in the EU.
Overall Goals (2)

- Development of a comprehensive toolbox for the design of nanoremediation operations, field scale nanoremediation performance and determination of the fate of NPs in the subsurface.

- Dissemination and stakeholder dialog to ensure that research, development and demonstration meets end-user and regulatory requirements.
  - Pre-deployment risk assessment - regulatory requirement,
  - sustainability,
  - market niche

- Provision of tests at representative scales to validate cost, performance, and fate and transport findings.

Numbers and Facts

- 11 Workpackages
  - Coordination
  - Production
  - Application

- 28 Partners from 13 countries
  - AT 1, CH 1, CZ 4, DE 8, DK 1, ES 2, FR 2, IL 1, IT 1, NL 1, NO 1, PT 1, UK 4

- Partner Background
  - Higher Education (9)
  - SME (8)
  - Multinational Industry (1)
  - Non-Profit Organization (1)
  - Research Institutes / Organizations (9)

Project Advisory Group PAG
- Stakeholders from EU, USA, Asia

NanoRem Structure

Project Structure

Approach
**Coordination**

- Time management and monitoring of deadlines, milestones, and deliverables
- Chairmanship of the Coordination Team and the Project Management Group (PMG)
- Web site editorial control
- Leadership for science strategy and publication
- Controlling of project finances and budget, financial and administrative processing
- Conflict resolution, risk management and contingency plans
- Report to the European Commission

**Production**

- Production of new types of nZVI particles with surface stabilization
- Production and improvement of nZVI based on grinding/milling
- Optimization and property adjustment of particles
- Chemical and physical characterization of particles
- Particle supply and upscaling of particle production for field application
- Identification and expansion of the range of potential applications

**Transport / Reactivity**

- Standardized experimental protocols to facilitate comparison of NP mobility and fate
- Optimization of NP delivery and derivation of the effective NP transport
- Provision of field-relevant information on NP reactivity
- Transport and reaction kinetic parameters for numerical modelling
- Provision of field relevant information on chemical and size transformations, decomposition, performance, and long-term fate of NPs
WP5
COMMON FORUM, Meeting Berlin, 14 May 2014

**Ecotox**

- Establish a baseline for potential (maximum) toxicity in aqueous suspensions
- Assess ecotoxicity of NPs, NP transformation products and pollutant metabolites under lab and field conditions
- Describe time-course of ecotoxicity and quantify the potential for toxicity alleviation after migration, oxidation and ageing of NPs in contact with soil
- Describe NP-microbial interactions during and after remediation with NPs

WP6
COMMON FORUM, Meeting Berlin, 14 May 2014

**Monitoring**

- Optimisation of monitoring and tracing tools.
- Application of modern high performance analytics for on-site measurements and *in-situ* characterization of natural and engineered nanoparticles
- Laboratory and field tests of the methods developed will be conducted, providing documentation of “fit for purpose”, detection limits and costs

WP7
COMMON FORUM, Meeting Berlin, 14 May 2014

**Numerical Model**

- Development of a user-friendly simulation tool (RT3D module) for the design and interpretation of laboratory tests and for predicting the fate and transport of nanoparticles and their effectiveness at the field scale.

WP8
COMMON FORUM, Meeting Berlin, 14 May 2014

**Upscaling and Sustainability**

- Upscaling and testing at representative scale of emerging NP applications in contained facilities.
- Feedback for optimisation of NPs and tools.
- Provide knowledge on degradation products under controlled large scale conditions.
- Testing of appropriate injection technologies for varying subsurface conditions.
- Risk model, sustainability appraisal and life cycle assessment (LCA) considerations.
**Large Scale Container (LSC)**
- Stainless steel walls
- Length: 18.5 m
- Width: 9 m
- Height: 4.5 m
- Division into 3 compartments (9m x 6m x 4.5m)
- 378 sampling and measurement ports in each compartment

**Large Scale Flume (LSF)**
- Stainless steel walls
- Glass front
- Length: 18 m
- Width: 1 m
- Height: 3 m
- Division into two compartments, 9m x 1m x 3m each
- 32 sampling and measurement ports in each compartment

**WP 8.4 Large Scale Experiments**

- **Large Scale Container (LSC)**
  - Plume Remediation (Toluene, LNAPL) using FeOx NP (Goethite)

- **Large Scale Flume (LSF) ZVI NP**
  - Source Remediation (PCE, DNAPL) using NANOFER 25s

- **Large Scale Flume (LSF) composite NP**
  - Source Remediation (PCE, DNAPL) using Carbo-Iron

**LSF – Sand Emplacement**

Location of holes for sampling points at back wall

Carbo-Iron

Nanofe 25s
**Pilot Site Applications**

- Testing of emerging NP applications on pilot field sites.
- Optimisation of NPs and tools via feedback from pilot sites and field demonstrations.
- Determination of degradation products at field conditions.
- Application of appropriate injection technologies for varying hydrogeology.
- Alleviating the current lack of validated field scale performance data for end-users and regulators.

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**NanoRem Pilot Sites**

<table>
<thead>
<tr>
<th>Site</th>
<th>Country</th>
<th>Site Primary Investigator</th>
<th>Target Cont.</th>
<th>NP-Type</th>
<th>Reaction Principle</th>
<th>Aquifer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zurzach</td>
<td>CH</td>
<td>Solvay</td>
<td>CHC</td>
<td>milled nZVI</td>
<td>Reduction/Sorption</td>
<td>porous / unconfined</td>
</tr>
<tr>
<td>Spolchemie 1</td>
<td>CZ</td>
<td>Aquatest</td>
<td>CHC</td>
<td>NANOFER 25s</td>
<td>Reduction</td>
<td>porous / unconfined</td>
</tr>
<tr>
<td>Spolchemie 2</td>
<td>CZ</td>
<td>Aquatest</td>
<td>BTEX</td>
<td>Iron-Oxide</td>
<td>Oxidation/microbial Enhancement</td>
<td>porous / unconfined</td>
</tr>
<tr>
<td>Barreiro</td>
<td>PO</td>
<td>GeoPlano</td>
<td>HM</td>
<td>Iron-Oxide</td>
<td>Immobilisation</td>
<td>porous / unconfined</td>
</tr>
<tr>
<td>Besor-Secher</td>
<td>IS</td>
<td>Negev, BGU</td>
<td>CHC</td>
<td>air-stable nZVI NANOFER STAR*</td>
<td>Reduction</td>
<td>fractured</td>
</tr>
<tr>
<td>Neot Hovar</td>
<td>IS</td>
<td>Negev, BGU</td>
<td>CHC</td>
<td>Carbo-Iron</td>
<td>Reduction/Sorption</td>
<td>porous / unconfined</td>
</tr>
<tr>
<td>Balassagyarmat</td>
<td>H</td>
<td>Golder</td>
<td>CHC</td>
<td>Carbo-Iron</td>
<td>Reduction/Sorption</td>
<td>porous / unconfined</td>
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<tr>
<td>Bizkaia</td>
<td>ES</td>
<td>Tecnalia</td>
<td>HM</td>
<td>Iron-Oxide</td>
<td>Reduction/Immobilisation</td>
<td>porous / unconfined</td>
</tr>
</tbody>
</table>

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**Dissemination Level “PP” (Program Participants) CONFIDENTIAL**
**Dissemination / Stakeholder Dialogue**

- Facilitate dissemination, dialogue and exploitation, transmitting the results of NanoRem widely amongst user communities,
- Support dialogue to collect of “soft” information from a broad range of stakeholders internationally and
- Provide a risk-benefit based identification of key exploitation opportunities.

**Dissemination: some interim results**

- **Stakeholder engagement**
  - LOM Predeployment Risk Assessment
    - Nottingham Workshop 16-17 July 2013
    - Deliverable: Potential Environmental Risks of Nanoparticle Deployment (under discussion)
  - Oslo Workshop 2-4 Dec. 2014
    - Sustainability and market research
      - SustRem 2014, Sept. 17-19, Ferrara as a “dry run”
- Project web site and Newsletter
  - www.nanorem.eu

**WP8.3 Sustainability assessment and preliminary LCA approaches**

- Determining most appropriate system boundaries (link with WP10 pilot studies);
- Applying one or more of the existing sustainable remediation tool (e.g. NICOLE? SuRF-UK) and determining most important impacts and benefits of practical remedial use;
- Investigating how quantitative tools (LCA, carbon footprint) best used to support decision making;
- Testing on a pilot study (comparison with alternative remediation techniques).
This presentation reflects only the author’s views and that the European Union is not liable for any use that may be made of the information contained therein.

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