

Short report on

## Special Session 1C.24S

### Nanoremediation - your future business opportunities (strategic and market intelligence)

at 13<sup>th</sup> International UFZ-Deltares Conference on  
Sustainable Use and Management of Soil, Sediment and Water Resources  
(AquaConSoil 2015)

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AquaConSoil has a focus on sustainable use and management of soil, sediment and water resources. The Special Session on “Nanoremediation - your future business opportunities” was co-organized by Paul Bardos (r3 environmental technology ltd, GB), Stephan Bartke (Helmholtz Centre for Environmental Research - UFZ, DE), Nicola Harries (CL:AIRE, GB) and Hans-Peter Koschitzky (University of Stuttgart, DE). The objective of the session was to provide business and strategic intelligence for delegates with interests in using nanoremediation at their sites or developing nanoremediation activities at their organisations.

The session was organized as part of the EU FP7 co-funded project NanoRem ([www.nanorem.eu](http://www.nanorem.eu)), which has been carried out an intensive development and optimisation programme for different nanoparticles (NPs), along with analysis and testing methods, investigations of fate and transport of the NPs and their environmental impact. Practical grounding in nanoremediation theory and practice, introducing also the spectrum of actions of NanoRem as a major initiative, which supports the effective deployment of nanoremediation technologies in Europe, was presented at AquaConSoil in a preceding Special Session on “all you wanted to know (a practical guide to nanoremediation)”.

That Session included presentations on “What nano-remediation is and what it can and cannot do” by Miroslav Černík (Technical University Liberec, CZ), “Practical experience in nanoremediation” by Dan Elliott (Geosyntec Consultants, US), “Regulatory perspective on nanoremediation use” by Elsa Limasset (BRGM, FR) and “The NanoRem experience: large scale and case study testing” by Jürgen Braun (University Stuttgart, DE). This session was well attended by likely more than 100 conference participants. Also a Q&A section was part of that preceding session.

The Special Session on “Nanoremediation - your future business opportunities” was intended to provide conference delegates with a deeper insight on business and strategic intelligence for developing nanoremediation activities at their organisations or sites. The set-up of the Session was to allow for open, interactive exchange on the topic based on a presentation of “Preliminary scenarios for the EU nanoremediation market in 2025 – assessment of market drivers (opportunities and challenges) affecting the take-up of nanoremediation” by Stephan Bartke (UFZ, DE). Facilitated by Paul Bardos (r3, GB) and Nicola Harries (CL:AIRE, GB), the remainder main part of the session was foreseen for discussion in groups about market prospects and drivers. A plenary reporting back of discussions from the groups was to conclude the session.

Only about twelve participants – half of them from the NanoRem project half external experts from science, regulation, consultancy and problem owners, participated in the Special Session. Asked for their motivation, they indicated different objectives ranging from specific interest in applicability and market potential by a consultant, via a general interest of the potential of the technology by a problem owner to regulatory questions by a municipality delegate or questions of dealing with perceived uncertainties regarding the application of NPs in the environment by a scientist.

The introductory presentation on “What will drive the EU nanoremediation market till 2025?” introduced the participants to the scenario-approach applied in NanoRem in order to assess factors determining opportunities and challenges for the take-up of nanoremediation. Table 2 at the end of this report gives an overview about the factors. Detailed information on the approach used to identify the factors can be found in Bardos et al. 2015 [D9.1] or the conference paper to this Session.

Nicola Harries (CL:AIRE, GB) introduced to the participants the interactive part of the Session. This was a splitting-up of the delegates in two groups. Both groups were rather heterogeneously formed with participants from inside and outside the NanoRem project. Both groups had discussions next to a flipchart, where discussion points of attention and conclusions were kept. The discussions focused on three questions related to expected market changes, critical information needs and factors influencing in particular the delegates/their organisations. Despite or even as a consequence of the small number of participants, the discussions in the two groups were very intense. They indicated a considerable interest in the potentials and limitations of nanotechnology for remediation. Table 1 summarizes the discussions to each of the questions:

**Table 1: Results from group discussions on determinants of the development of the nanoremediation market in Europe by 2025**

| Group I | Group II | 1) How is the nanoremediation market changing / likely to change by 2025?                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| X       | X        | <ul style="list-style-type: none"> <li>• Lack of case studies / success stories               <ul style="list-style-type: none"> <li>○ Lack of proven results</li> <li>○ Public acceptance – public could be scared but with time and more case studies more acceptance will arise</li> </ul> </li> <li>➔ Success stories needed to convince customers, regulators, public</li> </ul>                                                                                                                                                   |
| X       | X        | <ul style="list-style-type: none"> <li>• Need to change people’s minds / perception               <ul style="list-style-type: none"> <li>○ Usually this technology is seen for polishing (plume) rather than healing the source</li> </ul> </li> <li>➔ Need to convince that nanoremediation could become a main technique</li> <li>• Injection technology improving larger volumes + longer lifetimes               <ul style="list-style-type: none"> <li>○ NanoRem improving to optimize. Injection still key</li> </ul> </li> </ul> |
| X       |          | <ul style="list-style-type: none"> <li>• Service providers need to be convinced that it is a good solution.               <ul style="list-style-type: none"> <li>○ This will support convincing the industry for going for nanoremediation as “their clients”</li> <li>○ Contractors interested in investing in nanoremediation</li> </ul> </li> </ul>                                                                                                                                                                                  |
| X       |          | <ul style="list-style-type: none"> <li>• Convince the authorities for remediation targets</li> <li>• Regulatory hurdles               <ul style="list-style-type: none"> <li>○ Occupational</li> <li>○ REACH</li> </ul> </li> </ul>                                                                                                                                                                                                                                                                                                     |
| X       |          | <ul style="list-style-type: none"> <li>• Investment needed for demonstration               <ul style="list-style-type: none"> <li>○ In particular from EU/Life+</li> </ul> </li> </ul>                                                                                                                                                                                                                                                                                                                                                  |
| X       |          | <ul style="list-style-type: none"> <li>• We don’t know how the future will change, but we do now that it has potentials</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                      |
|         | X        | <ul style="list-style-type: none"> <li>• Cost burden: likely to change</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

| Group I | Group II | 2) What is the most critical information needed to achieve a positive shift in the uptake of nanoremediation?                                                                                                                                                                                                                                                                                                                       |
|---------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| X       | X        | <ul style="list-style-type: none"> <li>• Critical shift is enabled by guaranteed results (← Case studies) + solid base of knowing how nanoremediation works in lab and field               <ul style="list-style-type: none"> <li>○ In particular important for service provider</li> </ul> </li> </ul>                                                                                                                             |
| X       | X        | <ul style="list-style-type: none"> <li>• What set of guarantee?               <ul style="list-style-type: none"> <li>○ E.g. remedial level/goal * ppm guaranteed?</li> <li>○ Decision criteria – boundaries / parameters                   <ul style="list-style-type: none"> <li>▪ Decision support tool / check list</li> </ul> </li> </ul> </li> <li>→ Operating window: High level of certainty for known conditions</li> </ul> |
|         | X        | <ul style="list-style-type: none"> <li>• For public perception &amp; buy-in, know what does and doesn't work               <ul style="list-style-type: none"> <li>→ Transparency</li> </ul> </li> </ul>                                                                                                                                                                                                                             |
|         | X        | <ul style="list-style-type: none"> <li>• Ethics framework               <ul style="list-style-type: none"> <li>→ good procurement</li> <li>→ Education what works</li> </ul> </li> </ul>                                                                                                                                                                                                                                            |
| X       | X        | <ul style="list-style-type: none"> <li>• Economics / Cost efficiency</li> <li>• Costs for customers               <ul style="list-style-type: none"> <li>○ All cost drivers in particular</li> <li>○ Insurance costs</li> </ul> </li> </ul>                                                                                                                                                                                         |
| X       |          | <ul style="list-style-type: none"> <li>• Stop loss / cost cap insurance</li> </ul>                                                                                                                                                                                                                                                                                                                                                  |
| X       |          | <ul style="list-style-type: none"> <li>• Nanoremediation should cover more pollutants               <ul style="list-style-type: none"> <li>○ Novel contaminants like PFOS</li> </ul> </li> </ul>                                                                                                                                                                                                                                    |
|         | X        | <ul style="list-style-type: none"> <li>• Ecosystem services – risk / benefit information</li> </ul>                                                                                                                                                                                                                                                                                                                                 |
| Group I | Group II | 3) How are the factors identified likely to influence you or your organisation?                                                                                                                                                                                                                                                                                                                                                     |
| X       | X        | <ul style="list-style-type: none"> <li>• What gives confidence on performance?</li> <li>• Guarantee or confidence needed?</li> <li>• Public perception</li> <li>• UK - moratorium</li> </ul>                                                                                                                                                                                                                                        |
| X       | X        | <ul style="list-style-type: none"> <li>• More into practical factors</li> <li>• Application: Nanoremediation can be a tool in the toolbox as injection technology improves</li> </ul>                                                                                                                                                                                                                                               |
| X       |          | <ul style="list-style-type: none"> <li>• Be on the safe side for new technologies               <ul style="list-style-type: none"> <li>→ Early failures are particularly damaging</li> </ul> </li> </ul>                                                                                                                                                                                                                            |
| X       |          | <ul style="list-style-type: none"> <li>• Implementation of the technology               <ul style="list-style-type: none"> <li>→ Testing large scale lab → in-situ   field deployment</li> </ul> </li> </ul>                                                                                                                                                                                                                        |
|         | X        | <ul style="list-style-type: none"> <li>• Ease of use → extra training, Health &amp; Safety → costs for companies</li> </ul>                                                                                                                                                                                                                                                                                                         |
|         | X        | <ul style="list-style-type: none"> <li>• Science / Policy - Research funds</li> </ul>                                                                                                                                                                                                                                                                                                                                               |
|         | X        | <ul style="list-style-type: none"> <li>• New technologies / emerging contaminants</li> </ul>                                                                                                                                                                                                                                                                                                                                        |
|         | X        | <ul style="list-style-type: none"> <li>• Environmental awareness &amp; sustainability</li> <li>• Role of environment (especially soil) policies</li> </ul>                                                                                                                                                                                                                                                                          |

As a summary, the existence of validated data on case studies is critical for market development – in particular if this information can be told as success stories. In addition, dialogue between the stakeholders (science – industry – policy – general public) is crucial. An open debate is the question: Who is best to initiate the communication: Does the science bring information to the consultants and then to the regulators? – The session left open an answer, but there seems agreement to state that those interested in the promotion should invest, i.e. politics should fund research in innovative NP to tackle emerging contaminants; researchers to communicate their results in a way that is understood by the market, consultants to dare the venture and gain from early mover and so forth.

**Table 2: Factors likely to influence the nanoremediation market in Europe by 2025**

| <b>Scenario framing elements</b>                                                    |                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Validated information on nano particle (NP) application potential                   | 'Information' dimension describing the quality of available information for decision-making. Information quality can range from a level with great uncertainty with regards to the potential developments of the market and the set of factors driving the market, to a situation where information about nanoremediation is readily available, well tested, and broadly accepted (i.e. "validated"). |
| Science-Policy-Interface - Communication with others                                | Broadly understood as 'Dialogue' process by which stakeholder groups (in particular those from science, policy and regulation) have informal/formal discussions, consultations and other forms of engagement in order to ascertain the potential application of nanoremediation (in general or in specific cases).                                                                                    |
| <b>Market determining factors as known now</b>                                      |                                                                                                                                                                                                                                                                                                                                                                                                       |
| Innovation on treatment of known contaminants with nanoparticles (NPs)              | NPs are effective in treating a range of contaminants. They may be superior to existing remediation approaches (being quicker or cheaper to apply or offering another added value) on a site specific basis.                                                                                                                                                                                          |
| Regulation of nanoparticles                                                         | While moratoria against use of NPs for remediation still exist in a few instances, the emerging trend is that NPs can be deployed using existing regulatory regimes. Uncertainties are those experienced in general for the injection of "new" types of material into the subsurface.                                                                                                                 |
| Costs of competitive technologies                                                   | There are already competitive nanoremediation technology solutions, but their international market penetration is low and they face strong competition from more established in situ technologies. Cost effectiveness is highly site specific                                                                                                                                                         |
| Innovations along NPs production chain                                              | The production of NPs could be boosted by improved efficiency based on increasing knowledge and economies of scale, making NPs cheaper.                                                                                                                                                                                                                                                               |
| Environment (especially soil and groundwater) protection policies                   | There is policy uncertainty at a European level for remediation drivers in general (e.g., withdrawing of Soil Framework Directive versus increasing concerns over 'emerging contaminants'). Specific to nanoremediation 'moratoria' against use exist in some countries/regions but these may be reconsidered, particularly as a result of current research work                                      |
| Synergies with technologies                                                         | NPs can be applied in remediation integrated with other approaches, e.g. bioremediation.                                                                                                                                                                                                                                                                                                              |
| Public stakeholder dialogue                                                         | Refers to communication with general public. Risks, uncertainties and benefits should be communicated in targeted formats with relevant public stakeholders. (Dialogue work currently being conducted in the UK may indicate increasing acceptability of nanotechnology use in remediation.)                                                                                                          |
| NP treatment of emerging contaminants                                               | NPs are may be effective in remediating various emerging contamination problems, but research and practical experience are fairly limited at present.                                                                                                                                                                                                                                                 |
| Public perception of NPs in general - What people think of nano                     | Public perception of NPs is patchy with low consumer knowledge and ambiguity in risk perception. The increasing use of 'nano-products' implies increasing levels of public acceptance for the technology in general, although concerns over some specific potential pollutants such as nano-silver remain.                                                                                            |
| Technology and research policies                                                    | European and national policies fund R&D into innovative technologies, generating new knowledge, including a range of nanoremediation R&D and demonstration work (such as NanoRem).                                                                                                                                                                                                                    |
| Growing number of nanoparticles suppliers - supplier having available more produces | More producers are entering the market. Suppliers are typically remediation service providers, such as consultancies. More suppliers are considering nanoremediation, although the number investing in expertise, capacities and credibility to provide nanoremediation remains relatively small at present                                                                                           |
| Real estate market development                                                      | The property market has begun to recover since the financial crash increasing the demand for suitable areas for development – which in turn influences the demand for the remediation of contaminated land.                                                                                                                                                                                           |
| Innovation attitude – People like new technology                                    | There is an increasing openness in the remediation sector towards innovation paired with willingness to invest in inventions and knowledge creation along with greater readiness to apply innovative technologies.                                                                                                                                                                                    |
| Environmental awareness and sustainability                                          | There is increasing support for ensuring a more sustainable approach to contaminated land management, and this will increasingly affect remediation decision-making. This is a highly site specific consideration.                                                                                                                                                                                    |