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## Nanoremediation for Soil and Groundwater Clean-up - Possibilities and Future Trends

### NanoRem Final Conference

Frankfurt am Main, Germany, 21<sup>st</sup> November 2016

### Panel Discussion

**Chair: Paul Nathanail, (LQM, Land Quality Management Ltd, Great Britain)**

**Participants:**

- Paul Bardos (R3 Environmental Technology Ltd, Great Britain)
- Harald Burmeier (ITVA, Ingenieurtechnischer Verband für Altlastenmanagement e.V., Germany)
- Rolf Gerhardt (Deutsche Bahn AG, Germany)
- Thomas Held (ARCADIS GmbH, Germany)
- Dietmar Müller-Grabherr (EEA, Environment Agency Austria and COMMON FORUM, EU)

**What is the most exciting and promising NanoRem particle you have heard about today, and why?**

*Harald Burmeier (ITVA, Ingenieurtechnischer Verband für Altlastenmanagement e.V., Germany):*

Carbo-Iron seems to be better than pure nZVI particles. Especially in combination with other remediation approaches in treatment-trains, it may be used for source remediation.

**What benefits do you think NanoRem particles can offer that are not already available from other technologies? (And which particles do you think are most likely to deliver those benefits?)**

*Paul Bardos (R3 Environmental Technology Ltd, Great Britain):*

Carbo-Iron is a big step forward. Air stable nano-iron is also very innovative. The niche / opportunity for nanoremediation is fast remediation and source treatment. You can use a nanoremediation approach for a rapid knockdown and combine it with In situ biological remediation, ISBR against rebound effects. Nanoparticles offer remediation for previously intractable / emerging pollutants.



**As a consultant, which information do you take back?**

*Thomas Held (ARCADIS GmbH, Germany):*

Formerly, the nanoparticle transport radius was too small, so it did not work for bigger plume sizes. The presentations have shown that the radius has been enlarged. This also increases cost-effectiveness. The applicability of this remediation technique strongly depends on injectability.

**As a client, which is the most likely scenario where you think a NanoRem particle may be able to help you achieve remediation that is currently impossible or too slow / expensive?**

*Rolf Gerhardt (Deutsche Bahn AG, Germany):*

Most likely is a combination with other remediation technologies. Issues of regulatory acceptance: A definition of remediation success is needed (monitoring, definition of clean-up).

Nanoremediation is an option for a fast remediation. Some years ago, it started with only a few nanoparticle types. Now there are more types available, and there are more possibilities to use them, e.g. as permeable barriers and / or as filters to clean water. A look to other sectors might show additional options for nanoparticle use.

**As a regulator, are there now scenarios where you think the risks posed by injecting NanoRem particles into polluted groundwater are so low that their use would get regulatory permission?**

*Dietmar Müller-Grabherr (EEA, Environment Agency Austria and COMMON FORUM, EU):*

There is not a single answer, this issue has to be discussed on 3 different levels:

- 1) European level: There is no general nano-specific barrier. In terms of the European GWD deploying nano-particles to the saturated zone means a direct input of substances. Accordingly this touches upon the prevent & limit-objective defined by the WFD intending a 1<sup>st</sup> line of defense by preventing "hazardous" substances and limiting (controlling) further "potentially harmful" substances. Referring to this it will be necessary to be substance/particle-specific. E.g. whereas nZVI-particles could likely equal other "limit-substances", I could imagine that palladium-particles might get compared to "prevent-substances" – which would create a regulatory barrier for use.
- 2) National level (Austria): Direct inputs of fluids to the saturated zone (like injecting nano-particles) are generally handled conservative. However given that quality of a groundwater already has been impacted it would be necessary (like for any other in-situ-technology) to  
- provide an analysis of benefits, disadvantages and likelihood of unintended effects and to  
- prove the overall benefit and site-specific tailoring.
- 3) Field level: Working with the competent authority (and technical practitioners at regional or local level), practice could be even more restrictive, which usually is triggered by a general work-overload and missing access to credible information. Consequently the response to overcome would need to be



- a. establishing a transparent dialogue and thereby create confidence between the involved parties
- b. providing general information on the technology (also emphasising on a “self-evident” fact: there is hardly any “dispersion potential”, the distance/radius of transport of the deployed nano-particle is strongly limited to the injection point), and
- c. demonstrating the site-specific tailoring and management of the project.

## **Comments to answers of the other panelists:**

*Rolf Gerhardt (Deutsche Bahn AG, Germany) to regulators:*

Previously, there was no solution for certain problems. Now there is – and if you present it to the regulator, he will say: Go! But currently, nanoremediation is still quite expensive, with prices expected to decrease in the future.

So the question is: What to do? Don't use nanoremediation and wait for the prices to drop - or do something for the environment, even if it's expensive?

*Paul Bardos (R3 Environmental Technology Ltd, Great Britain):*

The Nanoremediation situation is similar to the situation of ISBR 15 years ago. ISBR is now widely applied. So what NanoRem has to do is spread the word and provide information to the regulators in small chunks that can easily be used for documents (e.g. factsheets). These documents would have to be in the respective language.

Nanoremediation will not replace other remediation technologies but increase the number of technologies available.

*Thomas Held (ARCADIS GmbH, Germany):*

Nanoremediation will not be able to replace other remediation technologies. And this has not been the goal. Nanoremediation is an addition to the in-situ remediation toolbox; this is exactly what is needed to address site remediation in a best way.

*Dietmar Müller-Grabherr (EEA, Environment Agency Austria and COMMON FORUM, EU):*

Consultants have a specific set of technologies they are able to use - if “nano” is not in the box, they will not use it. Also, the big advantage of nanoremediation has not yet been seen - time might be a big argument.



*Harald Burmeier (ITVA, Ingenieurtechnischer Verband für Altlastenmanagement e.V., Germany):*

The acceptance of in-situ remediation depends on downstream protection. This needs additional measures which of course increases costs, e.g. for the additional pump & treat facilities.

Another remark: Who explains these technologies to the local authorities? The documents should not be too theoretic to be able to quickly understand what nanoremediation is about. A very good marketing is needed combined with a planning tool, e.g. a workshop for in-situ technologies for local authorities.

*Paul Nathanail, (LQM, Land Quality Management Ltd, Great Britain):*

You should train authorities, customers and consultants.

### **Is there enough knowledge and guidance for treatment trains?**

A treatment train is a combination of 2-3 remediation technologies (simultaneously or sequentially).

*Thomas Held (ARCADIS GmbH, Germany):*

Usually, technologies are switched when the chosen technology is no longer cost effective. Once developed to maturity nanoremediation may be part of a treatment train. Often, the end of the treatment train is monitored natural attenuation.

*Paul Bardos (R3 Environmental Technology Ltd, Great Britain):*

It depends on the site. On some sites, lactate can't be used because of proximity to drinking water. Nanoremediation can be used to kick-start an in-situ bio process in parallel. So we have a rapid initial effect, bio is secondary and natural attenuation is tertiary.

*Dietmar Müller-Grabherr (EEA, Environment Agency Austria and COMMON FORUM, EU):*

The typology of the specific site setting is most important. Often, sites with similar pollutants have a similar hydrogeology. A newly developed routine is needed, looking at operationalising technology trains.

*Petr Kvapil (Aquatest, Czech Republic):*

Consultants are often thinking about treatment trains, especially on complicated sites with difficult conditions or complex contaminations, where one technology is not enough.

With a technology train, planned from the start or implemented during the project, nanoremediation could be made more effective or efficient, e.g. combining it with bio or photochemical technologies. Also, a combination with electric field to lower the remediation costs is possible



**Question** by Hans-Peter Koschitzky (VEGAS, University of Stuttgart, Germany):

**The project language is English – is this a barrier for use of the results?**

*Harald Burmeier (ITVA, Ingenieurtechnischer Verband für Altlastenmanagement e.V., Germany):*

Reading English takes longer for non-native speakers, so a translation would be helpful. In Switzerland, all documents are available in at least 3 languages.

*Dietmar Müller-Grabherr (EEA, Environment Agency Austria and COMMON FORUM, EU):*

It is a barrier, many people shy away from English documents.

*Paul Nathanail, (LQM, Land Quality Management Ltd, Great Britain):*

Suggestion: Provide 1 Bulletin and 1 Overarching presentation about NanoRem in different languages. Please use an easy to understand language and avoid e.g. talking about the zeta potential.

### **Final Comments**

*Harald Burmeier (ITVA, Ingenieurtechnischer Verband für Altlastenmanagement e.V., Germany):*

Don't worry, be optimistic.

*Dietmar Müller-Grabherr (EEA, Environment Agency Austria and COMMON FORUM, EU):*

Nanoparticles do only show a short distance migration.

*Thomas Held (ARCADIS GmbH, Germany):*

Like the overall coverage of the NanoRem project from production to application.

*Rolf Gerhardt (Deutsche Bahn AG, Germany):*

Nanoremediation has a broad application and can be combined with other approaches. Go on!

*Paul Bardos (R3 Environmental Technology Ltd, Great Britain):*

NanoRem has done a lot, difficult so see from the inside.

*Note from Dominique Darmendrail (COMMON FORUM, EU):*

NanoRem was one of the most interesting projects. The progress should be clarified.