Practical Applications of Nanoremediation
RemTech, Ferrara, Italy
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Keywords:
nanoremediation, nanoparticles, soil and groundwater remediation, applications, contamination, risk-benefit, market opportunities, NanoRem,

Aim

Two sessions will provide delegates with context, background, and case studies to ascertain whether nanoremediation and new techniques in nanoremediation can benefit their organisation and address implementation skill sets. The sessions are particularly targeted at practitioners such as site owners/managers service providers (consultants and contractors), and regulators.

The **first** session focuses on providing a practical grounding in nanoremediation theory and practice with particular reference to applied examples in the field. The **second** session focuses on discussing business and strategic intelligence for delegates with interests in using nanoremediation at their sites or developing nanoremediation activities at their organisations.

Background

Nanotechnologies could offer a step-change in remediation capabilities: treating persistent contaminants which have limited remediation alternatives, avoiding degradation-related intermediates and increasing the speed at which degradation or stabilisation can take place (Müller and Nowack 2010), among other potential benefits. In 2007 in Europe it was forecast that the 2010 world market for environmental nanotechnologies would be around $6 billion (JRC Ispra 2007). In fact, adoption of nanoremediation has been slower, with fewer than 100 field scale applications, since the first field application in 2000. However, the recent emergence of nanoremediation as a commercially-deployed remediation technology in several EU countries, notably the Czech Republic and Germany indicates that it is timely for service providers and site owners or managers in Europe to reconsider its potential applications and the consequent implications for their business activities.

Since early 2013, the EU FP7 NanoRem project (www.nanorem.eu) has been carrying 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. NanoRem is a €14 million international collaborative project with 29 Partners from 13 EU countries, and an international Project Advisory Group (PAG) providing linkages to the USA and Asia. It is a major initiative, which will support the effective deployment of nanoremediation technologies in Europe. As part of its work it offers these two sessions to provide key information for organisations considering diversifying into nanoremediation, or already beginning that process.

References:

Joint Research Centre - JRC 2007. Report from the Workshop onNanotechnologies for Environmental Remediation. JRC Ispra 16-17 April 2007. David Rickerby and Mark Morrison. www.nanowerk.com/nanotechnology/reports/reportpdf/report101.pdf

Müller, N.C. and Nowack, B. 2010. Nano Zero Valent Iron – THE Solution for Water and Soil Remediation?, ObservatoryNANO Focus Report. www.observatorynano.eu/project/filesystem/files/nZVI_final_vsObservatory.pdf

Session 1: Practical Applications for nanoremediation 9.30 am to 1 pm

Over the past fifteen years, nanoscale zero valent iron (nZVI) has been the subject of burgeoning interest by the environmental consulting, regulator, and academic research communities. Bench-scale studies indicate that nZVI can rapidly degrade a wide variety of redox-amenable contaminant classes including halogenated organics, nitrate, perchlorate, nitroaromatics, and various heavy metals in groundwater. Larger specific surface areas contribute to estimated treatment rates that are significantly faster than those for microscale and granular zero valent irons. The small particle size of nZVI offers the possibility of cost-effective subsurface dispersion and deployment. Since 2000, more than 70 field-scale demonstrations have been performed in North America, Europe, and Asia have shown that nZVI can be effectively deployed for treatment of contaminant source areas and dissolved plumes in both unconsolidated and fractured bedrock aquifers.

Despite these promising developments, the utilization or inclusion of nZVI in site remediation strategies is not commonplace. Several factors likely underscore this including: (i) a dearth of commercial manufacturers of nZVI and concomitant cost and quality issues; (ii) challenges associated with the injection and distribution of nZVI in situ; and (iii) a lack of understanding of the implications of using this technology: fate and transport issues, reactive longevity of nZVI, and receptor exposure and toxicity issues, etc.

Many of the reservations identified in connection with the nZVI technology may be addressed by the growing body of peer-reviewed research from university groups around the world. The academic advances in the fundamental understanding of the properties and behavior of nZVI, coupled with the increasing experience of consulting practitioners, is expected to drive continued development of this promising technology.

This session will explore the current state-of-the-practice of the nZVI technology through discussions of global experience with nZVI; modern manufacturing methods; fate, transport, and toxicity issues; and illustrative case studies from the U.S. and Europe.

Presentations:

1. Introduction about the method
2. Short history which started in US
3. Experiences in Europe till now
4. Key findings from the NanoRem project
5. Strengths and weakness of the method
6. Possible combination of nZVI with other methods (e.g. electro-kinetics, *in situ* bioremediation)

Trainers:

Miroslav Cernik, Technical University of Liberec, Liberec, Czech Republic (miroslav.cernik@tul.cz) (*contact*)

Dan Elliott, Geosyntec, 7 Graphics Drive, Suite 106, Ewing, New Jersey 08628 (www.geosyntec.com; DElliott@Geosyntec.com)
Petr Kvapil, AQUATEST a.s., Geologicka 4, 15200, Prague 5, Czech Republic (www.aquatest.cz, kvapil@aquatest.cz)

Trainer biographies:

Miroslav Cernik, www.researchgate.net/profile/Miroslav_Cernik

Dan Elliott, Dr. Elliott has more than 25 years of experience as an environmental engineer from the diverse perspectives of industry, consulting, and the university sector. At Merck, Dan supported wastewater treatment and hazardous waste management activities at the Rahway, NJ complex of factories, pilot plants, and research laboratories. As Corporate Environmental Engineer at American Standard Inc., he managed permitting, compliance, internal auditing, environmental liability, supporting more than 100 global manufacturing facilities. Dan also served as Environmental Affairs Manager for UNC-Chapel Hill sandwiched between two consulting roles at Geosyntec Consultants Inc. Dr. Elliott has significant expertise in the application of the nanoscale zero-valent iron technology and co-led the first field demonstration in 2000. He is a member of the Project Advisory Group of NANOREM. Dr. Elliott holds a Ph.D. in Environmental Engineering from Lehigh University, an M.S. in Environmental Science and Engineering from UNC-Chapel Hill, and an A.B. in Chemistry from Vassar College.

Petr Kvapil, Petr is 39 years old R&D director and member of the board at AQUATEST a.s. company. He has graduated at Faculty of natural sciences of Charles University (Prague, Czech Republic). His PhD. Degree he obtained at the University of Provence (Marseille, France) and Ecole des Mines d´Ales (France) with the specialization on Environmental chemistry. He has more than 20 years professional experience in the remediation field, 15 years experience in in-situ oxidation and reduction remedial processes field, and 12 years of experience with nanoiron enhanced contaminant reduction. An important part of his actual working activity is new remedial technologies research and development in collaboration with Czech and European scientific organizations. He has assisted on one of first European field and laboratory nanoiron applications in 2004. Until now he has assisted or managed more than 20 field pilot nanoiron applications provided in EU and assisted or managed 5 full-scale nanoiron remediation projects.

Session 2: What will drive the EU nanoremediation market till 2025 – opportunities and challenges for the utilistion of nanoremediation 2.30 pm to 5 pm

The session comprises a review of stakeholder meetings and focus group information collected by NanoRem over 2013-2016 on factors determining market developments in Europe. Part of the strategic and business intelligence provided by this session will be from self-learning as the session delegates interact with each other in a facilitated way in small groups.

Various external determinants from economy, technology development, politics and society affect the property market in general and the industry for contaminated land remediation in particular. In order to develop an exploitation strategy that considers the medium to longer term potential market development for nano-particle based remediation, any analysis has to deal with an uncertain future. The factors (i.e. drivers and uncertainties related to driver development) that foster or inhibit the evolution of the market need to be better understood. A scenario approach has been used to help better understand potential market developments.

Over a number of workshop and focus group events in several Member States, NanoRem has found that the same two dominant factors will affect market developments:

Validated information on nano particle (NP) 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).

The presentation will describe the broad market drivers and possible futures for nanoremediation markets by 2025 in the context of these two major dimensions, and their interaction with other market drivers.

Delegates will then have the chance to debate this presentation and develop a more regionally focussed perspective, form the perspective of different stakeholder interests (e.g. service providers, regulators, researchers) during a series of guided interactive discussions using a World Café™ format. This will involve discussion in small groups, each with a NanoRem facilitator to provide a chance for active discussion and exchange of ideas about market prospects, drivers and recommendations we can conclude on the day.

Discussions will be encouraged to address in particular the following questions:
1. How are things changing / likely to change?
2. What is the most critical information to achieve positive shifts in the uptake of nanoremediation?
3. How are the factors presented likely to influence the various organisations and people taking part in the session?

Group discussions will be followed by a plenary session where each group can report back and ideas can be exchanged.

Trainers:

Paul Bardos, r^3 environmental technology ltd, H9, TOB1, Whiteknights, Reading, RG6 6AT, UK (www.r3environmental.com; paul@r3environmental.co.uk), and University of Brighton, Brighton, UK (contact)

Dan Elliott, Geosyntec, 7 Graphics Drive, Suite 106, Ewing, New Jersey 08628 (www.geosyntec.com; DElliott@Geosyntec.com)

Trainer biographies:

Paul Bardos, Paul Bardos is the managing director of r3 Environmental Technology Ltd (www.r3environmental.com). He is a part-time adjunct Professor at the University of Brighton working on stakeholder engagement and decision making for low input contaminated land management. He is Visiting Professor in Environmental Engineering at the University of Nottingham where he helped initiate and develop their MSc in Contaminated Land Management, and a visiting professor at the University of Reading. His professional interests are: r3 offers a range of research, management and consultancy services for brownfields, renewables and sustainability, contaminated land and waste management, environmental information dissemination and management, stakeholder engagement and supporting small users and householders in environmental decision making.

Dan Elliott, Dr. Elliott has more than 25 years of experience as an environmental engineer from the diverse perspectives of industry, consulting, and the university sector. At Merck, Dan supported wastewater treatment and hazardous waste management activities at the Rahway, NJ complex of factories, pilot plants, and research laboratories. As Corporate Environmental Engineer at American Standard Inc., he managed permitting, compliance, internal auditing, environmental liability, supporting more than 100 global manufacturing facilities. Dan also served as Environmental Affairs Manager for UNC-Chapel Hill sandwiched between two consulting roles at Geosyntec Consultants Inc. Dr. Elliott has significant expertise in the application of the nanoscale zero-valent iron technology and co-led the first field demonstration in 2000. He is a member of the Project Advisory Group of NANOREM. Dr. Elliott holds a Ph.D. in Environmental Engineering from Lehigh University, an M.S. in Environmental Science and Engineering from UNC-Chapel Hill, and an A.B. in Chemistry from Vassar College.

Advisor:
Stephan Bartke, UFZ, Permoserstr. 15, 04318 Leipzig, Germany (www.ufz.de; stephan.bartke@ufz.de)

Biography: www.researchgate.net/profile/Stephan_Bartke

Agenda

30 min: Introduction and background
- Welcome / Objectives of session
- *Tour de table*
- Presentation on market assessment research from NanoRem project

90 min: World Café™ on nanoremediation market futures
- Introduction to World Café format and points of discussion
  Discussions and exchange in different facilitated breakout groups

30 min: Concluding plenum
- Reporting back from World Café groups in plenum
- Concluding discussion on practical applicability of nanoremediation joing the morning and afternoon sessions