Overview of Nanoremediation and Update on the NanoRem Project

Catherine Leaf

RAMBOLL ENVIRON

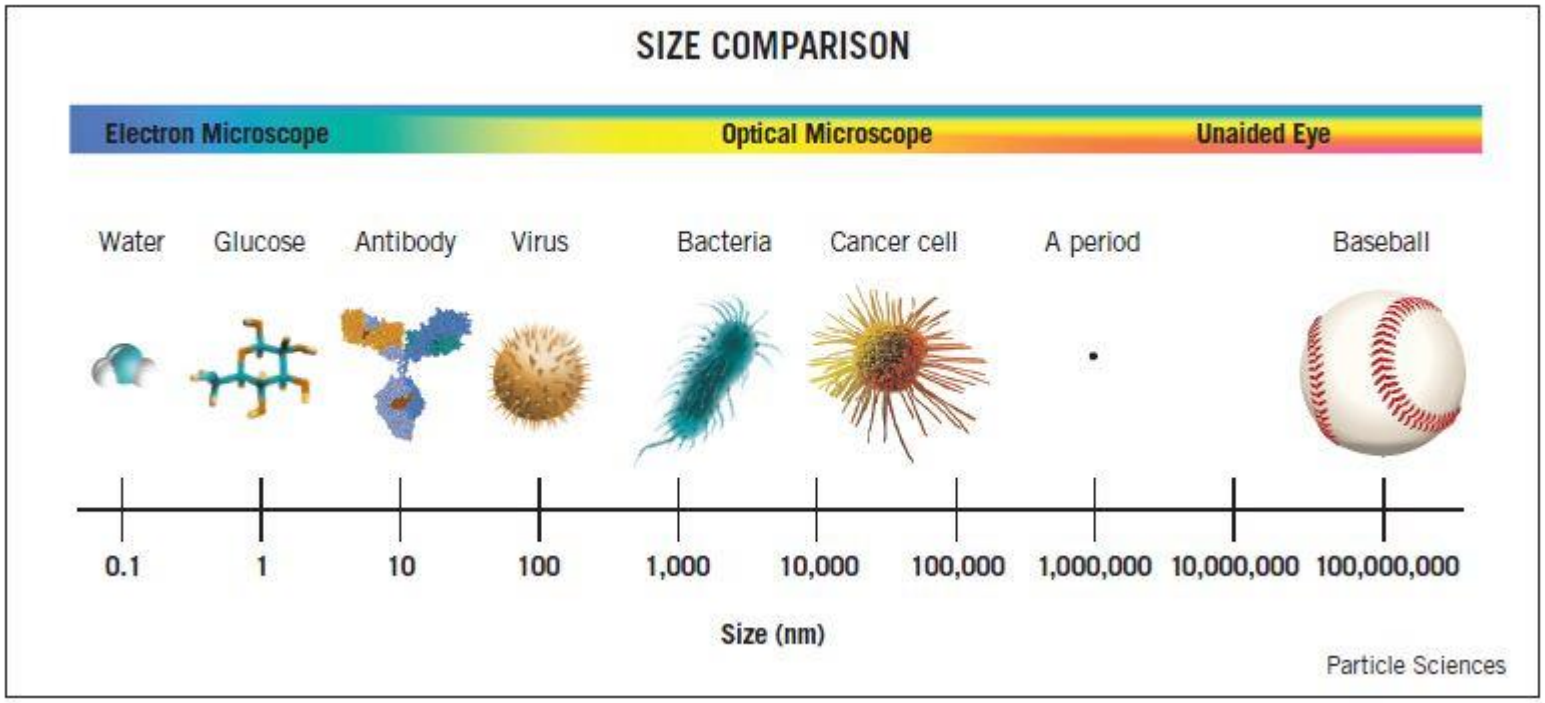
Presentation Overview

- What are nanoparticles (NPs)?
- What is nanoremediation?
- What are the potential benefits?
- What are the perceived risks/current unknowns?
- What is the NanoRem Project?
  - Objectives
  - Structure
  - Summary of progress to date

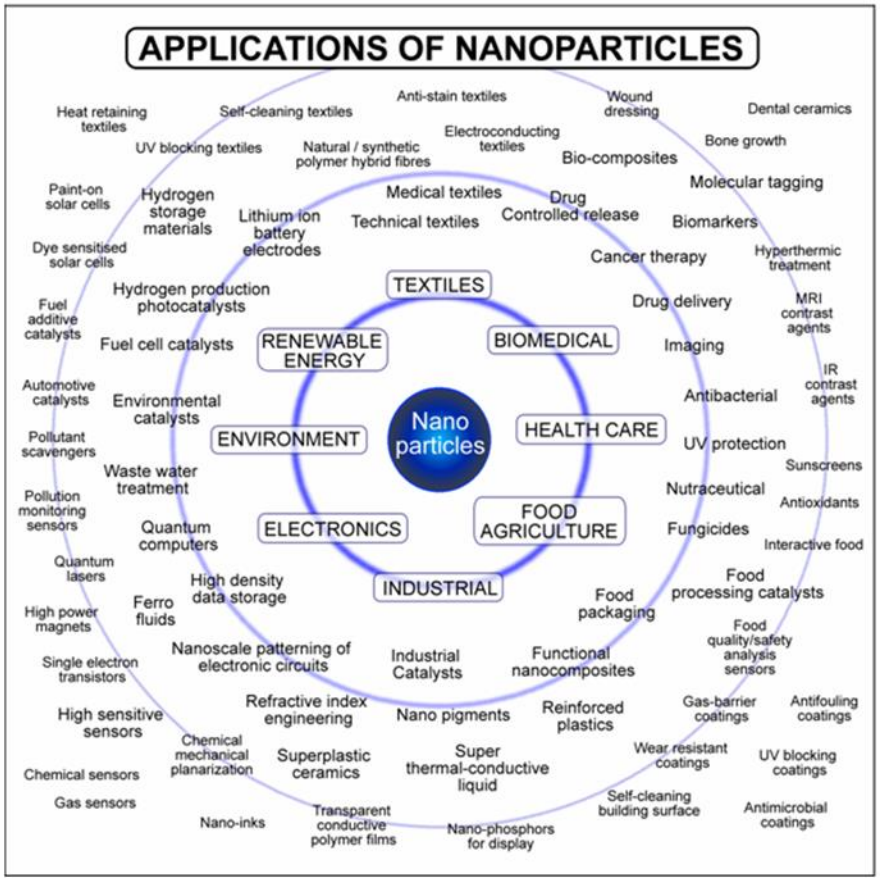
What are Nanoparticles (NPs)?

- NPs have one or more dimensions <100 nm

Figure 1



NPs (cont.)



- Three types of NPs:
  - Natural (e.g. some clay particles);
  - Incidental (e.g. resulting from burning diesel);
  - Engineered (designed with specific properties).

What is Nanoremediation?

- *In situ* use of NPs to remediate contamination.
- Zero valent iron (ZVI) already used in permeable reactive barriers – nZVI is the NP version.
- Non-ZVI and composite NPs can also be used.
- NPs:
  - Are three dimensional = larger reactive surface;
  - Penetrate small subsurface spaces and remain suspended in groundwater;
  - Can add surface coatings to target different contaminants and influence mobility.

Nanoremediation (cont.)

- Trenton, New Jersey, 2000: first field scale trial nZVI (TCE in groundwater).
- To date, circa 70 field scale trials worldwide (17 in Europe), but uptake of nanoremediation remains limited.

Potential Benefits

- Faster in situ treatment of recalcitrant contaminants (e.g. PCE, TCE, organochlorines);
- Reduction in formation of toxic intermediate degradation products;
- Potential to expand the treatable range of contaminants thus freeing more brownfield land for redevelopment – sustainable development.

Potential Issues/Current Unknowns

- Mobility and fate
  - Where do NPs go?
  - How fast do they get there?
  - What happens then?
- Toxicity
  - Controlled waters – ecotoxicity?
  - Human health?
- Cost
  - nZVI currently circa $30 – 40/lb
  - granular ZVI circa $1-5/lb

Potential Issues (cont.)

- Environmental regulation – varying regulatory position globally, including Europe

- Voluntary moratorium on release of engineered NPs in UK

The NanoRem Project

- Taking Nanotechnological Remediation Processes from Lab Scale to End User Applications for the Restoration of a Clean Environment.

- €14M, four year research project funded via the European Commission:
  - Commenced 2013;
  - 28 partner organisations;
  - 13 countries;
  - Universities, research institutions, private companies, consultancies.

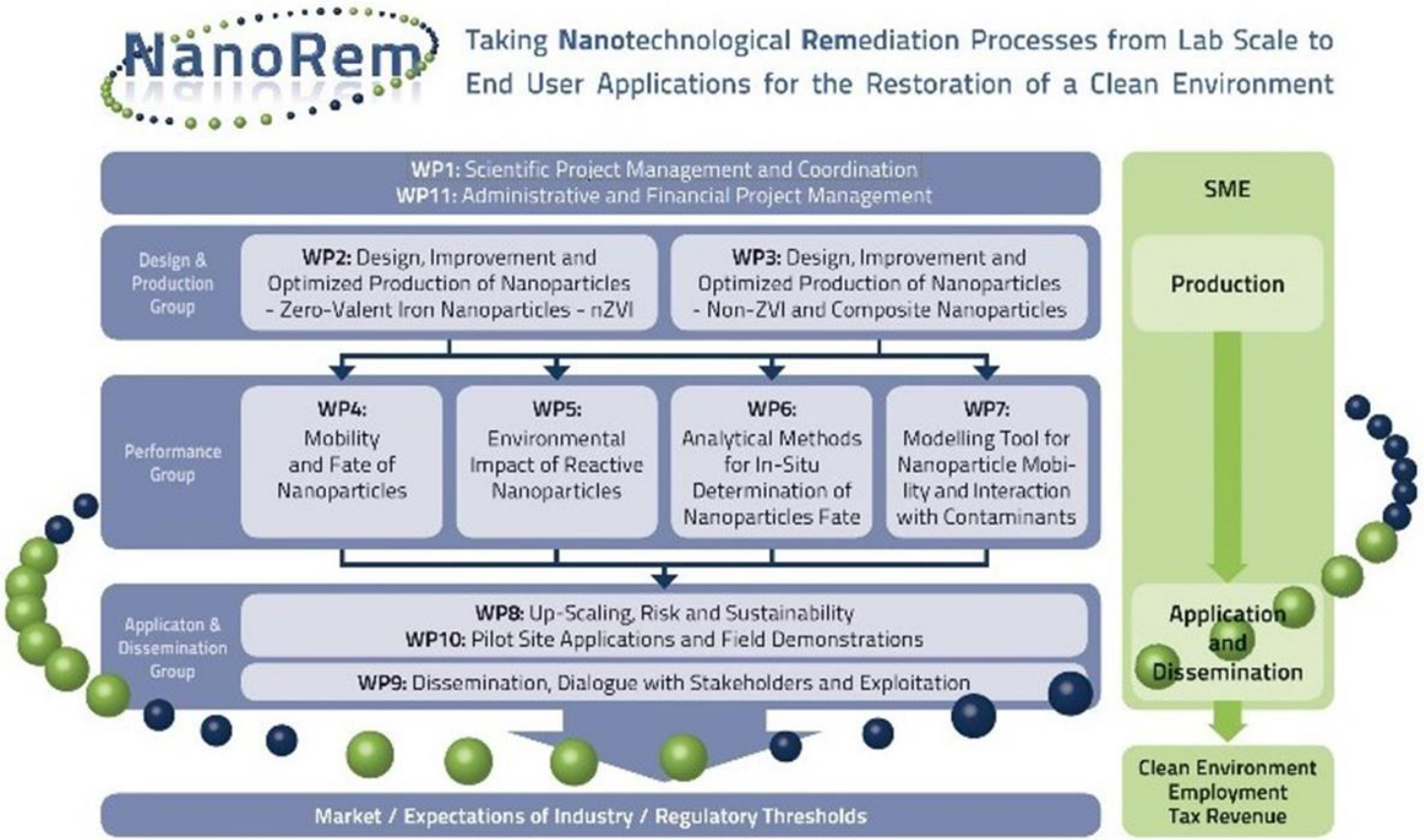
NanoRem - Objectives

- Identify most appropriate nanoremediation technological approaches to achieve step change in remediation practice.
- Develop lower cost production techniques and production at commercial scale.
- Determine mobility and migration potential of NPs in the subsurface:
  - Potential usefulness;
  - Potential harm.

NanoRem – Objectives (cont.)

- Develop a comprehensive set of tools to monitor NP performance.
- Engage in dialogue with key stakeholder and interest groups.
- Carry out a series of full scale applications in several EU countries.

NanoRem – Structure



NanoRem – My Role

- Member of the Project Advisory Group (PAG);
- Represent Ramboll Environ and NICOLE;
- Focus is on practical and commercial application:
  - What are the benefits to “problem site owners”?
  - How does the practical application compare to other technologies, including treatment time and cost?
  - What are the regulatory considerations?

NanoRem Personified (!)

NanoRem – Summary of Progress to Date

- Public face of NanoRem is WP9 which has:
  - Developed project website: www.nanorem.eu
  - Developed FAQs for Decision Makers
  - Facilitated a “risks” workshop, outcomes of which have been collated into a report; a summary of which is available via the website;
  - Facilitated a sustainability and markets workshop; outcomes will be reported this summer;
  - Conducted a risk-benefit appraisal of the application of nanoremediation based on existing knowledge – included SWOT analysis; findings collated into a report published via website.

NanoRem – Summary of Progress to Date (cont.)

Behind the scenes:

- WP2: designing and manufacturing nZVI for relevant WPs;
- WP3: designing and manufacturing non-ZVI and composite NPs for relevant WPs;
- WP4: designing the means of testing the mobility and fate of the NPs produced by WP2 and WP3;
- WP5: establishing baseline ecotoxicity of NPs;

NanoRem – Summary of Progress to Date (cont.)

- WP6: developing in situ (i.e. groundwater monitoring) NP measurement techniques;
- WP7: developing a modelling tool to predict NP mobility;
- WP8: undertaking tank experiments to further develop NP delivery and provide means of testing the outputs of WP2 – 7;

NanoRem – Summary of Progress to Date (cont.)

- WP10: in the process of undertaking field trials at sites in Switzerland, Hungary, Portugal, Spain, Israel and Czech Republic.
  - Varying objectives for the different field trials (e.g. degradation of pollutant, field monitoring of NP mobility and fate);
  - Provides practical experience of the differing regulatory attitudes.

NanoRem – Summary of Progress to Date (cont.)

- WP10: in the process of undertaking field trials at sites in Switzerland, Hungary, Portugal, Spain, Israel and Czech Republic.
  - Varying objectives for the different field trials (e.g. degradation of pollutant, field monitoring of NP mobility and fate);
  - Provides practical experience of the differing regulatory attitudes.

NanoRem – Keeping up to Date

- NanoRem website: http://www.nanorem.eu
- Have your say via current online questionnaire accessible via the website:
  - Promoting Nanoremediation Using Nanoscale Zerovalent Iron (nZVI): Risk-Benefit and Markets Appraisal, Initial Exploitation Strategy and Consultation;
  - Consultation is open until 31st July 2015.

This project received funding from the European Union Seventh Framework Programme (FP7 / 2007-2013) under Grant Agreement No. 309517.