



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

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The NanoRem Project

- **Unlock potential** of nanoremediation processes from lab scale to end user applications
- Facilitate **practical, safe, economic and exploitable** nanotech for in situ remediation
- Develop comprehensive understanding of the **environmental risk-benefit** of using NPs.
- 28 Partners from 12 EU countries,
- PAG links to the USA and Asia



Moratorium

- “the use of free manufactured nanoparticles in environmental applications such as remediation be prohibited until appropriate research has been undertaken and it can be demonstrated that the potential benefits outweigh the potential risks”

(Royal Society/ Royal Academy of Engineering working group)



EU Project Officer Challenge

- Does it work?
- Does it work better?
- Does it work safely?

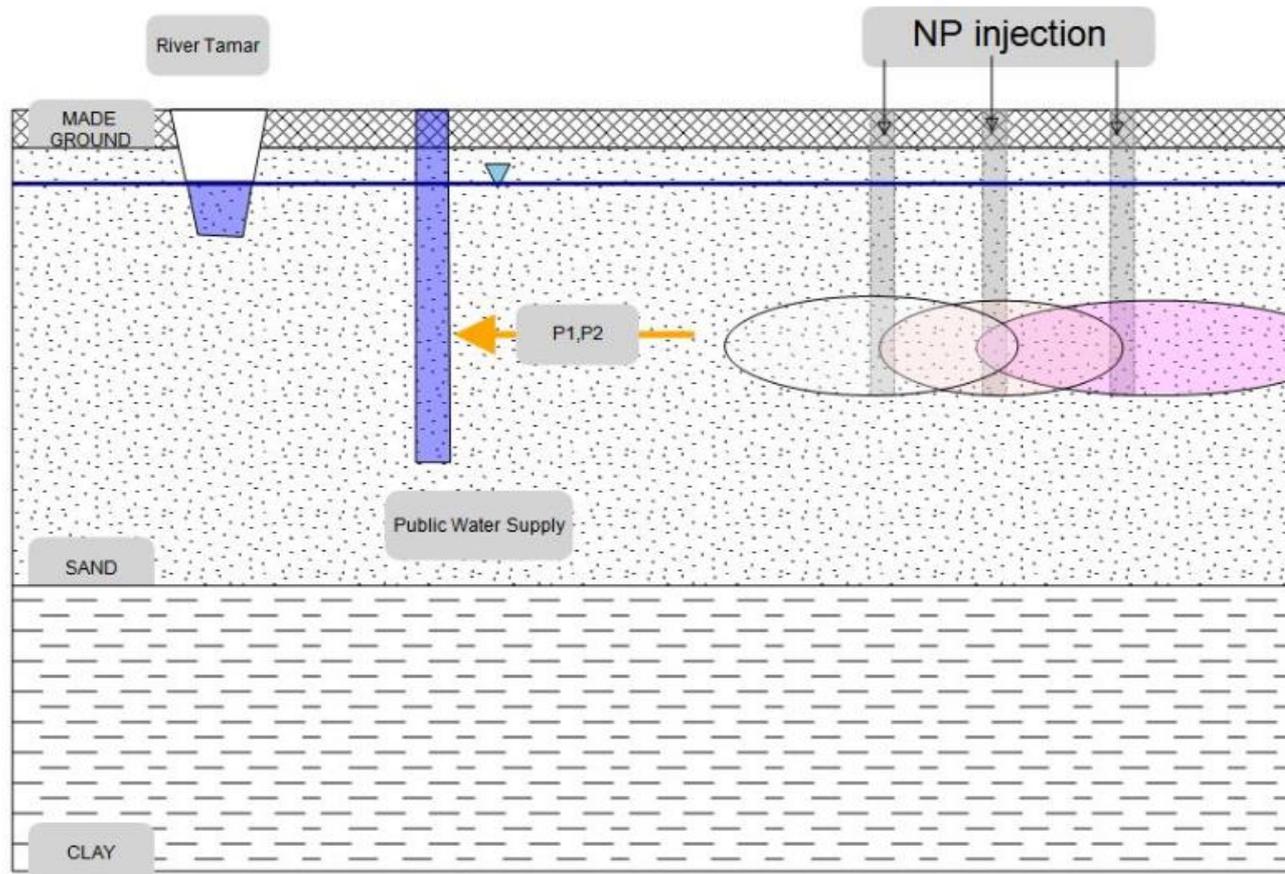


Background- Using NPs to treat GW contamination

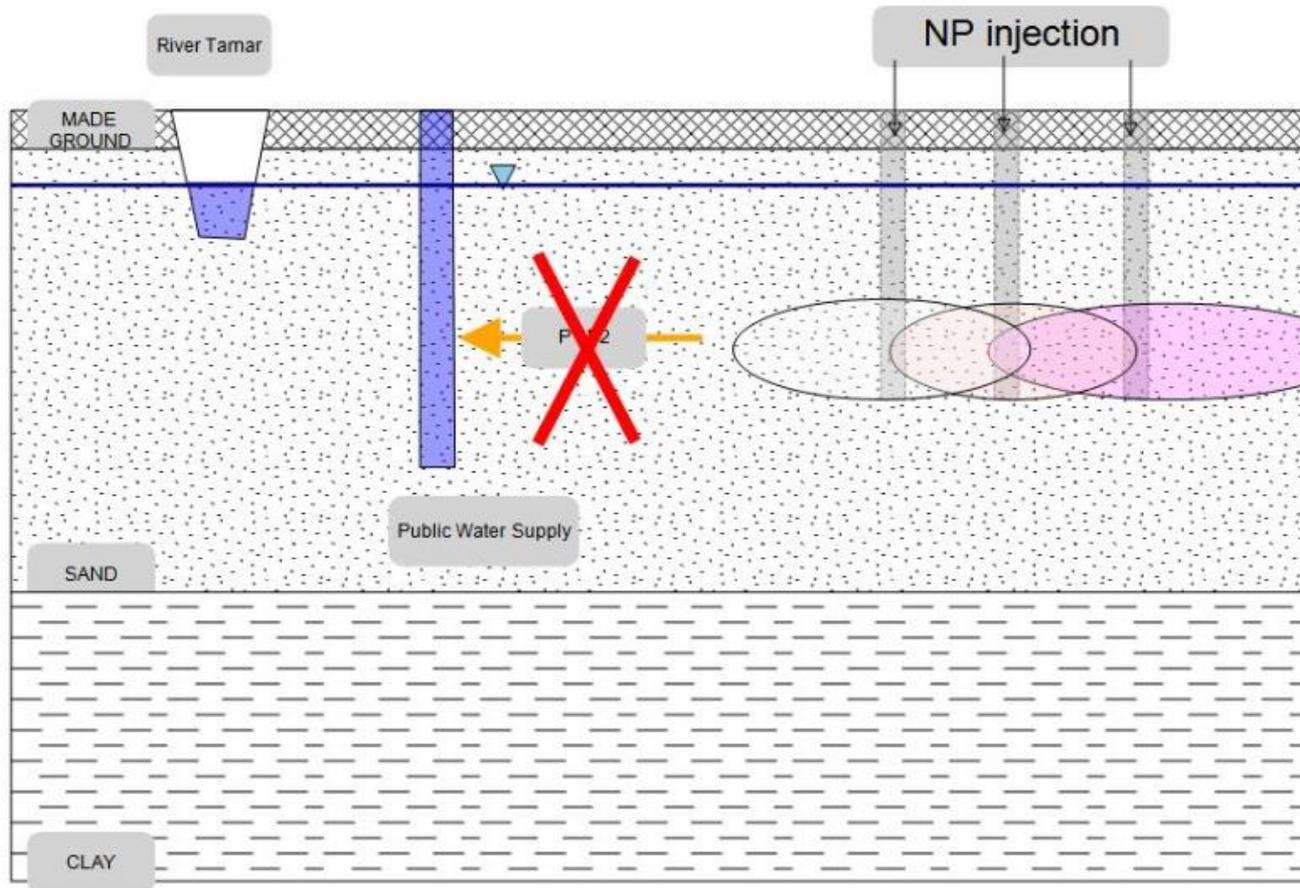
- Small size = higher surface area = more reactive
- NPs (in a carrier fluid) injected into saturated zone via wells



Background- Using NPs to treat GW contamination - CSM



Background- Using NPs to treat GW contamination – PL broken



Potential benefits

- Faster reaction
- Increased range of treatable contaminants
- Complete degradation / transformation
- Capacity for source term treatment
- Compatibility with *in situ* bio
- Limited environmental persistence
- More sustainable; no excavation, transport nor disposal is necessary



NanoRem NPs - nZVI

Different production methods

- Reduction/milling
- Affects cost of production

Different shapes

- spherical/flakes
- Linked to production method

Different structure and coatings

- Air stability
- Increase transport distances

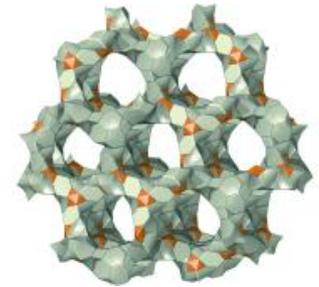
Mechanisms of action: reduction

Applied at pilot sites



NanoRem NPs

- Fe (II, III) oxide particles
 - Carbon iron composite particles
 - colloidal Fe-zeolites
 - Fe (VI) salts (ferrates)
 - non-Fe metals & alloys (Al & Mg)
- pilot sites*
- Emerging*
- Mechanisms of action include oxidation, reduction and pollution adsorption



Pilot sites

- To show proof of concept in the field
- Different hydro-geological settings
- Various contaminations including CHC and metals
- Sites across Europe (including Spain, Hungary, Switzerland, Czech) & Israel (transport in fractured media)
- Need for predeployment risk assessment
- Regulatory approval for trials obtained
- Results show sufficient but not excessive movement



Exposure Scenarios for PDRA

Receptor	Exposure Scenario	Comment
Human	Direct ingestion/inhalation/ vegetable uptake/dermal uptake	Would need NPs to get into the soil zone – UNLIKELY
Human	Drinking water/irrigation water/swimming	Would need NPs to get into abstracted water, but dependant on transport distances of NPs – POSSIBLE
Groundwater	Migration in groundwater	Dependant on transport distances of NPs – POSSIBLE
Surface water	Migration in groundwater	Dependant on transport distances of NPs – POSSIBLE
Building materials	Accumulation of H ₂ gas	Speculative
Ecosystems (microbiology in groundwater)	Injection NPs into sub-surface	LIKELY - but no worse than ISCO
Ecosystems (far)	Migration in groundwater/surface water/wetlands	POSSIBLE - but no worse than ISCO



Qualitative pre deployment risk assessment protocol

- Renegade particles
 - Hazard (toxicity)?
 - **Fate?**
 - **Transport?**
- + Receptor vulnerability
- = Risk



Post laboratory experiments and field trials

- Reduced uncertainty
- Broader range of scenarios where NP deployment is demonstrably safe
- Shorter stand-off distances



Next steps

- Does it work?
- Does it work better?
- Does it work safely?



Any Questions?

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