# Testing on emerging nanoparticles for arsenic removal under real conditions on a pilot field site, in Asturias, Spain.

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www.nanorem.eu

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## Introduction

**Nanotechnologies** could offer a step-change in remediation capabilities as indicated by laboratory scale findings, which show that the range of treatable contaminants and the speed by which they can be degraded or stabilized can be substantially increased over conventional in-situ saturated zone remediation technologies. Within the European **NanoRem** project, the main objective of performing **field test** sites is just to provide the opportunity for a **positive proof of nanotechnologies** application, i.e. a closed mass balance on site, addressing other current limiting factors such as their **cost, sustainability** and **environmental safety.**

## Site description and case study approach

The Spanish test site is an abandoned 20Has brownfield site in Asturias (Northern Spain), used historically for the production of chemical **fertilizers** during 48 years (1950 – 1998). Contaminants include predominantly **heavy metals** both in soil and groundwater, associated to site's madeground.

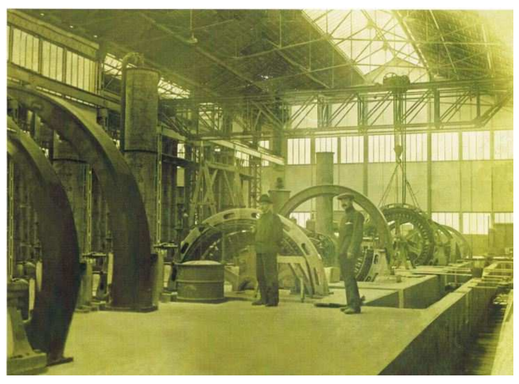

Figure 1. Picture of site's past activity
(Source: https://vegalafelguera.wordpress.com/industrias/factoria-de-nitrastur-"nitrogeno")

Figure 2. Current site's general view

It has been decided to focus the research on a single metal treatment, facilitating the interpretation of results and the technology validation: solved **Arsenic** in groundwater has been selected as the target contaminant, given its high concentration (5527,2ppb max., 1378,5ppb mean concentration) and the lack of field cases in the literature that pay attention to this element, which makes this field experiment **particularly groundbreaking**.

The main **source of arsenic is related to the sulphuric acid production** by arsenopyrite (FeAsS) burning. Pyrite ashes rich in As in the form of $AsO_4Fe$ resulting from this burning process were then uncontrolledly dumped on site as madeground.

The study will also consider the collateral effects of the treatment on the other metals and compounds like organic matter and dissolved anions such as nitrates, sulphates and phosphates.

As a result of this **holistic approach**, the effect of NPs injection on natural biogeochemical processes of the soil-groundwater interface and therefore the sustainability of the treatment with NPs will be better understood.

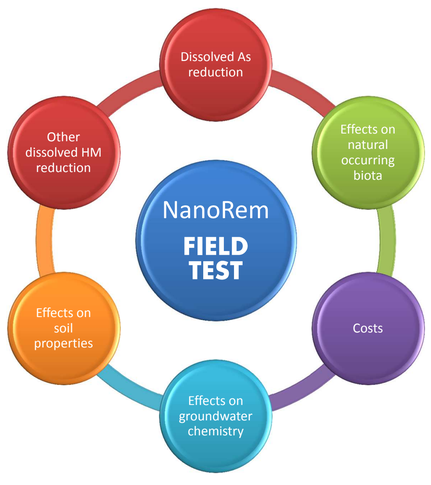


Figure 3. NanoRem field tests approach

## Preliminary site and laboratory works

**Five different types of nanoparticles** (NPs) have been tested in the laboratory with the Spanish material in the Technicka Univerzita v LibercI (Czech Republic) including the commercially available products based on nano zero valent iron (NZVI), NANOFER 25s and Star and milled particles (KKM2, A2), carboiron and goethites (Nano Iron SRO and the University of Duisburg-Essen provided NPs).

According to these results, it is possible to assess the **effect of the different NPs on the arsenic content:**

- Concentration of solved arsenic decreases significantly in all treatments (with goethites, carboiron and NZVI) except for the non activated NF Star.
- Reactivity with zerovalent iron is stronger (more efficient) than with iron oxides (goethites) and carboiron in terms of the presence of arsenic in solution.
- Arsenates - main species presence in the Spanish site - and arsenites can be fully transformed into As(0) by reaction with zerovalent iron. As(0) is insoluble, thermodynamically stable, and this reaction is not expected to be reversible.

The **chemical reaction between arsenite/arsenate and NZVI is preferred** to adsorptive interactions occurred with iron oxides NPs, being the latter weaker bonds that can then be more easily desorbed and restored to groundwater.

## Pilot test design

A total of **eight (8) monitoring wells** will be installed down into the aquifer and the **NPs injection** will be done in **two (2) wells** so that a good NPs distribution in the underlying aquifer is assured. The injection will be performed by **Geoplano Drill, S.A**. over the entire aquifer's column, at low pressure, in open boreholes previously fitted with packers.

The monitoring strategy won't be focused only on the arsenic removal and NPs efficiency determination but also on most of the key challenges associated to nanotechnologies application that currently hamper their real and extended use in the European environmental market.

The starting of the injection works is planned by **September 2015**, following the design of the monitoring strategy and the implementation of the necessary equipment in the field.


Figure 4.a) Diamond core drilling works, 4.b) pyrite ashes in madeground and 4.c) heavy metal content

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

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