Funded by the European Union

ALL4BIOREM
Alliance for Environmental Bioremediation

Upscaling of Nanobiopiles with Nanoremediation, Biostimulation and Bioaugmentation

Short Description

IRAGAZ launched the BIO-NANO Project in 2013 to develop several on-site soil remediation techniques: namely, bioremediation of contaminated soils using organic waste and the application of zero-valent iron nanoparticles. The project also explored a hybrid approach, combining both methods to assess potential improvements and synergies in addressing mixed contamination, a frequent challenge in contaminated sites. This innovative mixed method, called Biona, represents a significant advancement in the field.
Lab and pilot-scale tests confirmed that combining both technologies – biological and (nano) chemical – can enhance the effectiveness of soil remediation. To advance the experimental work, a new round of pilot-scale tests was initiated using 5m³ of real contaminated soil. These tests aimed to demonstrate and validate the Biona nano-bio decontamination technology at an industrial scale.

Location

Security bucket outside the Iragaz Watin facilities in Azkoitia, Basque Country, Spain. Soil taken from Burtzeña (Bilbao, Basque Country, Spain).

Methods

Nanoremediation using zero-valent iron nanoparticles is employed to degrade organic compounds and reduce or immobilize heavy metals, which decreases soil toxicity and enhances the effectiveness of the subsequent bioremediation phase.

Subsequently, biostimulation of native hydrocarbon-degrading microorganisms is achieved by adding municipal solid waste compost as an amendment. By carefully controlling key parameters such as moisture, aeration, and nutrient levels, this approach accelerates the reduction of organic contamination in the soil.

Outcomes

The pilot nanobiopile mix treatment with nZVI and compost, shows around 70% TPH degradation in 3 months of treatment. This study has further demonstrated a clear synergy between zero-valent iron nanoparticles (nZVI) and bioremediation when applied in a static biopile format. Initially, the nanoparticles create a reducing environment that breaks down the molecular structures of various contaminants, making them more bioavailable and easier for microbial communities to degrade. This process enhances the efficiency of biological degradation. Additionally, it can be noted that compared to traditional bioremediation processes, which usually take longer than six months to produce results, the presented technique has reached almost the maximum results after the first three months.

Importantly, the use of nZVI in this experiment did not exhibit any toxic effects on the soil's native microorganisms, ensuring that microbial activity remained unaffected.

Additionally, other laboratory tests have shown that nZVI nanoremediation can reduce heavy metal leaching by up to 60%, with specific reductions of 70% for lead (Pb), 90% for antimony (Sb), 64% for arsenic (As), and 66% for chromium (Cr).

Outreach

The work linked to this study was presented in various scientific publications, including in the following papers:

1. https://doi.org/10.3390/ijerph17165817
2. https://doi.org/10.1016/j.reffit.2017.03.008

In addition to this, the findings were presented in several key conferences, including the Econst conference 2021, the PhytoSUDOE conference 2018, the POSIDON conference 2018 8th European Bioremediation Conference and the VIII Congreso Ibérico de las Ciencias del Suelo 2018.

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