ALL4BIOREM
Alliance for Environmental Bioremediation

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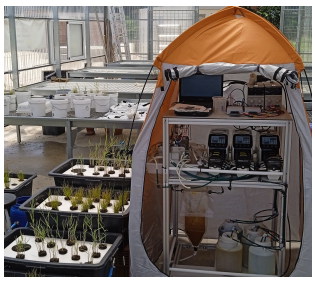
Integration of Bioelectrochemical systems & Phytoremediation for decontamination of Metal(liod)s polluted groundwater



Short Description

Contaminated groundwater puts enormous strain on already stressed water. If the metal(liod)s associated contamination is deliberately introduced or present in deep soil strata, these pollutants can weaken the aquifer's ability to self-purify and sustain healthy groundwater. Bioelectrochemical system (BES) and phytoremediation technologies can sequentially not only remove the metal, but also reduce the toxicity of treated water. The higher levels of metal(liod)s and extreme physical parameters (such as pH and salinity) of water can limit the choice of potential plants for phytoremediation. However, a coupled BES with phytoremediation can remove this issue. In this way, the BES can operate in multistage configuration, and the effluents generated (i.e. exhausted anolyte and treated catholyte) can be fed to subsurface vertical flow constructed wetland systems.

Location

ICCRAM - University of Burgos (off-site), Polluted water collected from an abandoned metallurgical industry, located in Belgium (managed by TAUW).

Methods

1. Selection of tolerant macrophytes for the phytoremediation of metal(liod)s polluted groundwater.
2. Definition of a cathodic approach aiming to remove wide range of metals & metalliods from polluted groundwater through direct reduction & co-precipitation in BES reactors.
3. Identification of sustainable applied voltages in BES reactors to enable metal removal from polluted groundwater, thus preventing electroactivity decay due to high anodic potential.
4. Preliminary and lower TRL integration of BES-Phytoremediation and subsequent characterization of toxicity reduction.
5. Upscaling of BES reactors and use of sequential BES reactors for sequential metals removal.
6. Integration of Upscaled-BES and coupling with phytoremediation for continuous batch remediation.

Outcomes

Overall, by using the combined BES-phytoremediation application, the contaminated groundwater was treated efficiently. By using BES, up to 90% of the metal(liod)s content from the polluted groundwater was removed. However, as anticipated, the treated water was still having acidic pH (~4) and a high level of dissolved solids, as well as the remaining 10% of metals. This was also accompanied with the exhausted anolyte that was used as carbon source for the electrogenic biofilm on anode, and the spent buffer (i.e. containing electrolytes recovered in the concentration chamber) of the up-scaled BES reactor. The treated groundwater along with the other effluents was combined and fed to constructed wetlands for phytoremediation. This combined process reduces nutrient levels, adjusts pH and salinity, and completely eliminates the ecotoxicity of the final treated water.

The phases of development for the BES-integrated wetland system are further presented below:

- Laboratory development phase (TRL 4)
  - Mainly the selection of plants to be used were identified, and translocation capacity was assessed. Also, the BES reactor approach was defined and reactors were designed, built and the technology was validated at laboratory scale.
- Integration phase 1 (TRL 5)
  - Scale-up of BES reactors and operation using real polluted water. Preliminary study of the integration, including first experiments without physical integration of both technologies. Posterior scale up design of the CW was done based on these results.
- Integration phase 2 (TRL 6)
  - Based on the findings on the previous phases, the final pilot was designed and constructed to operate both technologies together at the facilities of the University of Burgos.

Responsible

LEITAT & ICCRAM - University of Burgos in the frame of the EU-funded Horizon 2020 GREENER project

Outreach

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

1. https://doi.org/10.1016/j.nbt.2023.12.003
2. https://doi.org/10.1007/s11356-024-33934-2
3. https://doi.org/10.1051/e3sconf/202233408006

In addition to this, the findings were presented in several key conferences, including the AquaConSoil 2023, the Bioremid 2023, the 8th European Bioremediation Conference and the European Fuel Cell and Hydrogen Conference 2021.

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