Phytoremediation of dredged sediments polluted with mineral oil, naphthalene and PAHs

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Introduction: Phytoremediation is a sustainable bioremediation technique that uses plants and their associated microorganisms to remove, degrade, extract or immobilize pollutants from soil and (ground)water. In order to ensure an efficient degradation and to avoid evapotranspiration of volatile pollutants to the atmosphere, microorganisms equipped with the appropriate degradation pathways are enriched inside the plants by means of inoculation.
In addition to clean-up polluted soil and groundwater, phytoremediation offers added values in terms of sustainability by lowering the use of materials and energy, CO_2 sequestration, increasing biodiversity, and producing biomass for bioenergy.

In the Interreg project RESANAT (Remediation of Residual Pollution with Nature-based Techniques) the re-development of polluted sites in Flanders and the Netherlands is stimulated by increasing the practical applicability of nature-based techniques, such as phytoremediation.
In one of the pilots, we explored the possibilities of remediating excavated sediment by means of phytopiles and using microorganism-stimulated phytoremediation.

Methods: Dredged sediment was dewatered and beginning of October 2020 stacked in piles of different sizes (3m x5m x0,5m and 4m x8m x1,5m) with or without topsoil and passive aeration via drains.
The piles were seeded with different grass species based on the results from a previously conducted feasibility study. In addition to frequent monitoring of pollutant concentrations, degradation potential was examined using qPCR for EUB and alkB. Furthermore, via GC/MS and determination of diagnostic ratios, degradation through biological processes was investigated. Monitoring ended in July 2022.

Fig. 1:*Phytopiles*

Results: The phytopile that was not equipped with an aeration tube and to which no topcoat was applied continues to have the highest mineral oil content. The smaller phytopiles were also found to exhibit lower final mineral oil concentrations compared to the larger piles. No specifically adapted bacterial strains were picked up with the qPCR assay perhaps due to the heavy load of PCR inhibitors. Interpretation of diagnostic ratios showed evidence of degradation of pyrene and fluoranthene. Over 18 months, for PAHs, there is a reduction from 52% to 90% at a depth of 15 cm and from 62% to 89% at a depth of 80 cm. For mineral oil, there is a reduction from 49% to 70% at a depth of 15 cm and from 43% to 68% at a depth of 80 cm. Furthermore, the results show that performing inoculation with suitable microorganisms results in about 10% more degradation.

Discussion: Both the feasibility study and monitoring show that mineral oil and PAH degrading microorganisms are naturally present in sediments polluted with these compounds and are able to metabolize the pollutants in constructed phytopiles. Smaller size and presence of passive aeration appears to stimulate these processes as well as inoculation with suitable microorganisms.
As a result, the use of phytopiles and microorganism-stimulated phytoremediation may offer particular added value for treating cleared sediment. This may be possible on site in the riparian zone and reduces the ecological footprint of remediation.