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Alliance for Environmental Bioremediation

Phytomanagement of a red gypsum landfill


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Short Description

Extraction of titane from ilmenite using the sulfuric process leads to the production of red gypsum during the neutralization of the TRONOX company's wastewater with limestone. This red gypsum, accumulated over decades, allows the formation of a technosol, on which the development of vegetation is reduced due to the presence of various mineral oxides and TEs. The lack of vegetation potentially leads to mineral (including TEs) leaching and dust enriched in TEs. Moreover, this red gypsum is stored on a waterproof structure that requires appropriate management of the incoming and outgoing water masses. The revegetation of landfills is therefore an important issue to better manage water flows via evapotranspiration and to limit the spread of dust. Phytostabilization has been identified as a relevant strategy to remediate soil pollution.

Location

The experimental site of Thann is located in the valley of the Thur in the French region of Alsace, near the border with Germany and Switzerland, on a chemistry-based industrial complex. The Thann plant owned by the TRONOX company is one of the most important sites for TiO2 production in Europe and is the second-largest production facility in the world.

Methods

The landfill site was prepared before plantation by adding a 30-cm layer of soil obtained from a local source and incorporated into the red gypsum layer by plowing to a depth of 50 cm. Briefly, woody species were planted on an industrial landfill (Thann), representing 4752 trees on 8 plots, themselves divided on 33 individuals per tree species, for a total of 18 species. The trees were uprooted by using a mechanical shovel. Non-rhizospheric soils were also sampled as a control (n=3 per plot). For each woody species, different tissues were analyzed and growth paralters were measured. The study also combined a UAV-based remote sensing approach and a surface integration method using 3D imagery to determine the physiologcial parameters of the different species of trees. Rhizospheric fungal and bacterial communities were further assessed at the site by using high-throughput amplicon sequencing.

Outcomes

A number of tree species that produced a clean biomass could be considered as good candidates for the phytomanagement of marginal lands, for their valuation in various industrial sectors. Among them, Ostrya carpinifolia had the greatest potential to maximize transpiration flows in these harsh conditions. These field measurements were confirmed by measurements performed under controlled conditions on the same substrate.

In contrast, other species from the Salicacea family were able to take up high quantities of one or more of the analyzed trace elements without presenting toxic symptoms. For this reason, they could be classified as phytoextracting species and used with regard to the restoration objectives and a metal phytomanagement strategy. As advanced sensors with large spectral diversity are being developed, the study foresees the use of remote sensing as a method to evaluate both plant and soil metal concentrations, and thus correlate metal concentration and UAV-based ecophysiological parameters for a better assessment of phytomanagement strategies in landfill restoration.

Regarding the study site, which is representative of landfills from the extractive industry, the key issue is the implementation of a plant cover that maximizes water evapotranspiration after deposits have ceased and that limits the aerial dissemination of red gypsum dust, which is imposed by the French regulator. The presence of trees with high evapotranspiration capacities would allow to maximize these impacts. The site owner is now willing to accelerate the revegetation of the site in ca. 10 ha by using the described tree species.

Concerning microbial communities, despite the strong anthropization of the industrial landfill-technosoil, microbial colonization of tree roots after four years of phytomanagement occurred, but strong variations were observed between tree species. The potential for root colonization by microbes was high and led to successful revegetation, improving the applied phytomanagement strategy.


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Outreach

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

1. DOI: 10.1016/j.ecoleng.2019.02.010
2. https://doi.org/10.1016/j.jhazmat.2021.127977
3. https://doi.org/10.1016/j.scitotenv.2023.168600

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