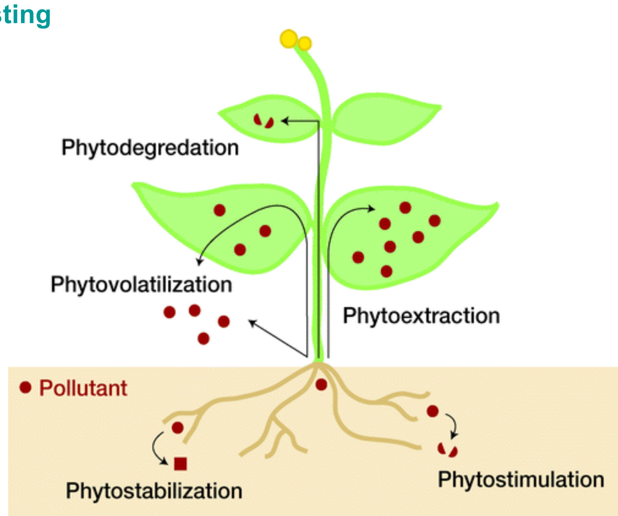
Objects/shapes/ physical projects > On the ground > Ecological restoration

> MANAGEMENT of POLLUTED AREAS by PLANTS (PHYTOREMEDIATION)

I/ General description and characterization of the NBS entity

I.1 Definition and different variants existing	
Definition	T his NBS is based on the use of plants and trees and their interactions with microorganisms for the treatment of polluted soils. The concept is very broad and therefore covers a range of relatively different technologies. We should talk about phytoremediations.

Different variants existing



Mode of action of plants on soil pollutants (*Pilon-Smits, 2005)*

Phytoremediation brings together four different modes of action:

=>Phytostabilisation

The surface is protected against degradation phenomena, which limits the transport of particles charged with pollutants by water and wind. When you implant a plant cover, it stabilizes the soil.

=>Phytoextraction

This is the principle of the vacuum cleaner. The plant takes pollutants by its roots. They are transferred to the aerial parts where they are sequestered.

=>Phytodegradation

This process results primarily from the stimulation of biological activity, which can contribute to the degradation of organic pollutants as the result of plant enzymes, with the production of carbon dioxide, but also of intermediate products. With the help of rhizospheric microorganisms to transform organic pollutants, it is called rhizoremediation.

=>Phytostimulation/ rhizodegradation

This is a stimulation of the biodegradation activity of organic contaminants in the roots (rhizosphere)

=>Phytovolatilization

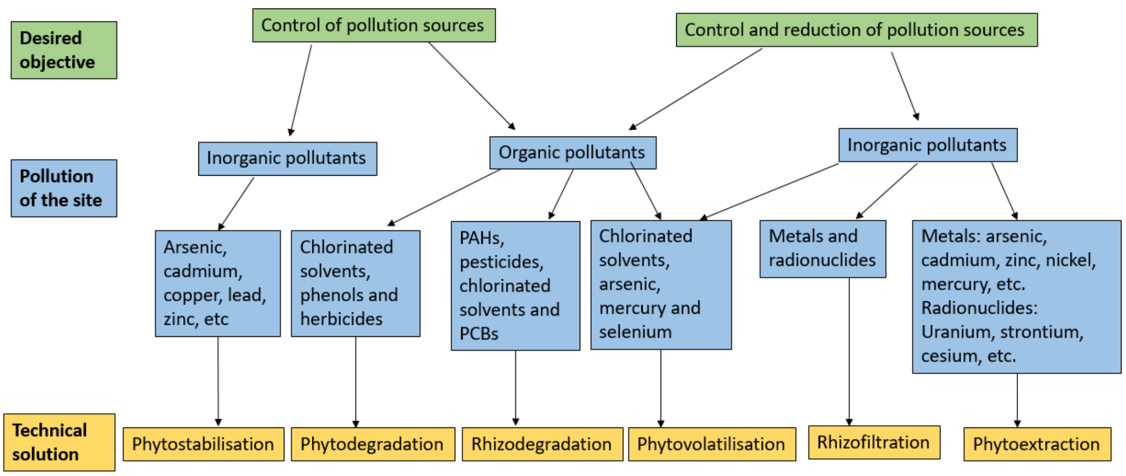
This process is an extension of phytoextraction, since the plant is capable of volatilizing pollutants. Plants can also transform trace elements that then take on volatile chemical forms.

I.2 Urban challenges and sub-challenges related + impacts		
Main challenges and sub-challenges targeted by the NBS	05| Soil management >05-1 Soil management and quality 04| Biodiversity and urban space >04-2 Urban space development and regeneration > 04-3 Urban space management	- Rehabilitation of polluted sites - Can restore or manage soil fertility (Alori, 2012)
Co-benefits and challenges foreseen	02| Water management and quality > 02-1 Urban water management 04| Biodiversity and urban space >04-1 Biodiversity 06| Resource efficiency >06-2 Raw materials 07| Public health and well-being >07-3 Health 11| Green economy >11-3 Direct economy value of NBS	- Phytopurification - Provide a habitat for living beings - Extraction of valuable metals (phytomining) - A successful phytoextraction reduces the total or bioavailable concentrations in urban soil below the threshold at which they are recognized to present a risk to human health, groundwater, or other receptors (Dickinson et al., 2009)"
Possible negative effects	07| Public health and well-being >07-3 Health 11| Green economy >11-1 Circular economy	- Presence of undesired insects - Recovery of contaminated residues (ashes)

II/ More detailed information on the NBS entity

II.1 Description and implication at different spatial scales	
Scale at which the NBS is implemented	Entity to district in a garden on an individual scale as along streets, roads…
Impacted scales	The scales impacted are in most of case limited It concerns the area to be cleaned up or the close neighbourhood.
II.2 Temporal perspective (including management issues)	
Expected time for the NBS to become fully effective after its implementation	Long treatment time: on average 5 to 10 years. The main factor determining the duration of phytoextraction is the mass of PTEs (Potentially Toxic Elements) removed by the crop per unit of time (years) compared to the mass of PTE in the soil.
Life time	The time of the depollution. For example, Dushenkov, D. (2003) founded that for Phytovolatilization has been successful in tritium (3H), a radioactive isotope of hydrogen, it is decayed to stable helium with a half-life of about 12 years. However, it is possible to keep the plants or trees on the site cleared for the entire life of them.

Sustainability and life cycle	Phytodegradation, phytoextraction and phytostimulation are solutions on long term, because they allow then a re-use of depolluted soil. Regarding phytoextraction, it implies the exportation and the treatment of green debris (considered as wastes), to be a solution on long term. At the opposite phytostabilisation is temporary solution, it fixes the pollutants, but the area remains polluted.
Management aspects (kind of interventions + intensity)	Little or no maintenance of plants, bur fertilisation is necessary in certain cases.
II.3 Stakeholders involved/ social aspects	
Stakeholders involved in the decision process	The public, the owner of the site, non-governmental organizations, the owners of neighbouring sites
Technical stakeholders & networks	Companies or associations specialized in depollution
Social aspects	Requires a lot of time
II.4 Design/techniques/strategy	
Knowledge and how-know involved	- Identify the appropriate phytotechnology according to the type of contamination (cf. diagram) - Select the appropriate plants or trees to the type of contamination and the local climate (almost all contaminants can be treated with varying efficiency) - Can be used alone or in combination with other decontamination techniques (e.g., bioremediation) - Generally used on large sites (plants or trees need space for growth) - Contaminant concentration assessed from low to medium- Better that the contamination is shallow (<5m)



Flow diagram to identify appropriate phytotechnology by type of contamination (Bert, 2013)

Materials involved	No specific material is required

II.5 Legal aspects related

- Lack of specific regulations for polluted soils
- To install plants or trees on a polluted site, you should have the agreement of the owner of the site.

II.6 Funding Economical aspects

Range of cost	- Low cost of decontamination (up to 10 times lower than conventional techniques) - Ex for a lead contaminated site: - Conventional in situ decontamination techniques: estimated cost between 15 and 50 €/t (venting), 40 and 120 €/t (oxidation or reduction), 15 and 50 €/t (bioventing) - Phytoremediation technique: estimated cost between 2 and 40 €/m^2 (i.e. 3.5 and 70€/m^2)
Origin of the funds (public, private, public-private, other)	- Depending of the owner of the polluted site - Public structures (to be consulted for each country) are involved in the financing of the depollution activities - Territories invested in reconversion of polluted site (municipalities, regions…) - European fund (e.g. the ERDF 2014-2020 program finances projects involving soil remediation)

II.7 Possible combinations with other kinds of solutions

- Possibility of combining different soil remediation techniques to increase the performance and reduce the number of treatments:
- Interaction bioaugmentation / phytoremediation
- Interaction phytoextraction / energy recovery of biomass (soil remediation and use of biomass to produce energy, biocatalysers)
- Multiprocessing phytoremediation system

- Double benefits:
- Phytoremediation / agromine: Soil remediation, biomass production and metal extraction (metals contained in plants are separated and purified to produce high value added salts)

The blue sap of Pycnandra acuminata (accumulation of nickel by this tree species)
(photo: Antony van der Ent)

III. Key elements and comparison with alternative solutions

III.1 Success and limiting factors	
Success factors	- Use the correct plant and the appropriate phytotechnology according to the type of contamination -The decontaminated area must not exceed more than 50 cm deep (except in case of decontamination by trees)
Limiting factors	-The treatment is impossible if the pollutants are distributed too heterogeneously -Treatment is not possible if pollutant concentrations are too high -Treatment times are important

III.2 Comparison with alternative solutions	
Grey or conventional solutions counterpart	Traditional techniques: -Excavation is the technique of extracting soil from the soil before processing. - Containment (polluted soil) which consists of installing an underground bulkhead to prevent the migration of pollutants to the water table. - Washing (contaminated soils) stimulates the circulation of active agents added to the water in the soil, in order to release and entrain the organic products, which are then separated by decantation at ground level.
Close NBS	Constructed wetland for phytoremediation.

IV/ References

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