Recovery and environmental recycling of sediments: CNR-IRET Pisa experience

Cristina Macci[1], Serena Doni[1], Eleonora Peruzzi[1], Francesca Vannucchi[1], Stefano Lucchetti[2], Maria Castellani[3], Grazia Masciandaro[1]

[1]CNR-IRET Via Moruzzi 1, 56124 Pisa; Italy
[2]Agri Vivai s.r.l. Via Vecchia Casalina, 118/G, 51100 Pistoia, Italy
[3]Flora Toscana Soc. Agr. Coop. Via Montecarlo, 81, 51017 Pescia (Pistoia), Italy

Phone: +39-050-6213547
E-mail: cristina.macci@cnr.it

Introduction: The CNR-IRET Pisa experience in sediment recovery and environmental recycling started about 15 years ago with a small lysimeter experiment on sediment phytoremediation. The knowledge learned during this first attempt led to a deeper phytoremediation study in the framework of the European project AGRIPORT ECO/08/239065/S12.532262. These sediments were then undergone to a refining landfarming process in CLEANSED LIFE12ENV/IT/000652 and HORTISED LIFE13ENV/IT/113 project, to obtain a substrate to be reused in nursery activity (*Viburnum, Eleagnu*s and *Photinia*) and road construction, and horticulture sector (strawberry, pomegranate, and lettuce), respectively. Nowadays, we are involved in other two life projects on the recovery and recycling of sediments. The SUBSED LIFE17ENV/IT/000347 project aims to confirm the suitability of saline phytoremediated sediments after landfarming process as a new substrate to replace the conventional substrates in several different cultures: fruit trees (olive and citrus), ornamental plants (protea, calla, laurel), cultivation of food plants (basil, blueberry, wild strawberry, and citrus). Instead, the AGRISED LIFE17ENV/IT/000269 project objective is to recover brackish sediments through a co-composting process with green waste to produce i) a growing media for nursery sector (*Photinia x fraseri* and *Viburnum tinus* ii) a reconstituted soil (technosol) for degraded soil rehabilitation.

Methods: In the AGRIPORT project 80 m^3 of saline sediments and 8 m^3 of brackish sediments, mixed with agronomic soil (30%) to improve their clayey granulometric composition, were undergone to two years phytoremediation with: *Paspalum vaginatum, Phragmites australis, Spartium junceum, Nerium oleander,*and *Tamarix gallica.* In CLEANSED, HORTISED and SUBSED projects, brackish and saline phytoremediated sediments were undergone to a refining landfarming process, consisting in periodical (once a week) mechanical mixing and then reused in road construction, nursery, and horticulture. A 6 months of co-composting process of brackish sediments and green wastes in the ratio 3:1, 1:1, 1:3 v/v was, instead, carried out in AGRISED Project.

Results: In two years of sediment phytoremediation in AGRIPORT project, the plants resulted effective in heavy metals (20%) and hydrocarbons (50%) decrease, and chemical-nutritional and biological properties improvement, thus contributing to create a "functional soil" to be reused in the environment [1]. In the HORTISED project, plants grown on substrates prepared with peat and remediated sediments (50%) showing yield, number, weight, and quality of fruits comparable with those grown in peat [2]. While, in the CLEANSED project all the plant species adapted very well to the sediment-based substrates (33% and 50%), showing similar biomass to those grown on an alluvial soil [3]. In addition, the direct application of landfarming to fresh brackish sediments reduced the content in organic contaminants and organic matter to values suitable for their reuse in the construction of a cycling road.
In SUBSED project, the plant trials are ongoing, however the landfarming was effective in further reducing organic contamination and in reaching characteristics in accordance with the Italian regulation for agronomic substrates (D.lgs. 75/2010) with the only exception of organic carbon and bulk density. Finally, the stability and maturity of the co-compost in AGRISED project was demonstrated by the decrease and stabilization of organic matter content, electrical conductivity, microbial activity, and increase in humification rate.

Discussion: The results obtained so far are promising and clearly demonstrate that sediments can be recovered in different eco-sustainable ways (phytoremediation, landfarming, co-composting) and recycled in different environmental sectors (infrastructure, agronomy, nursery, horticulture) with significant environmental, economic and social advantages. Many other efforts are needed to demonstrate the complete safety of the recovered sediments, also in long periods, and enclose this resource, in the common production chains.

References: [1] Doni et al. (2013) *Biodegradation* **24:** 499-512; [2] Tozzi et al. (2020) *Chemosphere* **238:** 124651; [3] Ugolini et al. (2017) *Journal of Environmental Management* **197:** 681-693.