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SUSTAINABLE SUBSTRATES FOR AGRICULTURE FROM DREDGED REMEDIATED MARINE SEDIMENTS: THE EXPERIENCE OF THE LIFE SUBSED PROJECT

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Abstract
When canals and harbours are dredged, huge amount of polluted sediments has to be stocked and transported to the landfill with incredibly high costs of management. Among the remediation techniques for the reclamation of polluted sediments, phytoremediation represents a sustainable and effective technique for reclaiming dredged sediments and for safely using them as growing media for several plants.
Most plants are produced in containers, and demand for growing media will also likely increase in the future. Exploitation of peatlands for plant cultivation in containers has led to the 70% loss of peatland areas in Europe with destruction of several natural habitats at the local ecosystems; this is due to the fact that peatland regeneration is very slow as compared with the destructed peatland areas, and their decline is likely to continue at the current peatland exploitation intensity. Therefore, the use of alternative peat-free growing media, constituted by locally available low impact materials, is an interesting option to prevent limitations and losses of value for the plant production.
The SUBSED project will demonstrate the potential of an innovative sediment-based material as growth substrate for nursery production and for cultivation of different food/non food crops at farm scale in Italy and Spain.
The performance of the new substrate will be demonstrated by comparison with the typical production of the same crop cultivated on a peat-based commercial substrate.
The SUBSED project will also highlight the current legislative and cultural reasons for hindrance in the use of innovative substrates in agriculture and will produce guidelines for a safe and sustainable use of sediments as constituents of a substrate.

keywords: *dredging sediments; sediment recycling; sediment-based substrates*

Introduction

In Europe, about 200 million m^3 of contaminated sediments are estimated to be dredged yearly from ports and waterways in order to maintain adequate depths for ship navigation (SedNet, 2004). The fate of these sediments is an issue discussed worldwide. Indeed, heavy metals and organic pollutants, which are principally produced by navigation and by surrounding industrial and civil activities (Taylor et al., 2004), accumulate in sediments because of the limited hydrodynamic energy in the internal portions of harbors. Usually, when contaminated sediments are dredged, they are disposed in longshore confined facilities or inland landfills and may cause environmental problems due to the possible risk of contaminant transfer to the environment. Dredged sediments reuse in civil engineering as building material or in habitat restoration has been suggested (Wang et al., 2012).

Such management strategy requires specific treatments to reduce their contamination level.

In order to remove sediment contamination, effective techniques, such as thermal desorption, sediment washing or flushing, solvent extraction or phytoremediation must be utilized (Libralato et al., 2008; Beolchini et al., 2009). Compared to physico-chemical and engineering techniques, phytoremediation represents an attractive alternative for low or medium polluted matrices decontamination which, in addition, results in increased ecosystem fertility by promoting restoration and biodiversity (Vangronsveld et al., 2009).

In a previous study, we showed that phytoremediation using *Paspalum vaginatum*, *Spartium junceum* and *Tamarix gallica* could be a suitable technique for reclaiming dredged marine sediments (Masciandaro et al., 2014; Doni et al., 2015) and allow them to be used as growing media for several ornamental plants (Mattei et al., 2017).

The main objective of the SUBSED project will be the set up of a protocol to optimize the production and commercialization of an environmental friendly substrate derived from remediated marine sediment for replacing the current peat-based substrates.

Experimental Layout

Polluted marine sediments were dredged from the port of Livorno and decontaminated by phytoremediation. Brifely, the phytoremediation facility was designed to treat about 80 m^3 of dredged sediments, previously mixed with 24 m^3 of soil to improve the particle size composition. In addition, a dose of 4 kg m^{-2} of compost was uniformly added on the top of the soil-sediment mixture and was incorporated into the top 20 cm layer of sediment by soft harrowing in order to favour the initial plant adaptation and growth. The facility was planted as follows: (1) *P. vaginatum* (P treatment); (2) control (unplanted); (3) *P. vaginatum* + *S. junceum* (P + S treatment); and (4) *P. vaginatum* + *T. gallica* (P + T treatment) and the sediments were monitored for 2 years after planting. The results proved that the three selected plants in association with the application of compost had the ability to degrade organic contaminants and to remove heavy metals (Zn, Cu, Cd, Ni, and Pb) from contaminated sediments. In addition, the characterization of the sediments after the phytoremediation treatment highlighted the effectiveness of the process in remediating and recovering the sediments from an agronomical and functional point of view, making them

feasible for several environmental uses, such as plant growth substrate.

In view of this, the dredged phytoremediated sediments were used in the framework of the LIFE projects CLEANSED and HORTISED as an alternative to peat in the preparation of growing media in nursery and horticulture, respectively. In both projects, the landfarming process was carried out to quickly homogenize and improve chemical (also by further reduction of organic contaminants) and biochemical characteristics of the phytoremediated sediments to be recycled in agriculture. The results obtained from the agriculture recycling of phytoremediated marine sediments demonstrated that standard fertilization of sediment-based substrate was sufficient to produce plants with a comparable plant grade as those grown on traditional peat-based growing media.

Based on the experience gained with the previous CLEANSED and HORTISED projects, the landfarming for three-six months will be carried out in the SUBSED project to achieve sediments of chemical quality in order to be recycled in agriculture. The sediments, sampled at the start and every month during landfarming process, will be characterized from the physical, chemical and eco-toxicological points of view.

At the end of this stage, the sediments will be transported to the plant sites for the demonstration of plant growth in Italy and Spain. The demonstration trials will be set up using different mixture of sediment based substrates and common commercial substrates at least at different rates (i.e.: sediments (100%), sediments/peat (50%/50%) and compared with standard peat based growing substrates).

In particular the sediment-based substrates will be applied to nursery production of ornamentals (laurel) and fruit trees (olive and citrus), and to cultivation of non food crops (protea, calla lily, laurel) and food crops (basil, blueberry, woodland strawberry and citrus).

Expected results

The expected results will be:

- Demonstration of the suitability of sediments for the nursery production of food/non food species (laurel, olive and citrus);
- Comparable growth and commercial quality of non food crops (calla lily, protea and laurel) in sediment-based and peat substrates;
- Characterisation from the morphological, biochemical and sensorial point of view of basil, blueberry and woodland

strawberry cultivars grown in sediment-based substrates;

- Suitability sediment-based substrates for food crops in relation to heavy metals and organic pollutants;
- Improvement of the knowledge on the treated sediments and their influence on plant growth and fruit quality;
- Suitability of treated sediments to be converted into a marketable product, also considering the normative and legal issues related to the use of dredged remediated sediment as substrate in agriculture;
- 10-20% of reduction of the use of peat and its substitution with treated sediment-based substrates with a conseguent 80-90% reuction of CO_2 emission.

The circular economy proposed by SUBSED project is based mostly on the concept of recycling of nutrients present in sediments, that are responsible of the high fertility observed in the obtained sediment-based substrate. In addition, growing media obtained by reclaimed sediments have shown to be greater water retainer, thus alleviating the water scarcity, increasingly present in the world and especially in the Mediterranean area.

In particular, the higher water efficiency will be a valuable mean for plant nursery sector, one of the most intensive agriculture sectors.

In addition, SUBSED will contribute to the EU 'Water Framework Directive' (2000/60/CE) which promotes the research for sustainable and eco-compatible solutions for the management of sediments and the 'Waste Framework Directive' (Directive 2008/98/CE) which faces the problem of sediment management.

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