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Paper sludge as amendment of substrate in urban green infrastructure: properties, use and perspectives

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Abstract

The recycled paper industry produces tons of waste, de-inked paper sludge (DPS), with resulting disposal costs and environmental impacts. In Italy, DPS can be used for environmental purposes, as maximum 30% in soil, if it is within legislated threshold limits for pollutants.

We examined the suitability of pelletized DPS coming from production of recycled tissue paper, generated by mechanical cleaning, without additives for a component of growing media for plants. The study includes DPS use as amendment in substrates for green roofs, urban trees and ornamental plants grown in nursery.

The analysis of DPS revealed concentrations below the threshold limits for potential contaminants, including heavy metals and chlorides, and low content of N_{tot} (0.2 %).

Recycled waste materials are often used as substrates for green roofs, where ideal characteristics are light weight, good drainage, and stability: a control (commercial product with tephra and compost), and two experimental substrates containing (1) tephra, DPS and compost and (2) tephra and DPS. The substrate containing both DPS, and compost proved best in terms of diversity, canopy cover and species composition, while the least fertile substrate (containing DPS and no compost) took longer to recover its vegetation after summer drought. The gaps in vegetation enabled annual seedlings to establish and persist, and slow-growing stress-tolerant plants were able to adapt.

Since urban conditions often cause plant stress, better substrates could help sustain growth both in nurseries and after transplanting. Studies with DPS as a substrate amendment for tree cultivation have previously shown equal or better results when compared with non-sludge media. Three ornamental trees popular in urban environments were studied from the establishment in nursery to the transplant in urban setting: *Quercus ilex* L. (Holm oak), *Lagerstroemia indica* L. (Crape myrtle), *Prunus serrulata* 'Kanzan' (Kanzan cherry). The substrate was composed of green waste compost 62%, pelletized DPS 20%, pumice 13%, and zeolite 5%. Prunus and myrtle grown in DPS mixed with compost showed better photosynthetic performance.

DPS in pelletized and sludge form was mixed with coconut fiber (30% DPS, 52% cocconut fiber, 13% pomice, 5% zeolite) to grow nursery ornamental plants: *Nandina domestica* Thunb. and *Phormium tenax* J.R.Forst. & G.Forst. "Variegatum". As the paper producer is close to the Pistoia nursery district, one of the largest in Europe, the waste could be recycled with low transport-related carbon emission and environmental impact in a circular economy perspective.

The research highlighted the DPS properties to suitably and complementary mix with other materials such as compost, to produce a substrate for different uses in green infrastructure: green roofs, walls, tree pits and containers.