Waste meets poor soils: perspectives on sewage sludge recycling

**Politecnico di Torino**

**Doctoral Program in Chemical Engineering (32nd Cycle)**

**PhD Candidate**: Enrico Camelin

**Supervisor**: Prof. Debora Fino

**Co-supervisor**: Dott. Tonia Tommasi

**Thesis title:** Waste meets poor soils: perspectives on sewage sludge recycling

## Abstract

Sewage sludge and nutrient depletion of soil are two themes strictly related to actual environmental problems, such as waste management and soil degradation. On one hand, sewage sludge (SS) is the main by-product generating from wastewater treatment, whose production has grown in the last twenty years; sewage sludge has different destinations, however a proper solution for a suitable reuse has not been found yet. On the other hand, soil nutrient depletion is a phenomenon increasingly occurring, with tremendous drawbacks directly on soil health and functions, and, to a broader extent, on economy and society.

Land application of sewage sludge is a practice carried out since many years, as SS can behave as valuable source of organic matter and nutrients under an agronomic point of view. Nevertheless, its long-term application may pose serious risk of soil contamination as SS still contained unwanted residues from wastewater treatment, such as organic and inorganic pollutants.

The aim of the present research is thus to reprise the land application practice of SS and to challenge it to demonstrate its effectiveness also on poor soils. More in detail, the research work started from a detailed characterisation of the waste used, which were anaerobic digestates from sewage sludge (SSAD). Then the attention was moved on the evaluation of fertilizing and phytotoxic effects of SSAD application on the growth of a vegetal model species (*i.e.* cucumber plants) in a controlled environment. Successively, particular interest was devoted the characterization of rhizosphere microbial communities of tomato plants grown on a poor soil and treated with SSAD, exploiting a molecular ecology approach. Finally, the last part of the work was dedicated to the implementation of an extraction protocol of an added-value part of SSAD organic matter, which are humic acids.

The results revealed that investigated SSADs had interesting contents in organic matter and nutrients (N, P). SSAD application on sandy soil induced an improvement of different growth parameters of cucumber at an intermediate dosage of SSAD (170 kg N/ha). As concerns microbial communities, bacteria of tomato rhizosphere were influenced by treatment with SSAD, showing that its application induced a higher presence of Plant Growth Promoting Bacteria (PGPB). Finally, the extraction of humic acids turned out to be feasible and might help in getting rid of toxic molecules such as heavy metals.

The work conducted in the present thesis had a strong interdisciplinary vocation, ranging from chemical engineering to analytical chemistry, from agronomy to molecular ecology. Hence, this variety of topics could be covered thank to the productive collaborations with external institutions. Pot experiments for plant growth in climatic chamber and greenhouse where conducted in collaboration with Agroinnova, Centre of Competence for the innovation in the agro-environmental field. Extraction of soil DNA and molecular characterisation of soil microbial communities were conducted during the PhD period spent at Molecular Ecotoxicology and Microbiology Laboratories of Joint Research Centre in Ispra (VA, Italy). Extraction of humic acids from SSAD was performed during the PhD period spent at Escuela de Ingeniería Bioquímica of Pontificia Universidad Católica de Valparaíso (Chile). Hence, the present work aims to be pioneering in the exploitation of an effective interplay between different scientific branches to deal with relevant actual problems in a clever and integrated manner. The future research will rely even more on scientific interactions and, within this perspective, the engineering approach should wisely drive the next investigations and challenges.