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Nutrient and microbial dynamics of soils amended with sewage sludge stabilzed with clay minerals and biochar; a preliminary study.

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Sewage sludge production from wastewater treatment plants (WWTP) progressively exceeds 60 Million m^3 p.a. in the EU. Although it is rich in organic matter (OM) and essential nutrients for crop production, sewage sludge is mainly disposed in landfills. Under the framework of Cyclic Economy and EU Green Deal, sewage sludge represents an ideal soil amendment and fertilizer with a potential to increase soil OM, provide nutrients and reduce chemical fertilization. Nonetheless, its agronomic use comes with limitations due to the presence of heavy metals and pathogenic microorganisms. Several stabilization technologies, including composting, thermal treatment and liming, aim to produce safe sewage sludge products suitable for agronomic use.

This incubation study investigated the effects of municipal sewage sludge (stabilized by alternative and common methods) on nutrient and microbial dynamics in two soils; an acidic (pH 5) and an alkaline (pH 8). Stabilized sewage sludge (Thessaloniki WWTP, Greece) with clay minerals (bentonite and vermiculite), biochar (pine residues), $Ca(OH)_2$ and air-drying, was applied at 1% and 3% dw, in soil mesocosms (300 g). Non-amended soils were also included as control. Soils were incubated (15 days; 25^{o}C) and equilibrated with periodic wetting and air-drying. Then, chemical soil properties, heavy metal concentrations and microbial abundance were determined using standard methods.

Treated sewage sludge addition in the acidic soil, noticeably increased soil pH (pH 5.2 – 8.5), compared to the control treatment (pH 5.0). In the alkaline soil, pH remained at similar levels (pH 8.1 – 8.6). Interestingly, EC increased from 0.42 up to 4.10 and 0.80 up to 3.08 dS m-1 for the acidic and alkaline soils, respectively. The C/N ratio was approx. 10 for all treatments, except biochar (C/N=16). Higher $NO_3^-/_2^-$ concentrations were observed for $(CaOH)_2$, biochar and vermiculite stabilized sewage sludge treatments, and higher NH_4^+ concentrations were observed for air-dried, bentonite and vermiculite stabilized sewage sludge treatments, in both soils, when compared to the control. Heavy metal concentration increased in all treatments, yet, it remained below legislative critical levels. Sewage sludge amendment increased total heterotroph abundance in all treatments (5.4 – 7.5 $\log_{10}$ CFU g^{-1}) compared to the control. Antibiotic resistant prokaryote abundance ranged between 3.9 – 7.0 $\log_{10}$ CFU g^{-1} and no persistent pattern was found. Pathogens remained below legislative critical levels in all treatments.

Our preliminary results show that stabilized sewage sludge has the potential to be a safe soil conditioner and fertilizer under the framework of Cyclic Economy and EU Green Deal. A desirable increase in soil fertility and organic C was observed for both soils, and an advantageous pH increase for acidic soil. Though, care should be taken not to exceed EC>2 dS m^{-1} when amending agricultural soils with sewage sludge products. Also, further experimentation is required to understand the effects of soil amendments on plant nutrition and productivity.

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