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Smart sludge: monitoring of granulated biosolid degradation in soil

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Highlights:

- The formation of granulated biosolids with organic binders has the potential to reduce environmental impacts and enhance soil fertility.
- Pelletized biosolids offer a convenient alternative to powdered forms for agricultural use, enhancing safety and ease of application.

Keywords: Wastewater treatment; sewage sludge; organic fertilizer

INTRODUCTION

The application of biosolids in agricultural soils has the ability to improve their nutritional properties. However, its conventional powdered form poses a risk of environmental dispersion and compromises its viability as an agricultural fertilizer, which may limit compliance with safe disposal criteria according to legislation (Brasil, 2020). The pelletization of biosolids has emerged as a potential solution for enhancing product logistics and reducing environmental impacts (Siyal, 2021). This study aimed to evaluate the effects of applying granulated biosolids produced in different formulations with organic binders on the physical, chemical, and biological parameters of the soil.

METHODOLOGY

This study was conducted in a laboratory with controlled temperature and humidity using samples of a Cambisol and sewage sludge. The experiment involved molding pellets with different formulations composed of different types of organic binders and additives, which were then incubated in soil in Petri dishes. The analyses included measurements of pH, electrical conductivity (EC), phosphorus (P), ammonium ($N\text{-}NH_4^+$), nitrite ($N\text{-}NO_2^-$), and chemical oxygen demand (COD) in the soil solution, as well as the identification of microorganisms.

The methodology proposed by Nikiema et al. (2013) was adapted to assess the disintegration rate of the pellets in water by counting the number of pellets dissolved during the process. Treatment means were compared using the Tukey test at the 0.1% probability level. Additionally, Scanning Electron Microscopy (SEM) analysis was conducted to examine the physical characteristics of the mineral binder (MB), comparing treatments with and without it.

RESULTS AND CONCLUSIONS

The disintegration of the pellets in water was faster in treatments with higher amounts of mineral binder and lower amounts of organic binder (TR and P). The treatment means differed significantly from those of the control group (distilled water only), with a statistical significance of 0.1%.

Treatments incorporating a mineral binder [T1 (SS:P:MB:W – 5:0.2:0.8:3); T2 (SS:P:MB:W – 5:0.3:0.7:3); T3 (SS:TR:MB:W –5:0.2:0.8:3); T4 (SS:TR:MB:W –5:0.3:0.7:3)] exhibited heightened porosity in contrast to those without it [T5 (SS:TA:W – 5:2:2.5); T6 (SS:P:W – 5:1:2.5)], as revealed by visual examination of void spaces in scanning electron microscopy (Figure 1), attributed to water utilization during the hydration process, which led to void formation upon evaporation (Malathy et al., 2023).

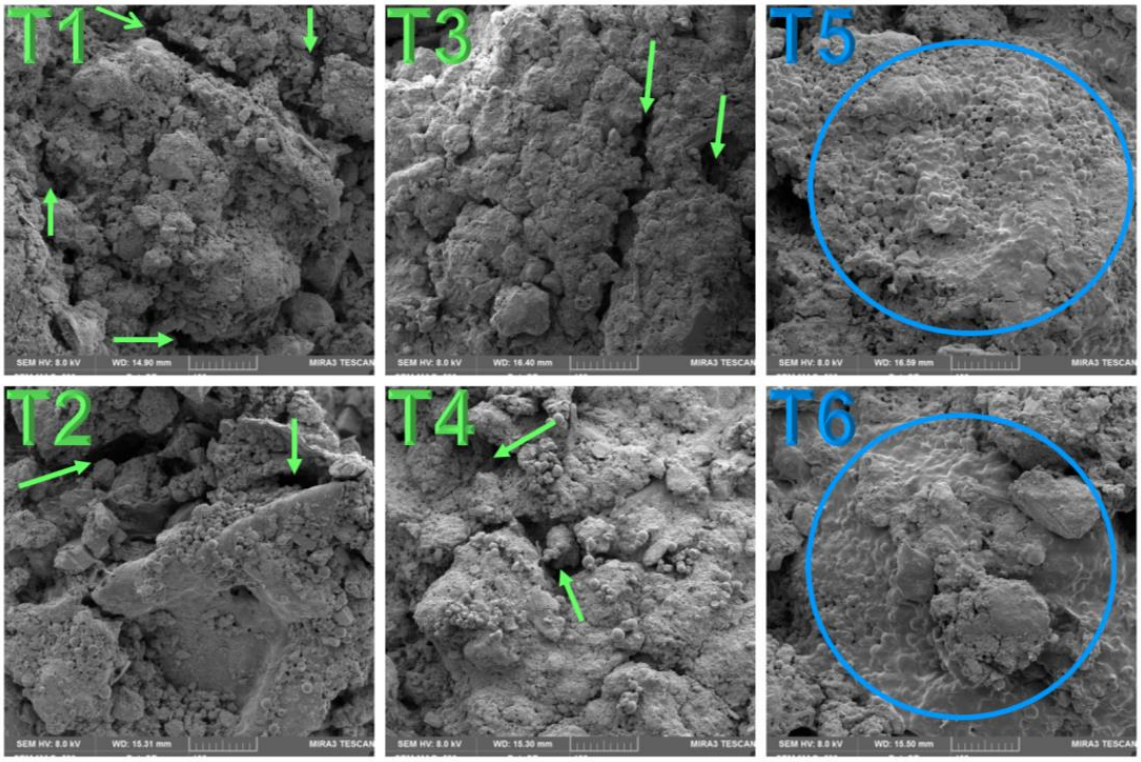

Figure 1. Comparison via scanning electron microscopy (500x magnification) among treatments, showing a greater presence of void spaces in mineral binder containing treatments (T1-T4) compared to those without it (T5-T6).

Regarding biodegradation, there were no significant differences in soil characteristics after 52 days of incubation between the pellet treatments and the control group, which consisted only of soil (Table 1). Microbiological succession revealed the presence of fungi from the genera *Fusarium*, *Cladosporium*, and *Alternaria* in all samples.

Table 1. Average values of chemical and physical parameters of the soil solution after the incubation period of 52 days

Treatments	$N\text{-}NH_4^+$	$N\text{-}NO_2^-$	P	Ca	COD	pH	EC
			mg/L			-	µS/cm
1 – SS:TR:MB:W (5:0.3:0.7:3)	12.4	0.1	0.1	8.0	545	5.1	209
2 – SS:TR:MB:W (5:0.2:0.8:3)	12.5	0.1	0.2	8.5	700	5.2	113
3 – SS:P:MB:W (5:0.2:0.8:3)	15.9	0.1	0.2	8.0	664	5.3	147
4 – SS:P:MB:W (5:0.3:0.7:3)	15.2	0.1	0.3	7.8	773	5.2	137
Control (only soil)	10.9	0.1	0.2	3.9	552	5.3	73

MB = mineral binder; P = starchy organic binder; SS = sewage sludge; TR = powder product that provides elasticity; TA = vegetable binder that provides coagulation; W = water.
There were no significant differences among the treatments based on the Tukey test ($p > 0.05$).

There is a direct relationship between the disintegration rate of the pellets and the proportion of additives in their composition. Research focusing on the long-term decomposition of pellets is needed.

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