Circular Economy: A New Biodegradable Product—Granulated Fertilizer from Biosolids

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Highlights:

- Tests to improve a sustainable granulated product using sewage sludge;
- Use of sewage sludge in new formulations;
- Sustainable improvement of biodegradable organic fertilizer formulations with recovery of sewage sludge.

Keywords: Granulated product; Sewage sludge; Byproduct

INTRODUCTION

Sewage treatment plants (WWTPs) produce solid waste, called sludge, through sewage treatment. Sludge is called biosolids when it is subjected to the disinfection process, one of which is the addition of calcium oxide, which generates an exothermic reaction and According to (Fonseca, 2015), sludge treatment is completed by storing the sludge for 30 days.

Sludge is a globally produced material, since it is a waste generated in wastewater treatment plants with biological process where is originated this material. It is sustainable to seek an appropriate destination. According to Andreoli (1999), this material contributes to the biological activity of the soil, in addition to being a good soil regularizer. For this reason, this material can be combined with limestone, minerals, gypsum or other substances that have soil conditioning characteristics, in addition to some biodegradable organic binders, aiming to create an ecological product with mechanized application.

Then, the aim of this work was to improve the formulation and the physical and mechanical properties of a new biodegradable product, a granulated fertilizer made from disinfected sewage sludge and binding compounds, developed based on circular economy principles, with the goal of obtaining an eco-friendly and safe product.

METHODOLOGY

The methodology adopted in the research used biodegradable organic binders (BOBs), a binding mineral produced from heating gypsum (MB) based on $CaSO_4$ and biosolids (B) with a particle size already preestablished in research by Gouveia and Doll (2022), to model and structure the compound in granule form.

To model the granule, it was heated in a Bunsen burner, and the mass was made by mixing the materials in varying proportions and conditions established in the test. This methodology cannot be detailed because the research is in the patent generation consultation phase.

Through different tests, 6 formulations were defined as standards for testing, with their characteristics evaluated using scanning electron microscopy (SEM), density using the helium gas pycnometry method and moisture content based on Annex A of the NBR standard 6457 (ABNT, 2016). Moisture was analyzed in 3 periods: 2 hours, 24 hours and 48 hours after molding the granules.

RESULTS AND CONCLUSIONS

The six different and most promising formulations containing different organic binders, mineral binders and biosolids were optimized according to the following most relevant criteria: the difficulty of modeling and structuring, the amount of water released after making the dried granules at room temperature and the financial cost of each formulation. Table 1 shows the 6 formulations that were adopted for SEM and density and moisture content analyses. In the Table, it is possible to observe that some formulations are combinations of 2 organic and mineral binders.

Table 1. Promising assay formulations.

Formulation	Origin of the binder*	Proportions*				temperature molding (°C)
		B(g)	AO (g)	AM (g)	Water (mL)	
1	Binder 1 + AM	5	0.2	0.8	3	70
2	Binder 1 + AM	5	0.3	0.7	2.5	74
3	Binder 2 + AM	5	0.2	0.8	3	81
4	Binder 2 + AM	5	0.3	0.7	3	89
5	Binder 3	5	2	0	2.5	52
6	Binder 4	5	1	0	2.5	54

*Binder 1 – starchy organic binder, Binder 2 – powder product that provides elasticity, Binder 3 – vegetable binder that provides coagulation, Binder 4 – starchy organic binder extracted from cassava *(Manihot utilissima)* modified by fermentation and solar drying, MB – mineral binder.
Source: The authors (2024).

SEM was used to observe the conformation of the materials in the manufactured granule; for example, if the binder was surrounding the biosolid particles and if there were undissolved binder molecules, this analysis impacted the rigidity of the granule since if the binder was not dissolved, it did not clump together.

Of the formulations observed via SEM, the presence of structured starch molecules was minimal in all the samples; that is, due to the modeling of the granules, the homogeneity of the binder with water may not have occurred. The impact of these structures can be analyzed through resistance testing.

Through the density test, the formulations were described as having a uniform density, as the standard deviation between the samples was 0.1. This occurred because the amount of biosolids was the same in all formulations, and the amount of binder was lower than that of biosolids.

The humidity of the granules was analyzed, and the results revealed that the humidity in the initial 2 h was between 33 and 59%, that after 24 h was between 11 and 34%, and that after 48 h was between 3 and 20% (Table 1).

It is concluded that biosolids cannot be considered a residue but rather a byproduct of sewage treatment, as they are highly rich in organic matter that is already applied in agriculture as agricultural fertilizer. The developed granule formulations enable mechanized application, in addition to having attractive agricultural market value.

So, this research evolved innovation, education, training and certification, was important in the circular economy theme since the work sought to emphasize the use of a material with potential changings the application of sewage sludge in agriculture.

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