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# INFLUENCE OF SOME ADDITIVES – BINDER AND NUTRIENT SOURCES, ON SOME CHARACTERISTICS OF BIOSOLID FERTILIZER GRANULES

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**Abstract:** Obtaining granular biosolid fertilizers by extrusion requires the addition in the manufacturing formula, in addition to some minerals to improve the nutrient composition, of certain substances that also have a binder role to ensure physicochemical characteristics that meet the requirements of the organo–mineral fertilizer category. Granules obtained from two recipes using starch, molasses and urea both as a nutrient source and as a binder in the extrusion process were studied. The paper presents research on the influence of binder additions on physico–chemical characteristics of biosolid–based granular fertilizers, such as particle size fraction, grain moisture, pH and compressive strength.
**Keywords:** biosolid, granular, molasses, physico–chemical characteristics

## INTRODUCTION

The use of sludge in agriculture can contribute to reducing environmental pollution due to the disposal of waste sludge from wastewater treatment plants, thus avoiding incineration or other polluting and costly processes (*Adugna G., 2016; Bowszys T. et al., 2015*).

Biosolids for agriculture are obtained from raw sewage sludge by digestion and stabilisation processes. These processes ensure the reduction of toxic chemicals and pathogen concentrations in sludge so that its use in agriculture does not harm soil, plants, groundwater and not least the health of consumers of agricultural plant and animal products (*Kominko H. et al., 2018; Kumar V. et al., 2017; Pöykiö R. et al., 2019*).

The nutrient content of biosolids varies depending on the quality of the sludge from which they come, as well as the technologies used to stabilize the latter (*Azim K. 2017; Bożym M. and Siemiątkowski G., 2018; Popa M. et al, 2019*). A fertilizer made by mineral and organic (biosolids) fertilizers combined give us a variety of advantages (*Parent L.E.et al. 2003*).

In order for biosolids–based organo–mineral fertilizers to be balanced in content it is necessary to add in the manufacturing recipes chemical compounds which generally contain both the three nutrients N, P and K, indispensable for plants, as well as micronutrients (*Kominko H. et al., 2017*).

The best production technology used to improve the transport, storage and application properties of organo–mineral fertilizers is granulation (*Deeks L.K. et al., 2013*). One of the most modern applicable methods for granulating organo–mineral fertilizers is reactive extrusion which, by being a thermo–mechanical process, ensures in addition to good compaction and the development of chemical reactions between components, which leads to a homogeneous physical and chemical structure of granules.

The characteristics of granular organo–mineral fertilizers based on biosolids must correspond to the existing requirements imposed on organo–mineral fertilizers. The knowledge of the physical – chemical characteristics of the fertilizers contributes to the assurance of their proper management.

## MATERIALS AND METHODS

The granular fertilizer material based on biosolids was manufacture by reactive extrusion and then granulation, according to the two variants of manufacturing recipie (Table 1) in which the organic part is provided by biosolids, protein hydrolyzate and molasses (*Cioica N. et al, 2020*). In addition to organic and mineral components, for both Sample I and Sample II starch has been added to the reciepis to provide the matrix required for reactive extrusion processing. In addition, Sample I also contains molasses both as binder and as source of organic nitrogen and potassium.

The experiments aimed to determine the influence of the addition of molasses in the granular fertilizer recipie on its properties. The properties studied were particle size fractions, particle moisture, compressive strength and pH.

In order to determine the particle size fractions, samples of about 50 g of each Sample were sieved through diferent sieves with an eye size of 4; 2; 1; 0.5 and 0.25 mm.

Table 1. Composition of manufacturing recipies

| No. | Substance in formula | Percentages, % | |
|---|---|---|---|
| | | Sample I | Sample II |
| 1 | Dry biosolid, 20% humiditaty | 30.00 | 30.00 |
| 2 | Monoammoniumphosphate (MAP) | 24.50 | 25.00 |
| 3 | Potassium nitrate | 22.20 | 23.00 |
| 4 | Urea | 5.30 | 6.20 |
| 5 | Starch | 7.98 | 7.50 |
| 6 | Protein hydrolyzate, 11 % solution | 4.00 | 4.00 |
| 7 | Molasses from sugar beet | *2.23* | *0.00* |
| 8 | Manganese sulfate | 3.30 | 3.56 |
| 9 | Zinc sulfate | 0.08 | 0.09 |
| 10 | Copper sulfate | 0.05 | 0.06 |
| 11 | Iron sulfate | 0.11 | 0.11 |
| 12 | Manganese sulfate | 0.22 | 0.24 |
| 13 | Cobalt sulfate | 0.03 | 0.03 |


Figure 1 – Determination of moisture content with thermobalance AXIS –100

To determine the particle moisture samples of about 5 g of granules, were dried with a thermobalance type AXIS–100 at 80°C (Figure 1). At every 20 seconds the masses were recorded until at least 3 consecutive equal values were obtained. The moisture content was determined by the difference between the initial mass of the samples and the final mass (after drying).

For the most of cultivated plants the consumption of nutrients depends directly on the pH. For example calcium and magnesium are easily assimilated by plants at pH 7 – 8.5, nitrogen at pH 6.0 – 6.8, phosphorus at 6.5 – 7.5, potassium at higher pH of 6, and the trace elements are assimilated more easily in the acidic environment.

Therefore, any organo–mineral fertilizer must ensure that the pH is kept within optimal limits for plants. In order to determine the pH of the biosolid based fertilizer (Figure 2), samples of 10 g granules were dissolved in 100 ml of distilled water, every 15 min the pH was measured with pH indicator paper from Merck.

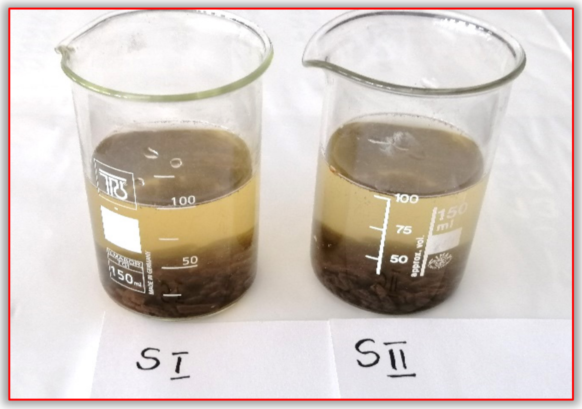

Figure 2 – Granular fertilizer based on biosolid dissolved in distilled water

The compression tests (Figure 3) were performed for biosolid based granules with a manual press equipped with a 5 kN force transducer, the data being taken over and processed by means of a Spider 8 data acquisition plate. One granule of fertilizer from each Sample was used for the measurements and the measurements were repeated by 5 times to determine the average value of the compressive strength for each variant.

Figure 3 – Test equipment for determining the compressive strength of granular fertilizer material based on biosolids

**RESULTS**

In table 2 are presented the results obtained from the granulometric analysis of the granular organo–mineral fertilizer based on biosolids.

From the analysis of the data obtained we observe that the granules in both variants falls within the technical requirements established by EC Regulation no. 2003/2003 regarding the granulometric structure of fertilizers, namely: min. 90% between 1 and 4 mm and max. 10% less than 1 mm or more than 4 mm. Also, the addition of molasses (Sample I) leads to a slight increase in fraction in the percentage of granules between 1 and 2 mm.

Table 2. Granulometric composition of the samples of fertilizer based on biosolid

| Granulometric fraction | Granule mass,g / percentage parts,% | | | |
|---|---|---|---|---|
| | Sample I (with molasses) | | Sample II | |
| between 2 and 4 mm | 43,10 | 85,6% | 45,81 | 91% |
| between 1and 2 mm | 6,46 | 12,8% | 4,22 | 8,4% |
| between 0,5 and 1 mm | 0,52 | 1% | 0,18 | 0,4% |
| between 0,25 and 0,5 mm | 0,21 | 0,4% | 0 | 0% |
| < 0,25 | 0,09 | 0,2% | 0,09 | 0,2% |
| Total | 50,38 | 100% | 50,30 | 100% |

Table 3. Values of moisture content, water absorption capacity and ph in solution

| Characteristics | U.M. | Fertilizer material based on biosolids | |
|---|---|---|---|
| | | Sample I (with molasses) | Sample II |
| Moisture content | % | 1,33% | 1,70% |
| pH in solution | | between 5 –6 | between 5 – 6 |
| Water absorption capacity | % | 47,9 | 50,7 |

Analysing the data obtained and presented in table 3, we note that the moisture content falls within normal limits, the higher value being registered for Sample II–with no molasses. Also the water absorbtion capacity is slighty higher for the Saple II without molasses.

The values of pH, measured for a solution of 100 ml of distilled water and 10 g of biosolids fertilizer, are between 5– 6.


Figure 4 – pH in solution for Sample I–with molasses and Sample II without molasses

Good properties in terms of transport, storage and application of granular form of biosolids based fertilizers can only be ensured by knowing the compressive strength of the granules.

From the graphs shown in Figure 4 and Figure 5 it can be seen that for both Samples we observe an almost linear behaviour of the granule deformation in relation to the applied compressive force. For both Samples with or without molasses in composition, the maximal values of compressive strength is between 40 and 50 N.

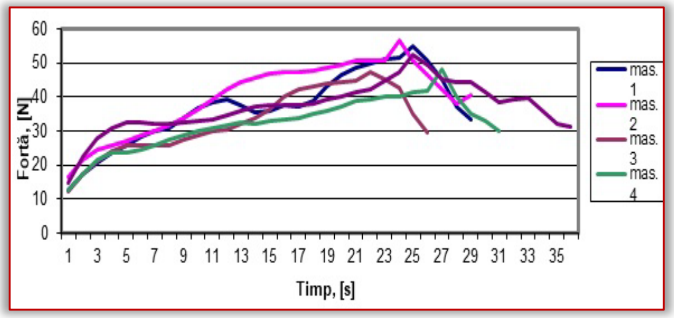


Figure 5 – Diagrams of compressive strength for Sample I– with molasses

Above these values of compressive strength, the granules do not deform anymore during mechanical stress.

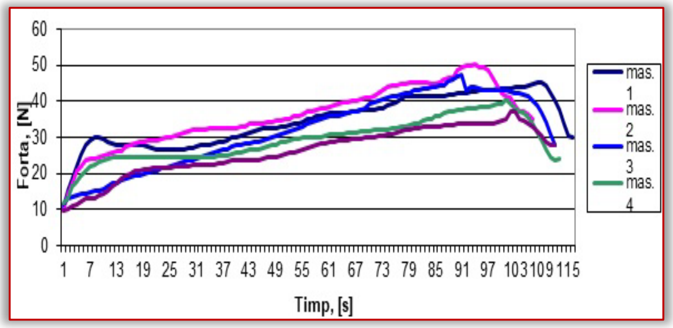


Figure 6 – Diagrams of compressive strength for Sample II – without molasses

**CONCLUSIONS**

Granulometric structure of the granular fertilizer falls within the technical requirements established by EC Regulation no. 2003/2003, namely: min. 90% between 1 and 4 mm and max. 10% less than 1 mm or more than 4 mm. For both samples we obtained 98–99% for fraction between 1 and 4 mm and 0,6–1,6% for the fraction less than 1 mm, so molasses content do not influence the granulometric structure.

From the analysis of the data resulting from the measurements made, it is observed that the material obtained in both variants has values of compressive strength between 40 and 50 N;

In both Samples, the moisture content tested falls within normal limits, the higher value being registered in Sample II which contains no molasses, in which case also, the water absorption capacity is higher;

The pH measured in solution of both Samples falls between 5–6, so the molasses content seems to not influence the pH of granular fertilizer;

The researches highlighted the fact that the applied manufacturing recipes allow to obtain granular biosolid based fertilizer that falls within the requirements imposed for organo–mineral fertilizers;

The addition of molasses as binder and source of organic nitrogen and potassium, was a good choice to obtain granular fertilizer based on biosolids trough reactive extrusion.

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