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INFLUENCE OF MINERAL ADDITIVES IN THE COMPOSITION OF GRANULAR ORGANO–MINERAL FERTILIZERS BASED ON BIOSOLIDS ON THEIR PROPERTIES

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Abstract: 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. 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. Biosolids can be used as a source of organic matter for some organic or organo–mineral fertilizers. In order to obtain a valuable organo–mineral fertilizer in terms of nutrient composition, it is necessary to enrich the biosolid by adding minerals/ingredients to the recipe. The characteristics of the resulting fertilizers must meet the requirements of the organo–mineral fertilizer category. The paper presents research on the influence of mineral fertilizer additions on some physico–chemical properties of granular biosolid fertilizers, such as: grain moisture, grain size fraction, compressive strength and bulk density.
Keywords: mineral**,** biosolids, fertilizer, properties

INTRODUCTION

In order to reduce the negative effects of the use of chemical fertilisers on the environment, research in recent years has focused on finding new sources of fertilisers with a higher organic content. In order to benefit from similar advantages as mineral fertilizers, ways of processing organic fertilizers are currently being sought that allow for the easiest possible application, ensure the necessary concentration and stability during plant growing seasons (*Aguilera, J., et al., 2012*).

An important source of organic matter and nutrients that can be used in agriculture as a fertilizer is sludge from sewage treatment plants. 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, 2016; Bowszys 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 et al., 2018; Kumar et al., 2017; Pöykiö et al., 2019*).

Organo–mineral fertilizers, according to the European Parliament Regulation on CE–marked fertilizer products, are obtained by mixing organic material with mineral fertilizers and nutrients of biological origin (*EC No. 1069/2009 and EC No. 1107/2009, Annex 1, 2016*). Organo–mineral fertilizers obtained by mixing organic material (e.g. biosolids) and minerals in well–established proportions offer various advantages (*Blaga, Gh. et al, 2008; Parent et al. 2003; Lee & Bartlett, 1976; Tishkovitch et al., 1983*).

Generally organo–mineral fertilizers are made in granular form, a form that allows precise application with chemical fertilizer application equipment, reduction of storage space and pollution due to dust arising during handling (*Deeks et al., 2013*).

In this paper some properties of biosolids–based fertilizer granules obtained after a technology developed by INMA Bucharest (*Siminiceanu, I., 1980; Nagy, M. E., et al. 2018*), were studied to highlight the influence of some mineral additions in the recipe on their properties.

MATERIAL AND METHOD

To obtain organo–mineral granular fertilizers, a mixture of organic (biosolid, milasses and protein hydrolyzate based on wool) and mineral (N,P,K) components was processed by reactive extrusion and granulation. The main organic component used in the formula was the biosolid obtained from raw sewage sludge from Mioveni wastewater treatment plant. The main quality indicators of the biosolid used are presented in table 1.

The manufacturing formula was prepared in two variants whose composition is presented in table 2. The saples subjected to experients are presented in figure 2. In addition to organic and mineral components, starch has been added to the formula to provide the matrix required for reactive extrusion processing. The experiments aimed to determine the influence of the addition of minerals in the granular fertilizer formula on its properties. The properties studied were particle size fractions, the water content of the granules, bulk density of the granules and compressive strength.

Table 1. Biosolid quality indicators *(Raport de încercări INCDPM)*

No.	Quality Indicators	U. M.	Determined values
1	Dry matter	%	67.86
2	Volatile substance	%	35.34
3	pH measured at 20,6 ^{0}C	pH units	7.09
4	Nitrogen	% D.M	1.52
5	Organic carbon	% D.M	21.5
6	P_2O_5	% D.M.	1.38
7	K_2O	% D.M	0.675
8	CaO	% D.M	0.35
9	Cadmium	mg/kg D.M	1.04
10	Chromium	mg/kg D.M	44.8
11	Copper	mg/kg D.M	74.3
12	Nickel	mg/kg D.M	26.5


(a)


(b)

Figure 1 – Granular fertilizer material based on biosolids
a) –variant V1, b)–variant V2

Table 2. Composition of formulas used to manufacture granular fertilizer material based on biosolids

Nr crt.	Substance used	Percentages, %	
		Variant 1	Variant 2
1	Dry compost, humidity 20%	30,00	30,00
2	Monoamoniufosfat (MAP)	24,50	0,00
3	Mineral fertilizer NP 20:20	0,00	24,00
4	Potassium nitrate, KNO3	22,20	23,10
5	Urea	5,30	6,30
6	Protein hydrolyzate solution,11 %	4,00	4,00
7	Starch	7,98	7,47
8	Magnesium sulphate, $MgSO_4$	3,30	2,82
9	Zinc sulphate, Zn SO_4	0,08	0,07
10	Copper sulphate, $CuSO_4$	0,05	0,04
11	Iron sulphate, $FeSO_4$	0,11	0,09
12	Manganese sulphate, $MnSO_4$	0,22	0,19
13	Cobalt sulphate, $CoSO_4$	0,03	0,03
14	Molasses of sugar beat	2,23	1,89

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

To determine the water content of the granules we used samples of about 5 g of granules, which were dried at 80 ^{0}C, with a thermobalance type AXIS–100 with a weighing accuracy of 0.01%, fig.2. At every 20 seconds the masses were recorded until at least 3 consecutive equal values were obtained. The difference between the initial and final mass of the samples gives us the moisture content.

Figure 2 – Determination of moisture content with thermobalance AXIS –100

In order to determine the bulk density of the organo–mineral fertilizer we used a calibrated vessel of volume V = 0.03 dm^3 with mass m = 27.55 g. For measurements we poured the granules into the vessel from a height of 5 cm, than the vessel was buffered 50 times by a wooden table and weighed again, to obtain the mass m_1. Compact bulk density was calculated using the formula:

$$\rho = (m_1 - m) / V \quad (1)$$

The compression tests, figure 3, were performed with a manual press equipped with a 5 kN force transducer, a mechanical dial indicator, the data being taken over and processed by means of a Spider 8 data acquisition plate. One granule was used for the measurements, the measurements being repeated by 5 times to determine the average value of the compressive strength for each variant.

Figure 3 – Compression test

RESULTS

In table 3 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 NP 20–20 (variant 2) leads to an increase in the percentage of granules between 1 and 2 mm due to a lower phosphorus content compared to variant 1 to which MAP with a P_2O_5 content of 61%has been added. The data obtained from the determination of water content and bulk density are presented in Table 4.

Table 3. Granulometric composition

Granulometric fraction	Granule mass, g / percentage parts,%			
	Variant 1		Variant 2	
between 2 and 4 mm	43,10	85,6%	34,73	68,9%
between 1and 2 mm	6,46	12,8%	15,09	29,9%
between 0,5 and 1 mm	0,52	1%	0,21	0,4%
between 0,25 and 0,5 mm	0,21	0,4%	0,29	0,6%
< 0,25	0,09	0,2%	0,11	0,2%
Total	50,38	100%	50,43	100%

Table 4. Results obtained from experiments

No.	Characteristics	U.M.	Fertilizer material based on biosolids	
			Variant I	Variant II
1	Water content	%	1,33%	3,74%
2	Bulk density	kg/m^3	855,1	854,7

Analysing the data obtained, we note that the water content falls within normal limits, the higher value being registered for Variant 2–with less phosphorus. The bulk density is not influenced by mineral additions (phosphorus content), and has relatively low values due to the biosolid component which is characterized by low specific weight.

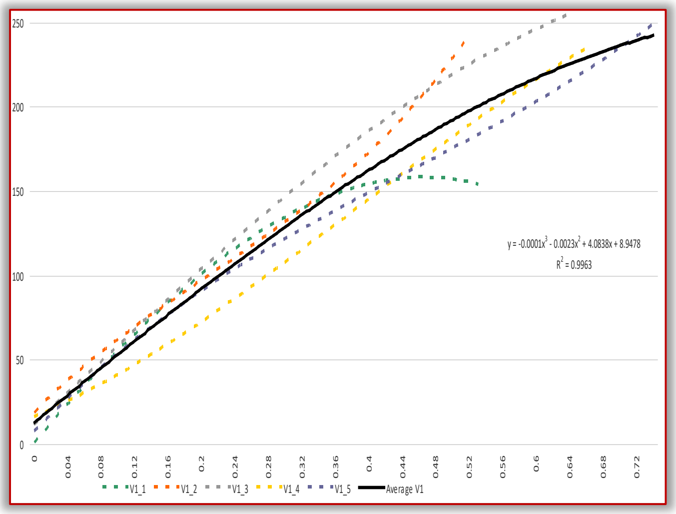

Figure 4 – Diagrams of compressive strength for Variant 1– with Monoammoniumphosphate (MAP)

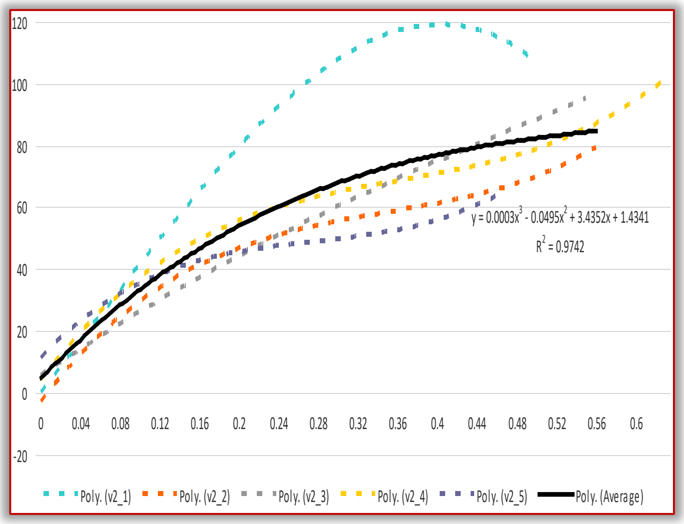

Figure 5 – Diagrams of compressive strength for Variant 2 – with NP 20–20

From the graphs shown in figure 4 and figure 5 it can be seen that for both variants the polynomial equation obtained shows an almost linear behaviour of the granule deformation in relation to the applied compressive force. For Variant 1 the predominantly linear character is observed up to a stress of 150 N and an average deformation of about 0.36 mm, while in the case of Variant 2 – with a lower phosphorus content, the value up to which the predominantly linear character is observed is less than 60 N at a deformation of about 0.24 mm.

Above these values, polynomial character is observed for both samples, in the case of variant 1 up to a maximum value of 250 N with a deformation of about 0.68 mm, and for variant 2 up to a maximum value of 85 N at which the deformation reached the value of 0.56 mm.

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

CONCLUSIONS

From the research carried out, it was observed that the manufacturing recipes used allow obtaining a granular fertilizer material based on biosolids that meets the requirements for organo–mineral fertilizers.

The analysis of the obtained results shows the influence of the phosphorus content on the properties of the granules, respectively the samples of the variant 2 with a lower phosphorus content have a lower compressive strength (60–85 N) which leads to a higher fraction of granules with diameters between 1–2 mm (12.8%).

Also the lower phosphorus content means that the granules in variant 2 have a higher water content (3.74%) than those in variant 1 (1.33%).

A good understanding of the characteristics of granular organo–mineral fertilizers based on biosolids allows the identification of the mineral additions needed to optimize formulations according to requirements.

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