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GRANULATION STUDY OF COMPOSITE MIXTURES ON THE BASIS OF ASH FROM BURNED WOODEN BIOMASS, FOR PRODUCTION OF SOIL CONDITIONERS

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ABSTRACT

The granulation of composite mixtures with potential use in agriculture as soil-conditioners gives good possibility for their mechanical distribution in the soil through different fertilizer-spreader machines. The granulated products ensure slower speed of the nutrients extraction in the soil solution and in the same time long-term presence in the soils and better utilization by the plants.

This work presents the results from investigations on the granulation of composite mixtures for production of soil-conditioners. All used mixtures are based on ashes from burning wooden wastes and green lye – wastes from pulp production. For some mixtures sulphuric acid was also used in order to compensate of alkaline reactions of other components and to obtain better properties of the soil-conditioner. The granulation process was realized by the method of press granulation, and the obtained granules were tested with a hydraulic press to determine the compressive strength of the products. The obtained values were compared with similar products. The moisture content of the granulated soil-conditioners were determined and compared also with similar type soil-conditioners.

Keywords: composite mixtures, biomass ash, granulation, soil-conditioners, wastes utilization.

INTRODUCTION

The utilization of wastes for production of new types of composite mixtures as soil-conditioners helps to achieve higher agricultural yields, avoiding acidification and contamination of agricultural lands and recovery of their productivity. There are a number of publications of different researches related to obtaining good properties of soil-conditioners using different substances, standard products, raw materials and wastes. For example, in [1–12] are given results from investigations on the efficiency of soil-conditioners, obtained on the basis of different oil processing sewage wastes and fly ash from thermal power stations. Their influence on the soil characteristics and the growth of some vegetables are also studied. In [13–15] the efficiency of soil-conditioners based on zeolites and clay raw materials are studied. In [16] was considered the use of potassium humate as a soil-conditioner and was found that it improved the aggregate stability of two types of soils.

The use of granulated fertilizers and granulated soil-conditioners has some advantages as a chemical composition over the powdered or the small-crystal forms of the same type of products. The main advantages can be summarized as follows: avoiding dusting during the process of introduction in the soil; lower losses during transport and storage; better energy efficiency during drying, pneumatic transport, dosage and packaging; higher mechanical strength and density; easy mechanical use of fertilizer-spreader machines; a moderate process of solubilization of the granules and more efficient speed of nutrients utilization during the process of plants growth [17, 18].

In the current work the results from the granulation of composite mixtures for production of soil-conditioners, obtained on the basis of ash from burned wooden biomass, green lye and sulphuric acid are presented.

EXPERIMENTAL

The used biomass ash and green lye, represent industrial wastes, generated from the Kraft pulp production factory in the city of Svishtov, Republic of Bulgaria. The biomass ash is generated from the process of burning of the wood barks and the wood particles. The green lye is generated from the regenerations furnaces after burning of organic substances in the black lye. Objects of the research were twelve composite mixtures, obtained in quantity of 1 kg each, in the presence of different amounts of wood ash (WA) and green lye (GL). The chemical characteristics of wood ash were as follows: moisture – 0.40 %; organic matter (in dry substance) ~ 0.37 %; nutrient elements (in dry substance) are 0.032 % N, 0.72 % P_2O_5, 2.19 % K_2O, 48.7 % CaO, 1.3 % MgO; heavy metals (in dry substance) – Cd, Pb, Cr, Ni, Cu, Zn, As. Ions like Cl^-, SO_4^{2-} and Na^+ are as impurities and their content is below the legal limits. Green lye contains: 5 – 6 % of organic mass, 17 – 18 % of active calcium and magnesium oxide, 15 – 16 % of other oxides. The properties of those industrial wastes were described in details in [19]. During preparation of some of the mixtures as a third component sulphuric acid (H_2SO_4, pure for analysis, M = 98.08 g mol^{-1}) has been used. Twelve mixtures with different content were prepared (Table 1).

The mixtures which contain sulphuric acid (M-1 to M-9) were prepared in the following manner: the sulphuric acid was added to the biomass ash, slowly, in drops and at the same time, the mixture was continuously mixed for better homogenization and fragmentation of the formed agglomerates. After the addition of the whole quantity of sulphuric acid, slowly, in little portions, was added the green lye and the mixtures were further mixed to achieve full homogeneity. Mixtures M-10, M-11 and M-12, which contain only biomass ash and green lye, were prepared in the following manner: the green lye was added directly to the biomass ash at constant mixing.

The granulation of the mixtures was done by press granulation. Hydraulic press with potential for application of pressure up to 49.03 MPa, was used. The two used press-forms had inside diameter, respectively, 10 and 20 mm. The obtained granules (tablets) are with a cylindrical form (Fig. 1) with geometric sizes (diameter and height), respectively: d_1 = 10 mm, h_1 = 10 mm and d_2 = 20 mm, h_2 = 10 mm.

At least three granules from each mixture at six different pressures, respectively: 7.35 MPa, 9.81 MPa and 12.26 MPa – for granules with sizes d_1 = 10 mm

Table 1. Quantities of the components used for production of different soil-conditioners.

No	Biomass ash, kg/%	Green lye, kg/%	Sulphuric acid, kg/%
M–1	0.50 / 50	0.15 / 15	0.35 / 35
M–2	0.60 / 60	0.30 / 30	0.10 / 10
M–3	0.45 / 45	0.40 / 40	0.15 / 15
M–4	0.50 / 50	0.30 / 30	0.20 / 20
M–5	0.55 / 55	0.30 / 30	0.15 / 15
M–6	0.55 / 55	0.35 / 35	0.10 / 10
M–7	0.45 / 45	0.30 / 30	0.25 / 25
M–8	0.50 / 50	0.40 / 40	0.10 / 10
M–9	0.60 / 60	0.20 / 20	0.20 / 20
M–10	0.50 / 50	0.50 / 50	0
M–11	0.55 / 55	0.45 / 45	0
M–12	0.60 / 60	0.40 / 40	0

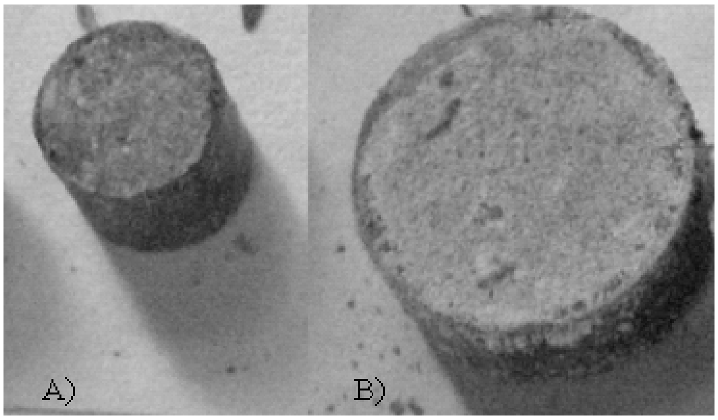

Fig. 1. View of the prepared granules (tablets): A) d_1 = 10 mm and h_1 = 10 mm; B) d_2 = 20 mm and h_2 = 10 mm.

and h_1 = 10 mm, and 14.71 MPa, 19.61 MPa and 24.52 MPa – for granules with sizes d_2 = 20 mm and h_2 = 10 mm were obtained and used for the next steps of the studies.

RESULTS AND DISCUSSION

During the adding of sulphuric acid it was found that a gas with acute smell is released. Forming of agglomerates from the ash (lumps of ash, with irregular form and absorbent surface), around the acid drops was also observed. The moisture content in the produced granules was determined by the weighting method [20]. The obtained values are shown in Table 2. The moisture values of the mixtures obtained from ash and lye (M-10 to M-12) are in the limits from 12.94 to 22.62 %. For mixtures, where sulphuric acid is added (M-3, M-6 and M8) all values are in the same range. The values for the other granules are below 12 % for all ranges of the applied pressure. So, it is obvious that there is a

Table 2. Experimental data for the moisture content of the granules.

Pressure of press, MPa	*Diameter of the granules, mm*	*Moisture contents in the granules from the respective mixture (W), %*											
		M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9	M-10	M-11	M-12
7.35	d_1 = 10	2.43	4.86	14.31	4.45	7.89	16.62	6.36	12.27	1.71	21.46	22.18	18.70
9.81	d_1 = 10	2.75	4.98	14.03	4.69	8.32	14.66	5.78	11.60	1.56	22.62	19.43	17.85
12.26	d_1 = 10	2.59	4.67	13.27	4.53	8.76	13.91	6.16	11.69	1.61	22.42	20.70	16.55
14.71	d_2 = 20	2.57	4.63	10.98	3.69	9.77	15.61	6.96	12.04	1.69	15.57	17.12	15.37
19.61	d_2 = 20	2.34	4.40	11.32	3.77	9.85	15.61	6.72	11.49	1.63	15.93	16.27	13.37
24.52	d_2 = 20	2.14	4.30	11.66	3.79	10.30	15.05	6.37	11.52	1.61	13.86	16.24	12.92

Table 3. Experimental results for the compressive strength of granules with a diameter – d_1 = 10 mm and height – h_1 = 10 mm.

Pressure of press, MPa	Compressive strength for the granules from the respective mixture, MPa											
	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9	M-10	M-11	M-12
7.35	10.99	14.42	6.17	13.30	12.80	8.45	12.16	4.19	11.11	5.68	3.04	4.08
9.81	8.43	13.56	5.38	11.13	16.44	5.68	9.71	4.73	9.97	5.50	4.31	5.11
12.26	7.38	13.60	7.34	14.46	14.07	6.94	14.63	4.72	8.71	6.06	4.47	5.65

Table 4. Experimental results for the compressive strength of granules with diameter – d_2 = 20 mm and height – h_2 = 10 mm.

Pressure of press, MPa	Compressive strength for the granules from the respective mixture, MPa											
	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9	M-10	M-11	M-12
14.71	4.85	6.47	3.63	6.32	6.67	7.50	6.33	2.60	5.39	6.37	3.92	3.96
19.61	5.25	7.06	3.60	7.09	8.04	6.37	6.57	4.22	5.79	5.39	4.90	5.79
24.52	5.39	7.40	5.20	7.49	8.53	9.41	7.40	4.56	6.42	6.87	3.60	6.51

relationship between the used green lye quantity and the moisture of the products obtained.

The reference data for standard granulated fertilizers show that the moisture content varies from 3 to 4 % for superphosphates [18]; from 0.4 to 1 % for ammonium nitrate [17]; and from 0.2 to 1.7 % for different NPK fertilizers [21]. The results from Table 2 confirm that the closest to standard fertilizers moisture are the values of the granules from mixtures M-1 (2.14 – 2.75 %) and M-9 (1.56 – 1.71 %).

The pressed down and dried granules were tested for compressive strength. The tests were done as described in [19]. In Tables 3 and 4 are shown the values of the applied pressures when obtaining the granules and respectively – the values of the pressures where breakage is coming. The values of the compressive strength for mixtures with sulphuric acid vary from 2.60 to 16.44 MPa. These values are comparable to the values for the compressive strength of some standard fertilizers, like granulated ammonium sulphate = 4.00 MPa; ammonium nitrate = 1.83 – 1.96 MPa; simple ammonium double superphosphate = 3.43 – 5.88 MPa; nitroamofoska (N:P:K = 1:1:1), from disk granulator = 9.02 – 10.93 MPa; amofos (N-12 %, P_2O_5–52 %) = 2.94 – 9.81 MPa; carboamofos, granulated in a boiling layer = 1.67 – 6.87 MPa [17, 21]. The obtained values for the compressive strength of mixtures M-2, M-4, M-5 and M-7, for both diameters of the granules are the highest. The obtained strength values confirm that the produced new soil-conditioners will have better stability during storage and transport. The granules from mixture M-5 with diameter d_2 = 20 mm have the highest values of compressive strength, and with diameter d_1 = 10 mm – are among the first three. The compressive strength of the granules with sulphuric acid (M-1 to M-9) shows that only the products from mixtures M-3 and M-8 are very close to the two component mixtures (M-10 - M-12). It is obvious that both – two and three component mixtures are suitable for obtaining soil-conditioners with the needed compressive strength - *2.60 – 16.44 MPa* for *biomass ash, green lye and sulphuric acid,* and *2.13 – 15.49 MPa* for *biomass ash, green lye and ammonium sulphate* [19]. The experimental work proved that the needed compressive strength of the granules could be achieved at a wider range of initial mixture moisture. This allows for using different ratios of the components, depending of the soil types and other conditions. Taking into account the cost of the raw materials used, for practical production of granulated soil-conditioners mixture M-5 (*biomass ash:green lye:sulphuric acid = 3.7:2:1*) can be recommended. The content of biomass ash in this mixture is 55 %, green lye – 30 % and sulphuric acid – 15 %. The moisture values for the obtained granules from this mixture are in the limits between 7.89 – 10.30 %.

During the three-month storage of the granules (of room conditions), it negative changes in relation with surface or volume caking or changes of the geometric form were not registered. This proves that the obtained products are stable and suitable for practical use.

CONCLUSIONS

The experiments proved that the production of granulated soil-conditioners on the basis of biomass ash, green lye and sulphuric acid is completely feasible. The determined values for compressive strength of the granules from the studied mixtures are comparable to, and even better (in some cases) than for some standard mineral fertilizers. For practical application and implementation of further tests, with the aim of realization of industrial production of soil-conditioners mixture, M-5 is recommended.

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