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COMPOSITE COMPOST PRODUCED FROM ORGANIC WASTE

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Abstract. The soil fertilization in ecological agriculture is done mostly using organic fertilizers. Some of them are prepared as compost from waste, but other haven't, until now, any recycling possibility. In this context, for the preparation of new types of compost, we used three type of waste: sewage sludge from waste water treatment, marine algae and farmyard manure. We have made four different composting variants, each consisting of different proportions of the three waste: equal parts (33.33%) of each waste, 50% of each of the three wastes separately, the difference being made up in equal amounts (25%) of the other two wastes. Composting process was performed in Könemann silos (cubs with side by 1.20m) and lasted 60 days, from July 19 until September 16, when the composted material has passed the stages of reduction and oxidation. During composting process, in the reductive stage the material has reached a temperature up to 63^{o}C Celsius, enough heat for its sterilization. Initial material, semi composted and final composted material were been chemical analyzed, especially in terms of macro- and microelements, analytical results revealing high and normal content of such chemicals. Therefore the achieved compost could be used in organic farming systems.

Introduction.

Expansion of organic farming requires increasingly quantities of organic fertilizer consisting of semi-fermented manure, compost made up from various organic materials, or green fertilizers. But, as such materials are to be found more and more difficult in desired quantities, obtaining new composts from organic materials that have not found a clear way of recycling, remains a goal of our time.

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In this context, we have initiated a research program to develop a recycling project by composting such materials and their use in agriculture. We have chosen three waste, one of which being used for thousands of years as a source of nutrients for soils and plants, namely farmyard manure. On the second waste we used, sewage sludge from municipal waste water treatment, there are still controversies with regard to its use in agriculture (Bengtsson and Tillman, 2004). Considering the fact that sewage sludge may contain different components and chemicals potential pollutant for soil and plant, must be always known its composition to know that it can be used or not in agriculture. The third waste used by us, seaweed, it has been tested with the aim of use in agriculture in the form of extracts with fertilizing or protective role (Zodape S. T., 2001; Raja Sulochana and Krishnamoorty, 2014).

The present paper presents the composting technology of three wastes and chemical composition of the final material obtained, possibly to be used as organic fertilizer in agriculture.

Material and methods

Farmyard manure was collected from several livestock farms in Agigea, Constanta County, sewage sludge derived from wastewater treatment plant of Eforie South, also Constanta County, and marine algae were collected from the Romanian shore of Black Sea, between Agigea and Eforie South. Waste were composted in composting silos Könemann type, each with a volume of 1.78 m^3, in four different mass proportions representing the following variants: equal parts (33.33%) of each waste, 50% of each of the three wastes separately, the difference being made up in equal amounts (25%) of the other two wastes. Composting lasted about 50 days, while temperature and humidity were recorded at regular intervals of time. In the first part of the time, represented by the reducing phase, the temperature rose to 50-60º value C, the material is subjected to a sterilization process becoming thus free of pathogens. In the last part of the period, in the oxidative phase, temperature has lowered and remained at a relatively constant value of 30^{o}C, indicating that the composting process has completed. It has achieved a dark material, without unpleasant odors. Compost was finely ground in a special mill until the centimeter level size.

Initially the three wastes were analyzed in terms of content in nutrients and toxic substances. Similar analyzes were carried out during composting and the end of the process.

The material reaction (pH) was measured by potentiometric method in aqueous suspension using a couple of glass electrode-calomel. The total soluble salts (TSC) content was measured by conductometry, the total organic carbon (TOC) was determined by Walkley-Black method, modified by Gogoașă, total

nitrogen was determined by Kjeldahl method, the contents of mineral forms of nitrogen (N-NO_3 and N-NH_4) was potentiometric measured using ion electrode indicators. Mobile forms of phosphorus and potassium carried out by spectrophotometry, respectively flame spectrometry, in acetate-lactate ammonium solution (AL) at 3.7 pH, by Egner-Riehm-Domingo method. The total content of microelements (Co, Cu, Fe, Mn, Zn) and heavy metals (Cd, Cr, Ni, Pb) was measured with flame atomic absorption spectrometer in hydrochloric solution resulted by digestion of material samples in $HClO_4$-HNO_3 mixture. The contents of macro-elements, excluding N, trace elements and heavy metals in samples of the marine algae were determined by spectrophotometric and flame photometric methods, and by atomic absorption spectrometry in clorhydric solution obtained after solubilization of ash resulted by the seaweed calcination for several hours at 450ºC. The analytical methods used are standardized in ISO and STAS systems.

Results and discussion

Chemical composition of the wastes used.

The farmyard manure has a weak alkaline reaction, a high content of organic carbon and total nitrogen, moderate of nitric nitrogen, of ammonium nitrogen and mobile phosphorus, soluble in acetate-lactate ammonium at pH 3.7, but very high mobile potassium content, soluble in the same conventional reagent. The contents of microelements and heavy metals recorded are normal, comparable to those existing in unpolluted soils (Lăcătușu, 2006).

The sewage sludge from wastewater treatment plant of Eforie South city has a neutral reaction and high and very high content of organic carbon, total nitrogen, ammonia nitrogen and mobile forms of phosphorus and potassium. The quantity of nitric nitrogen is reduced, which demonstrates that at the time of analysis, the sludge was fresh, not having the time necessary for the initiation and development of the nitrification process. Of the microelements and heavy metals determined, it can be noticed high levels of Zn, and slightly raised levels for Cr, Cu and Pb, as compared with normal values of agricultural soils.

The marine algae are represented mainly by two species *Cladophora sp.* and *Ulva lactuca*. The analytic data of the two species, as well as the mixing sample reveals higher content of N, K, Ca and normal content of microelements and heavy metals.

Regarding the content of total soluble salts, the two waste (farmyard manure and sewage sludge) have moderate concentrations (531-658 mg/100 g), being present each of hydrosoluble ions, standing out, however, K^+ in farmyard manure stable SO_4^{2-} in sewage sludge. Potassium ions are released from the

chloride and sulfate in the case of farmyard manure, and sulfate ions from sodium sulfate and magnesium sulfate in sewage sludge.

Composting of three organic masses

In order to achieve a good nutritional quality compost, were tested four variants, distinguished from each other by the ratio between the three organic components:

V1= 33.33% farmyard manure + 33.33% sewage sludge + 33.33% marine algae
V2 = 50% farmyard manure + 25 % sewage sludge + 25% marine algae
V3 = 25% farmyard manure + 50 % sewage sludge + 25% marine algae
V4 = 25% farmyard manure + 25 % sewage sludge + 50% marine algae

Experimental mixtures variants have been introduced in four composting cubes with the sides equal to 1.20 m, known as Könemann silos. At the top was made an oblique roof to protect the composite mixtures from precipitation water.

The composting operation started on 19 July 2014. Every day temperature measurements, in three positions (the top of the mixture, middle part and the lower part), and at three different times (7.00, 12.00 and 19.00), were carried out. The measured values show that the maximum temperatures were been achieved in the composting cubes go up to 63^{o}C, primarily in the evening and at measurements taken on the top and middle sections of the composting cube. It should be noted that temperatures above 60^{o}C have been achieved in the third variant of mixture composite, consisting of two parts sewage sludge (50%) and as far as a part of farmyard manure (25 %), respectively, of marine algae (25 %). The explanation is quite simple, the double dose of sewage sludge along with those simple of farmyard manure has allowed development of a reducing environment faster than the other experimental variants. Maintaining the composting environment at temperatures above 55-63^{o}C for 19-20 days has fully contributed to sterilization of organic masses subjected to the composting process. On August 19th 2014, a reshuffling of material from the composting cubes were done, temperature reaching those of the ambient, around 30^{o}C. After rebuilding of the composting cubes, other new phase of the reduction process did not occurred, recorded temperatures remaining practically constant, meaning that the composting process has completed. Finally, the cubes were deployed, compost obtained was dried at ambient temperature, and then it was passed through a special mill obtaining compost in the form of pellets.

Chemical analysis of compost

Although there have been slight changes in pH, the values have been maintained in slightly alkaline domain. The changes were been higher, with an increase up to 0.5 pH units to the variant V1 (table 1).

At the end of composting important to note is the significant decrease of organic C content, averaging almost seven times (6.9), and a slight increase in total N content of 1.4 times, as compared to the values recorded to the analyzes performed in the intermediate stage of the composting process. These changes in the content of organic C and total N led to major changes in the C / N ratio. Thus, if in the intermediate phase of composting it was on an average of 136, in the final stage of the process it has reached 14.6, a C / N ratio normally for soil. This aspect reinforces the fact that the timing of completion of the composting process was correctly recorded.

If the final stage of composting were not reported significant changes in the content of $N\text{-}NH_4$ instead of $N\text{-}NO_3$ content increased up to 10 times, which is another signal for the completion of the composting process. A significant decrease of 1.9 times was registered for mobile P content, soluble in AL, instead of mobile K, also soluble in AL, which has remained in relatively constant limits. The average difference between the two content was only 179 mg • kg^{-1} (table 1).

Table 1. The main agrochemical properties of organic materials at the intermediate and final phase of composting process

Variant	pH	TOC	Nt	C/N	$N\text{-}NO_3$	$N\text{-}NH_4$	P_{AL}*	K_{AL}
	H_2O	%			mg·kg^{-1}			
Intermediate phase								
V1=1MA+1SS+1FM	7,54	87,8	0,71	145	133	65	414	6550
V2=2FM+1MA+1SS	7,83	94,7	0,68	164	301	46	311	4850
V3=2SS+1MA+1FM	7,90	75,2	0,69	127	25	83	292	4900
V4=2MA+1SS+1FM	7,72	79,4	0,81	106	36	118	330	4700
Final phase								
V1=1MA+1SS+1FM	8,09	11,92	0,99	14,0	439	89	181	5983
V2=2FM+1MA+1SS	8,10	12,06	0,88	15,9	1224	76	187	5833
V3=2SS+1MA+1FM	7,92	13,78	1,09	14,6	2243	105	196	5517
V4=2MA+1SS+1FM	7,82	11,09	0,94	13,8	1124	74	205	4383

MA-marine algae; SS-sewage sludge; FM-farmyard manure

*) values calculated according to the reaction of the material

In the case of microelements and heavy metals, we can talk about a trend of decrease in the concentration of heavy metals with toxic properties (Cr, Ni, Pb), and an increase in the concentration of metallic microelements with role in plant nutrition (Cu, Zn), (table 2).

The total soluble salts content (Table 3) shows high values ranging between 1944 and 3225 mg/100 g material on the intermediate composting stage, consist in sulphates and chlorides associated with sodium and potassium (Table 4), which determines that sodium sulphate and potassium chloride to be dominant salts, followed by magnesium sulphate.

Table 2. The content of the microelements and heavy metals ($mg \cdot kg^{-1}$) of organic materials at the intermediate and final phase of composting process

Variant	Cd	Co	Cr	Cu	Fe %	Mn	Ni	Pb	Zn
Intermediate phase									
V1=1MA+1SS+1FM	0,42	8,7	118	26	1,56	459	47	75	97
V2=2FM+1MA+1SS	0,41	7,4	128	16	1,68	524	52	58	77
V3=2SS+1MA+1FM	0,47	10,7	124	19	1,43	479	37	67	102
V4=2MA+1SS+1FM	0,65	12,7	93	23	1,47	477	37	61	82
Final phase									
V1=1MA+1SS+1FM	0,54	6,74	102	43	1,66	462	38	53	200
V2=2FM+1MA+1SS	0,47	6,66	102	37	1,71	508	38	63	151
V3=2SS+1MA+1FM	0,55	7,73	82	40	1,61	472	33	46	188
V4=2MA+1SS+1FM	0,46	5,51	81	42	1,50	410	30	50	166

Table 3. Total soluble salt and hydro-soluble ions content of organic materials at the intermediate and final phase of composting process

Variant identification	TSC	HCO_3^-	SO_4^{2-}	Cl^-	Ca^{2+}	Mg^{2+}	Na^+	K^+
	mg/100 g material							
Intermediate phase								
V1=1MA+1SS+1FM	3225	3	114	1189	557	189	135	392
V2=2FM+1MA+1SS	1944	0	68	676	317	97	70	237
V3=2SS+1MA+1FM	2813	6	94	1108	448	169	126	377
V4=2MA+1SS+1FM	2772	9	121	1051	472	193	125	367
Final phase								
V1=1MA+1SS+1FM	2358	102	981	396	102	117	250	410
V2=2FM+1MA+1SS	2216	119	886	372	92	92	228	428
V3=2SS+1MA+1FM	2891	195	1594	614	126	187	418	429
V4=2MA+1SS+1FM	2500	105	1164	392	124	135	280	301

If in the intermediate stage of the composting process, the amplitude of the total salt content values was larger, namely 1281 mg/100 g of material, in the

final stage values were closer, the difference reducing to 675 mg/100 g of material. Although not very much, the average value of total salt content has decreased in the final stage as compared to intermediate stage of composting process, from 2688 mg/100 g material to 2491 mg/100 g material.

In terms of ionic distribution a slight increase in the content of the sulphates, in the final stage of composting, it was occurred. In fact, Mg and Na sulphates were the dominant salts in aqueous extract, in particular in the variant where sewage sludge and marine algae are in double proportions as compared to the other two materials (table 4), followed by potassium chloride.

Table 4. Percentage composition (%) of soluble salts of organic materials at the intermediate and final phase of composting process

Variant identification	Na_2CO_3	$Ca(HCO_3)_2$	$CaSO_4$	$MgSO_4$	Na_2SO_4	NaCl	KCl
Intermediate phase							
V1=1MA+1SS+1FM	0,2	1,0	0	21,1	37,3	0,4	36,6
V2=2FM+1MA+1SS	0	0,9	0	16,6	36,0	0	37,0
V3=2SS+1MA+1FM	0,5	1,1	0	23,2	38,5	2,4	31,3
V4=2MA+1SS+1FM	0,8	1,3	0	23,2	35,2	6,2	29,3
Final phase							
V1=1MA+1SS+1FM	0	5,0	9,1	26,7	25,6	4,5	29,1
V2=2FM+1MA+1SS	0	6,3	7,6	22,9	29,3	0,7	33,2
V3=2SS+1MA+1FM	0	6,0	6,4	30,4	25,0	10,7	21,6
V4=2MA+1SS+1FM	0	4,6	12,1	29,7	23,7	9,1	20,8

Conclusions.

Original organic materials used for developing a new organic fertilizer contain large amounts of macronutrients, slight increase amount of microelements (Cu, Zn) and normal content of heavy metals.

The composting operation lasted for 52 days, during which time alternated the reducing and oxidative phases of the process, thermal values generated by organic matter decomposition have reached 50-63^{o}C, temperature which have contributed to sterilization of material represented by the mixture of waste.

The obtained compost had a neutral-slightly alkaline reaction, a high content of organic C, total N, nitric N, mobile P and K, normal content of microelements and heavy metals and a medium contents of soluble salts, predominantly KCl, $MgSO_4$ and Na_2SO_4.

The compost achieved has all the qualities to be used for soil fertilization in organic farming system.

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