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Physico-chemical and microbiological composition of composts from Bucharest municipal waste

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Abstract

Average composition of household waste in Bucharest has a large variability. The average amount of waste collected is 0.048 m^3 /man. year compared with the U.S. 1m^3/ man. year, South Africa 0.8 m3 / man . year and Australia 0.4 m^3/ man. year. These wastes are sorted, the size which could be sorted and reused according to their composition, remaining part, about 64 % of the original composition is subject to biodegradation by composting. The material resulting from the biodegradable composting was analyzed in terms of the physical- chemical and microbiological properties. Physical analyzes aimed material granulometry, humidity and porosity. Chemical analyzes were conducted on fractions and consisted in determining pH, salt content and soluble elements such as Ca, Mg , N , P , K, as well as heavy metals (Cu, Zn , Pb , Cd , Ni , etc.). In order to assess biodegradability of the waste material the breath was determined. The results showed variability in physical characteristics between batches of compost from municipal waste, variability of the chemical characteristics of graded according including especially heavy metals and other hazardous elements. This variation indicates that the coarse fractions have a higher amount of N, P, K and small in high fractions of heavy metals. Determination of breath biodegradable material can be a valuable indicator of degradation phenomenon completion.

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Keywords: environment, solid waste, composting, agriculture

1. Introduction

The waste management is based on Romanian National Strategy for Waste Management (RNSWM) and National Plan for Waste Management – approved in 2004 – by Government Decision No.1470/2004.

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Ministry of Environment and Sustainable Development is preparing a new RNSWM for the period 2016 – 2023, which will take into consideration all the requirements of the Thematic Strategy on Waste Prevention and Recycling – COM(2005)666. The general objective of RNSWM 2016 is: Environmental protection and health population protection through generation of low quantities of waste that will be sustainable managed with the reduction of impact on the environment.

One of the most serious problems of the environmental protection field is the waste generation in large quantities and their inadequate management.

The collection and disposal of municipal waste is the municipality responsibility, directly, through the specialised departments within the Local Boards, or indirectly – by granting this duty to special sanitation services, on a contract basis. The sanitation services exist and operate mainly in the urban areas.

In Bucharest in 2015 were 358 operators recorded as authorized for the activity of collection and / or recyclable waste of which 30% was collecting of scrap metal.

The waste management means the management, administration and control systematic pre-collection activities, selection, proper collection, transport, treatment, recovery, disposal and waste storage.

The amount of municipal waste (Bucharest town collected) from the population is estimated at about 633 203 t/year (~ 50,000 m³ / week average density of 0.25 kg/l).

"Municipal waste" means both household waste and bulky waste collected separately and waste to clean public spaces (waste from parks, markets, street waste).

Bucharest has several companies that deal with the collection, sorting and disposal of municipal waste.

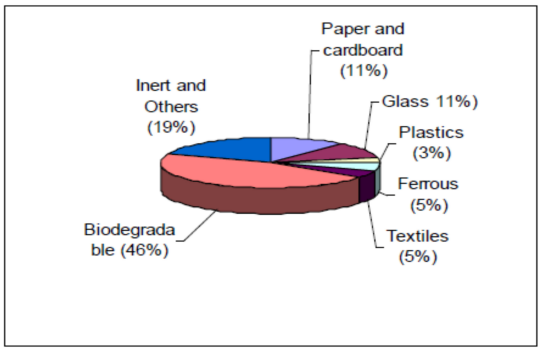

Fig. 1 - Composition of household and assimilative waste – Romania – 2013

Waste management should aim to reduce the source of waste production and its harmfulness, various waste treatment technologies and specific as possible complementary controlled storage of waste ensuring a minimum impact on the environment and human health.

According to the EU's strategy for waste management systems hierarchy is based on the minimization-reuse-recycle [principle] and in the second stage on the elimination (Zucconi, 1987).

Waste management options follow (Pedra, 2007; Richard, 1992):

-prevent occurrence - by applying "clean technologies" in activities that generate waste;

-reducing quantities - by applying best practices in each field generator of waste;

-capitalization - through reuse, recycling material and energy recovery;

-elimination - by storage, incineration and composting.

In principle, recovery and recycling solutions are represented by composting (aerobic digestion) and anaerobic digestion with biogas production and collection (Giusquiani, 1995; Shekdar, 1992).

Given the international experience, Romania is aware that in order to effectively use composting is necessary to have a selective collection of biodegradable waste from landfills.

Compost represents an important source of soil fertility and particularly in those countries where the organic matter content of the soil is low. Soil organic matter plays a major role in maintaining soil quality (Pedra, 2007). In

addition to supplying plant nutrients, the type and amount of soil organic matter influences several soil properties, increasing the soil organic matter, enhances soil quality, reduces soil erosion, increases plant productivity and soil microbial biomass.

Thus, in the regions where organic matter content of the soil is low, agricultural use of organic compost is recommended for increasing soil organic matter content and consequently to improve and maintain soil quality. Apart of increasing soil organic matter content, application of organic compost can affect soil quality by:

- decreasing the need of chemical fertilizers;
- allowing for more rapid growth in plants;
-increase the C in soil and soil organic matter and N and P contents;
- improving tillage and workability of soil;
- increasing soil microbial biomass and activity.

However, heavy metals such as Cd, Cu, Pb and Zn are found in all compost, and there are obvious concerns about such toxic elements entering the food chain through food crops to which composts have been applied as fertilizer (Gillett, 1992).

According to Richard (1992), heavy metals are not biodegraded by process of composting, and can become concentrated due to the loss of carbon and water from the compost due to decomposition.

In order to regulate the land application of heavy metals in municipal solid waste compost, various countries from European Union and the USA have regulated the heavy metal content in municipal solid waste compost by providing permissible limit. The limits for toxic compounds in composts were set by Compost Legislation and Standards - Heavy Metals and Organic Compounds from Organic Wastes Fertilizers Used as ANNEX 2. Thus, the application of municipal solid waste compost in soil can promote changes in soil microbial biomass and activity, mainly due heavy metals content.

The objectives of the research are to investigate physical, chemical and microbiological properties of different biodegradable compost size fractions, to determine the distribution of nutrient elements and heavy metals among fractions of compost.

2. Materials and methods

In the research were carried out chemical analysis, physical and microbiological environments on five samples taken from the material obtained by treating samples stabilized by composting of municipal waste from Bucharest. After sampling these were analyzed according to Methods for the Analysis of Compost (Federal Compost Qulity Assurance Organisation FCQAO).

Biologically stabilized material samples were made up of several individual samples collected according to the methodology in force existing in the European Community. These samples came from removing coarse material consisting of glass, plastic, metal. Composting material to be included 36% food waste, 5.2% plastics, 4.8% paper, 2.2% glass measured by obtaining the dry weight of a known volume of sample.

Chemical analyses consist on organic matter content, total nitrogen (Kjeldahl method), phosphorus content by photocolorimetric method and potasium content using phlamphotometric method.

To determine the pretability of biodegradable material for agriculture use there were made the pH contents , total soluble salts and heavy metals (Cr, Ni, Zn, Cd and Cu)contents. pH content was made with potentimetric method, and 51.8% dust and construction material. The compost was produced in composting reactor with aeration. The level of humidity was maintained at 50-60% and temperature at the moment of composted was 60-65oC (Epstein, 1997; GallardoLara, 1987).

The material sampled for the analyses was made after this process. The samples were air-dried at 70oC and 105^{o}C to determine the humidity and TS (total solids)%. Initialy the samples were sieved by hand to separate nonbiodegradable components (sand, wood and glass)greater than 5mm. The material results was analysed with automatic sieves at dimensions : < 0,2mm, < 0,2mm – 0.2mm, 0.2mm-0.5mm, 0.5mm – 1mm, 1mm – 2mm, 2mm – 5mm.It was made also bulk density total soluble salts with conductometric method and at heavy metals content was used humid digestion with mixted concentrated acids and absorbtion spectrophotometric method for determination.

Microbiological test consist in breath and catalaze analyses to determine the level of biodegradation process. The breath indicator was analyse with Stefanic method and catalaze analyse with Kőnig method (Dommergue, 1960; Stefanic, 1988; Stefanic, 1994).

3. Results and discussions

Particle size analysis of biodegradable compost samples (Table 1) revealed a high content of 29.03% biodegradable particles with sizes over 5 mm which shows a great loosening of the material analyzed. In terms of particle size distribution is between 0.5mm majority and 2mm (49.826%). The large amount of small particles shows that the composting material is high and its application on agricultural land does not affect soil composition (Chen, 1993). It can be seen that the variation in particle size is small so composting biodegradation process is one with high efficiency.

Humidity compost is high 33.10% which ensures composting process continuity and ensuring appropriate conditions for biological activity during composting material.

Chemical analyzes were performed on separate granulometric fractions to see their impact on soil that will be incorporated in these composts.

pH of the material analyzed (Table 2) varies between 6.85 and 7.32, a favorable pH plant growth and this value shows a good biological stabilization of the analyzed material. Data analysis can say that it has a slight increase during growth in particle size.

Organic C content or organic matter varies between 8.84% and 13.56%, characterized as a high content which shows that the application of these composts on soil have the ability to provide a good intake and an adequate supply of land (Anderson,1989).

Table 1. Granulometric analyses of compost samples

Sample no.	Granulometric analyse, %							Dry matters, %	Bulk density, t/m3
	< 0.2mm	0.2mm	0.5mm	1 mm	2 mm	5 mm	> 5mm		
1	5.27	8.016	11.426	15.438	21.75	6.43	31.66	33.3828	0.68
2	5.35	8.27	11.52	16.327	22.05	6.52	29.96	32.5870	0.75
3	5.02	8.35	12.32	15.21	21.95	7.32	29.83	33.1250	0.74
4	6.25	9.21	13.20	14.36	23.12	6.98	26.88	32.9856	0.81
5	6.54	9.32	12.03	16.30	22.13	6.85	26.83	33.4251	0.83
Medium value	5.686	8.633	12.099	15.527	22.20	6.82	29.03	33.1011	0.762

Table 2. Some chemical characteristics of compost depending with particule size

Compost particule size, mm	pH	Organic matter, %	Soluble salts, %	Nitrogen,%	Phosphorus, %	Potasium, %
< 0,2mm	6.85	8.84	1.2138	0.57	0.34	1.21
0,2mm	7.15	10.23	1.1879	0.65	0.23	1.11
0,5mm	7.20	11.35	1.1925	0.87	0.13	0.98
1 mm	7.22	12.36	1.2356	0.75	0.42	1.02
2 mm	7.23	11.12	1.3546	0.90	0.37	0.95
5 mm	7.32	13.56	1.2254	0.92	0.45	0.97

High amount of organic matter must be correlated with a high intake of nitrogen. When analyzed nitrogen content in compost increases during growth of particle size from 0.57% in particle size <0.2 mm to 0.92% for coarse particles greater than 5 mm. This increase is concomitant with increasing organic matter which provides a satisfactory report between C / N which can lead to the formation of humus in the soil (Barral, 2009).

Where these composts are used in ecological reconstruction of degraded soils or as a coating material for plant growth and development is required to N fertilization with balancing C and N lifting content (Bastida, 2007; Bundela, 2010; Canellas, 2001).

Analyses carried out indicate phosphorus content ranging from 0.13% to 0.45%. This variation is related to particle size material but overall phosphorus content of compost is low and if this material is applied to the soil with fertilizer intervention is required phosphorus addition.

Potassium also has a small variation in particle size material with high values at 1.21% respectively grained to <0.2 mm and 1.11 to 0.2mm to 5mm but potassium content is 0.97% and in this case if the compost biodegradable material is used as ground cover is necessary additional fertilization with this element.

Table 3. Concentrations of heavy metals in different compost particle size fractions

Compost particule size, mm	Pb, ppm	Cr, ppm	Ni, ppm	Zn, ppm	Cd, ppm	Cu, ppm
< 0,2mm	122 ±12	82 ± 2	74.9 ± 2,3	582 ± 12	2.3 ± 0.06	396 ± 22
0,2mm	209±11	74±1	80±7.4	654±23	2.1±0.11	423±21
0,5mm	220±20	112±3	106±2.1	745±20	2.2±0.10	450±20
1 mm	210±12	82±2	96±3.2	760±32	2.3±0.13	523±23
2 mm	125±10	108±2	102±2.3	687±30	2.4±0.10	465±25
5 mm	118±12	68±2	78±2.5	548±25	2.3±0.08	325±21
MPL, ppm	300	100	100	1000	3	600

Among the toxic elements were analyzed heavy metals Cr, Ni, Zn, Cd and Cu. Analysis of total forms of these elements show a low potential for pollution of biologically stabilized material analyzed. Comparing the values obtained from the analysis of the Maximum Permissible Levels approved by the European Community for compost is observed that all values fall below the toxic potential. (Compost Legislation and Standards - Heavy Metals and Organic Compounds from Organic Wastes Fertilizers Used as ANNEX 2).

Microbiological analysis included determination of respiration and catalase. In this case it was considered biodegradable compost and was compared to a garden soil to see if the decomposition is total. Results of the breath are the rate of biodegradation of the material analyzed. From this point of view, the results indicate that the degradation process is not fully completed.

Table 4. Microbiological analysis composting biodegradable

Sample no.	Breathing, CO2 (mg / 100g)		Catalase, cm3O2 / 100g	
	compost biodegradable	Garden soil	compost biodegradable	Garden soil
1	96.99	44.09	588.893	233.731
2	91.57	46.10	596.998	231.968
3	94.27	42.05	592.945	232.849
4	93.25	45.20	589.745	232.965
5	94.10	43.10	591.654	233.415

4. Conclusions

The analyses made on the composted municipal solid waste showed a large variability of particle size. The humidity of these composts are higher 33.10%, pH of the material varies between 6.85 and 7.32 which ensure the potential of use of them in agriculture.

The content of carbon and nitrogen contents were high but phosphorus and potassium are low so it is necessary a supplementary use of fertilizer for the growth of plants.

Because of the presence of heavy metals in the compost it is necessary to analyze every biodegraded compost to limit the charge of soil with these elements.

The conclusion is that analyzes conducted biological material under investigation is stabilized at less than 90%. If after biological stabilization period follows a period of maturation of this material, the degree of stabilization can reach 95%.

The material can be used as compost for potted ornamental plants but also material for ecological restoration of degraded soils.

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