Studii şi Cercetări Ştiinţifice
Chimie şi Inginerie Chimică, Biotehnologii, Industrie Alimentară

2012, **13** (2), pp. 169 – 176

Scientific Study & Research
Chemistry & Chemical Engineering, Biotechnology, Food Industry

ISSN 1582-540X

ORIGINAL RESEARCH PAPER

BIOHUMUS PRODUCTION BY WORMS' COMPOSTING OF SOME FOOD WASTES

Daniela Suteu[1*], Carmen Zaharia[2], Marinela Badeanu[3]

[1] "Gheorghe Asachi" Technical University of Iasi, Faculty of Chemical Engineering and Environment Protection, Department of Biochemical Engineering, 71A Prof. D. Mangeron Blvd, 700050, Iasi, Romania
[2] "Gheorghe Asachi" Technical University of Iasi, Faculty of Chemical Engineering and Environment Protection, Department of Environmental Engineering and Management, 71A Prof. D. Mangeron Blvd, 700050, Iasi, Romania
[3] University of Agricultural Sciences and Veterinary Medicine of Iasi, Faculty of Horticulture, 3 Aleea M. Sadoveanu, 700490, Iasi, Romania

*Corresponding author: danasuteu67@yahoo.com

Received: July, 14, 2011
Accepted: May, 10, 2012

Abstract: A laboratory set-up scale application of a simple worms' composting technology is presented together with the waste and biohumus characterization, description of technological process and operational conditions. The laboratory application is not a complicated one, when the optimum conditions necessary for the digestion process are accomplished and is recommended in the farms where the biodegradable wastes are produced and accumulated in moderate quantities. The main product, *biohumus,* can be used as fertilizer for the soil, in agriculture or flower cropping.

Keywords: *biocompost*, *domestic food wastes*, *solid waste management, worm composting*

INTRODUCTION

The methodology used to develop systems to treat and dispose the industrial wastes is distinctly different from the methodology used for municipal or domestic wastes. There are a lot of similarities in the characteristics of wastes from one municipality, or one region to another. Because of this, the best approach to design a treatment system for municipal wastes is to analyze the performance characteristics of many existing municipal systems and deduce an optimal set of design parameters for the system under consideration [1-6].

The solid domestic wastes are normally deposited in trash cans and dumpsters and collected by a local trash hauler for disposal in a municipal landfill or treatment at a municipal incinerator, composting or anaerobic digestion plant. Waste treatment processes can be understood as treatment processes (i.e. mechanical, chemical, physicochemical or biological processes) of substances (i.e. liquid, solid and/or gaseous substances) resulting from a system of interrelated activities [4, 7].

The organic (biodegradable) wastes represent an important part of the city wastes, approximately 40-70 % [8, 9]. There are also important quantities of wastes from the agriculture and zootechnics, from agro-industrial processes, as well as the mud from the water treatment stations [8, 10].

Biological treatment processes based on anaerobic or aerobic digestion processes are used for an energetic reason or for the production of other useful products (i.e. biohumus) or by-products. Thus, among the biotechnologies applied for the waste exploitation and treatment, the digestion technology is highly considered in the last times (i.e. aerobic – compost and anaerobic – anaerobic fermentation).

Composting is a complex biological process of fermentation-decomposition, under the microbiological and enzymatic action of the biodegradable organic material, animal, vegetal, or/and industrial wastes and by-products. All these wastes are transformed through biosynthesis processes in a new organic product, practically non-contaminating one, with higher quality than the waste it comes from, rich in humic substances and nutritive elements, called *compost* [11, 12]. There are many composting technologies specific to small or individual systems, or individualized ones, high technology and advanced plants.

Worms' composting is a relatively cold composting process of the organic waste with the help of the worms, mainly based on them capacity to use various types of organic wastes as food [10]. The worms crumble mechanically the compostable organic material, and partially decompose it after swallowing. Then biochemical decomposition is realized through bacteria and different chemical substances presented in the worm's digestive tract [1]. Eventually, the waste is transformed into organic fertilizer called **biohumus** or **biocompost**.

Earthworms intervene in the transformation of the organic waste into biohumus (*Annelida*, *Oligochaeta* class), by nutrition processes using several types of organic wastes, which are passing through some fermentation processes [13 – 15]. The wastes with a high biodegradable fraction are used in wormculture as: domestic waste, vegetal waste, or animal debris.

The worms' composting technology is not a complicated one, when optimal conditions necessary for a good fermentation process are accomplished. It is recommended in the farms where the biodegradable wastes are produced and accumulated in moderate quantities. The duration of the fermentation depends on the types of wastes used as a nutritive layer for earthworms [10].

The *biohumus* can be used as fertilizer for the soil, in agriculture or flower cropping. It can be used one year after fermentation. The biohumus produced with certain standardized quality indexes is dried, screened and packed in polyethylene bags or send directly to the cropping fields.

This paper has as the main target the presentation of authors' results performed into a laboratory set-up scale application of a simple worms composting, starting with the used waste characterisation, and after the biohumus characterisation and description of procedure used (i.e. type of earthworms, types of wastes, operational conditions).

MATERIALS AND METHOD

Materials

Some of the used biodegradable domestic wastes are represented by some paper and alimentary vegetable wastes (i.e. wastes of potatoes, carrots, apples, radishes).

The principal organisms that contribute to the transformation of biodegradable wastes in biohumus are the earthworms (category of *Annelida*, *Oligochaeta* class), that use into the nutrition process diverse types of organic wastes that are passed through the phases of the fermentation process. The principal species of earthworms used in worms' composting and producing of biohumus must be mentioned: *Eisenia foetida*, *Lumbricus terestris*, *Lumbricus castaneus*, *Lumbricus rubellus*, *Dendrobaena veneta* etc.

The experimental study was performed by using 4 - 6 earthworms from *Eisenia foetida* species (Figure 1).

Figure 1. Earthworm species of *Eisenia foetida*

Working methodology into the worms' composting of biodegradable wastes

It is introduced into a perforated plastic box a quantity of paper waste minced with the role of support, and after is added a part from the finely choped up alimentary wastes. Above these layers, there are added the earthworms and a new quantity of alimentary wastes. All these layers are covered with some paper wastes, that represent both cellulosic materials for earthworms and also a covering material, with the main role of humidity keeping and prevention of the escape of earthworms.

The whole ensembly is maintained at a temperature of 20 – 25°C, taking care that the humidity must to be kept around 50 – 70 % by sprinkling. After a time interval of two weeks it is verified the degree of wastes' composting, collecting a quantity from the biohumus produced and analysing it. The collected quantity of biohumus is replaced with an almost equal quantity of alimentary wastes.

Wastes characterization

Before introducing of wastes into the worms' composting process of wastes these are physical-chemically characterized in order to determine the possible chemical pollutant substances that can affect or even inhibit the earthworms' growth (e.g. traces of heavy metals or pesticides). The analysis methods are adapted after the viable and legal standards for soil characterization [16].

Because the wastes used in worms' composting contain paper and some alimentary wastes (i.e. wastes of potatoes, carrots, apples, radishes) the composition of a waste sample consists of ca. 0.3 – 1.6% mineral substances, humidity of 77.6 – 80%, 1.2 – 14.3% total glucides, 0.2 – 1.3% pectides, 0.3 – 6.5% protides, 0.15 – 0.5% lipids, total amino acids of 4910 – 5200 $mg \cdot g^{-1}$ nitrogen, an other organic portion consisting of cellulose, hemi-cellulose, lignin and derivates (Na-lignate etc.) (no more than 4.1 – 20.5%), and also an inorganic portion consisting of mainly filling and loading material such as calcium carbonate, clay, titanium oxide (ca 0 – 5%) etc. [15].

The determination of iron was performed by extraction into a specific volume (50 mL) of Morgan reagent (i.e. sodium acetate and acetic acid, pH= 4.8). The filtrated extraction solution was analyzed concerning the iron content with the help of o-fenantroline that forms a complex combination of red color with the bivalent ferrous ions. The spectrophotometric analysis method is applied and absorbance measurements were done at λ= 510 nm. The real concentration is calculated by comparison with the values from the calibration curve [17, 18].

For *the determination of other heavy metals* (i.e. Cu, Cd, Zn, Pb) the sample of wastes was disintegrated with a specific volume of Aqua Regis reagent (10 mL) for complete organic matter degradation into a porcelain vessel onto a heated sand bath, and after solid dissolution into HNO_3 2N, and analysis using the atomic absorption spectrometry, with an AAS – AVANTA GBS Spectrometer.

The determination of total content of pesticides. The pesticides were extracted from wastes using a mixture of petroleum ether and acetone (2:1, V:V) [17]. The extract is purified by passing through a Florisil column and after analyzed by gas-chromatography using an Agilent 6890N gas chromatograph with FID detector.

Characterization of the new synthesized biohumus

The biohumus produced by worms' composting of wastes was analyzed by two categories of analysis methods: (i) *organoleptic methods*, and *(ii) physical – chemical methods*, including the following ones: determination of pH, humidity, total organic carbon, total phosphorus, total nitrogen, total soluble salts content, exchangeable calcium and magnesium content.

Potentiometric determination of pH was done on the aqueous extract of humus [17, 18], using a HACH One pH-meter.

Determination of humidity was performed by the gravimetric method [17, 18].

Determination of total organic carbon was done by using the method with 0.2 N $K_2Cr_2O_7$ and conc. H_2SO_4, in which the sample is maintained 10 minutes on a sand bath beforehand heated at 170 – 180°C, and after analyzed by titration with solution of Mohr salt (0.25 N) in the presence of ferroine as indicator [17, 18].
Dermination of total phosphorus was done by using the Eguer-Riehm method [19].
Determination of total nitrogen was performed by using the capability of the organic compounds with nitrogen to be mineralized by heating with concentrated sulfuric acid, in the presence of catalysts, the nitrogen being transformed into ammonia, respectively into ammonium sulfate [18, 20].
Determination of the total soluble salts content (TSSC) was performed by treatment with distilled water of selected wastes during 30 minutes under stirring and after evaporation on a water bath of a specific volume of extraction solution [21].
Determination of exchangeable calcium and magnesium content was made by titration with EDTA in the presence of specific indicators (murexid, erio T) and alkaline pH conditions (pH 10 or 12) of the extraction solution obtained after the treatment of a biohumus sample with an aqueous solution of KCl 1% during 30 minutes under stirring [17].

RESULTS AND DISCUSSION

Characterization of wastes subdue to the worms' composting

The results performed after the analysis of waste samples collected from the mass subdue to the worms' composting were indicated the values for some heavy metals content presented into Table 1.

Table 1. *The experimental data for the characterization of the domestic wastes (content of heavy metals)*

Analyzed chemical species	Experimental value [mg·kg dry mass^{-1}]	Alert limit into standard [mg·kg dry mass^{-1}]
Total pesticides	under detectable limit	< 0.1 [mg·kg^{-1}]
Heavy metals		
Fe	0.8375 – 2.75	< 500 [mg·kg^{-1}]
Cu	1.24	5.00
Cd	2.94	2.50
Zn	9.84	40.0
Pb	-	100.0

It must be mentioned that the value of all analyzed heavy metal contents from the experimental wastes are close or lower than the alert limits from standards. This case of worms' composting could be performed with no restriction due of the pollutant inhibition.

Characterization of the organisms used into the worms' composting

As a result of worms' composting of selected domestic biodegradable wastes at a laboratory set-up scale there were produced modifications both of waste structure by transforming it into biohumus with the help of earthworms under the digestion process, and of the implicated organisms. Thus, if it was worked in the process with 4 – 6 individuals, at the time when we considered the end of the process (after 2 months) into the householder box there are identified 15 individuals. Therefore we can conclude that together with the waste processing, the earthworms were participated also to a multiplication process, in favorable conditions created into this space during the whole developing of the composting process: temperature of until 25°C, humidity of 70 – 80%, and organic foods.

Characterization of the biohumus produced by the worms' composting of some domestic biodegradable wastes

As a result of worms' composting of specific domestic biodegradable wastes it was produced a product, named *biohumus*, of black color and paste consistency, having a very high humidity (71.8%) and acidity of 8.1 (in pH units).
For the subsequent utilization into the agriculture, as an improvement agent of soil properties (soil conditioning agent), the characteristics of produced biohumus must correspond to the required viable standards of the conditioning soil product.
Our performed data are synthetically presented in Table 2 and compared with the values of the same indicators established into the product standards.

Table 2. *The standard values and experimental results of the biohumus analysis produced by worms' composting of some domestic biodegradable wastes*

Characteristics	International standard for the worming compost		Experimental results	
	min.	*max.*	*min.*	*max.*
Active acidity, (pH)	6.5	7.5	-	8.1
Total soluble salts content (TSSC), [%]	-	-	-	0.11
Exchangeable calcium content, [%]	-	4.0	0.35	0.4
Magnesium content, [%]	-	1.0	0.06	0.13
Humidity, [%]	30	40	-	71.83
Total organic carbon (TOC) content, [%]	20	30	1.05	22.77
Phosphorus content, [%]	0.8	1.5	0.23	-
Nitrogen content, [%]	0.9	1.0	0.8	-

As can be seen into the above table the analysis results of biohumus are good in agreement with the international values from standards. Some improvements must be made for reducing of active pH, and humidity but also the increasing of exchangeable calcium content and total organic carbon. This biohumus can be used in agricultural cropping or soil fertility improvement.

CONCLUSIONS

A case study of worms' composting was presented at a laboratory set-up scale. The principal characteristics of the tested domestic wastes, of the produced biohumus were determined based on specific physical-chemical analysis methods similar with the ones applied for soil analysis.

The biohumus produced by worms' composting can be applied with no problems as a conditioning soil agent in some different agricultural cropping.

Because of his properties, the biohumus is alike with the Romanian term of ***'mraniță'***, and so it must be considered the fact that the biohumus will have the same uses as the 'mranița'.

REFERENCES

1. Duca, G., Tugui, T.: *Management of Wastes* (in Romanian), Academia of Sciences of Moldova Republic – Regional Centre of Environment – Moldova, Chisinau, **2006**, chapter 2;
2. Popescu, G., Meglei, V., Bucur, D.: *Environment protection and valorisation of wastes, residues and wastewaters in agriculture* (in Romanian), Tehnopress Ed., Iasi, Romania, **2002**, chapter 1 and 4;
3. Ungureanu, C., Ionel, I., P. Oprisa-Stanescu, D., Gruescu, V.: *Integrated management of municipal wastes* (in Romanian), Politehnica Ed., Timisoara, Romania, **2006**, chapter 1 and 2;
4. Zaharia, C.: Environmental legislation and management applied into a machine-tools manufacturing plant, in: *Proceeding of the 14th International Conference – Modern Technologies, Quality and Innovation – ModTech International Conference – New Face of T.M.C.R.* (Editors: D. Nedelcu, L. Slatineanu, S. Mazuru, O. Milosevic), 20-22 may, 2010, Slanic Moldova, **2010**, 691-694;
5. Zaharia, C.: Sustainable Agricultural Development - Concepts, Principles, Eco-Efficiency, Eco-Equity, Eco-Conditioning, *Cercetari agronomice in Moldova*, **2010**, **XLIII** (3), 91-100;
6. Zaharia, C., Suteu, D.: The Natural Resources and Sustainable Development, *Cercetari agronomice in Moldova*, **2011**, **XLIV** (1), 93-10;
7. Gavrilescu, M., Nicu, M.: *Pollutants reduction at source and wastes minimization* (in Romanian), Ecozone Ed., Iasi, Romania, **2004**, chapter 2;
8. Zaharia, C., Irimita, G.: Aspects of environmental legislation application concerning the municipal wastes landfills into Iasi county area, *Bulletin of Polytechnic Institute Iasi*, series: Chemistry and Chemical Engineering, **2010**, **LVI (LX)** (1), 87-97;
9. Zaharia, C., Suteu, D.: Some aspects of e-wastes management in Romania, *Bulletin of Polytechnic Institute Iasi*, series: Machines Construction, **2010**, **LVI (LX)**, (2b), 51-60;
10. Suteu, D., Badeanu, M., Zaharia, C.: Valorisation of biodegradable waste using worm`s cropping, *Lucrari Stiintifice*, series: Horticultura, **2009**, **52**, 1173-1178;
11. Istrati, L., Harja, M.: *Biotechnologies in the environment protection* (in Romanian), Tehnica-Info Ed., Chisinau, **2006**, chapter 5;
12. Nicu, M., Suteu, D.: *Technologies of wastes' treatment and valorization, Vol.5. Technologies of biodegradable wastes' digestion* (in Romanian), Ecozone Ed., Iasi, Romania, **2009**, chapter 2;
13. Badeanu, M., Filipov, F., Suteu, D.: Researches on the fauna of Oligochaeta- Lumbricidae from greenhouses, *Lucrări ştiinţifice*, Seria Agricultura, **2009**, 52, 284-288;
14. Pop, V.: Lumbricidele din România, *Annals of Romanian Academia*, Series A, tom I, Memoria 9, Romanian Academia Ed., Bucureşti, Romania, **1949**;
15. Beceanu, D., Chira, A.: *The technology of horticultural products. Valorisation in fresh stage and industrialization* (in Romanian), Economica Ed., Bucuresti, Romania, **2003**, chapter 2;
16. Catalogue, "Catalogue of Romanian standards" (in Romanian), ASRA Press, Bucuresti, Romania, **2003**;
17. Surpateanu, M., Zaharia, C.: *ABC – Analysis methods of the environmental factors* (in Romanian), T Press, Iasi, Romania, **2002**;
18. Manescu, S., Cucu, M., Diaconescu, M.L.: *Sanitary chemistry of the environment* (in Romanian), Medicala Ed., Bucuresti, Romania, **1994**, chapter 4;
19. Davidescu, D., Davidescu, V.: *Modern agrochemistry* (in Romanian), Academia R.S.R. Ed., Bucuresti, Romania, **1981**, chapter 3;

20. Davidescu, D.: *Agrochemistry* (in Romanian), Agrosilvica Ed., Bucuresti, Romania, **1956**, chapter 4;
21. Surpateanu, M., Zaharia, C.: Tehnogenic soils – a solution for environment protection, in: *Lucrări ştiinţifice*, Seria Horicultură, **2000**, **XXXXIII**, vol. 2 (43), 481-486.