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Composting Municipal Waste for Soil Recultivation in Bulgaria

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Authors' contributions

This work was carried out in collaboration between all authors. Author AZ collected the materials about the processing plant, composting and chemical analyses. Author SK prepared materials about soil re-cultivation and technology description. Author AA managed the literature searches, and wrote the final manuscript. All authors read and approved the final manuscript.

Case Study

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ABSTRACT

Aims: Agriculture is the main source of soil degradation processes in Bulgaria. Therefore the re-cultivation of soil is an important task. The possibilities for using composted municipal waste for soil re-cultivation in Bulgaria are discussed on the case of plant processing municipal solid waste in Plovdiv.
Presentation of Case: The plant for processing of municipal waste with capacity 125,000 t/yr built in the neighbourhood of Plovdiv is presented. The case study has been prepared in the Department of Agro chemistry and the Department of Mathematics, Informatics and Physics of the Agricultural University, Plovdiv in collaboration with the National Biomass Association between March 2013 and August 2013.
Discussion: Bulgaria has a good infrastructure and an adequate waste management framework. About 85% of the generated waste is transported to the depots and approximately 52% of the total amount of waste is biodegradable. Plant for processing of municipal waste with capacity 125 000 t/yr is built in Plovdiv region. The installation is designed for the processing of municipal solid waste in Plovdiv and other regional municipalities. After primary separation of the components of municipal waste the organic

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component is used for composting. Data about compost content are presented because of its importance for the re-cultivation.
Conclusions: The processing of municipal waste for producing compost of organic origin that can be used for soil re-cultivation (to recover nutrients and improve structure) allows reducing the area of dunghills, unpleasant smell, and Greenhouse Gas emissions.

Keywords: Soil erosion; waste; compost; re-cultivation; Bulgaria.

1. INTRODUCTION

The rapid increase of world population in the last years accompanied by the intensification of human activities brought serious environmental problems such as the pollution of soil, water, and air, forest destruction, etc. These negative impacts may cause global climatic changes (greenhouse effect) and might be a menace for the existence of the human race. Immediate measures to avoid the negative influence of human activities are necessary. Many industrial processes result in a large amount of wastes. In the near future the management wastes will play an important role in the conservation of the natural resources.

The problem with organic waste treating and deposition has many aspects. Its negative impacts are noticeable as public health and environmental components (air, water, soil, etc.) are concerned. The pathways of pollutants transfer between sources and media are outlined in Fig. 1. [1]

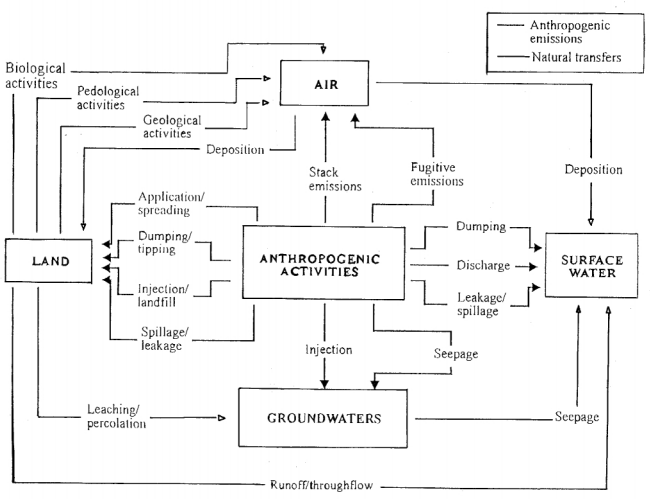

Fig. 1. Outline transfers of pollutants between sources and media [1]

The Landfill Directive of European Commission [2] requires Member States to progressively reduce land filling of municipal biodegradable waste to 35% by 2016 (compared to 1995). Member States relying heavily on landfilling in 1995 have a four year extension period (Bulgaria, Cyprus, Czech Republic, Estonia, Greece, Ireland, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia, and United Kingdom). The objective of these measures is to reduce the production and release of greenhouse gases from landfills.

The Communication from the Commission to the Council and the European parliament on future steps in bio-waste management in the European Union (EU) [3] points out that the compost and digestate from bio-waste are under-used materials. While offering an excellent contribution to EU resource efficiency and to the improvement of carbon-depleted soils, in many Member States demand suffers from a lack of end-user confidence. To address this concern, the use of these materials should be regulated in such a way that no adverse effects are generated on soils. The analysis conducted by the Commission confirms that improved management of bio-waste in the EU holds an untapped potential for significant environmental and economic benefits.

Agriculture is the main cause of soil degradation processes in Bulgaria. The generation of bio-waste causes top-soil depletion, because all biological matters of human use and consumption concern this soil layer. Wrong agricultural practices as the mistreatment of the soil, the overuse of plant protection products and fertilizers, burning of crop residues and other also bring about damaging the soil and reducing its fertility. Therefore the re-cultivation of soil is an important task for Bulgaria. Recycling of bio-waste can help soil regeneration. Among various regeneration processes the aerobic process is the focus of presented study.

About 80% of the arable land in Bulgaria is subjected to varying degrees of water erosion and 37% is subjected to wind erosion. As a result, more than 136 million tons of fertile soils are exported annually and in the same time 2.5 million tons of topsoil is washed [4]. Every year 70 000 t N and 30 000 t P2O5 are lost from the topsoil [5]. Through erosion and storm water runoff every year are exported main nutrients N, P, K and other macro-and micronutrients in amounts equivalent to the production of a large plant fertilizers [6]. The total losses of main nutrients base from eroded soil per year amounted to BGN 133 million or above € 66.5 million [7].

Most of the organic material, containing high dry matter percentage can be treated in aerobic way similar to composting. Treating this substrate in conventional biogas installations requires high volumes of water and the end product is waste water. Energy is needed to turn periodically the substrate and to maintain optimal temperature. These accelerate the technological process [8]. The compost as a final product can be utilized for erosion soil re-cultivation.

A review of the history of composting iin Europe [9] mentioned that the concept of large-scale municipal composting appears to have originated in Holland in 1929 with the setting up of N. V. Vuilafvoer Maatschappij by the Dutch Government. Nowadays this process has attracted the attention in all European countries and a cornerstone of the new approach to composting has been the realisation that only good quality compost derived from uncontaminated wastes has the potential to be sold to the public, used in agriculture and for soil re-cultivation.

2. PRESENTATION OF CASE

Plovdiv is the second-largest city in Bulgaria after the capital Sofia with a population of 339 077 inhabitants as of December 2012. It is the administrative center of Plovdiv Province. Together with the municipalities of the City of Plovdiv, Maritsa municipality and Rodopi municipality the whole municipal body had a population of 403 153 inhabitants as of February 2011. Until 1996 Plovdiv municipality did not have an ecological programme at all including solid waste management. Plovdiv generates annually about 180 thousand tons of waste [10]. National programme for waste management activities for the period 2009–2013

[11] has been published by the Ministry of Environment and Water. In implementation of the programme construction of wastewater treatment plants and construction of sewage networks has been started. The big generators of non-hazardous waste are in process of construction of their own waste disposal facilities.

About 85% of the generated municipal waste in Plovdiv is transported to the depots and approximately 52% of the total amount of waste is biodegradable. Plant for processing of municipal waste with capacity 125 000 t/yr is built in the village Shishmantsi located 30 km north-west from Plovdiv. The installation is designed for processing of non-hazardous municipal solid waste in Plovdiv and other regional municipalities. After primary separation of the components of municipal waste (Fig. 2.) the organic component is used for composting. The plant accepts only non-hazardous waste. A cell for hazardous waste deposition has been established earlier in Plovdiv accepting certain types of hazardous waste.

Fig. 2. Corpus''Primary processing'' of municipal solid waste in Shishmantsi
Source: http://ecozavod.com/ [15]

The term ''composting'' is used here to define the process of controlled biological maturity under aerobic conditions, where organic matter of animal or vegetal origin is decomposed to materials with shorter molecular chains, more stable, hygienic, humus rich and finally beneficial for the agricultural crops and for recycling of soil organic matter [12]. The process is mediated by different microorganisms actuating in aerobic environment: bacteria, fungi, actinomycetes, algae and protozoa, which participate naturally in the organic biomass or are added artificially [13]. The process can be described by the following equation:

$$\text{Organic matter} + O_2 \rightarrow \text{compost} + CO_2 + H_2O + NO^{3-} + SO_4^{2-} + \text{heat}$$

Compost offers many benefits to the landscape and garden. For example, compost (i) improves soil tilth condition and structure; (ii) increases the soil's ability to hold water and nutrients; (iii) supports living soil organisms; (iv) helps to dissolve refractory forms of nutrients; (v) buffers soil from chemical imbalances; (vi) may provide biological control of certain soil pests and (vii) helps to return organic materials to the soil and keeps them out of landfills and waterways. Compost can be used as a mulch, a liquid ''fertilizer'' or incorporated into the soil or potting mixes [14].

3. RESULTS AND DISCUSSION

As a result of the actions taken [11] a plant for processing of municipal waste with capacity 125 000 t/yr is built in the neighbourhood of Plovdiv. It is known as Ecozavod–Plovdiv [15]. The installation is designed for the processing of municipal solid waste in Plovdiv and other regional municipalities. Technological operations in the plant can be illustrated by the chart on Fig. 3.

Fig. 3. Technological chart of production of municipal waste compost

The advantage of composting over other technologies for the disposal of municipal waste is that there is no burning and this reduces the CO_2 emissions; composting takes place in chambers under controlled moisture and temperature not exceeding 60ºC; it is preceded by removing the components of municipal waste that can be reused or recycled (this is the second stage of the chart); the organic waste is selected (stage 3.) and then it is subjected to fermentation (stage 4.) and maturation is the next phase of composting (stage 5.). Last process is refining (stage 6.). At the end a useful product is obtained - compost that can be used in agriculture. As far as a part of household waste (about 30%) includes inert materials having inorganic composition, only they are subject to disposal.

The processing of municipal waste is performed in some phases.

In the 1st phase the input material is ventilated, so the substrate is aerated and the aerobic microbiological activity causes an increase of temperature. The temperature is controlled by regulating the ventilation. During the 1st phase the output is carbon dioxide and water. Easily degradable substances are reduced. The 1st phase lasts up to 3 days depending on the input substrate. It reaches temperatures up to 50ºC.

The 1st phase has the following effects on the substrate:

1. heating of the substrate for the 2nd phase without additional energy;
2. Reduction of easily degradable substances in order to decrease formation of acids.

Second phase includes fermentation and maturation of compost. The aerobic fermentation passes in 16 fermentation chambers with controlled humidity and temperature to form compost. The maturation is carried out at sites where compost is dumped in piles. Maturity describes a compost's fitness for a specific use. The C/N ratio is one of the indicators of the compost maturity. During both fermentation and maturation processes, the purification of air is carried out through aspiration of fermenting chambers and sites for maturation. Final process is refining (purification) of the compost after fermentation and maturation. It aims in control of compost particle size. The section is equipped with sieve with slotted perforations, densitometric table, aspiration system, and there finally the compost is prepared for expedition.

The result of waste composting technology is reducing of deposited waste. This technology allows decreasing the area of landfill, unpleasant smell and pollution of air, underground water and soil. The soil re-cultivation depends on the composition of compost. Compost is an organic fertilizer of about 36% water and 30-38% organic substance in dry mass. Its quality depends on its nutrient contents N-P-K, as well as the content of metals and organic toxicants. When organic compost is added to the soil aiming at soil-regeneration it finally results in higher yield that must be safe for the human physiology. Composting of municipal solid waste has potential as a beneficial recycling tool. Its safe use in agriculture, however, depends on the production of good quality compost, specifically, compost that is mature and sufficiently low in metals and salt content [16].

The content of N, P, K and organic C, as well as the pH and the presence of heavy metals As, Cd, Zn, Pb and Cu are analyzed in the accredited Laboratory for analysis of the components of the environment, part of the Executive Agency on Environment. These parameters are important for determination the quality of compost and it regularly is subjected to analyses of these components. Results in Table 1 present control measurements performed in 2010 and 2011. International Standard Methods (ISO) are used for the tests of parameters 1 to 8, and internally validated laboratory methods for the rest.

Table 1. Parameters of waste compost after the analyses of laboratory

No.	Parameter	Units	Value	Standard
1	pH	-	(7.32÷7.58)±0.05	6÷7.4
2	As	$mg.kg^{-1}$	<1.5	25÷35
3	Cd	$mg.kg^{-1}$	(0.50÷0.60)±0.03	2.0÷3.0
4	Zn	$mg.kg^{-1}$	(24÷34)±3	250÷300
5	Pb	$mg.kg^{-1}$	(57÷76)±6	80÷100
6	Cu	$mg.kg^{-1}$	<2,5	100÷140
7	Dry matter	%	(93.1÷94.2)±6.5	-
8	Water content	%	(5.8÷6.9)±0.7	-
9	Cr	$mg.kg^{-1}$	(11÷18)±2	200÷200
10	Ni	$mg.kg^{-1}$	<10	60÷75
11	Hg	$mg.kg^{-1}$	<0.01	1÷1
12	N (total, soluble)	$mg.kg^{-1}$	13100÷13200	-
13	C (organic, soluble)	$mg.kg^{-1}$	7370÷10210	-
14	Ratio C/N	-	0.6÷0.8	17
15	P	$mg.kg^{-1}$	38.5	-
16	K	$mg.kg^{-1}$	1932	-

Source: Regional Accredited Laboratory of the Executive Agency of Environment

The data in Table 1 show that the controlled parameters of toxic components as heavy metals are below the standard values where these exist, so the produced compost can be evaluated as not-harmful and be used for soil re-cultivation. The content of macronutrients also lies in largely communicated limits: N - approximately 13 $g.kg^{-1}$ compared to 5÷35 $g.kg^{-1}$ [16], P - 38.5 $mg.kg^{-1}$ compared to 0÷15 $g.kg^{-1}$ [16], and K – 1.93 $g.kg^{-1}$ compared to 0÷35 $g.kg^{-1}$ [16].

The compost is available for selling to the interested parties - farmers, industry etc.

4. CONCLUSION

First working plant for processing of municipal waste built in Shishmantsi, region Plovdiv, Bulgaria, demonstrates the advantages of waste processing over its deposition. These advantages include diminishing waste volume and shortening of dunghill area.

Processing of municipal waste allows producing compost of organic origin that can be used for soil re-cultivation (to recover nutrients and improve structure) as well as reducing unpleasant smell, and Greenhouse Gas emissions. The compost can be used for re-cultivation not only of agricultural land but also for mines and other industrially damaged soils.

The capacity of the plant allows to process the waste of other municipalities against payment and to realize incomes for the municipality which in combination with arising new jobs is an economical advantage.

The experience gained in the municipality of Plovdiv can be multiplied when planning waste processing plants in other big cities. Creation of waste processing plants at least in the regional centres with capacity satisfying the needs of the region is highly recommendable in view of the Landfill Directive of European Commission [2].

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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