Recovery of Biodegradable and Compostable Waste by Composting, a Solution for Sustainable Management

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Abstract
The main purpose of this paper is to identify and analyze a phenomenon that has become widespread today, namely the increase in the amount of waste and its improper storage, as well as the reduction of this amount of waste by the practice of recycling technologies, by composting, biodegradable organic waste, implicitly biodegradable packaging.
In order to achieve the fundamental objective and purpose of this paper, the specialized literature was studied. Statistical data from specialized institutions were used.
In conclusion, this paper investigates this topic, due to the huge amount of waste generated that must be reduced because improper landfilling is an acute problem that affects both the environment and society.

Keywords

Composting, organic waste, compostable, recycling, sustainable

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Introduction

The technical and operational indications given in this document are the result of the analysis of the technical-scientific literature of the sector and of the results of the experimental tests performed within the project.

The experiments looked at the effects of using quality compost as soil and mulch on soils and on some species of trees, shrubs and herbaceous plants and looked for indications for optimizing supply logistics and irrigation management.

The document therefore aims to be a guide for public administrations that have expertise in the construction, maintenance and management of public green spaces, for the use of quality compost produced by recovering organic waste from their territory. Additional users of the document can be professionals and all those who are included in the urban green supply chain.

In full compliance with the principles promoted by the European Union and implemented by national legislation, the recovery of organic fractions resulting from the separate collection of waste is materialized in the use of the product derived from their treatment. Composters are products that contribute to the improvement and maintenance of soil organic matter, promoting the maintenance of agronomic fertility, workability and better management of water resources.

The composting process has been known for over 10,000 to 12,000 years, when man became a farmer and found that the yields obtained from the same land year after year began to decline. Being a shepherd first, man did not forget the positive role of animal manure on the production of grass on pastures, and their application on agricultural land was the next logical step.

In modern times, the first scientific foundations of composters were formulated by Rudolf Steiner (1924) and later deepened by his remarkable disciples E. Pfeiffer and A. Howard.

Extensive research on the preparation and use of compost, as well as the invention of BD Compost Starter - a compost inoculant, by Ehrenfried Pfeiffer (1956), led to the development of biodynamic agriculture both in Europe and in America and Australia.

The first Westerner to document and publish sustainable farming techniques, now known as organic farming, was Sir Albert Howard (1943), a leading figure in the early organic movement.

In our country, the first information regarding composting, respectively soil fertility was stated by the first Romanian agronomist, Ion Ionescu de la Brad, who together with Gh. Ionescu - Sisești highlighted the role of organic fertilizers and manure of fermented manure on soil (Ionescu - Sisești et al., 1980).

1. Review of the scientific literature

In recent years, there has been widespread talk around the world about a "waste crisis". Huge amounts of waste have reached a critical level, with industry, trade and agriculture as the main sources.

Waste recycling has become a serious problem for the "life" of the Earth, growing with the industrial explosion of the twentieth century, which led to the development of industrial and agricultural activities, the diversification of consumption of material and food, and direct proportional growth. of waste.

Cherubini et al. (2008) states that “ecosystems recycle any type of waste, and the concept of waste itself is no longer appropriate. Products from one component or compartment are always a useful resource for another component or compartment. Ecosystems are self-organized systems in such a way that all resources are used as efficiently as possible so that no unusable resources remain. " In this way, ecological systems have the ability to self-recycle and use all resources with the greatest degree of efficiency, but anthropogenic activities disrupt all the component processes of these systems.

According to European rules, the recycling process consists of: recycling of matter and reusing energy.

Material recycling involves the replacement of primary resources with waste materials. Fricke, Kolsch and Pfaff-Simoneit (2009) consider that material recycling includes material recycling and biological recycling with compost (aerobic process) and fermentation (anaerobic process).

Recycling organic waste is an economical solution, used mainly in agriculture due to the nutrients it contains, the soil being able to degrade most of these substances.

The practice of intensive agriculture and the irrational use of chemical fertilizers to obtain rich crops result in the degradation of organic matter in the soil.

The main effects of the soil organic matter crisis are to reduce yields and increase the depth at which the soil is worked, and is caused both by the low number of soil decomposition organisms and by the increased presence of these organisms leading to accelerated decomposition due to changing factors natural and also to soil degradation.

For these reasons, the recycling of organic waste and its use as fertilizer must take into account the maintenance of an ecological balance in agriculture.

Composting is one of the most promising ways to recycle waste (Tam and Tiquia, 1999), as well as an important element in sustainable waste management (Slater and Frederickson, 2001).

Compost is an odorless organic product with no seeds or germs, and its quality can be improved.

The main purpose of the composting process is to obtain organic fertilizers from various biodegradable organic waste, such as some household waste, manure and animal manure, urban sewage sludge, sewage sludge and sanitation from septic tanks.

Composting is a biological process of transformation and recovery of biodegradable organic waste, in a hygienic product, rich in humic compounds, which allows the reintroduction of organic substances into the soil.

2. Research methodology

The use of quality compost is therefore an opportunity for public administrations and all subjects included in the urban green supply chain to implement environmental sustainability actions and to fully apply the theoretical principles that act as a context for the correct use of land and of the territory in general. By recognizing the potential arising from the use of these products and promoting actions that promote their

dissemination, Public Administrations become promoters of good environmental practices that cross-cutting the sectors of land management, waste recovery, urban landscape.

Therefore, the document provides an analysis of:

- the regulatory context and the opportunities and constraints it offers;
- technical specifications regarding the characteristics of the materials;
- areas of use;
- management methods for proper use.

3. Research results

Composting is an accumulation of microbial, physical, chemical and biological transformations that organic, vegetable and animal waste undergoes, from the initial stage to reach various stages of humification, under the action of factors (humidity, aeration, temperature, etc.), resulting in a new product that is qualitatively different from the original residue, called compost, a clean product with a high nutritional and energy value on soils and plants, and a strong amendment to the physical and chemical condition of soils (Ionescu-Sisești, Papacostea and Ștefanic, 1980).

The compost is obtained both by aerobic fermentation, the finished product being free of unpleasant odors and used as organic fertilizer, and by anaerobic fermentation, and the final product is used in the production of biogas, due to its high methane content. The effectors of this process are microorganisms represented by bacteria, actinomycetes and fungi.

The bacteria and actinomycetes involved in the composting process are cryophilic, mesophilic and thermophilic. Bacteria are the most numerous organisms in compost, being responsible for most of the processes of decomposition and heat generation. They are the most diverse group of nutrients in compost, using a wide range of enzymes to chemically degrade a variety of organic materials.

Actinomycetes, which resemble fungi but are actually filamentous bacteria, are responsible for the specific soil odor of compost and play an important role in the degradation of complex organic compounds such as cellulose, lignin, chitin and proteins. Their enzymes allow them to chemically degrade resistant organic waste, such as wood stalks, bark, paper, biodegradable packaging, etc.

Mushrooms are important in the decomposition of complex plant polymers and resistant residues (cellulose, lignin), allowing bacteria to continue the degradation process, once most of these residues have been destroyed. They can attack organic residues that are too dry, acidic, or have too low a nitrogen content for bacterial decomposition.

The microbial activity and the transformations during the composting process take place in four phases: the mesophilic phase, the thermophilic phase, the cold phase and the maturation phase.

Mesophilic phase (mesophilic fermentation stage). At the beginning of this stage the ambient temperature is usually between 4- 5 °C, reaching the upper limit of the stage to reach values of 40- 45 °C. Mesophilic bacteria and actinomycetes are active, which need both oxygen and moisture for growth and reproduction, as well as nitrogen, carbon, potassium and phosphorus. Mesophilic microorganisms use the oxygen they have to alter the carbon in compostable materials in order to obtain energy, producing CO2, H2O and heat as a result of metabolic processes. Biological oxidation of carbon from residual material gives energy to organisms (Gray, Sherman and Biddlestone, 1971).

The thermophilic phase begins when temperatures are above 40 ° C and the thermophilic bacteria take over the degradation process. At this stage the temperature rises to 60 - 70 ° C, at these temperatures most of the weed seeds, respectively pathogenic microorganisms are destroyed and the compost material stabilizes quickly. When the temperature inside the waste mixture drops, it must be turned over to ensure not only aeration, but also the introduction of the material from the surface of the mixture, undecomposed, inside to be degraded (Maynard, 2000). In this phase, resistant materials, such as cellulase, lignin and proteins, decompose.

The cold phase or hardening stage occurs when the temperature drops to values below 60 ° C and approaches the ambient temperature. When the temperature reaches 40 ° C, the mesophilic organisms reappear.

The maturation phase takes place over a longer period of time (several months). At this stage the temperature stabilizes, the mesophilic organisms dominate, and condensation and polymerization processes

take place (Gray, Sherman and Biddlestone, 1971). Macroorganisms (insects, worms, etc.) also appear, which ends the maceration and homogenization of the waste mixture, and the resulting final product is mature compost, which is a stable complex of humic acids (Zibilske, 2005).

Properly prepared and incorporated compost into the soil has beneficial effects on its quality and fertility, by increasing the intake of high quality organic matter, favoring the formation of a resistant structure with significant influences on water and air circulation in the soil, thus reducing the risks during periods of heavy rainfall and drought. In the first case, due to the organic matter in the soil, which has a high capacity of absorption and structuring of water, playing the role of surface that absorbs water, greatly increases the threshold of water content at which one can speak of excess moisture. In the second case, the large water supply achieved by inhibiting the organic matter prolongs the time of insolation and drying necessary for the appearance of the critical point of wilting of the plants.

But the organic matter introduced into the soil by composting, not only has the ability to retain water, but also nutrients that it releases as plants need. The range of nutrients that compost brings thus largely offsets the export of nutrients due to crop yields.

In order to obtain compost with superior properties to the residues from which it was formed and to increase the amount of organic matter in the soil, certain factors that influence the formation of such compost must be taken into account in the composting process. The main factors that participate in the fermentation processes of organic waste are: air, water, temperature, pH and C/N ratio, etc.

Composting is an aerobic process, which needs oxygen to perform the intense decomposition processes that take place in the early stages of the process. In the absence of a constant supply of oxygen, the process will decrease in intensity, becoming anaerobic, which involves other microorganisms and different biochemical reactions, which by their slow action will cause the emission of unpleasant odors.

A minimum concentration of about 6% oxygen is required in the pores of the mixture (the air contains about 21% oxygen). Aeration is the process of supplying oxygen to the compost material, but also the means of removing water vapor, gas and heat that resides in this mixture.

Water supports the metabolic processes of microorganisms, being a suitable environment for chemical reactions, for the transport of nutrients and, respectively, for the multiplication and dispersion of aerobic bacteria. The activity of microorganisms ceases if the humidity drops below 15%. The optimum moisture content of the mixture should be between 40% and 65%. If the value of 65% is exceeded, the water will take the place of the air in the pores of the composted material, compacting it and will lead to anaerobic conditions.

Water must be added to keep the moisture within the required limits, as the water content will decrease during composting.

Temperature

Microorganisms need certain temperatures for an optimal level of activity.

The optimum temperature of 60 - 70 ° C promotes rapid composting and destroys pathogens and weed seeds. The activity of microorganisms during composting generates large amounts of energy in the form of heat. At the same time, the water evaporates and the water vapor and gases are removed. Ventilation and turning of the mixture favors heat loss and is used to maintain temperatures in the desired range.

In some cases, the temperature may exceed the upper limit of 70 ° C due to the continuation of bacterial activity, which leads to the death of many microorganisms or their inactivity, and the process stops until they become active again.

pH

pH directly influences the activity of microorganisms. The optimum pH values for a mature compost are between 6.5 and 7.5. Composting materials have a pH that varies widely. Products derived from wood residues may have low pH values of 4.5, while animal manure is frequently alkaline (pH = 8 - 8.5). Because plants prefer a certain pH value, it is necessary to adjust it by adding lime (to increase the pH) and sulfur or iron sulfate (to lower the pH).

Compost with a very low pH (<4) should be used with caution, as low pH may be an indication of non-compliant composting practices, leading to the formation of toxic organic acids.

C / N ratio

Of particular importance in the composting process is the determination of the nutrient content of the raw materials used to obtain the compost. Of the many elements required for microbial decomposition, carbon and nitrogen (C/N ratio) are the most important.

Organic matter contains carbon atoms, which are combined with atoms of nitrogen, hydrogen, oxygen, phosphorus, sulfur, and can be said, directly or indirectly, with all the chemical elements that exist in nature. These carbon and nitrogen atoms combine in a varying ratio, optimally being 25/1, for this it is necessary that in the mixture of organic waste there are about 60% nitrogen-rich (green) and about 60% rich in carbon (brown).

4. European and national regulations on organic waste

In European and national legislation, the activity on waste management is regulated by numerous legislative documents.

Waste management activities (generation, collection, transport, treatment, recovery and disposal) must be in accordance with the rules required by European law. European directives transposed into national law have led to a new approach to waste management, emphasizing the need to protect the environment, improve its quality, make rational use of natural resources, and adopt effective solutions to reduce pollution.

EU waste policy focuses on the prevention of waste generation through the application of selective collection and reuse of organic waste. The recycling of organic waste is also intended to be used as much as possible as a raw material for the production of new products. Member States have an obligation to implement systems to achieve this goal. In many Member States, people are encouraged to compost organic waste in their own household, which is an essential part of organic waste policy.

One of the main objectives of the EU Commission 's work is to develop strategies, guidelines and directives that directly or indirectly affect the biological treatment of waste. These include the Landfill Directive, the Soil Protection Strategy and the Biodegradable Waste Directive. In addition, there is an awareness among technicians and decision-makers that composting will play a very important role in future European strategies on waste management and environmental protection.

EC Directive 99/31 on the landfill of waste

The Landfill Directive aims to reduce the amount of waste to be disposed of and to facilitate the increase in the recovery rate of biodegradable waste and to avoid its disposal.

One of the main issues related to the disposal of biodegradable waste in landfills is the generation of methane by these landfills, which involves taking measures to reduce methane in order to reduce global warming and improve the control of gas generated by landfills.

In order to replace the disposal of biodegradable waste, it is proposed to recycle, compost, produce biogas or combine them.

First of all, the levels that can be achieved after recycling must be determined. In this regard, targets should be set in line with the following key messages:

- The key elements of the municipal biodegradable waste stream are paper and cardboard; both can be collected separately at a low and affordable cost, thanks to operational integration and scheme optimization, as is the case in Eastern Europe. In Central and Western Europe, on the other hand, the very high cost of incineration makes the combination of differentiated collection + composting (or aerobic fermentation) competitive in terms of cost, despite the high costs of differentiated collection of the biodegradable fraction.

- The collection of the biodegradable fraction could be promoted by the Biodegradable Fraction Directive, and / or by the future Soil Protection Strategy and / or by the Thematic Strategy on Prevention and Recycling (whose current discussions have decided to set recycling and composting targets).

- In the Mediterranean countries, there is a pressing need for clean organic matter to be applied to infertile soils. This reinforces the need to implement differentiation at source, as a result of the strategies and forecasts of the soil strategy which highlight the need for a Biodegradable Fraction Directive to control potential contamination and to encourage the use of certified compost.

Directive on the biological treatment of biodegradable waste

In the last 5 years, the European Commission has taken the initiative to propose a Directive on the bio-treatment of biodegradable waste for the following purposes:

- Determining a balanced approach to meeting the requirements for reducing the amount of landfill waste in the Landfill Directive (99/31 / EC).
- Promoting programs for the recycling of biodegradable fractions, in order to ensure a similar development throughout Europe.
- Defining normal limits and conditions for the safe use and marketing of composted products in Europe.
- Further development of the production of the best quality soil fertilizers, which acts as a means of combating the process of "desertification" in the countries of Southern Europe.
- Covering those TMB (mechanical-biological treatment) processes for the treatment of residual waste, for defining their role in integrated waste management strategies and for defining the conditions of use or storage of stabilized final products.

One of the most important provisions included in the second Working Document for the Biodegradable Fractions Directive in 2001 was a mandate for Member States to implement programs for the separation of biodegradable waste at source. This was in line with the commission's mandate in the Soil Strategy Communication to prepare "by the end of 2004 a directive on compost and other biodegradable waste, in order to control potential contamination and encourage the use of certified compost". Undoubtedly, the most effective way to promote the use of certified compost to prevent contamination is to separate compostable waste at source.

EC strategy for soil protection

The impact on soil quality in Europe has become a major issue in recent years in the EU. The Commission points out that the reduction in the amount of organic matter in the Mediterranean countries is of great importance. Statistics show that in most regions with intensive traditional agriculture, the percentage of soils characterized by lack of organic matter and fertility has increased surprisingly.

Composting and aerobic fermentation play a very important role here, by placing on the market a humus material, of high quality, so that it can act as a continuous source of organic matter. High quality composting with valuable agronomic and microbiological properties can help restore the organic matter content in European soils.

In its Communiqué on Soil Protection, the Commission pointed out the possibility of regaining organic matter and fertility in European soils by using, in addition to other materials, composted organic waste.

An important point for the future biological waste treatment activity will be to establish the idea of humus management and maintain the quality of the soil in the EU. Maintaining the quality and structure of the soil as well as its fertilization overlap with soil protection policies.

Through the Soil Strategy, both the commercialization and the formation of a positive image for high quality compost can be ensured in the long run.

European Climate Change Program (CFSP)

In recent years, with the help of the CFSP, another major norm in environmental policy has been established in view of the need to comply with the requirements of the Kyoto Protocol on Climate Change. Some countries have begun to see the role of organic matter in soil as an important factor in the overall picture. What is to be considered is that "organic fertilization causes increases in carbon in the soil, and it acts as an absorber for carbon in the atmosphere, thus immobilized in the soil."

Another important effect of organic fertilization is the supply of nutrients, which involves the potential replacement of mineral fertilizers, and the energy and fuel savings required for their production and the reduction of related pollution, both with manufacturing and handling and application.

Other potential benefits, such as improved water efficiency and absorption, increased control of root pathogens, lower erosion and carbon loss, are difficult to quantify, but can also contribute to expanding energy resources and minimizing carbon losses in and out of agriculture and they are, as such, worthy of note.

The problems facing Romania in rural areas in the field of waste management have a major impact on society, pose a direct threat to health and have an adverse effect on quality of life. The uncontrolled storage of most of the waste is affected by the environment, directly the environment, the air, and due to the leachate from non-compliant landfills, leachate that enters the ground and affects both groundwater and surface water.

As a result, a sustainable waste management system needs to be implemented, which involves major changes in current practices, in order to comply with the requirements of the new national and European regulations.

In order to implement a sustainable waste management system in rural areas, it is necessary to inform the population as much as possible about the issues related to organic waste management, the role of municipal platforms and the negative effects of non-compliant storage of animal waste in households.

The avalanche of waste facing the Earth must be at least reduced, but more importantly, a way must be found to dispose of the huge amount of waste that is dumped in a non-compliant landfill and pollutes the environment, polluting it. The figure below shows a fairly obvious increase in the amount of waste generated between 2016 and 2021, and this proves the need to find alternative composting.

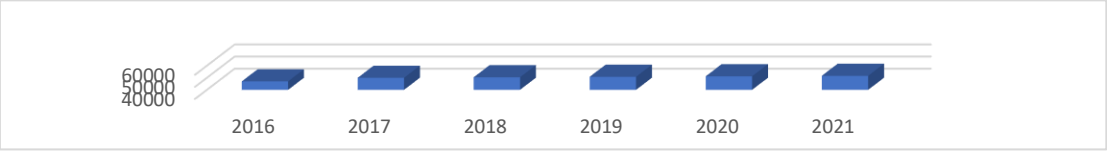

Figure no. 1. Waste in the form of packaging collected from trade, industry, institutions
Source: http://www.mmediu.ro, own processing.

Table no. 1 shows the average values of the specific weight of the packaging waste components, and it shows that paper, glass and aluminum packaging have the highest average values, but only paper can be composted.

Table no. 1. Average values of specific gravity of packaging waste components

Component of the materials	Specific weight [kilograms/m^3]
Paper	89
Carton	50
Plastic	65
Rubber	30
Wood	35
Glass	95
Aluminium	60

Source: http://www.mmediu.ro, own processing.

In order to be able to leave a legacy to our descendants, a clean environment in which to breathe fresh air and consume drinking water, it is necessary to urgently implement a waste management plan that aims to achieve the following objectives: elimination of non-compliant waste disposal; selective collection of organic waste from the population; increasing the degree of recycling / recovery of organic waste through composting and anaerobic digestion with the production and collection of biogas; reducing the amount of biodegradable waste sent to landfill, by using all possible recovery measures;

A first step in order to achieve the aforementioned objectives is the selective collection of organic waste and storage on specially designed platforms, where they will be transformed into a new, clean product that can be used as a natural fertilizer and source of organic matter for the soil. - at the same time both a saturation of the soil in organic substances and a reduction of nutrient pollution. In this way, organic waste is reintegrated into the natural cycles of transporting substances and elements through the soil.

The population must be well informed and understand the need to comply with environmental protection rules, so that concern for the environment gains ground in the face of archaic habits that affect the environment and endanger the health of all.

At county level, but also at local level, there is still work to be done, first of all, in terms of awareness, not only of the population, but also of the local and relevant bodies, of what means the non-polluting capitalization of municipal waste.

Conclusions

Proper waste management, which by its nature is both a source of pollution and a source of secular raw materials, must be done in an integrated way, with an understanding of the long-term consequences of the decisions taken. In this regard, current trends in waste management need to take into account the following issues: reducing the amount of waste; avoidance of environmental pollution.

Experience in other countries has shown that one of the ways to reduce the amount of waste generated is to replace fixed taxes with unit or mass taxes. This measure will also stimulate the recovery of recyclable materials from the population. In this context, there will be a normal tendency to reduce the amount of waste stored, it will require the introduction of separate waste collection from the population. Useful waste materials are a valuable source that should not be wasted. At county level, but also at local level, there is still work to be done, first of all, in terms of awareness, not only of the population, but also of the local and relevant bodies, of what means the non-polluting capitalization of municipal waste. Sustainable economic and social development without deteriorating the quality of the environment requires adequate waste management without depleting natural resources. Global concerns about the final disposal of waste and the concept of a sustainable society are growing. There is a general consensus on the planet's limited resources and the continuing increase in waste management costs.

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