

# Optimizing the Value Chain of Recycling Biodegradable and Compostable Packaging for Sustainable Development and the Circular Economy

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## Abstract

*Due to the imperative requirement to either reduce or taking into account the complete elimination of plastic packaging, packaging that is either biodegradable or that qualifies as compostable packaging gained popularity in recent years, and is now perceived by consumers as the solution for significant reduction of the negative impact on the environment, respectively of the pollution with plastic. This article thus addresses the issue, providing an overview of this situation, of the end-of-life environmental problem of biodegradable and compostable packaging. At the same time, it highlights important aspects regarding the solutions meant to answer the identified problems in order to optimize the value chain of the recycling of these packaging and the implementation of innovative approaches, in view of the sustainable development and the circular economy.*

**Key words:** biodegradable and compostable packaging, life cycle, composting, circular economy

**J.E.L. classification:** O44, Q01, Q53, Q56, R11

## 1. Introduction

There is no question that it is easy to observe the destructive effects of plastic pollution, it can be by acknowledging the images showcasing plastic waste in the oceans (including entire so-called "plastic islands"), the increasing and visible presence of packaging on beaches, as well as the harm brought to both animals and the entire biodiversity.

Recycling became an entire industry and within with, currently there are a number of issues such as the limitation of international markets, the identification of markets or the value of the resale for materials that are sorted which is at the lower end of the scale. Thus, we observe and witness in the present a reconceptualization of packaging and especially of plastic.

Also, worldwide, including in Romania, government strategies are being developed aiming to significantly decrease the amount of plastics used and even the disposable products are being signaled for a decrease in quantity. In response to this situation, environmental activists and consumers are urging government agencies and companies to take action to change the course of action. In the face of these pressures focused on the decreasing level of plastic packaging to the extent of considering eliminating it completely (especially disposable or packaging designed and aimed for a short-lifespan), packaging being either compostable or qualified as biodegradable started to gain attention and spiked its popularity levels recently. Clear example could be a survey taken upon the consumers from the United States that is showcasing how consumers are actually expecting to find more and more packaging that is compostable (Feber et al., 2020), whilst in the meantime a range of 77%-92% of the consumers that live in Europe perceive packaging that is qualified as biodegradable and the types that are entering under compostable packaging classification as being better suited and

less harmful towards the environment when compared to any other different types of packaging (CITEO, 2018; Green Alliance, 2020; INCPEN and WRAP, 2019). Thinking how to handle the pressure and solve the problem either focusing on reduction or to a more extreme level completely eliminate packaging made out of plastic (especially those that are disposable or designed to be used as short-life packaging) both biodegradable and compostable packaging started to spike the levels of popularity more recently.

## **2. Theoretical background on circular economy and sustainable development - a global priority**

It has been realized worldwide that the natural resources that society needs and that are limited, have been exceeded, while creating an ecological imbalance on a global scale, through irrational development. Reality shows that by supporting the three levers simultaneously - socially, economically and environmentally, sustainable development and a common global future can be achieved. In 2015, a historic paper - the 2030 Agenda for Sustainable Development - was followed at the UN General Assembly in New York. This document aims, through its 17 objectives, a better future, not only for us, but also for future generations. Structured on the three levers, the 2030 Agenda was also adopted by Romania. The national strategy for sustainable development represents the contextualization of the Agenda to the national specificity and, implicitly, Romania's transition to a sustainable society. The notion of circular economy represents a new, emerging perspective on sustainable development. The roots of this perspective lie in the biosphere, where anything can become a resource for the next level of the food chain, in order to eliminate waste.

Aiming to minimize mid to long term consequences, a series of measures have been taken at international level, Paris Agreement being one of them, which addresses the negative impact of human activity on the environment. In response, the concept of circular economy was born, which aims to increase resource efficiency and reduce waste. The biodegradable and compostable packaging sector has a high potential and the necessary levers that can act on the road to a circular economy.

The circular economy is meant to ensure the use of resources throughout the life cycle of products or services in the conditions of concomitant reduction of environmental influences and improving the satisfaction of consumers and users.

Various strategies, mechanisms and tools can be adopted for the development of a circular economy. They are integrated in all stages of the production process and are based, among other things, on the 3Rs: reduction at the source, reusing and recycling.

Simultaneously with the circular economy, economic models are also adapting when it comes to GDP, or level of employment, as well as values of investments and entry into new markets (Rizos et al, 2017). Thus, a study led and organized by the European Commission is highlighting that a 1% reduction in resource consumption by streamlining the use of materials could generate a range of 12 to 23 bil. euros in the sector of economic activity, which would result in the emergence of 100,000 to 200,000 euros. new jobs in Europe. (Montaigne Institute, 2016).

## **3. Research methodology**

This paper is based on both qualitative and quantitative elements of research. Regarding the qualitative side of our scientific approach, based on theoretical concepts and documentary study, the article analyzes the phenomenon of biodegradable and compostable packaging highlighting important aspects of their recycling in the context of sustainable economic development and the circular economy. Using data provided by the National Agency for Environmental Protection and Eurostat, quantitative aspects regarding the recycling and composting capacities as well as the management of waste materials were highlighted.

## **4. End-of-life management of biodegradable and compostable packaging**

Increased supply of packaging that is qualified as biodegradable or even compostable packaging, in the same manner of how the multitude of brand-names and logos, is causing misunderstanding and can become misleading for citizens preventing them from making the right sorting gesture.

Consequently, packaging being either biodegradable or compostable might be encountered on the three city collection routes:

- in the recyclable basket: the citizen out of instinct throws any type of packaging inside the basket that symbolizes recyclable, not taking into account any type of indication or guidance for any biodegradable or compostable quality of the respective packaging.

- in the bins allocated for organic rubbish (in the specific areas where the local administration enables the specific collection for those): here there is a specific sign (mark) on the packaging that symbolizes the either biodegradable or compostable nature of the packaging (in can sometimes be even another word that includes before the "organic" addition in front of the name); the citizen relies on this statement and throws the packaging in the organic bin.

- in rubbish: the packaging is labeled biodegradable or compostable; citizens are made to believe that it will decompose and disappear, even if it is thrown away. The citizen is annoyed and not sure where the packaging is going. If in doubt, he can throw it in the trash. The misconception that biodegradable and compostable ones can decompose quickly without harming the environment contributes substantially to the maintenance of abandonment of packaging in nature.

The fact that packaging either biodegradable or compostable packaging exists in three collection ways confirms that these packaging will be shipped to sorting centers, facilities handling composting or focused on anaerobic digestion, landfills and even incinerators. In reality, not all the packaging (be it biodegradable or compostable) is by default compatible to these specific treatment methods.

And so, the matter of the compatibility with treatment-channels should be analyzed soon given that none of the policies regarding waste-management does not clearly define by which method should be paired with which method of end-of-life to bring the best results.

This paper will look into both types of packaging: biodegradable and compostable, highlighting some important issues regarding their recycling. These will be accompanied by recommendations aimed at addressing the issues that were signaled aiming to further optimize the value obtained via recyclability from both point of views of sustainable development and the movement towards an economic system that is circular.

**a.** Consumers can easily be misled when it comes to biodegradable and compostable plastic packaging: apparently their belief is that they prevent the harmful impact of packaging on the environment, whilst representing an alternative to disposable plastic, which influences the consumer led genuinely choices as well as the actions being taken in the sorting process. The space of use for attributes such as biodegradable and compostable is limited, but this framework is not very efficient:

- the statement 'biodegradable' or 'compostable', which appears on a packaging, is a statement that is linked with the environment and there is no process to be either verified or certified by a party not involved (assessed as 3<sup>rd</sup> party) with the only exception being the packaging that comes already with it's own international certification and documentation, this makes it easy to question the way in which a packaging's biodegradability or compostability is being assess or identified in this way by the manufacturer;

- Despite there being certifications demonstrating the suitability of a product for composting, those are being handled and ran voluntarily and actually being undertaken in subspecific and controlled laboratories (in terms of air conditioning conditions) other than the one already know in the industry;

- To make a distinction between packaging that is made out of plastic when compared to the one that is compostable can be challenging, which is not enabling a clear and simple decision for the consumer at the moment of purchase nor does it enable simplification for the sorting process.

**Recommendation 1:** Aiming to enable a more simplistic and to that extent better framework for environmental statements, and in the same time secure an easier way of classifying (understanding) the conditions that should be encountered in a controlled environment (laboratory) to provide the composting certification as well as the conditions from the uncontrolled environment (anaerobic composting and digestion industry) and how the conditions might differ in here.

At European level, including in Romania, the standard that regulates the requirements when it comes to the compostable nature for packaging is EN 13432/2002 – it includes the "requirements for packaging that can be used for composting and biodegradation" as well as the type of test programs and the criteria used in the evaluation in order to grant the final blessing to the packaging. This one

can be recovered either via biodegradation or via composting but it must comply with the criteria established by the standard quo so that they are suitable for composting at industrial levels:

- biodegradation status: a minimum of 90% of the substance making reference to must be able to disintegrate in a shorter span than 6 months;
- composition: there are certain levels that establish the maximum amount of volatile solids as well as fluorine and heavy metals in the composition;
- disintegration: the initial material (considered original) must be able to disintegrate – under specific composting conditions;

Compostable packaging is identified by the application of labels that are certified based on International Standards for Quality and to this respect the authority that represents the certification body shall ensure that the standard is complied with at all times through continuous audits or recertification audits.

**b.** In a relatively short period of time, a significant increase in the amount of compostable packaging in circulation is expected, including in the field of anaerobic composting:

- it is necessary to implement a strategy for the recovery of municipal organic waste with the aim of managing 100% of the organic waste resulting from the residential sector, as well as from industries, enterprises and institutions;
- the ban on disposable plastic, be it under the form of products or directly that of packaging, linked mostly to the food industry, and the highlight and promotion of innovation regarding compostable solutions.

**Recommendation 2:** Implement a method to keep under control and quantify the progress on both the volume that is currently being secured as well as controlling the end-of-life channels, by intergrating compostable packaging under a new specific category in the pool of research conducted at regional level.

**c.** Regarding the 3R hierarchy, it is the duty of the government to clarify and simplify the management method that should be undertaken and adopted when handling organic waste, mostly it is about recycling (either via composting and anaerobic digestion). For compostable packaging, the situation is not defined:

- Consequently, there is compostable packaging waste in the three collection routes: the recyclable waste basket, the organic waste bin and the waste bin, and in consequence also in the 3Treatment channels with their specific respective problems:

- Recycling: risk of contamination for any other materials that are recyclable;
- Composting or anaerobic digestion:
- Disposal: are not suitable for decomposition.

**Recommendation 3:** The authorities must be clearly routing for the implementation of recycling from the perspective of an economy that tries to be circular, enabling thus the fiber packaging to be recycled and in consequence become new products.

**Recommendation 4:** The application of the 3R hierarchy in the management of end-of-life compostable packaging could be supported by publications on the subject, along with a list of materials, standardized packaging and the existence of field control measures.

**d.** In a practical manner, the circuit followed by a packaiga that is compostable with the industrial-sector of anaerobic composting and digestion is directly linked with way in which unwanted materials are being handled:

- the management of packaging or even sorting materials should not be carried out by the same industrial sector of anaerobic composting and digestion having the final goal to produce high-quality compost or digestate that will be returning to the soil (due to mixture possibility);
- plastic packaging (being it compostable or not) is at risk of being mixed with any other unwanted materials and then accidentally send for disposal altogether.

**Recommendation 5:** Following the model of some organization that defined by specific applications which type of compostable packaging could be considered as preferred and in turn make clarifications with respect to the type of management that should be considered as a priority in handling them.

**Recommendation 6:** Biodegradable and compostable packaging ought be covered by the extended responsibility of the manufacturer and be subject to price eco-modulation measures related to their impact on their end-of-life management.

**Recommendation 7:** In order for packaging in circulation to be reusable, recyclable or containing recycled material, it is necessary to ensure an easy-to-apply legal framework.

e. The purpose of anaerobic composting / digestion is to bring organic matter back into its production cycle:

- if not composted, compostable packaging is not harmful, but does not add value;
- despite plastic packaging being removed significantly upstream and / or downstream of the anaerobic composting / digestion process, small fragments could still be caught in the compost or digest. The impact brought to the environment by the residual microplastics representing a source of contamination for the soil, represents a top-concern for the specialists.

**Recommendation 8:** The impact of compostable packaging on the quality of the material used in soil structuring and also the impact of residual microplastics must be carefully documented.

f. We cannot say that any innovation brings progress. Companies can successfully use eco-design for an overview of the factors that influence the design, supply and final treatment processes of packaging, without compromising the protection and preservation of the product. For this purpose, life cycle analysis can be used for better environmental choices.

Key factors in green design enable the:

- fulfilment of certain needs that are to some extent specific to each product aiming to either protect in – focusing on avoiding the loss of the product or to preserve it – with applicability towards both reducing and avoiding the waste of food;
- creation of the conception of end-of-life thinking focused on designing and planning depending on the available system or even channels where is the packaging most likely to find the end-of-life and what is the context there;
- reduction of the impact upon the environment as well as a smart way of putting to use resources: thinking of it in the same manner as one would in an economy that is circular and relies on eco-design to facilitate and guide the life-cycle of the packaging taking into account from the very beginning the full impact upon the environment brought by each profile of each product – mostly referring to the life-cycle analysis, and referring in the same time also to the reduction upon the consumption of resources focusing on maintain them in the system and enabling their continuous circulation;
- transparency and traceability upon the placement and moment of life of the packaging starting from the moment of its purchase and looking at what is the choice of materials / suppliers / providers and following it towards the end of its life

**Recommendation 9:** Opening and ensuring easy-access to eco-design for packaging companies.

As a wrap-up, it is of great importance to take into account that the evolution in terms of both research and innovation in biodegradable and compostable materials is significantly stronger today compared with the past and it develops at an exponential rate. What is more, those were the subject of more than 1400 scientific publications year-on-year for the past 10 years (Gontard et al, 2018). And what is even stronger in acknowledging the importance of the subject – both the research and the innovation are coming from across the world signaling the increased importance upon the matter.

## 5. Findings

Concerning the regulatory framework looking at the level of recovery and the recyclability percentage of packaging being either biodegradable or compostable in Romania we can appreciate as follows:

The European Union's waste policy is based on the concept known as the waste hierarchy, this creates a level of classification of the options for managing waste looking at the impact upon the environment (sorted best-to-worst) taking into account measures linked with: level of prevention, ability to reuse, suitable for recyclability, ability to recover energy or dispose of it via incineration or types of storage. Based on the presented hierarchy it is easier to prioritize in an efficient manner the maximization of waste prevention, enable the minimization of the level of waste (in volume), increase the level of reusable waste, enable recycling, energy recovery and, last but not least, enable the disposal by either incineration or storage. This alignment and order is not meant to serve as a rule that is followed to the dot, but rather it aims to guide the process and fasten the transition to a society

that is focused on both recycling and reuse thus minimizing the need to focus on waste management linked with the process for incineration and storage.

By being a member of the European Union, Romania is also mandated to comply with the requirements of its legislation and has developed national strategic waste management documents that include two main components, namely:

-National Waste Management Strategy – legal-framework that is stating and setting the country’s objectives linked with the processes for handling waste management;

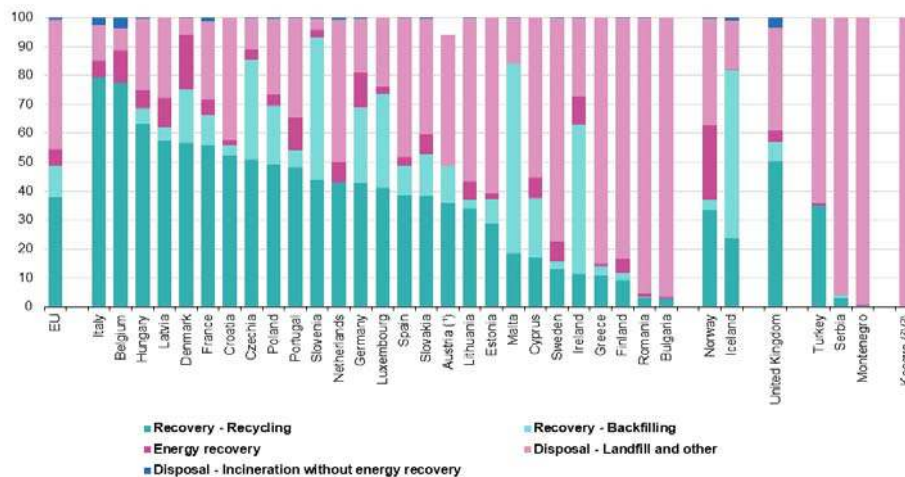
-The National Waste Management Plan – with is clarifying and stating the plan bringing to life the strategy and it includes both direction as well as clear steps to pave the path towards accomplishing the objectives as well as the methods to be followed in following the strategy and the respective owners of each step with their responsibilities.

The National Waste Management Strategy (nationally called “SNGD”) and the National Waste Management Plan (nationally called “PNGD”) are owned, developed and followed through by the Ministry of Environment and Sustainable Development, linked with it’s responsibilities, this being set by the national adoption and to certain extent adaptation of European legislation in the sector of waste management and this is linked with the provisions Government Emergency Ordinance no. 78/2000 regarding the waste regime, with the subsequent completions and modifications.

In recent years, the management of waste materials has received special attention from the government, and especially in the management of organic materials. Indeed, the collective awareness of the population about the end of the life of packaging and the increasing pressure on companies to demonstrate greater social responsibility have led the government to create a framework for the legal regulation of recovery activity and recycling of organic materials.

Although this process of recycling biodegradable and compostable packaging is currently highly developed in many European countries, it is still in its infancy in our country, as there is no organized network at the level of territorial administrative units dedicated to the recovery of organic waste. In order to integrate into an economy of circular organic matter, compostable biodegradable products must no longer end up in landfills or incineration.

Figure no. 1 Waste treatment by type of recovery and disposal, 2018 (% of total)



Source: Eurostat

In the European Union, the big majority of waste was treated in recovery operations (54.6%) splitted as follows: highest percentage towards recycling (37.9% of the entire amount of waste treated), another 10.7% going to landfill and significantly less towards energy recovery (6.0%). The rest of it, still above 45% was to the biggest extent landfilled (38.4%) or to a much smaller extent vs in the past, barely reaching 1% towards those that got incinerated without energy recovery, and the difference representing the part that was disposed of accounting for 6.3%. The figure above showcases the discrepancies in between EU Member States in their adoption, usage and preference of the various treatment methods. Examples might be in the sense of countries with very high

recycling rates (Italy and Belgium), or those that prefer waste disposal such as Greece, Bulgaria, Romania, Finland and even Sweden.

In countries such as Belgium, the Netherlands, Denmark, Sweden, Germany, Austria and Finland, waste disposal is almost non-existent. In these countries, incineration plays an important role alongside recycling. Germany and Austria are also the main EU countries where recycling is practiced.

As a consequence, a waste management program - the compost component - needs to be urgently developed in Romania. A first step was taken through the entry into force on February 20, 2021 of Law no. 181/2020 on the management of compostable non-hazardous waste. Thus, starting with January 1, 2021, the authorities respective with their power of influences – either local public administration or in some cases the subdivisions of municipalities with their respective counterparts in inter-community development associations, are obliged to put in place and secure the infrastructure to collect separately the waste that qualifies as biodegradable and to also extend this manner of collection in separate ways moving it from the micro level (door to door) to the large urban areas, which should be coming to complement the "pay for what you throw away" scheme and encourage individual composting in rural households (MO, 2020). So far, the collection of the fraction of organic waste in Romania has not been implemented.

Figure no. 2. Map of compost depots in Romania



Source: National Agency for Environmental Protection

According to the data of the National Agency for Environmental Protection, Romania has composting capacities of organic waste totaling not less than 1,433,533 tons / year. Of these, only 8.7% are functional installations. The rest is divided into unfinished installations (under construction) (36.4%) and (worst) installations that do not work for various reasons (54.9%) (Figure no. 2).

At large, the widespread promotion of waste prevention and product reuse is encouraged. Recycling (including composting) and, as far as possible, the use of waste in energy production are also encouraged. Waste disposal, even if one of the cheapest solutions, is considered the most harmful choice.

## 6. Conclusions

In order to optimize the value chain of the recycling of packaging that is either biodegradable or compostable, aiming to achieve a development that is also sustainable and to pave the way towards an economy that is circular whilst also taking into consideration objectively the problem brought to the environment when the packaging reaching its end of life, it must be borne in mind that:

Unlike biodegradable plastics, whose degradation time is highly variable, that of compostable plastics should correspond to that of green waste and even waste related with food in general. The lack of ability in controlling the use of statements linked with the environment that are based on self-reported data and the discrepancy between both laborator (controlled) and field (uncontrolled) conditions for the composting certifications showcase that the control is still don in an ineffective manner.

Both the accelerated rhythm to which usage of organic material is adopted as well as the level of recovery services and the development of the industrial composting and biomethane sector, planned for the coming years, will end with a big increase of quantities of organic materials recovered and treated. Thus, we should also note a greater presence of packing that is compostable in 3 collection options that are being handled locally (baskets made of recyclable materials, dedicated bins for the waste that is organic and the regular garbage bin). Currently the guidelines provided by the competent authorities regarding industrial composting or the sector of anaerobic digesting is not clear on recommending or imposing a specific approach.

Despite there being worries about the ability to handle and act upon the quality of the compost that returns to the soil, more specifically regarding the attempt to minimize the level of micro-plastic, this is still happening leading to micro-plasting being a source of soil contamination that cannot be ignored.

To attain innovation in the packaging world, the industry turns towards eco-design as a tool that enables analysis looking at a variety of criteria linked with the environment as well as socio-economic criteria. Such an approach that focuses on the prevention also benefits on choosing the level of compromise as well as the significance of certain actions that may vary. To this extent, the role of eco-design is to fulfill the role of a protector and enable preservation of products in order to avoid either food-loss or any other type of waste that is linked with a sizeable environmental impact. In the same time, this also makes it possible to think from the very beginning (considered as the design stage) about the level and classification of recyclability or if possible the compostability of the packaging by taking into account and thinking of the already existing channels and strategies whilst also taking into account the current moment when the existing packaging is ending its life. Thinking in terms of life-cycle enables a helicopter view upon the options and amount of possibilities aiming to reduce impact upon the environment, and in the meantime it also enables a control usage of the resources with the sole purpose of maintaining the cycle and design a circular system in turn avoiding the extraction of incremental raw materials. To conclude with, green design makes it possible to ensure responsible supply, striving for transparency and traceability.

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