EuRIC's position on the impacts of biodegradable plastics on circularity

EuRIC's position on biodegradable and compostable plastics- In regard to the forthcoming Commission's policy framework related to bio-based, biodegradable and compostable plastics, EuRIC is pleased to share its position about biodegradable plastics, especially on packaging, and with this document help to clarify some questions regarding the impact and challenges of these plastic types on mechanical recycling (incl. opportunities and recommendations).

Executive summary –

Nowadays, **fossil-based plastics account for the biggest market share and correct plastic management of this common plastics through mechanical recycling offers an opportunity for material circularity -with still a lot of untapped potential[1]- while curbing plastic waste and minimizing environmental pollution and combating global warming.**
As an alternative to solve plastic waste accumulation through recycling, which applies for both fossil-based and bio-based plastics, there are materials in the market like **biodegradable plastics (BDPs)**, especially used in packaging applications, which aim to tackle the problem of plastic waste accumulation at the production phase**.** However, and despite the fact that BDPs can theoretically shorten the life cycle of plastics, **due to lack of infrastructure and a misconception by the consumer about what biodegradability means**, most of **BDPs are not properly disposed at their end-of-life (EoL) and they are mixed with traditional plastics**. This creates a negative impact on the efficiency of conventional plastic sorting systems across EU and jeopardizes recyclates quality because **BDPs -contrary to bio-based plastics- do not fit in the sorting and recycling infrastructure and therefore they do not contribute to but hamper transitioning towards a circular economy for plastics**. Therefore, **BDPs should not be considered as a silver bullet to the plastic waste problem but just as another waste to be properly managed.** Even when BDPs are properly disposed at their EoL, problems may rise during composting, which is the reason BDPs are not allowed in the bio-waste of many Member States. As a consequence, BDPs from packaging are removed from the bio-waste and incinerated at waste to energy plants.

For the correct functioning of the circular economy, it is EuRIC's recommendation that all plastic products must be designed according to the design-for-recycling principles, which means that the **collection, sorting and recycling of the material must be possible within the existing infrastructure and this needs to be determined by extended producer responsibility (EPR) schemes.** For BDPs or other new types of polymers of which their production is more environmentally friendly than conventional plastics, it is necessary to manage their EoL in an efficient manner to effectively protect the circular economy and the environment because, unless very limited exceptions, right now, choosing for BDPs in the name of environmental protection is just wishful thinking.

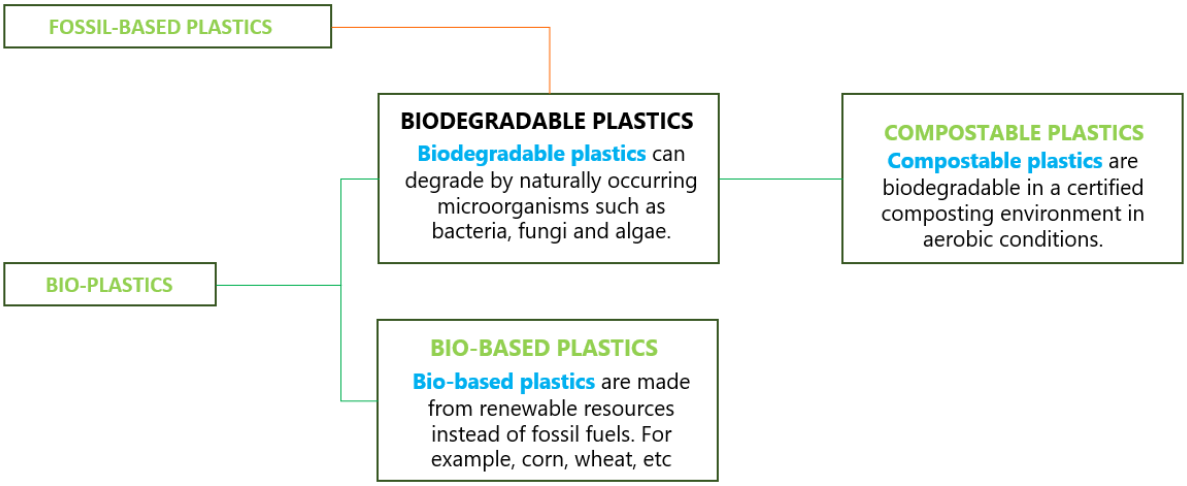
Tackling the many challenges arising from the use of biodegradable plastics is essential to fully deliver the circular economy for plastics. In particular, to achieve this objective, it is essential to:

- Focus on the improvement of plastic recycling by **following design-for-recycling principles.**
- The **use of *biodegradable* should be banned from all plastic packaging products** until a proper infrastructure is put in place to collect, sort and treat biodegradable packaging plastics.
- **Set strict criteria for the use of BDPs** in order to restrict the types of plastics that can be discarded in the bio-waste.
- **The only label needed on plastic products should be *recyclable*.** According to this, only plastic items with the recyclable label should go into the plastic bin.

[1] In Europe, approximately 29 million tonnes of plastic waste were collected in 2018, from which around 9 million tonnes of post-consumer plastic waste were sent to recycling.

State of play bio-plastics

The presence of bio-plastics in the market is growing together with an increased consumer conscience for sustainability and environmental protection. Yet **bio-plastics** can raise major issues for recycling or composting and due to their inefficient management at end-of-life (EoL), **not all bio-plastics are a sustainable solution to tackle plastics environmental pollution**. Based on their characteristics, bio-plastics can be classified into the main following groups:



Bio-plastics constitute only a small portion (~1 %, 3.68 Mt) of the total world production of plastics and only in Europe they are expected to amount up to 2.87 Mt by 2025[2]. Among this group we can find, bio-based plastics, biodegradable plastics and compostable plastics.

Bio-based plastics are made from renewable resources (e.g., corn, wheat, etc.) instead of fossil fuels but bio-based **does not necessarily mean the product is biodegradable or compostable**, it depends on their chemistry. The share of bio-based/non-biodegradable polymers, such as drop-in bio-PE -of the total amount of bio-plastics produced- is 41.9 %, with the remaining 58.1 % being biodegradable, such as PLA and PHA[3]. **Bio-based non-biodegradable plastics which are drop-in (such as bio-PE, bio-PET and bio-PP) are recyclable by conventional recycling processes** and contribute when properly managed, as recycled fossil-based plastics, to reach the goal of 10 Million tonnes of plastics recyclates in EU by 2025 as described in the European Strategy for Plastics. On the contrary, **biodegradable and compostable plastics are mostly non-recyclable and therefore do not contribute to the circular economy of plastics**. Even when they are biodegraded, they dissolve in water and CO_2 thus not contributing to material reuse. On the contrary, all resources leave the value chain. Besides, the lack of efficient management at the EoL for compostable and biodegradable plastics means these bio-alternatives are usually managed through landfill or incineration processes. Therefore, they **do not provide a sustainable solution to the plastic packaging waste problem**.

Furthermore, BDPs can be burned like conventional plastic, and the energy of BDPs is similar to that of conventional plastics[4]. However, in terms of landfill, conventional plastics and BDPs are quite different. Conventional plastics are difficult to decompose or not at all in landfill, however, during **degradation of BDPs in landfill, methane can be produced, a higher global warming potential gas than CO_2**[5].

[2] European Bioplastics (2019). Bioplastics market data. Retrieved from https://www.european-bioplastics.org/market/
[3] European Bioplastics (2020) https://www.european-bioplastics.org/bioplastics/materials/
[4] Dilkes-Hoffman, L., Pratt, S., Lant, P., Laycock, B., (2019). The Role of Biodegradable Plastic in Solving Plastic Solid Waste Accumulation, Plastics to Energy. Elsevier, pp. 469e505.
[5] Chidambarampadmavathy, K. Et al. (2017). Sustainable bio-plastic production through landfill methane recycling. Renewable & Sustainable Energy Reviews, 71, 555-562. doi:10.1016/j.rser.2016.12.083

Plastic biodegradation

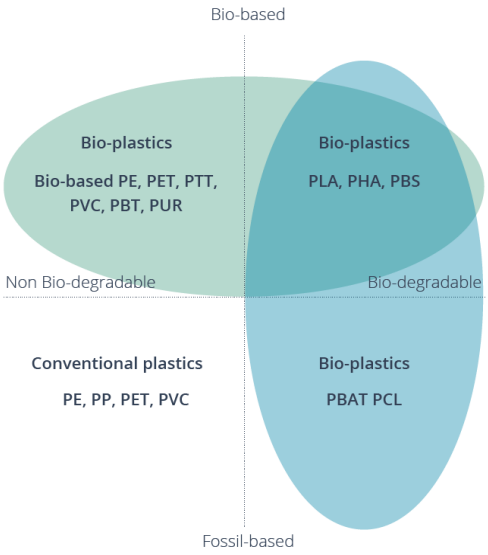
Most of fossil-based plastics do not biodegrade[6], which seems ironical as most of the plastics in the market today are petroleum-based, which is the product of million years of decomposition of what once was alive and made out of carbon. The lack of degradation is due to the manufacturing step, which turns petroleum into a high molecular compound with a polymerized resistant structure not recognizable by those organisms capable of breaking organic matter down. In other words, if nature does not make something like that, organisms cannot process something they have not seen before. **The principle behind biodegradable plastics (BDPs) is reducing the difficulty of breaking the long chain of carbon molecules, so that it is easy to decompose from polymer into small pieces, and then further degrade.**
In this regard, the development of BDPs from renewable biomass is a topic of great interest. BDPs are available both fossil origin and from renewable raw materials such as lignin, cellulose, starch and bioethanol.

Biodegradation is nature's recycling system, which basically means that microorganisms eat waste and convert it into nutrients (i.e., mineral salts), H_2O and carbon dioxide (CO_2) and/or methane (CH_4) with the production of new microbial biomass[7]**.** According to that definition of biodegradability, compostable plastics will not contribute to recycling if treated at a composting facility.
Furthermore, **biodegradation should not be confused with "compostable" (BDPs managed in a certified composting environment) or "bio-based"**. In this regard, the lack of info on product labels or the abundance of different labeling often causes additional confusion among costumers[8].
BDPs cannot substitute conventional plastics for all applications, however, BDPs production is growing annually and therefore there is an increasing need for correctly disposing BDPs. Consequently, whether BDPs are a friend or foe to solve the plastic waste disposal problem and plastic pollution in the long run is a question that needs further consideration. Where the impact of BDPs on existing recycling schemes (incl. sorting and recyclate production) should not be overlooked.

[6] Polymers such as polybutyrate adipate terephthalate (PBAT), polybutylene succinate (PBS), polycaprolactone (PCL) and polyvinyl alcohol (PVOH, PVA) are biodegradable polymers as their structure contains chemical groups that can be easily broken down by the action of microorganisms. Bioplastic Guide: http://www.bioplastics.guide/ref/fossil-based/biodegradable#:~:text=Polymers%20such%20as%20polybutyrate%20adipate,by%20the%20action%20of%20microorganisms.
[7] SAPEA (2020). Biodegradability of Plastics in the open Environment.
Retrieved from: https://www.sapea.info/topics/biodegradability-of-plastics/
[8] Lambert, S., Wagner, M., (2017). Environmental performance of bio-based and biodegradable plastics: the road ahead. Chem. Soc. Rev. 46, 6855–6871.

Questions to reflect on Biodegradable plastics (BDPs)

What are exactly BDPs and where to find them?



Biodegradable plastics (BDPs) ideally refers to a kind of plastic whose properties meet the use requirements of conventional plastic they are substituting for in certain applications, **mainly packaging**, and remain unchanged during the use period, but can be chemically transformed by microbes into environmentally sound substances[9] under specific conditions (e.g., temperature, pH, time …) at their end-of-life (EoL)[10]. It is however important to know that **even EN 13432 certified BDPs are not accepted in the composting process in many Member States** because of problems they generate in the composting of bio-waste. Nowadays, **BDPs are mainly used for packing and the best-selling products are garbage bags, soft/rigid packaging and disposable ceramics, with a growing market for packing/agricultural film, disposable bags and plastic tableware**[11]. The cost of BDPs is slightly higher than that of conventional oil-based plastic materials[12], however, due to greenwashing, consumers are willing to opt for BDPs. In consequence, the BDPs industry is annually growing and the application market is going broader.

At present, biodegradable and commercially available natural polymers on the market include mainly polylactic acid (PLA), polyhydroxyalkanoate (PHA), polyhydroxybutyrate (PHB), polyhydroxybutyrate valerate (PHBV) and polyhydroxybutyrate (PHV). All of these are bio-based plastics, however, **some fossil-based plastics can also be biodegradable** like polybutyrate adipate terephthalate (PBAT), polybutylene succinate (PBS), polycaprolactone (PCL) and polyvinyl alcohol (PVOH, PVA). Therefore, the term bio-plastics for BDPs should as far as possible be avoided as it remains unclear if it refers to the origin of the raw material ("bio-based") or the behaviour at the waste stage ("biodegradable").

Can BDPs solve the problem of plastic waste and plastic accumulation?

As an alternative to conventional recyclable plastics, technology solutions that decompose waste plastics into CO_2 and H_2O to return to nature[13] seem, in theory, a good idea to deal with plastic waste accumulation.
However, plastics on the market are marked as **"biodegradable" only according to certain** standards of the International Organization for Standardisation (ISO) or regional and national standards and when BDPs are mixed with common plastics they do not decompose and interfere with the recycling process of conventional plastics. BDPs used in packaging is usually certified to biodegrade in industrial or home composting processes. This means that they will not biodegrade in other environments, like in the soil or in (fresh and salt) water; and there are two fates in the environment: accumulate and break up. Like conventional plastics (e.g., PE and PP), **BDPs can also**

[9] Carbon dioxide (CO2) (or carbon dioxide and methane in conditions where oxygen is not present), new microbial biomass and mineral salts, within a timescale short enough not to lead to lasting harm or accumulation in the open environment.
[10] Pic_o, Y., Barcel_o, D., (2019). Analysis and prevention of microplastics pollution in water: current perspectives and future directions. ACS Omega 4, 6709e6719.
[11] European Bioplastics, (2019). Bioplastics Materials.
[12] Rujni_csokele, M., Pilipovi_c, A., (2017). Challenges and opportunities of biodegradable plastics: a mini review. Waste Manag. Res. 35, 132e140.
[13] Sedaghat, L., (2018). Things You Didn't Know about Plastic (And Recycling). National Geographic.

fragment into microplastics and nanoplastics posing a risk to the environment [14,15] and, by altering ecosystem functioning, have a negative impact on the carbon sequestration and, thus, increase global warming[16].
In consequence, it is vital to understand that the **time of biodegradation is conditioned by the chemical structure and the environmental conditions** and if under those conditions, the degradation rate of BDP is not significantly different from that of conventional plastics, limited biodegradability will not benefit the environment from the mismanagement of plastics waste and therefore the need to question the added value of BDPs applicability and BDPs production in the first place.

What are the applications where BDPs can prevent potential risk of using plastics to the environment?

As described in the 2018 EU Plastics Strategy, applications for BDPs with clear environmental benefits (and criteria for such applications) should be identified, and in those cases the Commission will consider measures to stimulate use. **If plastics are intentionally brought into the open environment** (e.g., mulch films), for those applications with a high-risk plastic loss (e.g., fireworks, fishing devices …) **and those for which loss is intrinsic to use** (e.g., dolly rope); and which are a necessary or unavoidable application without a more environmentally friendly alternative; **the use of BDPs can generate added-value products**[17]. Preferably in these cases, the plastics should be marked as soil-degradable or water-degradable, since biodegradable does not mean the material will break down in the natural environment.

For all the rest of the plastic applications, **end-of-life (EoL) should imply disposal in a managed waste stream**, where they can preferably be recycled.

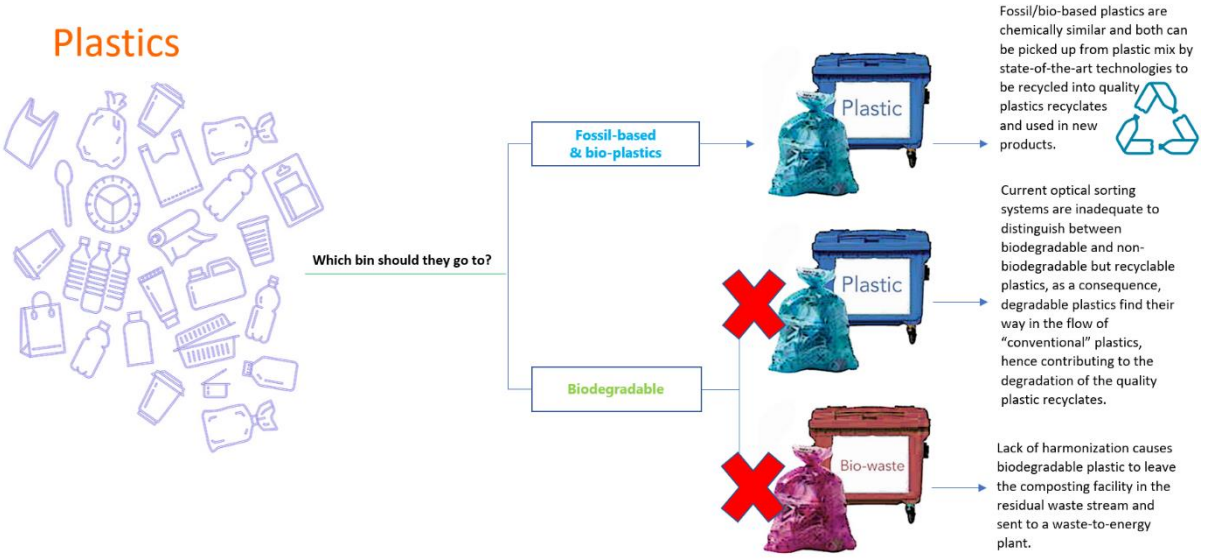
Can existing waste management systems accommodate BDPs?

There is a lack of a reasonable disposal method for BDPs. The large production and consumption of BDPs need a promising large-scale processing scheme. The confusion of traditional plastics and BDPs adds a lot of difficulty to an already complex waste management process because the **different plastic characteristics require different waste management options**. Consequently, the random use of BDPs undesirably impacts the existing recycling scheme, namely, the processes of sorting, and recyclate production. In other words, plastic waste is more difficult to collect, the classification process is more arduous and long, and the uncertainty of recyclates regeneration increases. Easy recycling depends on molecular structural compatibility and product processing requirements. According with waste trends and current waste sorting technology, **the difficulty of recycling will increase, and the quality of recycling will decrease owing to contamination with plastics of different characteristics ending up in the same waste stream**. For example, when BDPs (e.g., PLA) and conventional plastics such as PET, and HDPE are mixed with each other during waste treatment, it will reduce the recycling quality of traditional plastics suitable for mechanical recycling[18]. This is because current optical sorting systems in place are also inadequate to distinguish between biodegradable and non-biodegradable but recyclable plastics[19]. As a consequence, degradable plastics find their way in the flow of "conventional" plastics, hence contributing to the degradation of the quality of plastic recyclates. Therefore, i**t is important to be reticent with the use of polymer types for which there is no sorting and recycling infrastructure in place, like biodegradable plastics.**

[14] Shen, M., et al. (2020). Are biodegradable plastics a promising solution to solve the global plastic pollution? Environ Pollut. 2020 Aug;263(Pt A):114469. doi: 10.1016/j.envpol.2020.114469. Epub 2020 Apr 1. PMID: 32272422.
[15] Nazareth, M., Marques, M.R., Leite, M.C., Castro, ˙I.B., (2019). Commercial plastics claiming biodegradable status: is this also accurate for marine environments? J. Hazard. Mater. 366, 714–722.
[16] Sanz-Lázaro et al. (2021) Biodegradable plastics can alter carbon and nitrogen cycles to a greater extent than conventional plastics in marine sediment, Science of The Total Environment, Volume 756,143978,ISSN 0048-9697,https://doi.org/10.1016/j.scitotenv.2020.143978.(http://www.sciencedirect.com/science/article/pii/S0048969720375094)

[17] Group of Chief Scientific Advisors - Scientific Opinion No.10, (2020). Biodegradability of Plastics in the Open Environment Research.
[18] Hopewell, J., Dvorak, R., Kosior, E., 2009. Plastics recycling: challenges and opportunities. Philos. T. R. Soc. B 364, 2115–2126.
[19] Rujnic-Sokele, M., Pilipovic, A. 2017. Challenges and opportunities of biodegradable plastics: A mini review. Waste Management & Research, 35(2, SI), 132-140. doi:10.1177/0734242X16683272

Biodegradable plastics could also allow alternative after-use pathways, such as industrial composting (i.e., biodegradable into a certified composting environment). However, these **BDPs are currently mixed with the rest of bio-waste** (i.e., food and garden) **and most biodegradable plastic collected with bio-waste leaves the composting facility in the residual waste stream and it is sent to a waste to-energy plant, where it joins the residual household waste stream for incineration with energy recovery**[20]. As long as the EN13432 conditions do not correspond to the practical conditions in the existing industrial composting plants for bio-waste (Vegetables Garden Fruit-waste), most biodegradable plastics will not break down. Therefore, to grant efficiency in the process of composting, **no BDPs should be accepted at all in the bio-waste except for a few very specific applications, being collection bags for bio-waste, teabags and coffee pads**[21]**.** Another niche market for BDPs could be mono-streams (a single specific waste category), such as manufacturing waste from factories and plastic beakers used at festivals, where BDPs could be collected separately and processed in a particular way in specialized composting facilities; and only if a life cycle analysis shows that this is the most environmentally friendly processing route. The possibilities depend on the individual composter and waste collector[22].



What are the pitfalls of using BDPs?

- **BDPs is not a synonym for hazard-free.** It is also worth noting that a claim that a material is biodegradable or bio-based says nothing about the potential use of hazardous substances. Plastics contain a complex mixture of additives such as plasticizers, antioxidants and stabilizers that improve the material's functionality. This applies for both, conventional as well as bio-based and biodegradable plastics. A **comparison with conventional plastics indicates that bio-plastics are similarly toxic to conventional plastics**[23].

- **Lack of public awareness about BDPs management.** Raising the environmental awareness of the public is also an essential part of promoting BDPs. How to identify and deal with BDPs is not only a major concern of the public, but also **a problem to be solved**. It is recommended to raise awareness that BDPs (bags, containers, and other materials) **need to be separated from other recyclable materials**. BDPs may not have an adverse impact on waste management if appropriate labelling and differentiated waste collection systems are developed. They are an increasing waste that needs to be properly managed. In this regard,

[20] Member States composting facilities have different composting protocols which affects the effective breaking down many of the biodegradable plastics.
[21] In this regard, there can be variation between member states, depending on the available composting processes and their acceptance of BDPs.
[22] Fact Sheet Dutch waste management association Plastic: biobased and biodegradable? A guide to the bioplastics market (2018) https://www.verenigingafvalbedrijven.nl/public/Factsheets/9/bestand/DWMA-Fact%20sheet-Bioplastics.pdf
[23] Zimmermann, L. et al. (2020). Are bioplastics and plant-based materials safer than conventional plastics? In vitro toxicity and chemical composition, Environment International, Volume 145, 106066, ISSN 0160-4120, https://doi.org/10.1016/j.envint.2020.106066.

industrial setting, has created the **misconception that those plastics will also readily degrade in any other environment**. As described in the 2018 EU Plastics Strategy "It is important to ensure that consumers are provided with clear and correct information".

- **Misguiding labeling.** One of the main disadvantages of the term "biodegradable" is that it does not contain any information about the location, time scale, and extent of the decomposition process. In fact, **biodegradability is usually defined by purpose or related conditions**. Furthermore, a clear definition of biodegradable will prove problematic in reality, because the way composting facilities work differ across EU. As suggested in the European Strategy for plastics, specific labelling is needed to distinguish recyclable plastics from BDPs and compostable, as they may negatively affect the quality of recycled products and increase littering. Consumers will need to be informed about these differences in order to ensure correct disposal. However, although there can still be a clear definition for marketing purposes, it may not be harmonized across Member States[24] and, therefore, to simplify the lack of "clear labelling or marking" inherent to the difficulty of plastics classification and also taking into consideration to the lack of "adequate waste collection and treatment schemes for BDPs"; **the only label needed should be recyclable**[25] and only plastic items with the recyclable label should go in the plastic bin.

- **Lack of separate collection systems and harmonization.** Although biodegradable plastics theoretically could be industrially composted, the absence of widespread bio-waste separate collection and industrial composting facilities in Europe is translated into BDPs sent to landfills or incinerators. However, even when industrial composting facilities are present, it does not mean that BDPs are accepted in the bio-waste, even when they are EN 13432 certified. There are several reasons (e.g., hazardous chemicals[26]) BDPs hamper the process of producing clean compost from bio-waste. Another reason why so little BDPs are composted in practice is that the **composting periods used at different Member States composting facilities are different**, and in some cases shorter than is needed to break down many of the biodegradable plastics.
  Related to the previous point, plastic packaging should never be labelled as 'compostable' because by doing so it motivates consumers to dispose of it in the biowaste and this just fosters single use.

Considerations to move forward with biodegradable plastics (BDPs)

Nowadays, BDPs represent a very small share of the plastic market. However, their use should not be underestimated. The **lack of knowledge about BDPs affects the consumption of plastics products and creates an improper disposal of these materials that hampers the effectiveness of waste managing systems** and, same as commonly used plastics, also threatens the environment if not correctly managed. Environmental impact assessment of BDPs is still at its infancy, although it is already known that **BDPs exhibit a wide range of incomplete degradation rates under the extensive and complex physical and chemical conditions often encountered in conventional management systems or the open environment**.

[24] Plastics that are labelled 'compostable' or 'biodegradable' are not necessarily suitable for home or industrial composting because the norm EN 13432 does not comply to the composting reality in all member states.
[25] Where a minimumm % should be set for a plastic material to be considered as recyclable.
[26] Choi et al. (2019), Municipal Organic Solid Waste Composts. Environmental Science & Technology Letters, 6(6):372–377.

Therefore, **the effective way to solve plastic waste accumulation and minimize pollution** should not be too centered in the optimization of material technology but focused **on the improvement of plastic reuse and plastic waste management through existing schemes such as mechanical recycling, as both are the most effective ways to reduce plastic waste**.

Furthermore, proper plastic recycling is key to realize the circular economy for plastics and taking into consideration the present lack of adequate waste collection and treatment systems for BDPs and to avoid complexity, **the only label needed on plastic products should be recyclable.** According to this, only plastic items with the recyclable label should go in in the plastic bin.

To prevent **enthusiasm of green consumption and green purchasing turning into wishful thinking,** and taking the above into consideration:

- **All plastic products must be designed according to the design-for-recycling principles**, which means that the **collection, sorting and recycling of the material must be possible in existing infrastructure and this needs to be determined by extender producer responsibility (EPR) schemes**.
- The use of **biodegradable should be banned from all plastic packaging products** until a proper infrastructure is put in place to collect, sort and treat biodegradable packaging plastics.
- Under the current scenario, there is the **utmost need to set strict criteria for the use of compostable plastics** in order to restrict the types of plastics that can be discarded in the bio-waste. It is important to make an exhaustive list of applications where compostable plastics may be used in combination with the quality mark "compostable".
- For BDPs or other new types of polymers which their production is more environmentally friendly than conventional plastics, it is **also necessary to manage their end-of-life in an efficient manner** to effectively protect the circular economy of plastics and the environment.
- In line with the principles of circular economy, plastic recycling should be regarded as a priority. This would require a coordinated approach among **government, industry and citizens**.

Read more about plastic recycling:

EuRIC Plastics Recycling Fact Sheet

EuRIC is the Confederation representing the interests of the European recycling industries at EU level. EuRIC, through its various Branches covering the vast majority of waste streams, brings together National Recycling / Resource Management Federations and Companies in lieu from more than 23 European countries active locally and globally.

EuRIC represents across Europe over:

- 5,500+ companies generating an aggregated annual turnover of about 95 billion €, including large companies and SMEs, involved in the recycling and trade of various resource streams;
- 300,000 local jobs which cannot be outsourced to non-EU countries;
- Million tons of waste recycled per year (metals, paper, glass, plastics, WEEE, ELVs, tyres, batteries, textiles and beyond).

By turning wastes into resources, recycling is the link which reintroduces recycled materials into the value chains again and again. Recyclers play a key role in bridging resource efficiency, climate change policy and industrial transition.