SEALIVE
Strategies of circular Economy and Advanced bio-based solutions to keep our Lands and seas alIVE from plastics contamination

Policy Briefing

The Importance of Clear Definitions in Managing Bio-based and Biodegradable Plastics

Summary

- There is some confusion in what is meant by "bio-based", "biodegradable" and/or "compostable" plastics. This confusion is not only by consumers – there are differences in use of the terms in law and policy.
- The term "bio-based" refers to plastics manufactured, entirely or partly, from biological source material. However, issues arise as non-biologically sourced additives are used, or products combine more than one material from different sources.
- "Biodegradable" is used in different ways. Can materials be described as intrinsically biodegradable or can this term only be used in the context of specific environmental conditions in which materials are placed? What is the role of standards? Definitions of this term are used in different ways by different stakeholders and confusion may result.
- "Compostable" also has potential for confusion. Policy makers often limit this to industrial composting, yet the term itself does not do this and consumers may be misled.
- This briefing explores the different uses of these terms and proposes definitions which aim to overcome the confusion and inconsistency. It also makes recommendations for their use consistent with the principles of better law making. Law and policy should not use the terms without defining them.

Introduction

Plastics are of many different types. They have different properties that affect what products they can be used for. These properties also affect their end of life, such as whether they can be recycled or whether they degrade in the open environment. The SEALIVE project is researching new bio-based, biodegradable and compostable plastics. However, it is not always clear what is meant by the terms "bio-based", "biodegradable" or "compostable". Being clear is not an issue of semantics or a concern to a few specialists. Clarity is important so that claims made by companies about environmental performance are robust and that consumers know what to do with the plastics in their homes.

The importance of clear terminology and clear communication of those terms has been stressed by the United Nations (UN), European Union (EU) and national governments, as well as by industry and NGOs. As a result, one might expect that the terms used are, by now, clear in their definitions and uses. This is, however, not the case. Sometimes they are not well defined, and different organisations may interpret the terms differently.

This briefing, therefore, examines the different definitions that are used and makes proposals for clear use of these terms by policy makers and industry.

The Range of Plastics

This briefing is concerned with definitions that reflect the materials used to make a plastic and also the behaviour of a plastic at the end of its life. These are two different things.

Most plastics are derived from oil (or another fossil fuel source). These are termed “conventional plastics”. However, some plastic polymers are made from biological material (e.g. crops, organic waste, etc.) and these are termed “bio-based plastics”.

This briefing is also concerned with plastics, conventional or bio-based, which are biodegradable – that completely decompose in the environment (“biodegradable plastics”). There is a sub-set of these which decompose in composting conditions, termed “compostable plastics”.

The terms “bio-based” and “biodegradable” are simple in concept, but in practice their interpretation is complicated.

Before further exploring the issue of definitions, it is important to stress that bio-based plastics and biodegradable plastics are not the same thing. Just because a plastic is made from a biological source does not mean that it will biodegrade. Further, it is possible to make a biodegradable plastic from oil. It is often the case that a biodegradable plastic is bio-based, but this is not a necessary relationship. This can be particularly confusing for consumers who read the “bio” part of a label and may attribute all sorts of positive attributes to a product, which are not warranted.

A further issue that arises with regard to biological source material is whether that source is sustainable. Cutting down virgin forest to grow the material is clearly not sustainable, but many issues arise for other sources, such as use of fertilisers, the overall carbon balance, etc. However, as far as a definition of “bio-based” is concerned, the sustainability of the material is not relevant. If it is derived from a biological source, it is “bio-based”. Whether that is a good idea or not, is a different question[1].

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Bio-based

Box 1 provides some definitions of "bio-based" plastics from the UN, EU and industry. All are effectively quite simple – that bio-based plastics are derived from biological sources rather than sources such as oil. All sorts of biological sources can be used – crops, waste wood from forestry, organic waste from domestic sources, algae, etc. As long as the source is biological, the plastic made from it is "bio-based".

Box 1: Examples of definitions of "bio-based"

FAO 2021[2]: "Plastic polymers that are derived from plant based raw materials."

European Bioplastics[3]: "The term 'biobased' means that the material or product is (partly) derived from biomass (plants). Biomass used for bioplastics stems from e.g. corn, sugarcane, or cellulose."

EEA 2021[4]: "Bio-based plastics are fully or partly made from biological raw materials as opposed to the fossil raw material (oil) used in conventional plastics."

European Commission 2022a[5]: "Referring to plastics as 'biobased' points to the raw materials, or feedstock, used for their production. While conventional plastics are made from fossil resources (oil and natural gas), biobased plastics are made from biomass."

There is, however, a further complication beyond understanding "bio". This concerns the word "plastic" in "bio-based plastic". Does this refer to a plastic polymer? Is it a plastic material ready for use in making a product? Is it the product itself?

In developing a bio-based polymer, a manufacturer may use starch or cellulose from a biological source to create the requisite monomers and from these create the plastic polymer. If they sell this on to others, it is clearly "bio-based", without any issues. However, it is possible that more than one feedstock is used to make a polymer, biological and non-biological. In this case it may be appropriate to set a lower limit or standard of the amount derived from biological feedstock for the polymer to be termed "bio-based".

It is unlikely, however, that those wanting to use the polymer will be able to do so without some further modification. Small quantities of additives may be needed. These chemicals may affect the durability or flexibility of the material or, indeed, its colour. What is the origin of these additives? If they are not from a biological origin, but only added in small quantities, is the plastic still "bio-based"?

Then there is the product. It might be made from more than one type of plastic (or other material). If so, how far can it be described as "bio-based" if not all of it is from materials of a biological origin? How does this affect labels and other communication with stakeholders?

Where bio-based material is mixed with non-biobased material, one approach is to require a minimum amount of the material to be bio-based. This is a policy decision – any percentage

chosen is determined by what is considered reasonable rather than being a scientific threshold. In Europe, the European Technical Committee for Standardisation for biobased products (CEN/TC411) has set out standards, which are voluntary. The European Commission (2022a) states that "In order to avoid misleading consumers, claims should only refer to the exact and measurable share of biobased plastic content in the product, stating for instance, that the 'product contains 50% biobased plastic content'".

In practice a single minimum percentage standard for all products might be simple, but it may not be appropriate. If one purchases a complex product with many components, then one might expect some to be bio-based and some not. However, if a food processor purchases plastic trays and film to package ready meals, these are both items made of single plastics. They may have additives, but, if they are "bio-based", one might expect the overall bio-based content to be very high. This is a complication, but it is about ensuring a robust and practical approach to setting standards linked to a workable definition of "bio-based".

There is a further issue in setting standards for minimum levels of bio-based content and that is how reliably the bio-based content is determined. It is possible to calculate relative inputs to a final product in a mass balance approach. The European Commission (2022a) questions the reliability of this method and, instead, prefers a radiocarbon test of the final product itself. Again, while determining what tests are effective and practical is very important, these do not change the nature of a policy definition of a bio-based product based on a minimum percentage of bio-based material.

In conclusion, Box 2 sets out definitions of "bio-based" derived from the analysis within the SEALIVE project. These definitions acknowledge the difference between a fully biological origin of a basic plastic polymer and the more complex situation later in the manufacturing process and use of standards.

Box 2: Definitions of "bio-based" proposed by SEALIVE

"Bio-based plastic polymer": "A polymer that is fully or partly derived from biological source materials. A standard may be set for the minimum level of bio-based content".

"Bio-based plastic": "A plastic for which the main polymer is fully or partly derived from biological source materials. A standard may be set for the minimum level of bio-based content."

"Bio-based product": "A product for which the main component(s) is derived from biological source materials. A standard may be set for the minimum overall level of bio-based content."

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Biodegradable

The next definition to consider is "biodegradable". Box 3 contains some examples of definitions from European and UN sources. These all agree on the degradation part of the definition – that the material eventual converts to water, carbon dioxide, etc. However, the definitions also differ.

Box 3: Examples of definitions of "biodegradable"

European Bioplastics: "Biodegradation is a chemical process during which microorganisms that are available in the environment convert materials into natural substances such as water, carbon dioxide, and compost (artificial additives are not needed). The process of biodegradation depends on the surrounding environmental conditions (e.g. location or temperature), on the material and on the application."

EEA 2021: "Biodegradable plastics are designed to biodegrade in a specific medium (water, soil, compost) under certain conditions and in varying periods of time."

European Commission's Group of Chief Scientific Advisors 2020 : "Plastic biodegradation" is "the microbial conversion of all its organic constituents to carbon dioxide (CO2), new microbial biomass and mineral salts under oxic conditions [in the presence of oxygen] or to carbon dioxide (CO2), methane (CH4), new microbial biomass and mineral salts under anoxic conditions [in the absence of oxygen]."

European Commission 2022a: "'Biodegradable' [plastics] are designed to decompose at the end of their life by the conversion of all their organic constituents (polymers and organic additives) mainly into carbon dioxide and water, new microbial biomass, mineral salts and, in the absence of oxygen, methane".

UNEP 2015[7]: "Biodegradation" is the "Biological process of organic matter, which is completely or partially converted to water, CO2/methane, energy and new biomass by microorganisms (bacteria and fungi). "Biodegradable" is "Capable of being biodegraded".

FAO 2021: "Biodegradable plastic": "A biodegradable plastic is defined as a plastic that can be broken down into its constituent monomers and metabolized through the action of microorganisms, such as bacteria and fungi, over a period of time, into substances such as water, carbon dioxide and biomass. It can be produced from either bio-based or fossil-based precursors".

European Bioplastics includes the specific qualification that biodegradability depends on the surrounding environmental conditions. This is a similar point to the EEA inclusion of "certain conditions" in its definition. Indeed, although the European Commission 2022a definition here does not reference the conditions for degradation, the European Commission does later emphasise this point (see below).

Therefore, an important distinction is whether something can be inherently described as biodegradable, or whether that character can only be ascribed once the environment in which it is placed is known.

The EEA definition also includes the word “designed” – that the property of biodegradability is something that is designed into a plastic. Clearly plastics are manufactured, but it seems a step too far to include “design” here. The right plastic in the right environment will biodegrade irrespective of whether that was a conscious design decision. It may be that most biodegradable plastics are manufactured with biodegradability as a conscious end-point, but that may not be always the case.

Note also that the European Commission 2022a definition also emphasises that biodegradability is not a property limited to the basic polymers of the plastics, but should also apply to any organic additives.

Biodegradation is not absolute. It always requires the right conditions. Without them even materials such as paper and wood (commonly viewed as biodegradable) can last for centuries. The same applies to plastics. As a result, the European Commission 2022a correctly emphasises that “biodegradation must be regarded as a ‘system property’ that takes into account material properties, specific environmental conditions and risks.” In effect, this moves the assessment of whether something is biodegradable from “can it biodegrade?” to “will it biodegrade?”. The answer to that will change depending on the particular environment. A material may biodegrade in a tropical soil, but not an arctic soil (or at least much more slowly). Scientific testing and field observation can inform decisions on what materials or products might be used in different environments.

A problem arises where policy seeks to interpret “biodegradable” where the final location of the plastic is unknown. One might assume that the European Commission policy argues that this should be avoided in the use of the term. However, the European Commission has also proposed legislation which does exactly this. In its proposal for a new Regulation on Packaging and Packaging Waste[8] the European Commission states in Article 8: “By [date], packaging …., including packaging made of biodegradable plastic polymers, shall allow material recycling without affecting the recyclability of other waste streams.” Given the importance of clear definitions, it is firstly unfortunate that the terms “biodegrade”, “biodegradable plastic” and “biodegradable plastic polymer” are not defined in the proposal.

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According to the Commission Policy document (European Commission 2022a), published on the same day as the proposed Regulation, biodegradability is a system property – it depends on which environment the packaging enters. However, if a manufacturer is packaging a toy using a "biodegradable plastic polymer", such as PLA, for sale across the EU single market, how would they know what environment the packaging might or might not enter? Packaging should not leak into the environment (though some of it does). Leakage is rarely predictable and may occur in different environments, so it is likely that leaked packaging made with a "biodegradable plastic polymer" would sometimes biodegrade and sometimes not. A manufacturer cannot predetermine this. Of course, this is not the intended use of the term "biodegradable plastic polymer" in the proposed Regulation. The aim is to encompass the use of, for example, PLA in all packaging. As a result, the interpretation of "biodegradable" is viewed as an intrinsic characteristic of the material independent of the environment. The term is not being used in a system context.

Given that two European Commission documents published on the same day use the term "biodegradable" in two different ways without clarification is unfortunate. It is likely that those making products to put on the market and those using products in different environments may need to take different approaches to understanding the term "biodegradable". Policy and law may also need to reflect these differences. Having said this, at the very least the proposed Regulation should include a clear definition to avoid confusion with the Commission's own policy document. This need for clarity and consistency is a basic rule for better law making[9].

This is not the only difference in the use of the term "biodegradable". In the SEALIVE project we have, for example, been told by some stakeholders that no plastics are biodegradable in a particular environment because no standard for biodegradation in that environment in Europe has been agreed. A scientist, however, would argue that something is or is not biodegradable depending on its properties and those of the receiving environment. Whether someone has or has not adopted a standard is irrelevant to that behaviour. This is the difference between a scientific use of the term and a policy use of the term.

Policy makers need to consider the speed of biodegradation that is desirable. In some instances the policy maker may consider that unless the material biodegrades relatively quickly, there is little benefit to having it. In another case, slower biodegradation may be acceptable as it is better than any alternatives that exist. In any case, these policy conclusions can be translated into standards or expectations in policy and law (e.g. for a product to be sold as "biodegradable", it must fully degrade within 12 months, etc.).

Putting this all together, there are three possible aspects of the term "biodegradable" (intrinsic, system and standard):

1. A plastic has intrinsic characteristics which mean it will biodegrade if placed in the right environment.

2. A plastic placed into a specific environment will biodegrade (but the timeline for this might be long).

3. A plastic placed into a specific environment will biodegrade within an established desirable timescale.

It is, therefore, important to be clear of the context in which a definition is used. As a result, Box 4 sets out definitions of "biodegradable" derived from the analysis within the SEALIVE project. The first definition is based on the European Commission definition, but it includes the system condition that biodegradation is dependent on the environment. A generic definition cannot, of course, state what that environment is. It is important to note, therefore, that a product made with a plastic that meets this definition should not necessarily be labelled as "biodegradable". This would depend on its actual use and the specific environment it would be placed into.

The second definition is based around the intrinsic nature of a polymer. It also cannot refer to a specific environment, so it is linked to the first definition of "biodegradable plastics" and should be used with it. It is, therefore, usable by those making and using polymers who might have no knowledge of the final environment, yet the link to the first definition retains the system nature of biodegradability.

Box 4: Definitions of "biodegradable" proposed by SEALIVE

"Biodegradable plastics" are plastics that will decompose at the end of their life in one or more environments, by the conversion of all their organic constituents (polymers and organic additives) mainly into carbon dioxide and water, new microbial biomass, mineral salts and, in the absence of oxygen, methane.

"Biodegradable plastic polymers" are plastic polymers that could be used to make biodegradable plastics.

Compostable

A specific type of biodegradable plastic is compostable plastic (used, for example, in bags to collect food waste in the home). They are defined according to a specific human controlled environment, i.e. they are designed to biodegrade in composting systems. Box 5 contains some examples of definitions of "compostable" and its extension to plastics and packaging. An important issue with composting is whether the definition applies only to industrial composting (i.e. for organic waste collected in the waste management system) or whether "composting" also applies to compost systems that people might have in their gardens.

Photo by John Cameron on Unsplash

Box 5: Examples of definitions of "compostable"

UNEP 2015: "Compostable" is "Capable of being biodegraded at elevated temperatures in soil under specified conditions and time scales, usually only encountered in an industrial composter (standards apply)".

EEA 2021: "Industrially compostable plastics are designed to biodegrade in the conditions of an industrial composting plant or an industrial anaerobic digestion plant with a subsequent composting step." Also: "Home compostable plastics are designed to biodegrade in the conditions of a well-managed home composter at lower temperatures than in industrial composting plants. Most of them also biodegrade in industrial composting plants."

European Commission 2022a: "'Compostable plastics' are a subset of biodegradable plastics designed to biodegrade under controlled conditions, typically through industrial composting in special facilities for composting or anaerobic digestion."

European Commission 2022b: "'Compostable packaging' means packaging capable of undergoing physical, chemical, thermal or biological decomposition such that most of the finished compost ultimately decomposes into carbon dioxide, mineral salts, biomass and water, according to Article 47(4), and does not hinder the separate collection and the composting process or activity into which it is introduced in industrially controlled conditions".

FAO 2021: "Compostable', in the context of plastic, is a precisely defined term. It means that an item can break down into carbon dioxide, water, and biomass within a specific time frame and under specific, controlled conditions. 'Industrially compostable' and 'home compostable' are subsets of the term, for which internationally recognized standards have been developed".

Ellen MacArthur Foundation and UNEP 2020[10]: "Compostable packaging: A packaging or packaging component is compostable if it is in compliance with relevant international compostability standards and if its successful post-consumer collection, (sorting), and composting is proven to work in practice and at scale".

It can be seen that some definitions explicitly limit the definition to industrial composting. This is important as the biodegradation often only takes place in the higher temperatures that are found in these controlled environments. Home composting may not allow that to happen. However, the EEA includes a specific definition for plastics that biodegrade in home compost.

While it is perfectly possible to define "compostable plastics" as those that biodegrade only in industrial composting situations, these plastics are often designed to be used in the home (e.g. to collect food waste). The challenge, therefore, is to avoid confusion between a definition and a label. A policy maker and a manufacturer might agree on the specific understanding of "compostable", but will the consumer take the same narrow view if they see the word on a label? There are ways to tackle this issue (e.g. to say specifically what the plastic should be used for rather than give it a generic label). However, it illustrates a challenge in using a term from everyday language, but in a different sense to how the public would understand that term.

Box 6 sets out terms for compostable plastics derived from the SEALIVE analysis. The definitions include one for composting generally and one specific to industrial composting. We consider that stating a "compostable plastic" cannot be used in home composting is confusing to the public. The alternative is to use "industrially compostable plastic", which allows for some restriction and is certainly more precise. As noted above, however, it may be best to avoid the term in public discourse.

The third definition mirrors a similar one for "biodegradable plastic polymer" allowing the designation of material without confirmed reference to its end of life. However, as compostable plastics are a sub-division of biodegradable plastics, this final definition may be unnecessary.

Box 6: Definitions of "compostable" proposed by SEALIVE

"Compostable plastics" are plastics that will decompose at the end of their life in composting conditions, by the conversion of all their organic constituents (polymers and organic additives) mainly into carbon dioxide and water, new microbial biomass, mineral salts and, in the absence of oxygen, methane.

"Industrially compostable plastics" are plastics that will decompose at the end of their life in industrial composting conditions, by the conversion of all their organic constituents (polymers and organic additives) mainly into carbon dioxide and water, new microbial biomass, mineral salts and, in the absence of oxygen, methane.

"Compostable plastic polymers" are plastic polymers that could be used to make compostable plastics.

Recommendations

- Great care should be taken to ensure terms used for bio-based, biodegradable and compostable plastics are clear.
- In law and policy (and other contexts) all terms should be defined before they are used.
- As far as is possible, strive for consistency in use of the same term in different items of law.
- The same term may have different definitions depending on the context of use (e.g. scientific work vs law) and, therefore, care must be taken to ensure clarity and to avoid using terms at cross purposes in discourse.
- Be careful to avoid confusion in definitions that seek to explore intrinsic characteristics, behaviour in different environments, specific uses or some combination of these.
- This briefing includes eight proposed definitions for "bio-based", "biodegradable" and "compostable" plastics which readers are invited to consider.
- Finally, this briefing has not explored terminology other than in English, but sometimes translations can introduce confusion not present in English, change nuances, etc. Therefore, this aspect also needs to be considered.

[1] Similar questions arise in considering the sustainability of feedstocks for biofuels.
[2] FAO 2021. Assessment of Agricultural Plastics and their Sustainability: A Call for Action. Food and Agriculture Organization of the United Nations. https://www.fao.org/3/cb7856en/cb7856en.pdf
[3] https://www.european-bioplastics.org/bioplastics/
[4] European Environment Agency 2021 Briefing: Biodegradable and compostable plastics — challenges and opportunities. https://www.eea.europa.eu/publications/biodegradable-and-compostable-plastics
[5] European Commission 2022a. EU policy framework on biobased, biodegradable and compostable plastics. COM(2022) 682. 30.11.2022. https://environment.ec.europa.eu/publications/communication-eu-policy-framework-biobased-biodegradable-and-compostable-plastics_en
[6] European Commission's Group of Chief Scientific Advisors 2020. Biodegradability of plastics in the open environment. https://op.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/0c0d6267-433a-11eb-b27b-01aa75ed71a1
[7] Peter Kershaw 2015. Biodegradable Plastics and Marine Litter. https://wedocs.unep.org/bitstream/handle/20.500.11822/7468/-Biodegradable_Plastics_and_Marine_Litter_Misconceptions,_concerns_and_impacts_on_marine_environments-2015BiodegradablePlasticsAndMarineLitter.pdf.pdf?sequence=3&amp%3BisAllowed=
[8] European Commission 2022b. Proposal for a revision of EU legislation on Packaging and Packaging Waste. COM(2022) 677. 30.11.2022. https://environment.ec.europa.eu/publications/proposal-packaging-and-packaging-waste_en
[9] It is important also to note that the proposal is for a Regulation to replace a Directive. Therefore, the new law will be directly applicable and business will need to interpret what is written in the Regulation without any elaboration or clarification by national transposing legislation as would have been the case with a Directive.
[10] Ellen MacArthur Foundation and UNEP 2020. The New Plastics Economy Global Commitment. 2020 Reporting Guidelines for business signatories. https://emf.thirdlight.com/file/1579178488/60858495664/width=-1/height=-1/format=-1/fit=scale/t=445329/e=never/k=bc0ad550/2020%20Global%20Commitment%20Reporting%20guidelines%20for%20business%20signatories.pdf

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