BEYOND PLASTIC MED

Business Club

ConsultantSeas

Risks and opportunities of material changes

Some concepts and feedback

BeMed Business Club
Fact sheet
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Changes of material

BeMed Business Club Fact Sheet - October 2024

This fact sheet is based on the content of the two thematic sessions dealing with the issue of plastic substitution. The sessions on 11 April and 26 June 2023, during which Henri Bourgeois Costa (Fondation Tara Océan), Stéphane Bruzaud (UBS), Martin Blondel (L'Occitane en Provence), and Jean-François Ghiglione (CNRS) spoke about biodegradable plastics, their uses and the issues surrounding them. The session on 8 November 2023 invited Carole Charbuillet (ENSAM) and Matthieu Carrère (Veolia) to speak on the issue of replacing plastic with paper or cardboard alternatives.

Summary

This technical data sheet sets out the various factors to be taken into account when considering replacing plastic with another material.

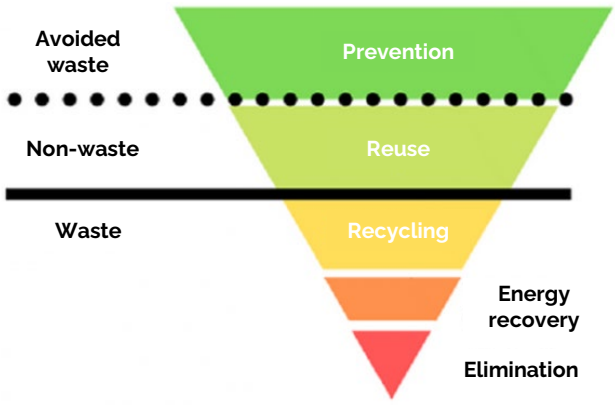
1. Consider reduction solutions
2. Ensure there is no transfer of impact
3. Take account of environmental, health and toxicity issues
4. Ensure compliance with current regulations
5. Be aware of the differences in properties between plastics and their alternatives

1.Consider reduction solutions

Respect the "waste hierarchy"

Before replacing plastic with another material, other solutions that are better for the environment and often less costly can be considered. The 'waste hierarchy' ranks the different waste treatment methods in order of priority[1], according to what has the least impact on the environment. It provides an essential framework for thinking about how to reduce the environmental impact of our plastics. The first thing to consider is whether the product in question is essential. If it is not, then doing without it avoids producing waste. If not, are there any re-use options available ?

After serious consideration of all these options, if the product proves to be indispensable and reuse is impossible, then replacing the plastic with another material may be considered.



[1] *The hierarchy of waste treatment methods before the courts : from incantation to application | Zero Waste France*

What is substitution ?

Here, substitution refers to the replacement of the material of a packaging/product or part of a packaging/product by another material.

Reviewing the properties required to meet usage needs without over-performing

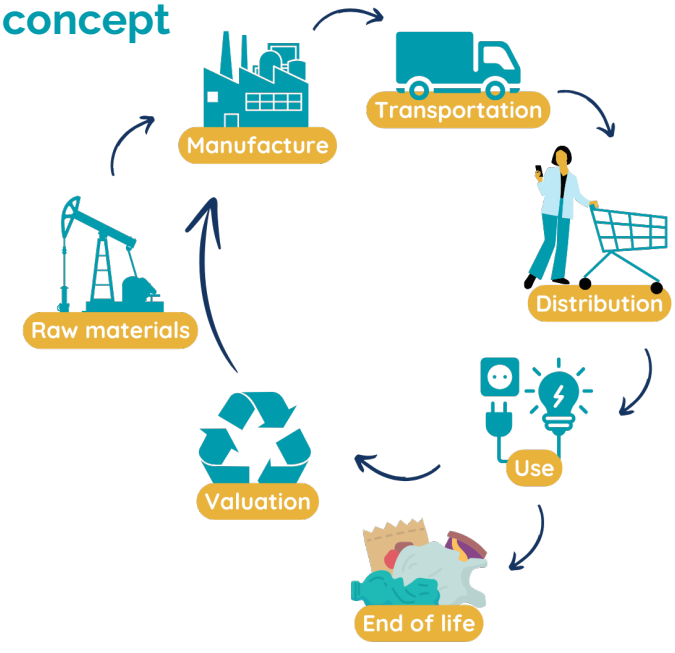
The first step in substituting one material for another is to adjust the properties required of the packaging according to the product's intended use and its most likely end-of-life scenario. Each material has different **properties** (resistance to humidity, recyclability, biodegradability, etc.) and generates different ecological and health **impacts** during its life cycle.

A packaging material that offers properties that are not necessary for its use can be described as 'over-performing'. The challenge is to find the **'right packaging'**, one whose properties meet a need for use and do not generate negative impacts associated with non-essential properties[2].

2.Ensure there is no transfer of impact

The importance of the life cycle concept

As part of the substitution process, it is vital to ensure that the chosen alternative does indeed reduce the environmental impact and does not create a transfer of impact[2]. To do this, it is important to bear in mind every stage in the **life cycle of a product** (from the extraction of the resources needed for its design to its end of life when it becomes waste). This is a key concept for understanding its environmental impact[3].



[2]*Displacement of impact to another stage of the life cycle, or to another impact criterion (ecotoxicity, resource depletion, etc.).*
[3]*Source of the diagram : https://www.cerema.fr/fr/actualites/materiaux-bio-geosources-cerema-realise-fiches-declarations*

For example, although paper/cardboard is based on the use of biomass, which is a renewable resource provided it is used wisely, its production exerts a number of pressures on forests, the climate, biodiversity and the use of water resources that should not be overlooked. A comparative environmental analysis (e.g. comparative Life Cycle Assessment) is needed to ensure that the substitution is **environmentally appropriate**.

End-of-life impact transfer: disruption of recovery systems

When one material is replaced by another, the impact can be transferred to the end-of-life phase of a product. This can occur :

- directly: e.g. the substitute packaging is no longer recyclable
- and/or indirectly on recovery systems: e.g. the substitute packaging interferes with the recycling of other products/packaging.

The layout of the sorting lines and machines in a centre is based on general knowledge of the composition of the waste streams. **Any development or change in the composition of incoming streams impacts sorting performance and alters the quality of outgoing streams, and therefore ultimately the volumes of material recycled** (see examples box below). The widespread substitution of plastic in packaging modifies the waste stream and can therefore **disrupt sorting**. This is an aspect that needs to be taken into account when **eco-designing packaging**.

The composition of packaging flows has an impact on recycling: a few examples

- **The replacement of HDPE (high density polyethylene) with opaque PET for milk bottles** has increased the presence of the opacifying agent titanium dioxide in PET recycling lines, which has had an impact on the resistance of the rPET produced.
- **The increase in the number of rigid 3D cardboard packaging items**, linked in particular to the boom in home deliveries, has led to a risk of sorting errors. This packaging is directed towards the hollow packaging stream (mainly made up of rigid plastics such as bottles and flasks), instead of the fibrous stream.
- **The increase in the number of complex multi-material packages (e.g. paper with plastic film)** whose different parts cannot or are not separated by the consumer is **disrupting sorting and reducing the quality of the recycled material.**

Sorting centres use the composition of the packaging flows from the 'Yellow Bin' to organise and optimise their sorting process. Using a range of equipment (screens, ballistic separators, optical separators, magnets, etc.), the packaging is sorted in several stages according to 3 main properties: **size, shape and material**.

3. Taking account of environmental issues and toxicity

Beyond the challenges of recyclability, alternatives to plastics - including biodegradable plastics and fibrous materials - can also present risks to the environment and human health.

Focus on the environmental and health impacts of paper and cardboard

Various comparative analyses have already shown that replacing plastic with paper/cardboard is not always THE best solution for reducing the environmental impact of plastic packaging.

Beyond the environmental impact, it is important to ensure that paper/cardboard **does not have a greater negative impact on health than the plastic it replaces.**

A number of studies have highlighted the risks involved when packaging comes into contact with food :

- In 2019, a BEUC (European Consumers' Organisation) study was carried out on more than 76 samples of paper/cardboard packaging and alerted to **the risks of transfer** between inks, treatment residues and food.
- A second study by Conchione et al (2020) on pizza boxes showed that food in contact with the cardboard packaging was **contaminated by mineral oils and polycyclic aromatic hydrocarbons**.
- The report by Générations Futures Throwaway Packaging, Forever Chemicals revealed **the presence of PFAS** (perfluorinated compounds) in moulded fibre food packaging and containers[4].

This contamination is often due to the presence of recycled materials that are not authorised for food contact, as well as the presence of ink and paraffin. Although the doses are low, the **accumulation effect** of these substances can have long-term consequences for human health.

[4]*Source : https://www.generations-futures.fr/publications/perflores-pfas-alimentaires/*
To find out more about the environmental impact of paper, "Disposable paper-based food packaging"

Focus on the environmental impact of biodegradable plastics

It is a common misconception that biodegradable plastics eventually break down and have no impact on the environment. However, the term 'biodegradable' should be distinguished from 'effectively biodegraded'.

→ **Just because a standard defines a plastic as biodegradable does not mean that it will biodegrade in all types of environment**. Biodegradability is a process that depends on several factors: characteristics specific to the polymer, format of the product/packaging, physical, chemical and biological conditions of the final environment[5].

Illustration with potato peelings : thrown into rich French forest soil, they degrade and nourish the soil. On the other hand, if it is thrown into the desert, there is a good chance that it will be found intact and not biodegraded months/years later.

→ Furthermore, **a plastic that biodegrades is not necessarily without consequences for the environment**. When they degrade, biodegradable plastics **generate microplastics and release additives** that affect the environment and have potential health impacts.

Illustration with phosphate and pig manure : Phosphate degrades well in an environment rich in micro-organisms (such as forest soil), but in a different environment (aquatic environment), it becomes highly toxic. As far as liquid manure is concerned, a small quantity has no environmental impact, but a large quantity in a system that is unable to absorb it will be highly toxic to the environment. This is known as **toxicity of scale.**

Focus on the health impacts of plastics

To date, our knowledge of the toxicity of plastics is limited. However, we do know that they have toxic effects at all levels of the food chain: microplastics are easily ingested by organisms. Through the phenomenon of bioaccumulation, they concentrate in their tissues and enter the food chain.

Added to this are the health risks associated with the toxicity of additives present in certain plastics (including biodegradable plastics). When plastic waste breaks down in the environment, these pollutants are found in all environments - air, soil, water, etc. - and are eventually ingested by humans. A study from Santé Publique France[6] has demonstrated the presence in our bodies of endocrine-disrupting or carcinogenic additives from plastics.

Did you know ? Ecotoxicity is the study of the potential impact of a plastic on the environment. Ecotoxicity is more difficult to measure and is less widely discussed today than toxicity (which, by definition, affects a living organism). It is virtually impossible to recreate the same conditions in the laboratory as in the environment.

[5] *For more details, consult the fact sheet on bioplastics.*

[6] *Study of Santé Publique France : "Everyday pollutants: new data on children and adults"*

Conclusions

To assess the environmental impact of the alternatives, it is therefore necessary to carry out comparative studies. However, these studies also have certain limitations: depending on the sources of the studies and the assumptions made, the results may differ. What's more, these tools do not yet take health risks into account.

Be careful with your interpretations !

4. Ensure compliance with current regulations

A number of regulations governing waste management need to be taken into account before substituting one material for another.

In France, the **AGEC law** ('anti-waste for a circular economy') of February 2020 provides for an end to the marketing of single-use plastic packaging by 2040. To this end, various decrees have set targets for the reduction, reuse and recycling of such packaging. These targets encourage the development of alternatives to plastic.

Point of caution!

If a pack is mainly made of cardboard/paper but contains more than 5% plastic, then under French law it is considered to be a plastic pack and is therefore subject to the same reduction targets.

Concerning **biodegradable plastics:**

- Several standards define the requirements for packaging that can be recovered by industrial composting and biodegradation (NF EN 13432:2000), the specifications for plastics suitable for domestic composting (NF T51-800), and the corresponding labels.
- There is no binding regulatory framework on the use of biodegradable plastics (apart from single-use plastics banned under the European Single Use Plastic Directive).
- In Europe, the European Commission has defined conditions to ensure that the environmental impact of their production and consumption is positive[7].
- In France, the AGEC law stipulates that products that can be composted industrially cannot be labelled 'compostable' (unlike products that can be composted at home). Compostable products must also bear the words 'Do not dispose of in the natural environment'. Claims such as 'biodegradable' or 'environmentally friendly' are prohibited on products.

[7] *For more details, see the European framework for biosourced, biodegradable and compostable plastics here*

Standards based on tests carried out in conditions far removed from reality

The scientific definition of biodegradation implies that all the material has been transformed into bacterial biomass or CO2. However, the biodegradability tests on which the standards are based are carried out in laboratories, **under conditions that are not sufficiently representative of the natural environment**, and without the plastic actually having been in contact with the natural environment. As a result, some plastics that meet biodegradability standards do not actually biodegrade in the environment.

So it's important to remain vigilant when it comes to biodegradability claims and standards. And if you want to be sure of a plastic's actual biodegradability, it's best to call in a specialist scientific laboratory.

Plastic degradation, a difficult characteristic to measure

From the mineralisation stage onwards, the rate of degradation of a plastic is measured as a function of time. The calculation of the quantity of CO2 produced from a certain quantity of plastic is called '**respirometry'**. However, studies have shown that micro-organisms deteriorate the organic matter attached to the plastic rather than the plastic itself. When scientists measure CO2 levels, **it is therefore difficult to determine whether the CO2 measured comes from the biodegradation of the plastic or from the transformation of the organic matter**. Added to this is the presence of numerous cyanobacteria, which produce CO2 and also affect the results of CO2 calculations. Calculating the exact respirometry is therefore difficult, even more so when you want the measurements to be representative of natural degradation conditions.

Plastics regulations (some examples)

Europe	Monaco	Tunisia	Mediterranean
- Following the adoption of a plastics strategy by the European Commission in 2018, a directive was approved in March 2019 by the European Parliament. It provides for a ban on a series of plastic objects. - In October 2020, the European Commission also strengthened measures concerning shipments of waste, notably banning the export of plastic waste unsuitable for recycling to countries outside the OECD (Organisation for Economic Co-operation and Development). - In February 2021, the European Union (EU) launched its Global Alliance for Circular Economy and Resource Efficiency (GACERE), bringing together a number of states and partners to drive forward initiatives for the transition to the circular economy in their policies and in international bodies.	- Back in 2016, the Princely Government drew up a Waste Prevention and Management Plan for Monaco to implement a 'Zero Single-Use Plastic Waste by 2030' policy. For more details on the measures of this policy: here - Monaco has signed the Charter on Plastics in the Oceans, pledging to recycle and reuse at least 55% of its plastic packaging by 2030.	- The production, possession, import and distribution of plastic bags of all kinds, obtained free of charge or in exchange for payment at commercial points of sale, should have been banned since the government decree of 16 January 2020. However, its application has been suspended under pressure from professionals in the sector. - On 23 March 2023, the Tunisian Ministry of the Environment announced a ban on single-use plastic bags in all the country's bakeries.	- In the Mediterranean, the Barcelona Convention and its protocols provide the legal framework for regional action plans. For example, the Action Plan aims to prevent and reduce pollution from ships, aircraft and land-based sources in the Mediterranean Sea. - The COP 21 of the Barcelona Convention in December 2019 underlines the urgency of preventing and significantly reducing plastic dumping at sea by 2025. Clear commitments have been made to reduce plastic consumption, support eco-design, innovation and resource efficiency, promote better waste management and put in place enhanced control and prevention measures.

5. Be aware of the differences in properties between plastic and its alternatives

In addition to regulatory constraints and consideration of environmental and health impacts, the choice of material is defined by the constraints of a technical specification. The **specifications** take into account the function of the packaging, the inherent characteristics of the packaged product and the context in which it is used.

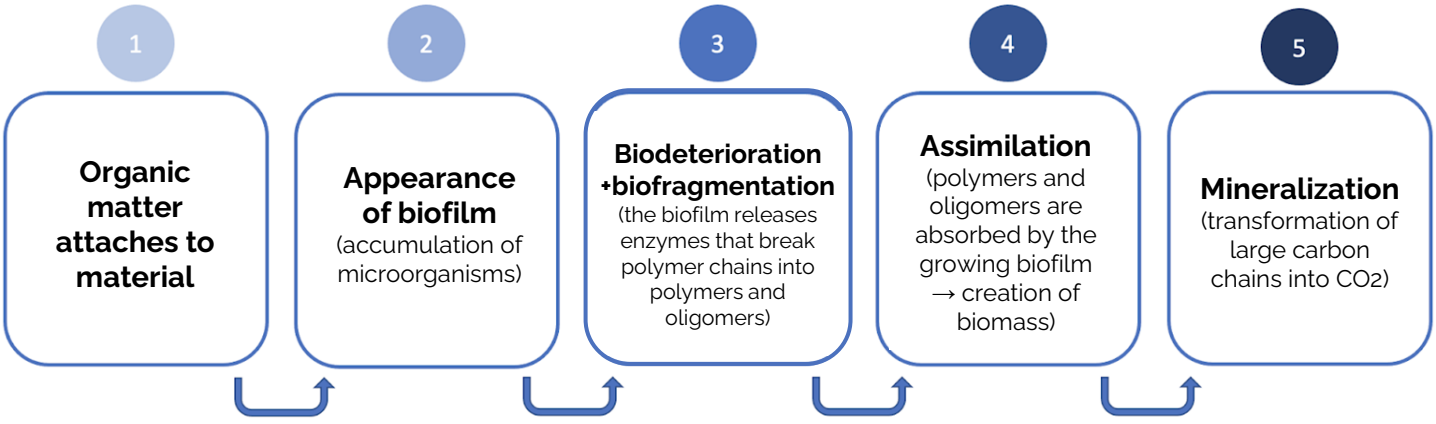
Plastic

Historically, plastics have developed rapidly because they have proved to be economically very attractive compared with other materials. What's more, by adding additives, it is possible to give plastics a wide range of properties: flexibility, colour, durability, resistance to heat, impact, etc.

Biodegradable plastics

Biodegradable plastics are plastics that can be broken down in a reasonable time by living organisms - in particular microorganisms - into water, CO_2, methane (CH_4) and possibly non-toxic residues (biomass)[8].

Biodegradability properties are independent of the raw material used to produce the plastic. Whether biosourced or not, a plastic's ability to biodegrade depends on the physico-chemical (temperature, humidity, pH) and microbiological (quantity and nature of micro-organisms) parameters of the environment. **The degradation process takes place in several stages:**



[8] *For more details, see the fact sheet on bioplastics.*

Biodegradables: uses that make sense

Although packaging accounts for 40% of plastics, it is not the area that makes the most sense for the use of biodegradable plastics. These materials have a future in niche markets and in other sectors where sorting and collection are complicated and the product is likely to end up in the natural environment:

- **Agriculture/horticulture**: mulching film, pots, wires, etc.
- **Fishing and shellfish farming**: ropes, nets, traps, etc.
- **Textiles**: microfibres, etc.
- The **formulation** sector: cosmetics, coatings, etc.
- **Pharmaceutical and biomedical** sectors: sutures, etc.
- **Packaging sector**: for materials that cannot be reused or recycled[9].

Designing the appropriate end-of-life scenario depending on the use of the plastic

The organic recovery of plastics (and therefore the use of biodegradable plastics) only makes sense for objects that can be collected for composting, or that cannot be collected and/or present a high risk of ending up - accidentally, deliberately or inevitably - in the environment. Once a plastic can be collected, priority should be given to recycling or even incineration.

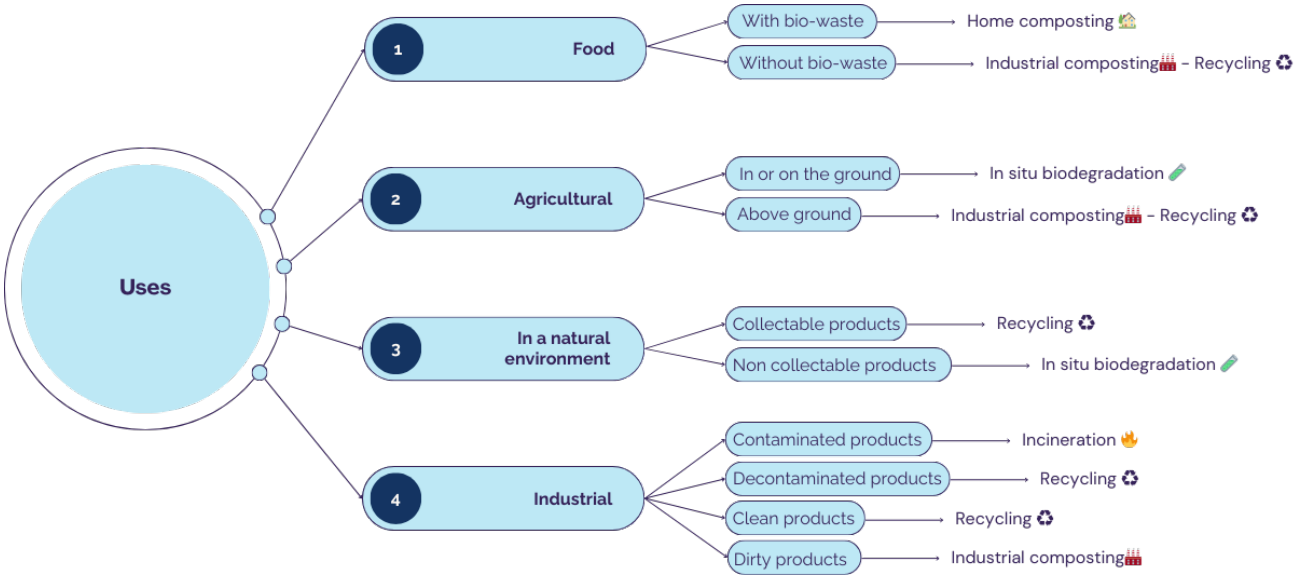
All types of recovery are complementary. To limit the amount of waste sent to landfill (a third of all plastic waste in France), we need to strengthen all recovery processes:

- Mechanical recycling (material recovery) and incineration (energy recovery) are already well established in France.
- Composting (organic recovery) and chemical recycling are being developed.

None of these solutions should be ruled out, and it is by choosing them wisely that we can benefit from their complementary nature.

End-of-life scenarios for plastics based on their uses

S. Bruzaud, Engineering Techniques (2022)



[9] *Pour plus de détails consulter l'article de Stéphane Bruzaud, Polyesters biosourcés et/ou biodégradables - From development to end of life*

Some relevant examples of substitution - L'Occitane en Provence's decision matrix concerning bioplastics

Strategy implemented for the different types of plastic used in packaging

This table shows L'Occitane en Provence's approach to finding alternatives to the various plastics used.

	Not biodegradable	Biodegradable
Petrofuels	= PP, PE, PET... (conventional plastics) L'Occitane is working on reducing the quantity of plastic placed on the market (lighter packaging, reuse of products, etc.), on incorporating recycled materials, on the recyclability of packaging and on replacing certain materials with alternative solutions. These plastics are recycled at the end of their life cycle, as there are collection and sorting channels.	= PBAT, PCL, PVOH... Materials not used by L'Occitane because certain studies show that their biodegradation is slow and limited depending on the environment. They may therefore represent a risk for the environment.
Biobased	= bio PP, PE, PET... L'Occitane considers these solutions to be interesting to the extent that we can maintain the recyclability & properties of a conventional resin while limiting the impact of certain environmental criteria. However, care must be taken with the type of biomass used (nature, location, traceability, etc.). L'Occitane rejects all 1st generation sources, in competition with the food sector, and from deforestation. Co-products/waste can be an interesting resource. The "mass balance "[10] approach is the most widespread for these resins: it is therefore important to ensure the traceability of the supply chain through the use of certification (ISCC for example).	= PLA, PHA, PBS... Materials currently not recycled. Recognized end-of-life: home composting. Certification difficult to achieve (impossible for thick rigid packaging / possible for flexible films, depending on resins). L'Occitane considers that these solutions may offer certain environmental advantages for very specific applications. Nevertheless, we must remain vigilant about the type of biomass used, and refer to recognized certifications to guarantee end-of-life (TUV, for example).

L'Occitane is also keeping a close eye on biosourced and biodegradable materials that are not considered plastics under the European SUP directive (natural polymer with unchanged chemical structure), and which could have interesting properties for niche applications. Examples include algae, mycelium, etc.

Paper and cardboard

Paperboard also has its share of advantages and disadvantages. Unlike plastic, cardboard comes from a renewable resource that does not depend on fossil fuels, but it is a less resistant material.

When the product's use calls for specific constraints to be taken into account (durability requirements, barrier properties such as moisture resistance, etc.), paperboard generally performs less well than plastic.

[10] *Mass Balance is a key concept in ISCC+ certification. It makes it possible to track the flow of raw materials and recycled products throughout the value chain, by allocating specific quantities of certified raw materials and recycled products to each stage of the process.* - Eura Materials (link)

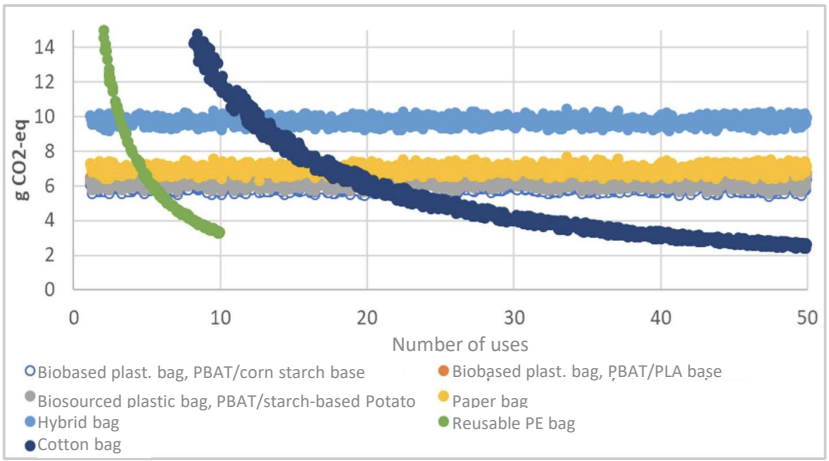
In some cases, therefore, it is necessary to make the paperboard more complex to meet the properties expected in the specifications. In the presence of humidity, for example, a plastic film must be added to the paperboard to make it waterproof. However, this does not necessarily solve the problems associated with plastic, and may even create new ones: **the addition of plastic film disrupts recycling**, and such films may contain toxic additives. In such cases, substitution should be avoided.

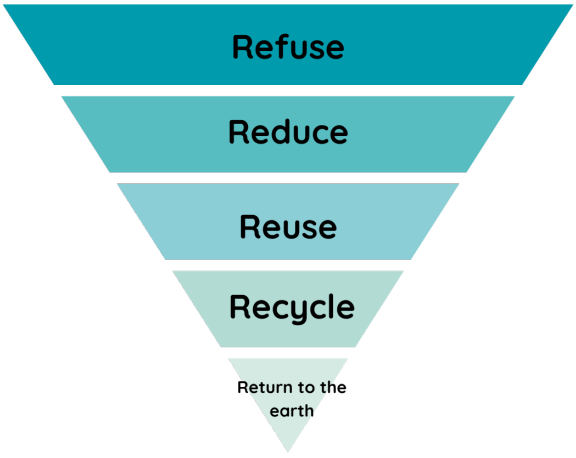
The relevance of substituting paper-cardboard for plastic depends on the conditions of use of the product and its packaging.

Paper/cardboard: an example of delicate substitution

In 2019, ADEME published a study comparing bags of different materials designed to carry fruit and vegetables. Through comparative LCA analyses, study[11] showed that for a single use, a paper bag is less environmentally impactful than a plastic bag. On the other hand, if we consider reusing a plastic bag (in this case PE), the latter rapidly becomes less impactful than non-reusable paper solutions (after around 5 uses). For a cotton bag, it will take at least 30 uses to become less impactful than the non-reusable paper bag[12].

This shows that, depending on use, reuse of a plastic product is sometimes more relevant than substitution, and reaffirms the value of the waste hierarchy model and the 5R rule.





[11] *ADEME. J.Lhotellier, X.Logel, I.Decos. 2019. Comparative LCA of bags for packaging goods at the point of sale other than checkout bags - Report. 221 pages.*

[12] *Climate change impact of reusable bags as a function of number of uses : source*

[13] *The 5Rs? The golden rule "Refuse, reduce, reuse, recycle, rot" or "refuse, reduce, reuse, recycle and return to the earth" comes from the book "Zero Waste" by Bea Johnson, and helps to structure an approach to reduce our waste, including plastic.*

Appendices

Contact

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Sources and resources

[1] The hierarchy of waste treatment methods before the courts : from incantation to application | Zero Waste France https://www.zerowastefrance.org/hierarchie-modes-traitement-dechets-juridictions-jurisprudence-application/
[2]Displacement of impact to another stage of the life cycle, or to another impact criterion (ecotoxicity, resource depletion, etc.).
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[5] BeMed Business Club, "Factsheet on bioplastics" : https://www.beyondplasticmed.org/en/resources/technical-sheet-on-bioplastics/
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[7] European framework for biosourced, biodegradable and compostable plastics : https://environment.ec.europa.eu/system/files/2022-12/COM_2022_682_1_EN_ACT_part1_v4.pdf
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This document is based on contributions from Carole Charbuillet, Stéphane Bruzaud, Jean-Marc Meurville, Jean-François Ghiglione, Joachim Jusselme and Matthieu Carrère.

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