G.R.E.E.N. Hospitality

WHEN "BIO" MEETS "PLASTICS":

A CASE STUDY OF BIOPLASTICS AND THEIR IMPACT IN HONG KONG

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METHODOLOGY

This report shares our findings on bioplastics as a replacement material for single-use plastics. We provide an analysis of publicly available information on the material as well as on all the semantic field commonly revolving around the term “bioplastics”. The report aims at presenting the knowledge within the reach of a non-scientific reader. Some of the findings, especially concerning Hong Kong, have been complemented and confirmed by interviews with local experts on plastic and recycling.

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INTRODUCTION

Here is the thing about plastic: While there is a general consensus on the urgent need to replace plastic, such a level of consensus is lacking for the best alternative to plastic, and least f or the definition of what is known as "bioplastics".

The main reason is **the incomplete information available on the composition of these plastic alternatives**, which could result in various kinds of negative environmental impacts when they are disc arded. When looking at the discard method of plastic alternatives, ranging from cardboard, bagasse, glass, metal, wood, bamboo, edible material, marine-safe films to bioplastics, one could think that they are strictly better than single-use plastic, given that they are all either **reusable, compostable, or biodegradable**. However, one should be particularly careful when trying to replace single-use plastic items, as **the impacts of the replacement's materials can be identical to that of single-use plastic**, depending on what the materials are used for, and the local context of waste treatment and management.

Such is the case for the so-called "**bioplastics**", about which there remains a lot of confusion.

This report is therefore a **case study of bioplastics** as a replacement material for single-use plastics: What they are, their impact on the environment, and what one should be aware of when considering bioplastics as replacements for single-use plastic items.

1 WHAT ARE WE TALKING ABOUT?

The first thing to know when talking about bioplastics is that the term encompasses a large array of materials, and this is where a lot of confusion comes from. As often, the mention of the prefix "bio" seems to indicate a more environmentally-friendly option, but in the context of bioplastics, it is far from necessarily the case. According to European Bioplastics, a plastic material is defined as a "bioplastic" if it is **either bio-based, biodegradable, or if it features both properties**. But what is "bio-based", exactly? And what constitutes a "biodegradable" material? Does that mean that bioplastics are always compostable? These questions surrounding the **very definition of bioplastics** are paramount to understanding the nature of bioplastics, and yet they are rarely precisely answered, especially on packaging made of this kind of material. Some **clarification** is then necessary around all the terms that gravitate on the semantic field of "bioplastics":[1]

"BIO-BASED"

Bio-based polymers are polymers that are obtained from other sources than petroleum, mainly renewable ones. These resources include, for example, sugar cane, which can be processed to produce the ethylene to make polyethylene, one of the most commonly used plastics today, or cornstarch, which is used to produce polylactic acid (PLA). However, the term "bio-based" **doesn't necessarily mean that the material is either compostable or biodegradable**. In fact, some materials called "bio-based plastics" can be the result of blends containing different percentages of different material. As there are **no universal standards for the use of the term bio-based,**[2] the term itself therefore doesn't guarantee any minimum amount of bio-based material used to create a product.

That means that products marketed as "bio-based" can then be 100% biobased, or "partly bio-based". What is currently lacking but needed is **a better communication about bio-based plastics**, which should include labels with the percentage of bio-based components in relation to the whole mass of the product/material.

"DEGRADABLE"

All plastics are technically degradable, even traditional plastics, in the ways that they can be broken down into tiny fragments due to factors like UV rays, sea waves, salt, heat, or humidity, for example.

Some additives to traditional plastics make them more reactive to some of these factors, which help them degrade more quickly. However, just because the material will eventually break down doesn't mean that its residue fragments are not toxic, or that they will ever be assimilated by plants, soil, or animals. By now, from various research studies, we know that the plastic we have created since 1950 looks likely to stay for several hundred years, from the greatest depths in our oceans[4] to Antarctic ice cores[5], in the form of toxic microplastics.

"BIODEGRADABLE"

Biodegradable plastic can be broken down by microorganisms and turned into biomass, water, and carbon dioxide (or methane in the absence of oxygen) but the term doesn't imply any time frame attached to it. **Whether a plastic is biodegradable does not depend on the resources used; it depends on its chemical structure.** Claiming a product to be biodegradable without any further specification is one main reason for the general confusion and subsequent misuse of bioplastic products, because the biodegradation. In order to properly communicate about the biodegradability of a material, the applied testing standard should be specified, and information about the test environment and timeframe provided[6].

"COMPOSTABLE"

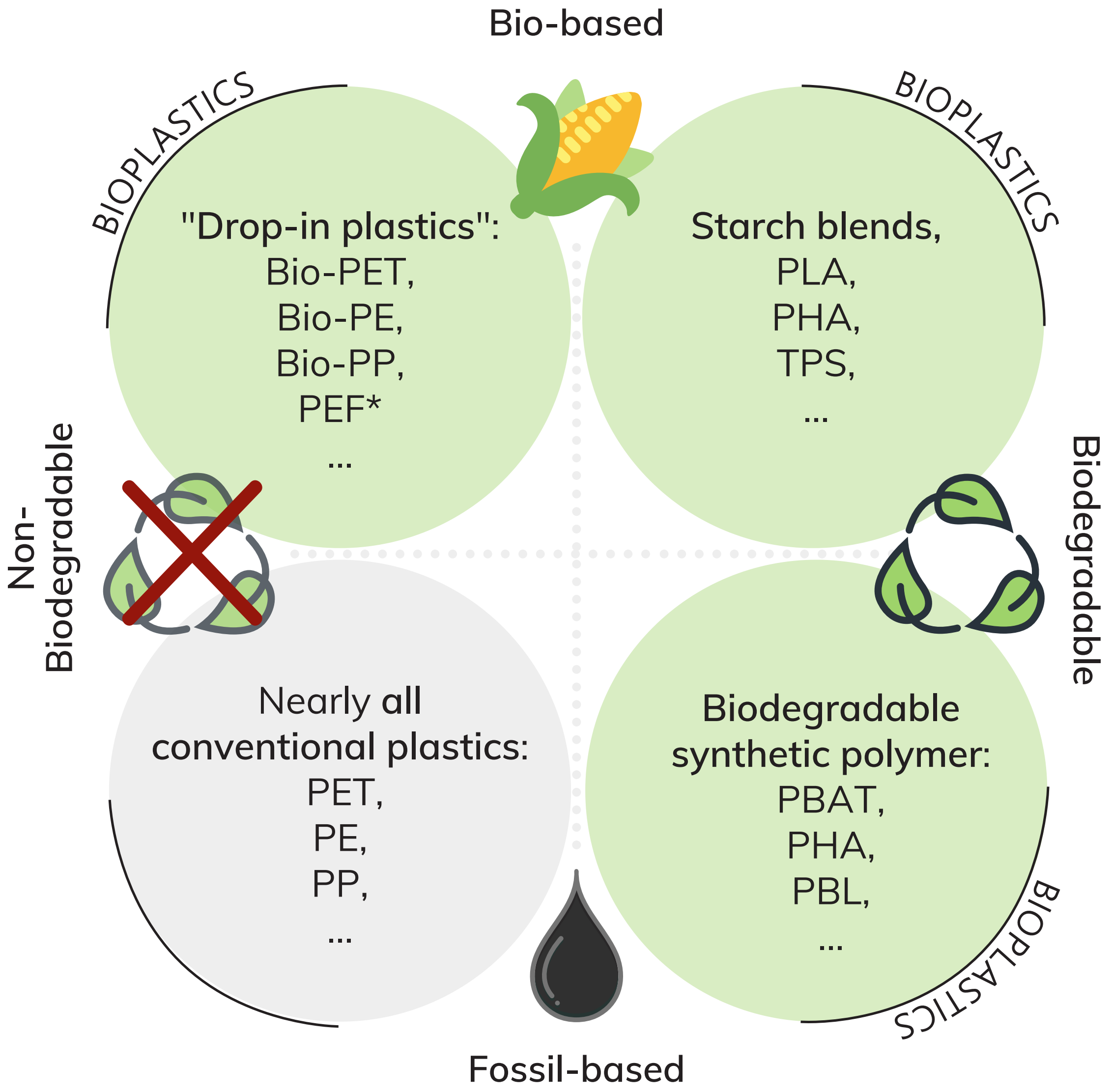
Compostable plastic will biodegrade, **most of the time in an industrial composting facility** (see section 4), where microorganisms break it down into carbon dioxide, water, inorganic compounds, and biomass at the same rate as other organic materials in the compost pile, leaving no toxic residue. In other words, compostable plastics can be turned into compost.

While everything that is compostable is biodegradable, **not everything that is biodegradable is compostable**. This is why **the term "compostable" usually has a timeframe attached to it**, and it varies across individual composters and their specific operational requirements. Generally, this limit is set **around 80 days** (12 weeks), the time it usually takes in order to get a stable compost, with low microbial activity left.[7] Without further description on the length of time and types of environment required, the term "biodegradable" as it is currently used alone **does not distinguish** between a product that will biodegrade in the soil in a thousand years, and one that will biodegrade in a compost pile in 180 days.

These definitions explain why the concept of "bioplastic" is so confusing: **some bio-plastics can be bio-based but not biodegradable**, and some types of **traditional fossil-based bioplastics can biodegrade**. This comes from the fact that bioplastics can be biobased, biodegradable, **or (but not necessarily) both**.

To better understand the different types of bioplastics, it may be helpful to divide them into **three sub-groups**[8], each with their own characteristics, as illustrated in Figure 1 below:

Figure 1 : Characteristics of the different types of bioplastic and comparison with conventional plastics

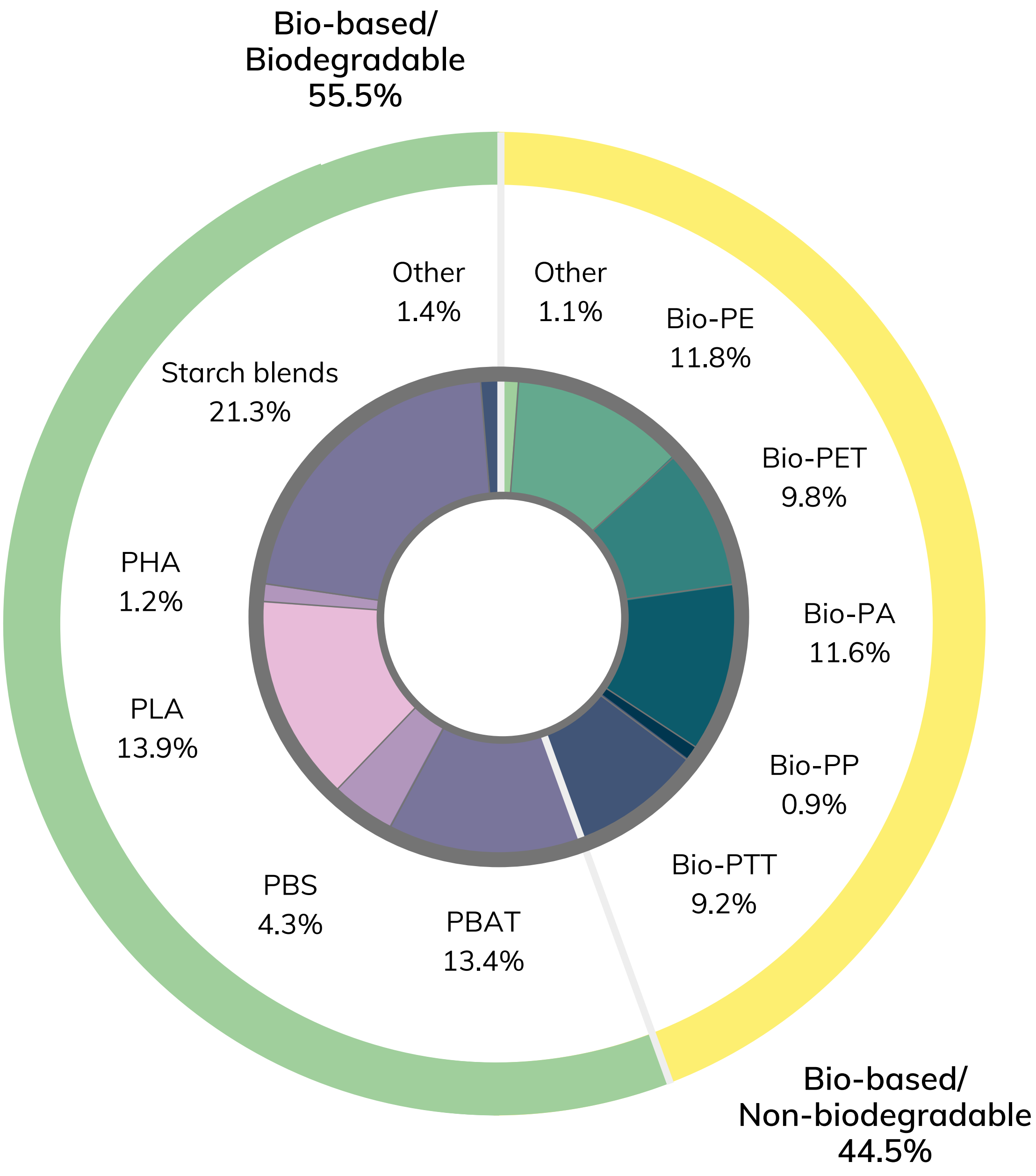


*PEF is currently in development and predicted to be available in commercial scale in 2023

Source: European Bioplastics

As such, bioplastics is **an umbrella term for various materials with different characteristics**. In terms of worldwide production (see Figure 2 below), the majority of the bioplastics produced are biodegradable (55.5%) but not necessarily bio-based - an example is PBAT, which is a biodegradable fossil-based plastic. A big share of the production is **the bio-based equivalent of fossil-based plastics**, mainly bio-PE, bio-PET, and bio-PP (22.5%). In the industry, they are known as **"drop-in" bioplastics**: they are composed of the same molecules of their fossil-based counterparts and, as such, have equal lifetimes, applications, and recycling capabilities. However, as we have seen in Figure 1, since these "drop-in bioplastics" have the same chemical structure, they will behave in the same way as their conventional counterparts and won't biodegrade.

Figure 2 : Global production capacities of bioplastics in 2019 (by material type)



Source: European Bioplastics, Nova-Institute (2019)

2 THE MARKET FOR BIOPLASTICS

Bioplastics as a concept **is not new**, but the discovery, after World War II, of large crude oil reservoirs halted the growth of their development as they **could not compete on price with fossil-derived plastics**[9]. As a consequence, fossil-based plastics enjoyed **several decades of research and development** to enhance the efficiency and the cost-effectiveness of their production as opposed to their bio-based counterparts.

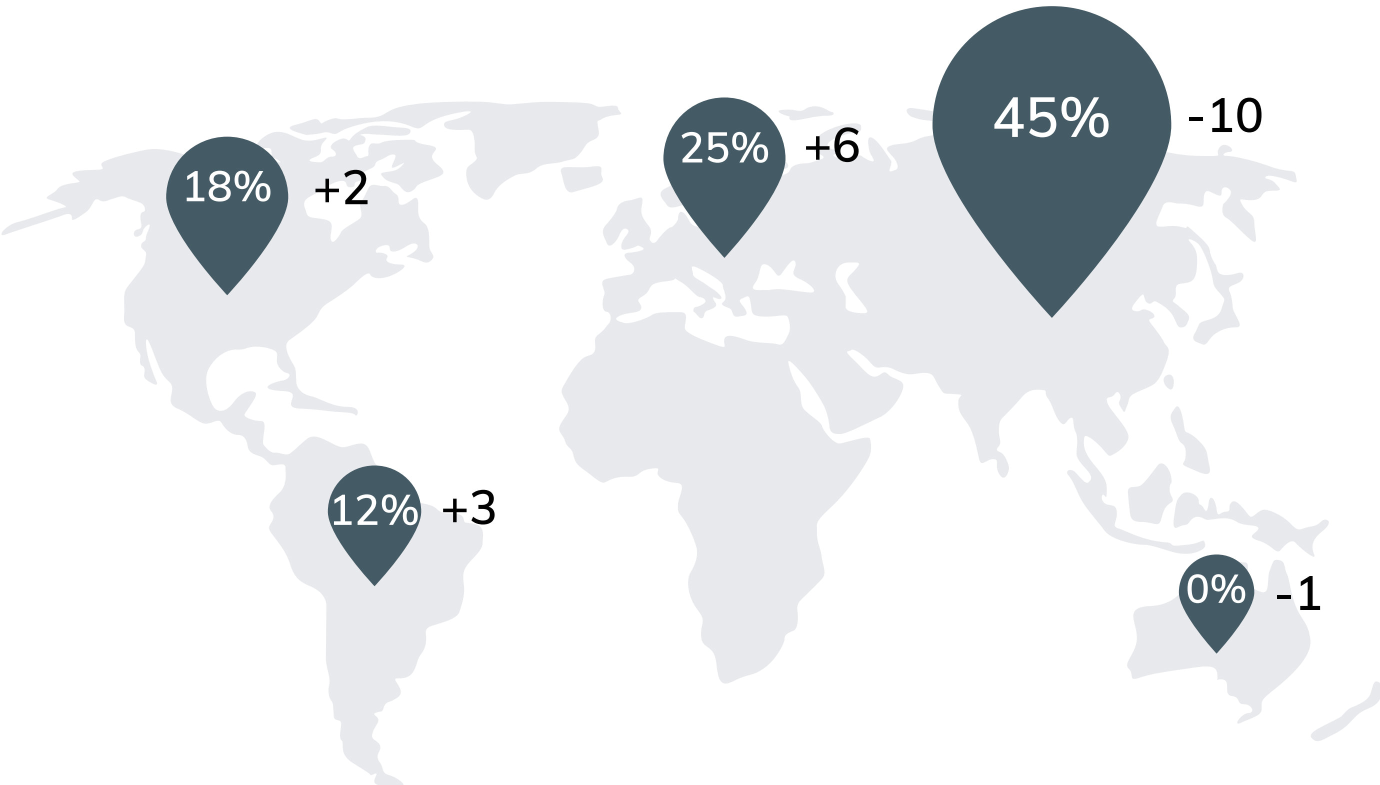
In the same way as for recycled plastic, the competitiveness of bio-derived alternatives to conventional fossil-based plastics is **highly dependent on the price of raw materials**. It means that in periods witnessing drastic drop in oil prices, like now during the Covid-19 pandemic, alternatives that were once already more expensive became even less competitive. As often, **economic incentives** explain why, today, **the total production volume of bioplastics remains small** compared to petro-plastics, and why the global pandemic will most likely constitute a challenge for the future development of the industry.

> **ECONOMIC INCENTIVES EXPLAIN WHY THE PRODUCTION OF BIOPLASTICS REMAINS SMALL COMPARED TO PETRO-PLASTICS.**

Just like conventional plastics, most of the applications for bioplastics are **within the packaging industry**, accounting for more than 53% (1.14 million tonnes) of the total bioplastics market in 2019,[10] most of it being in food packaging.[11] However, the scales are different: packaging represents 26% of the total volume of fossil-based plastics used.[12] As mentioned before, **economic incentives play a major role**: bioplastics are usually more expensive to produce than fossil-based plastics. As a consequence, the volume of bioplastics produced is still way behind conventional ones as the material only represents **well under 1% of the 335 million tonnes of plastic produced annually.**[13]

Geographically speaking, the Asia-Pacific region has the largest manufacturing capacity, with around **45% of the global production capacity**.[14] However, Asia is losing shares to other continents like Europe and South America, whose production capacity increased greatly from 2018 to 2019.

Figure 3 : Global production capacities of bioplastics in 2018 and 2019 (by region)



Legend:

X% Percentage of the global production per region in 2019

+X Change in percentage point in 2019 compared with 2018

Regions considered:

- Asia
- Australia / Oceania
- Europe
- North-America
- South America

Total production capacity (2018 and 2019): 2.11 million tonnes

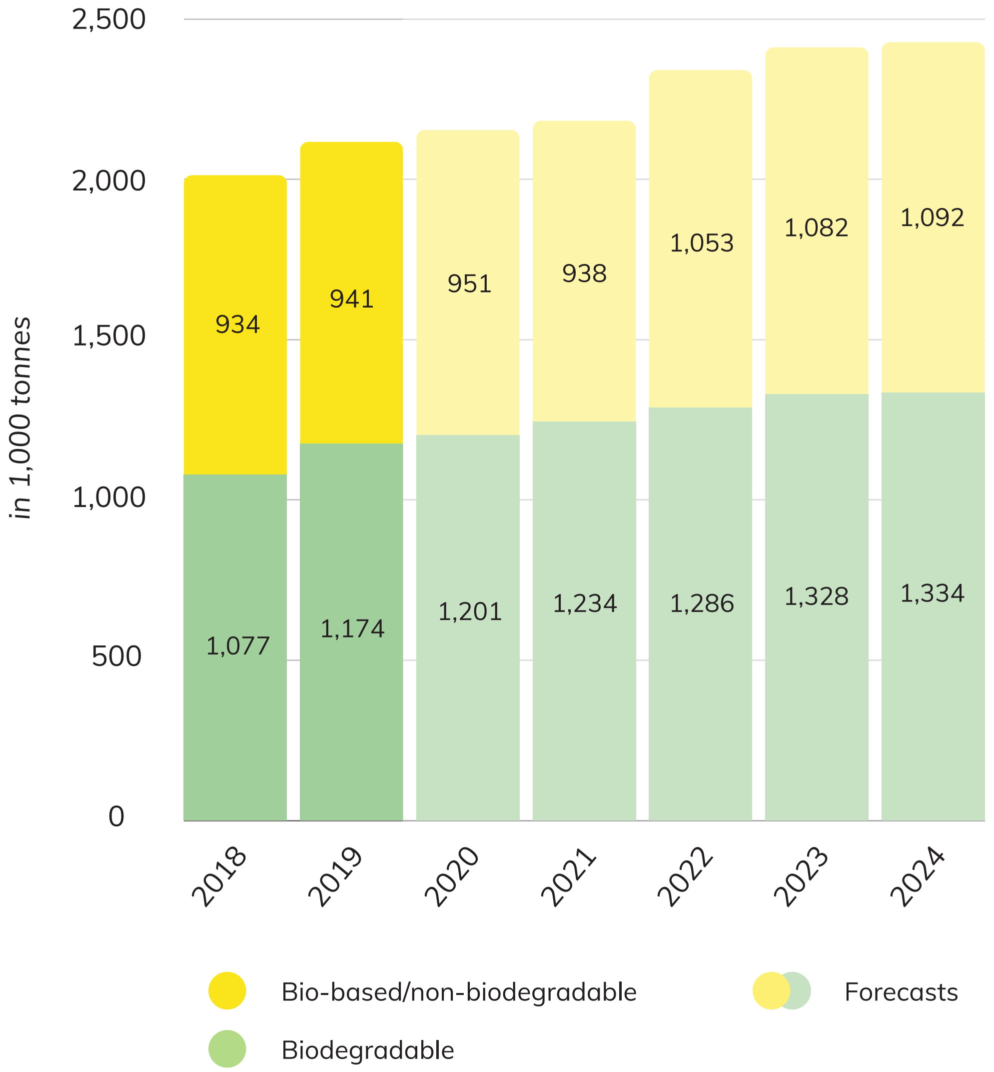
Source: European Bioplastics, Nova-Institute (2018, 2019)

While Asia went down from 55% in 2018 to 45% in 2019, Europe went from 19% to 25% of the total production, and South America from 9% to 12% (See Figure 3 above).

On the demand side, **Europe is the biggest market for bioplastics**, with countries like Germany, followed by France, Italy, and the United Kingdom constituting most of the demand for this type of products.[15] Before the pandemic, analysts from European Bioplastics and the Nova-Institute had good prospects for the future of bioplastics, as the global production capacities of bioplastics were predicted to grow from around 2.11 million tonnes in 2018 to approximately 2.62 million tonnes by 2023.[16] In 2019, they were less optimistic and estimated that the global production would go from **2.114 million tonnes in 2019 to only 2.426 million tonnes in 2024**.[17]

Throughout the forecasted period, the production of both biodegradable and non-biodegradable bioplastics is expected to grow keeping a stable ratio of ~45% of non-biodegradable and ~55% of biodegradable bioplastics of the total global production (see Figure 4 below). In other words, while the global volume of bio-based plastics production is expected to be increasing, there is **no prediction of an increase in the volume of biodegradable bio-based plastics** (the most environmentally friendly type) compared with non-biodegradable bio-based plastics.

Figure 4 : Global production capacities of bioplastics - Current and forecast



Source: European Bioplastics, Nova-Institute (2019)

As the family of "bioplastics" covers in fact different types of materials, the **growth rate of the sector depends on the materials' individual growth rates**. For example, in 2019, bio-based PP (polypropylene) and PHAs (polyhydroxyalkanoates), which are 100% bio-based and biodegradable polyesters, showed the highest relative growth rates, with production capacities predicted to almost sextuple by 2024.[18]

In the same way, European Bioplastics predicted **the production of bio-based PE to continue to grow**, as new capacities are planned to come online in Europe in the coming years. Their analysis also shows a sector that is highly innovative, with the development of new materials like PEF (polyethylene furanoate), a **new polymer** that is **expected to enter the market in 2023**. In technical performances, PEF is comparable to PET but is 100% bio-based and is said to feature additional barrier and thermal properties, making it an ideal material for the packaging of drinks, food, and non-food products. Hence, PEF will eventually have the potential to substitute increasing shares of PET.

THE PRODUCTION OF BIO-BASED PE WILL CONTINUE TO GROW, AS NEW CAPACITIES ARE PLANNED TO COME ONLINE IN EUROPE IN THE COMING YEARS.

Now with the pandemic and the scramble it caused for its main competitor, the fossil-based plastic industry, the bioplastics industry is facing an even more unpredictable market prospectt: on the one hand, bioplastics became even less competitive pricewise, but on the other hand, **individuals and governments around the world are calling for a paradigm shift towards more circular and sustainable economies that could boost such initiatives**, especially since, from a technical point of view, bioplastics have the capacity to replace conventional plastics. In 2007, a study by Shen et al. estimated **the total maximum technical substitution of conventional plastics by biobased plastics as 90% of the total polymers (including fibers) that were consumed in 2007 worldwide**.[19]

However, they balanced that statement with the fact that **reaching that technical maximum in the short to medium term would be impossible** due to economic barriers, technical challenges in scaling-up the production, the short-term availability of bio-based feedstocks, and the need for the plastics conversion sector to adapt to the new plastics.

Even if some of these barriers remain, it should be kept in mind that the study was written in 2009, and that, at the time, the authors considered the sector to be in its "infancy", with an estimated global capacity of emerging bio-based plastics at just 0.36 million tonnes by the end of 2007.

3 WHY DO BIOPLASTICS SOUND LIKE A GOOD IDEA?

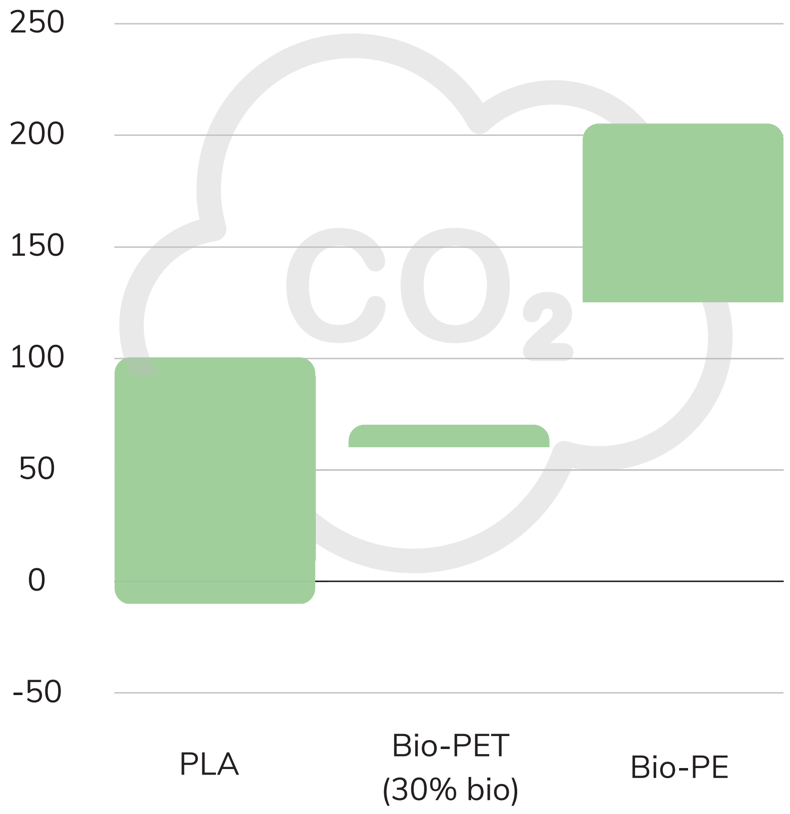
Bioplastics usually are seen as the perfect alternative to conventional plastics for several reasons. Their biggest advantage is without a doubt the fact that, as we have seen, **they can be made out of renewable feedstock**, like corn or sugarcane, while **keeping the same physical properties as their fossil-based counterparts**. Today, we are heavily reliant on fossil fuels to create plastics: **over 90% of plastics produced are derived from virgin fossil feedstocks**,[20] and about 10% of the global output of oil refineries is used as feedstock by the plastics industry, which is about the same percentage as the oil consumption of the global aviation sector.[21] According to the Ellen MacArthur Foundation's 2016 report, the New Plastic Economy, if the growth of plastic usage continues as expected, **the plastics sector will account for 20% of total oil consumption and 15% of the global annual carbon budget by 2050**.[22]

Unfortunately, compared to the predictions of the Ellen MacArthur Foundation in 2016, **fossil-based plastic production is expected to be even higher**. Indeed, with the pandemic-induced decline of the transportation sector and the more underlying trend of breaking free of fossil energy sources, plastic products became **a way for the petro-chemical industry to keep their margins**. In an interview to RFI (Radio France International), Judith Enck, a former administrator with the US Environmental Protection Agency and now President of the environmental platform Beyond Plastics, points out that the petro-chemical industry is now focusing on single-use plastic packaging as their replacement market, "*knowing that fossil fuels are not going to be so dominant in electricity generation and also transportation, as more people turn to electric vehicles and electric buses*."

In order to reach that goal, some actors within the plastic industry took advantage of the Covid-19 public health crisis to **lobby governments** in the US, the UK or in the European Union in order to **delay bans and regulations of single-use plastic items** like bags, in the name of hygiene, even though there is for now no evidence of food packaging or shopping bags spreading the disease. Some of these claims, including one by the Plastic Industry Association, often aren't backed by rigorous scientific research and merit further scrutiny. The drastic increase in the use of single-use Personal Protective Equipment (PPE) and takeaway containers and cups has set back the plastic-free movement that was gathering momentum up until the pandemic. Now, more than ever, **finding a renewable alternative is greatly needed** in order to reduce our dependence on products made of nonrenewable resources.

While it may be intuitive to think that bioplastics have less impact on climate change due to a smaller carbon footprint, when it comes to the greenhouse gas (GHG) emissions of bioplastics, a little nuance needs to be added to the picture. In almost all the cases, **biobased plastics do realize a climate change impact reduction in comparison to fossil-based plastics**,[23] but this reduction can vary widely when one takes into account **the whole lifecycle of the bioplastic products** and the additional negative externalities from growing the crops to make the products, like the use of chemical pesticides, for example.

Figure 5 : Climate change impact reduction compared to fossil-based alternatives



Source: CE-Delft (2017)

In a policy suggestion study carried out for the Ministry of Infrastructure and Environment of the Netherlands,[24] the consultancy firm CE-Delft found that, in the case of CO_2 emissions, **the climate change impact is mostly influenced by the type of raw materials used**, and as such **varies greatly depending on the type of bioplastics considered**. For example, bioplastics' GHG emission savings in comparison to fossil-based plastics is not as high if maize starch is used, as is the case with PLA-based material.

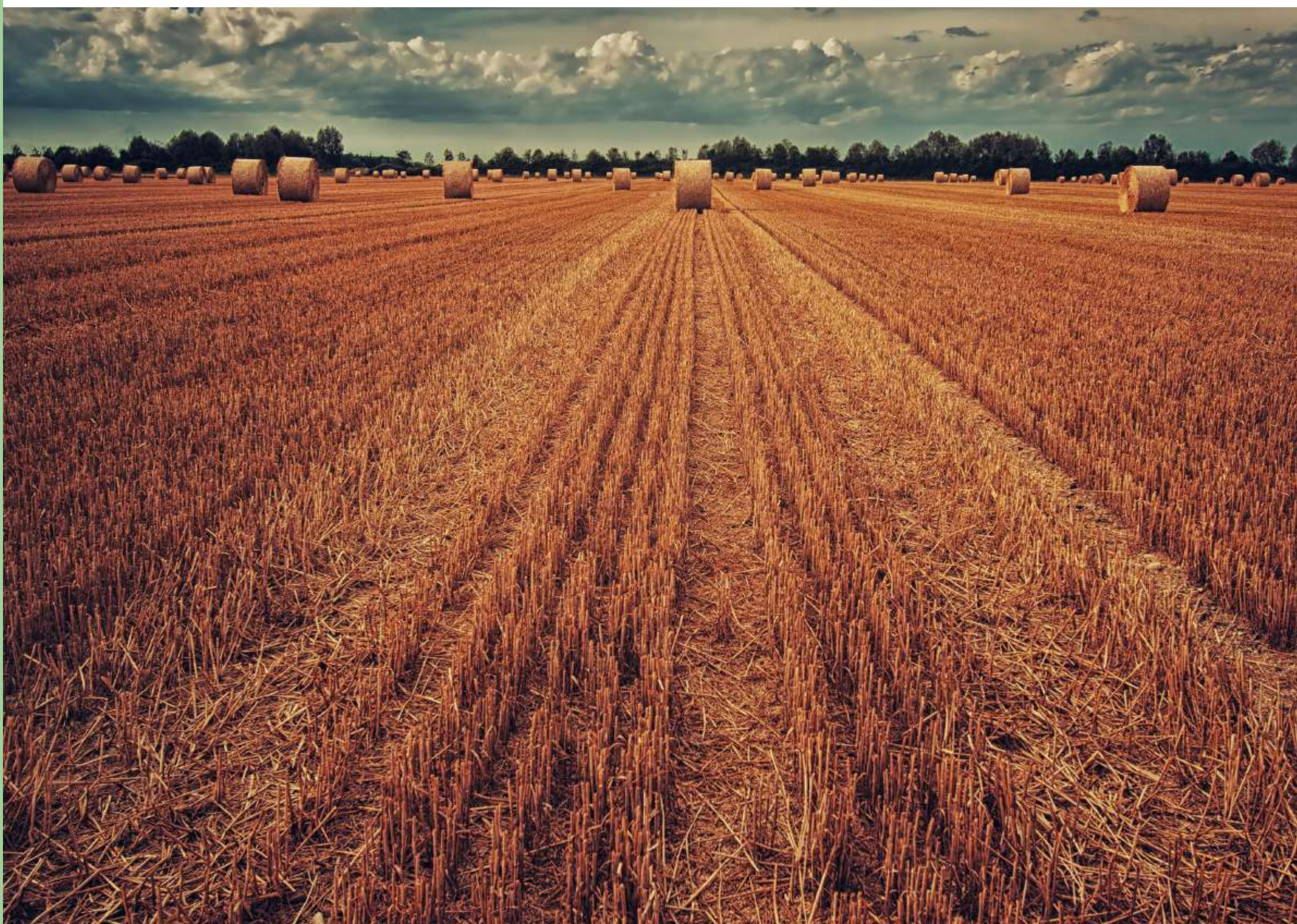
This is illustrated in Figure 5 above, which shows the reduction of climate change impact of three commonly used biobased plastics in 2014 (PLA, Bio-PET, and Bio-PE), compared with their fossil-based counterparts.[25] A reduction of 0% means a climate change impact equal to the fossil alternative, while a negative reduction means an environmental impact that is worse than the fossil-based alternative. Even if the reduction of GHG is mostly positive, **the range of the percentage of reduction illustrates the different impacts depending on the feedstock used**. For example, in the case of PLA production, it is preferable to use Brazilian sugar cane (the highest reduction potential) than European maize (lowest reduction potential). In general, in terms of feedstock for plastics that need fermentable sugars, the study points out that **sugar cane and sugar beet are preferable to cereal crops**. The CE-Delft report also stresses **the influence of the type of electricity being used** in the production process, as well as the use of by-products like bagasse, a by-product of the sugarcane - if the by-products are used as fodder or as feedstock for other bio-based products, then the carbon footprint of the produced biobased plastic decreases.

THE CLIMATE CHANGE IMPACT IS MOSTLY INFLUENCED BY THE TYPE OF RAW MATERIALS USED, AND AS SUCH VARIES GREATLY DEPENDING ON THE TYPE OF BIOPLASTICS CONSIDERED.

Last but not least, the CO_2 emission impact of bioplastic production depends also on **the effects of direct and indirect land-use change (LUC) induced by growing the feedstock for bioplastics**. Direct LUC happens when there is direct deforestation of land for crop production for biofuels, while indirect land-use change (ILUC) takes place when an increase in the demand for an agricultural product will expand the total area for production of that product, thus increasing the need for land and the amount of deforestation. According to the report, **ILUC has large GHG effects**, as the trees, which are natural carbon sequestering agents, release CO_2 once they are felled. By extension of the implications of deforestation, ILUC also has **negative consequences on biodiversity** that should be taken into account when considering the environmental impacts of bioplastics.

According to European Bioplastics, the land used to grow the renewable feedstock for the production of bioplastics amounted to approximately **0.79 million hectares in 2019**. It represents 0.016% of the global agricultural area (encompassing pastures for livestock and arable land) of 4.8 billion hectares. With the predicted growth of production for the next five years, the land use share for bioplastics will be around 0.021% of the global agriculture area and 0,03% of the arable land in 2024. In order to give a comparison, according to the FAO, about **60% of the world's agricultural land is used for livestock grazing**.

However, in the future, we can hope that competition with existing agricultural land will be reduced as new feedstock sources are being explored in order to create bioplastics out of food waste, for example. In 2012, Dr. Carol SK Lin, a visiting assistant professor at the City University of Hong Kong, developed such a project in the city, using food waste generated by Starbucks and beverage-maker Vitasoy. A more recent example is the BARBARA project in Europe, started in 2017 and expected to complete in 2020. It was funded by the European Union to create **new bio-based materials out of food waste and agricultural by-products to be used in the construction and automotive industries**.



4 WHAT IS THE IMPACT OF BIOPLASTICS ONCE DISCARDED?

Another reason why bioplastics generate a lot of interest is because they **offer additional end-of-life alternatives** compared with traditional plastics.

First, just like conventional plastics, some bioplastics like bio-PE, bio-PP and bio-PET can be (and currently are) mechanically recycled.[26] This is due to the fact that these bioplastics are **chemically identical to their fossil counterparts**, so their recycling can then be carried on in the same streams, with no additional processes or investments.[27] However, **this is not true for other types of bioplastics**: most of the sorting facilities are **not properly equipped to sort them**, and their stream is **too small to make it economically attractive** to invest in new sorting technology. This is the case, for example, for the starch blends, but also PLA and PHA, which are both bio-based and biodegradable. However, these materials rarely make it to the necessary critical mass to justify separate recycling streams and ensure commercial success.

> **STARCH BLENDS, PLA AND PHA RARELY MAKE IT TO THE NECESSARY CRITICAL MASS TO JUSTIFY SEPARATE RECYCLING STREAMS AND ENSURE COMMERCIAL SUCCESS.**

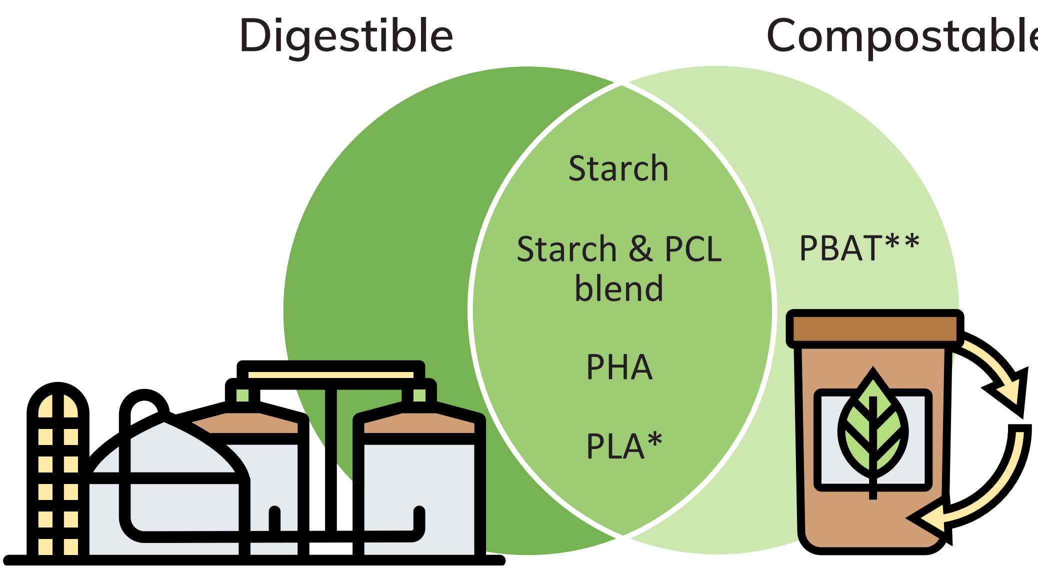
Also, as we have seen, a material called "bioplastic" can be in fact the result of **blends that are impossible to recycle** in the classic polymer-specific mono streams sorting facilities. Moreover, bioplastics like PLA have a similar density to PET, making mechanical sorting difficult. As such, it can contaminate the PET streams and **reduce the quality of the recycled product**. This drawback is not specific to bioplastics, as similar results can be induced by multi-layered fossil-based plastics, blends of fossil-based plastics with other additives, or fossil-based plastics waste with low volumes.

Bioplastics can also be incinerated, as **they undergo incineration in the same manner as fossil-based plastics**. Even if fossil-based plastics have generally higher calorie values (of the order of 25 GJ per tonne) than bioplastics (of the order of 10 GJ per tonne), bio-based equivalents of conventional plastics like bio-PET, bio-PE or bio-PP are composed of identical molecular structures.[28]

As such, they will **generate the same energy and be "as efficient"** when incinerated. The difference is that the incineration of bio-based materials releases a quantity of CO_2 that was already present in the atmosphere but which had been fixed during plant growth, while **burning fossil-based plastic releases into the atmosphere an additional quantity of CO_2 that was once trapped underground**.[29] Certified compostable plastics may also have lower environmental impacts upon incineration as the certification requires proof that the plastic contains low levels of heavy metals.[30]

In terms of end-of-life though, the real added value of bioplastics seems to be that **it adds "composting" and anaerobic digestion (AD)**, both of which are biological recycling processes, to the list of available discarding possibilities. **Composting** is the process of transforming organic matter under aerobic conditions (in the presence of oxygen) by microorganisms to CO_2, water, heat, and plant biomass. **Anaerobic digestion**, by contrast, is a more complex and expensive system than composting. As such, the method is less used than industrial composting. AD technology uses the biodegradation of biomass and organic waste under anaerobic conditions (without oxygen) to generate biogas (namely CO_2 and methane) that can be directly used as an energy source, in a so-called **waste-to-energy process**. The residual materials that are left (the digestate) can be further composted to be used in agriculture.[31] As shown in Figure 6, **most of the bioplastics that are compostable are also digestible**, and **vice-versa**, except for PBAT (Polybutylene adipate terephthalate), which is a biodegradable fossil-based plastic often found in blends with PLA.

Figure 6 : Digestibility and compostability of biobased plastics



*PLA is only digestible in thermophilic digestion
** PBAT is a fossile plastic that biodegrades. It is used in blends with e.g. PLA and TPS

Source: Hermann, et al., 2011.

One of the main advantages of these biological recycling processes lies in the fact that, in theory, **there would be no need for separating bioplastic items from biowaste**. As we have seen in our previous report about food waste, the current problem with plastic recycling is that food waste contaminates the plastic recycling streams, and vice-versa. Without an efficient segregation system at source, recycling processes become way less efficient, both for plastics and biowaste. With biodegradable plastics, organizations like European Bioplastic, Wageningen Food & Biobased Research,[32] and CE-Delft[33] stress that **the use of biodegradable bags could increase the amount of food waste collected from households** as "*compostable plastics make the collection of organic kitchen waste easier*". This particularity, also achieved with biodegradable food packaging, is called "**added benefit**" or "**co-benefit**". For the Netherlands Institute for Sustainable Packaging (KIDV), interviewed in the CE-Delft study, "*[b]iodegradable bio-based plastics should only be used in situations where there is a co-benefit; mainly the increase in consumer separated food waste.*"

> **BIODEGRADABLE BIO-BASED PLASTICS SHOULD ONLY BE USED IN SITUATIONS WHERE THERE IS A CO-BENEFIT; MAINLY THE INCREASE IN CONSUMER SEPARATED FOOD WASTE.**

However, according to authors of "*The role of biodegradable plastic in solving plastic solid waste accumulation*" report,[34] "*the current reality is that composting and AD only seem to be feasible for clean (source separated) fractions of biodegradable plastics. This is due to poor organic collection systems, the small number of available facilities, and the fact that existing facilities are often not equipped to take biodegradable plastic materials* [mostly because of a lack of economic incentive and streams that are too small]. *In the existing facilities, **biodegradable plastics are normally sorted out with nonbiodegradable plastics during screening**. For example, in Germany, in more than 50% of cases, biodegradable plastics will not be composted even if delivered to a composting facility; and, in the United Kingdom, composters will not accept biodegradable plastics due to concern for contamination. Similarly, a study performed in a wet AD facility equipped with a pretreatment demonstrated that all compostable plastics were skimmed off by a rake and ended up in the light fraction, which was then discharged into a rubbish container.*" This is mainly due to the fact that **conventional and biodegradable plastics are hard to differentiate for the end-user**, so there is actually a debate on whether it's a good idea or not to allow biodegradable bio-based plastics at all in the food waste streams.[35]

To enhance biological recycling, **informing the end-user** about the discarding methods for these materials is paramount. In order to achieve better understanding, different labels have been created. However, they can also **create confusion** because, even if the product is labelled “biodegradable” or “compostable”, it can refer to compostability and biodegradability standards for **industrial composting use** rather than home composting.

Actually, except for local exceptions like in Belgium or Australia for instance, there is currently **no international standard specifying the conditions for home composting of biodegradable plastics**. In other words, even when a bioplastic product is labelled “compostable” or “biodegradable”, **it is unlikely to biodegrade in your garden or in nature,** and this is where a lot of confusion comes from.

Figure 7 : Seedling Logo

compostable

Source: European Bioplastics

In Europe, the biggest market for bioplastics, one of the most common labels is the “seedling logo”, owned by European Bioplastics. As seen on Figure 7, although it certifies that a product is **industrially** compostable, only the word “compostable” appears on the logo.

Today, the most important standards related to biodegradability and compostability are developed by the **International Standards Organization** (ISO), the **European Committee for Standardization** (CEN), and the **American Society for Testing and Materials** (ASTM). The most widely used compostability standards are the American ASTMD 6400 and the European EN13432. The products by the UK company Vegware for example, which has a presence in Hong Kong, have 3 certifications, all of them complying to either the European or the American standards for **industrial** composting. They are roughly equivalent and set up the conditions under which bioplastics can be industrially composted.

These conditions are:

- **Biodegradation**: At least 90% of the materials have to be broken down to CO_2 by biological action within six months at 58°C +/- 2°C;
- **Disintegration**: After 12 weeks, at least 90% of the product should be able to pass through a 2 x 2 mm mesh;
- **Chemical composition**: Certain limits regarding volatile matter, heavy metals, and fluorine should be obeyed;
- **Quality of compost and ecotoxicity**: The quality of the final compost should not decline as a result of the added packaging material.

In the absence of such labels (for which companies need to pay), there is **no way to differentiate the different types of bioplastics**, like PLA from bio-PET, as they all fall under the Resin Identification Code (RIC) number 7, often with the mention of "other", which from a sorting perspective makes it even more confusing.

On the composters' side now, another problem arising with these standards is that they sometimes **don't match the technical capabilities of the private composters**. In the case of the Netherlands for example, the study conducted by CE-Delft revealed that most applications with the seedling logo require **13 weeks of composting** while in many composting installations in the Netherlands there is only capacity to support eight weeks of composting. Consequently, these plastics are not (fully) composted after six to eight weeks when the composting cycle is stopped. While some materials could be compostable in 13 weeks **if offered the right conditions, they might not be able to be fully composted by that time in practice**. For example, if coffee cups are stacked, they won't have time to decompose within 13 weeks. In the same way, bio-based plastic cutlery with a seedling logo can be too thick to biodegrade in time.

> **THE PROBLEM WITH BIODEGRADABILITY AND COMPOSTABILITY STANDARDS IS THAT THEY SOMETIMES DON'T MATCH THE TECHNICAL CAPABILITIES OF THE PRIVATE COMPOSTERS.**

Due to these various barriers, composting and/or AD are actually not the prefered method in the hierarchy of discarding bioplastics waste, as the most suitable end-of-life solution depends on the type of bioplastic, its volume on the market, application, carbon footprint, and the available collection and processing infrastructure. As such, several studies[36] have pointed out that **bioplastics' best end-of-life option is similar to conventional plastics: mechanical recycling**. This is due to the fact that, in the absence of co-benefits, biodegradable plastics in themselves have no added benefit in composting facilities. Nevertheless, compared with composting, anaerobic digestion is still preferable because it yields biogas.

Finally, and similarly to any other type of waste, **the last and least preferred of the discarding options for bioplastics is the landfill**. Unfortunately, there are several reasons why, despite the availability of other disposal options, bioplastics end up in landfills. It can be, as stated above, because of the difficulties for consumers and for sorting facilities to differentiate bioplastics from their fossil-based counterparts. Additionally, a typical recycling facility is not equipped to deal with food-contaminated packaging, which is one of the main applications for bioplastics, so currently **most of the bioplastic packaging is disposed of in landfills**.[37] Also, bioplastics can end up in landfills simply because the other local waste management infrastructures are inadequate.

How a bioplastic impacts the environment once discarded in the landfills depends on the nature of the materials it is made of. If the material is a bio-based, non-biodegradable drop-in bioplastic, with similar structure as conventional plastics, then **the material will behave in the landfill in the same way as its fossil-based counterparts**, meaning that it will stay there for thousands of years, if it decomposes at all. In the case of biodegradable bioplastics though, **the assumed levels of degradation can differ from 0% up to 85%.**[38] One of the main drawbacks with sending biodegradable bioplastics to landfill is that if the landfill does not have an efficient gas capture system, the **methane released during the degradation process** will enter the atmosphere and exacerbate global warming, as methane is a GHG that is 20 times more potent than CO_2.[39] So **the environmental cost of sending this kind of material to landfill is potentially similar to sending food waste to landfill**, where in some countries like South Korea it has been banned for 15 years. However, it is hard to draw definitive conclusions in regard to the impact of biodegradable plastics in landfill due to conflicting evidence in the literature.[40]

However, there is a general consensus that **bioplastics won't lessen the negative environmental impacts of plastic littering** (ie. the result of intentional and unintentional disposal of waste material in nature) nor to the so-called "**plastic soup**" in the ocean, which refers to different types and sizes of plastic which have ended up in the marine environment. This is due to the fact that, as seen above, even if some bioplastics are called "biodegradable", **the conditions in which they are able to biodegrade are often the ones provided at industrial composters that are far from normal natural conditions**. In the ocean, bioplastics still have a relatively long degradation time, meaning that they will behave like normal plastics, going from macro to microplastics, and pose the same hazards:[41]

- **ingestion of plastics** by marine life, which can lead to suffocation;
- **entanglement** of marine life;
- **chemical effects** on marine life (plastic is a transport vehicle for persistent organic pollutants, and plastic additives mimic hormones).

As a result, according to the policy recommendations made by CE-Delft to the Ministry of Infrastructure and Environment of the Netherlands, integrating more **bioplastics in the packaging industry comes as the last step to tackle the waste problem**: "*In general we recommend integrating stimulation policies for biobased plastics in the current policy frameworks for waste [...] and the Circular Economy. The focus should be on prevention first, reuse second, recycling third and finally on biobased plastic as an interesting solution if the biobased plastic fulfils sustainability criteria. Many biobased plastics are environmentally attractive, but to reduce risks we advise to only stimulate actively those which meet sustainability criteria.*" The impacts of discarding bioplastics vary indeed strongly depending on their application, their type (drop-in, biodegradable etc.), but most importantly, the **local waste management infrastructure**. Hong Kong, for example, is clearly not properly equipped to deal with bioplastics.

5 WHY AREN'T BIOPLASTICS A GOOD IDEA IN HONG KONG?

As we have seen above, disposing of bioplastics is far from trivial and requires **a cutting-edge waste management infrastructure and an efficient sorting system**, in order to keep bioplastics out of the landfill to prevent the release of methane. Unfortunately, as seen in our previous report, the waste management infrastructures in Hong Kong add several challenges to the proper disposal of bioplastics.

The first challenge to mechanical recycling of bioplastics in Hong Kong is its recycling sector. Indeed, due to various factors like its economy's focus on services) and its inherited culture of laissez-faire for businesses, Hong Kong has a very limited recycling sector, and recycling is mostly an exporting industry, at least until China's waste imports ban in 2018. For context, in 2018, **about 30% of the municipal solid waste in Hong Kong was recycled**,[43] among which **90% was exported**.[44] The quantity of materials recycled locally varies greatly depending on the value of the materials on the market. As such, the main materials that were sent for exports were in majority paper, ferrous metal and non-ferrous metals. For these three materials, **almost 100% of the quantities recovered were sent abroad in 2018**. However, for lower-value materials like plastics, glass, rubber tyres, textiles, food waste, wood, and yard waste, more than 80% of the total amount recovered for recycling was recycled locally. If we look solely at recyclable materials that are relevant for our bioplastics study, we find that about **87% of the plastic (55,800 tonnes) and 100% of the food waste (27,000 tonnes) collected for recycling were locally recycled** and not exported. Even if those quantities recovered represent respectively only 7.5% and 2.1% of the total plastic and food waste discarded in Hong Kong, it still shows that these infrastructures exist.

This means that, in theory, **drop-in bioplastics such as bio-PET or bio-PE could be recycled through local infrastructures**, like the new PET/HDPE recycling plant to be opened in 2020.

For other types of bioplastics like starch blends, PHA and PLA, they could in principle also be recycled through conventional mechanical means. The problem is that, despite technical feasibility, **the amount of bioplastic waste would need to be available in the necessary critical mass** to justify separating recycling streams and ensuring commercial viability, especially since, as we have seen, PLA is hard to differentiate from PET and its bio-based counterpart. This mass has been placed at around **200,000 tonnes of a single polymer produced annually**.[45] In comparison, 200,000 tonnes represents about **25% of the total volume of conventional plastic** discarded in Hong Kong in 2018.[46] It means that we would need to **switch 25% of the conventional plastic we discard for PLA**.

> **DESPITE TECHNICAL FEASIBILITY, THE AMOUNT OF BIOPLASTIC WASTE WOULD NEED TO BE AVAILABLE IN THE NECESSARY CRITICAL MASS TO JUSTIFY SEPARATING RECYCLING STREAMS.**

The low recovery rates for recyclables show another shortcoming of the municipal waste management in Hong Kong: **the fragmented waste sorting system and the lack of trust it created among the population**. No less than **four departments** are put in charge of setting up and managing the recycling bins depending on the locality:

- the Environmental Protection Department (EPD),
- the Food and Environmental Hygiene Department (FEHD),
- the Leisure and Cultural Services Department (LCSD), and
- the Agriculture, Fisheries and Conservation Department (AFCD).[47]

However, **only plastics that are collected by the EPD would be sent to the Eco-Park** (a waste-sourcing industrial business park sponsored by the Hong Kong government) for further processing, with the fate of the other bins' content left unclear. Several Hongkongers have witnessed contractors emptying the recycling bins into the undifferentiated ones, **causing distrust in the waste sorting infrastructures** and **undermining citizens' motivation and goodwill** to recycle as much as possible in their everyday life. Even if part of the sorting is made after collection at dedicated facilities that sort trash manually, it is hard to imagine how materials like bioplastics, which are hard to identify and require specific streams for certain types, are going to be easily incorporated in the already confusing sorting system in Hong Kong. It would then require to **teach the population how to discard bioplastics properly**, and consequently, additional investment in sorting technologies.

Also, we have seen that one of the main advantages of bioplastics could lie in the co-benefits they bring, which is to recycle packaging contaminated by food, thereby helping households and businesses better sort their food waste. However, **this is hard to achieve when there is no mandatory food waste segregation and collection system**.

In its Food Waste and Yard Waste Plan for Hong Kong 2014 - 2022, the government had planned to improve the infrastructures in order to process food waste, namely a network of Organic Waste Treatment Facilities (OWTF), whose first phase O.PARK1 opened in 2018 on Lantau Island.

These treatment facilities use AD to generate biogas from food waste. However, O.PARK1 is designed to recycle source-separated food waste with only a small amount of inerts. As such, **biodegradable plastic would not degrade fast enough and would likely be screened out by O.PARK1's pre-treatment system** with other inerts for disposal due to their large size.

Finally, bioplastics **cannot for now be incinerated**, as the upcoming incinerator will not be completed until 2024. Due to the lack of proper infrastructures and the inefficiency of the sorting system, it means that **most of the bioplastics found in Hong Kong today most probably end up in one of the three (already full) sanitary landfills,** where the methane they produce is at least recovered.

> **MOST OF THE BIOPLASTICS FOUND IN HONG KONG TODAY MOST PROBABLY END UP IN ONE OF THE THREE (ALREADY FULL) SANITARY LANDFILLS.**

Despite all the challenges of exploiting the co-benefits that can be achieved by bioplastics in Hong Kong, **some succeeded**. This is the case for the plant-based slow fast-food restaurant MANA!, which has been using compostable bioplastic packaging since 2012 (all their packaging became compostable from 2019). Aware of the fact that there was no suitable waste management system for such packaging in Hong Kong, **MANA! created their own**. First, they started by creating **custom-made bins** in order to help guests properly sort their garbage, with one big opening for "Food Waste and MANA! Packaging", along with other bins for "Glass" and "Rubbish" (see picture below), and by implementing a strict no-plastic policy.

MANA! go a step further to contract **a private industrial composter** to turn their packaging and food waste into compost, which is then supplied to the farmers who grow the vegetables they use, in a perfect example of circularity. As a reference, a restaurant like MANA! that serves 200 people per day, seven days a week, makes about **5 tonnes of compostable waste per month**, while the industrial composter they work with has the capacity to process about **30 tonnes a day**, meaning there is plenty of capacity for other restaurants to compost their waste as MANA! does.

Source: MANA!'s website

CONCLUSION

THERE IS NO SUCH THING AS "AWAY", EVEN FOR BIOPLASTICS

This report is an attempt to show that using bioplastics, or any type of replacements for plastics, must be **carefully considered**, taking into account the **businesses' needs, the local waste treatment infrastructures, and the use that is going to be made of the object**. Bioplastics is a good idea in theory, as they help us lower our reliance on fossil fuel, reduce GHG emissions at production and the release of additional CO_2 to the atmosphere. However, they **may well end-up forever in a landfill or as microplastics in the ocean just the same** if they are not discarded properly. This is why instead of focusing on the environmental impact of only one aspect of the product's lifecycle, like manufacturing, consumption, or disposal, one should look at **the global environment impact of the product**, "from cradle to grave", i.e. from the extraction of raw materials to disposal, including recycling, reusing, and energy recovery.

This lifecycle approach analyses the environmental impact of all those phases through the lens of several environmental aspects - like CO_2 emissions, water pollution, waste generation, and resource consumption - and measures the impacts of a product or service's lifecycle on climate change, resource depletion, ocean acidification, human health, etc. However, the Life-Cycle Analysis (LCA, an internationally standardized methodology called ISO 14040 ff) doesn't take into account the local context of where the product will be used or disposed of, so you should also be aware of the **local impact** your choice has on the environment.

Without considering the whole LCA for the choice of a product, at best the use of alternatives to plastics can be a transitional phase that allows for the setting up of more environmentally friendly procurement practices and operations, which is great, because everyone needs to start somewhere. At worst, however, **it can become a symbolic gesture only to create a "green" image in the eyes of environmentally conscious (but not so informed) consumers**. And who could blame them?

You've just read through **17 pages of this report** to know why bioplastics are not as good as they sound. And here we analyzed only one type of alternative to plastics, **for one city**!

This is why, as a business, you should **take the responsibility for your own trash:** how much you discard, how you discard it, and where it ends up, to make sure it's disposed of in the most environmental way, **regardless of whether it is food waste, plastic waste, or bioplastics**. To help you achieve this goal, if you decide to go with bioplastics, you should first perform your due diligence on the manufacturer and manufacturing practices behind the bioplastic products of your choice, then **extensively inform your staff and guests** about what the labels on your products' packaging mean - the difference between "compostable" and "biodegradable", and how to discard it in a proper way.

With heightened awareness of plastic pollution and the plethora of plastic alternatives, it is only natural to **expect a demand for transparency coming from the guests as well**. For its clear and easily accessible "Environmental Communication Guide for Bioplastics", European Bioplastics introduces the document with the following statement: "*The willingness to contribute to environmental protection goes hand in hand with an increasing demand for truthful, accurate and easily verifiable information on products that claim to have a reduced impact on the environment. The demand for simple information is high, especially for complex products such as bioplastics and products made thereof.*"

As the example of MANA! shows, it takes a lot of money and energy in Hong Kong to discard bioplastics properly and responsibly, and turn it into compost - **MANA! dedicates between 5 and 10% of its revenue to their zero-waste goal**. They also spend tremendous efforts into educating their guests with their custom-made bins, and they **dedicate part of their workforce as "ambassadors" to help people discard their trash the right way**. This is the true cost of responsible bioplastics disposal in Hong Kong, and one should be aware of this cost if one wishes to start using bioplastics: **using bioplastics alone is only a small part of a "sustainability achievement"**.

Here is the lesson from bioplastics: **Waste is still waste, and it has consequences**. This is why the best way to solve the waste crisis in Hong Kong and other countries plagued by plastic is not replacing plastic **- it is reflecting on the level of convenience that plastic has brought to us**, and that which we are now addicted to. Bioplastic single-use items are still single-use items. The true focus should be on reducing waste, regardless of the materials they are made of, as there is no magical recipe to replace plastic. Even bioplastics have consequences, so they shouldn't be an excuse to go back to single-use items. This is actually one of the strongest criticisms of bioplastics: just as plastic in the beginning, it gives the illusion that there are no consequences to the discarding of it. Just like any other types of waste, **the best way to get rid of bioplastic packaging is not to have it in the first place**.

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SOAP CYCLING 再皂福

Soap Cycling, a Hong Kong based charity, works with students, hotels, corporates, volunteers and WASH charities across Asia to recycle soap in a movement to reduce preventable hygiene-related diseases and suffering by distributing this life-saving resource to where it is needed the most. Soap Cycling is part of the Foundation for Shared Impact (FSI) portfolio and hosts students from the University of Hong Kong through its Social Venture Management (SVM) Course.

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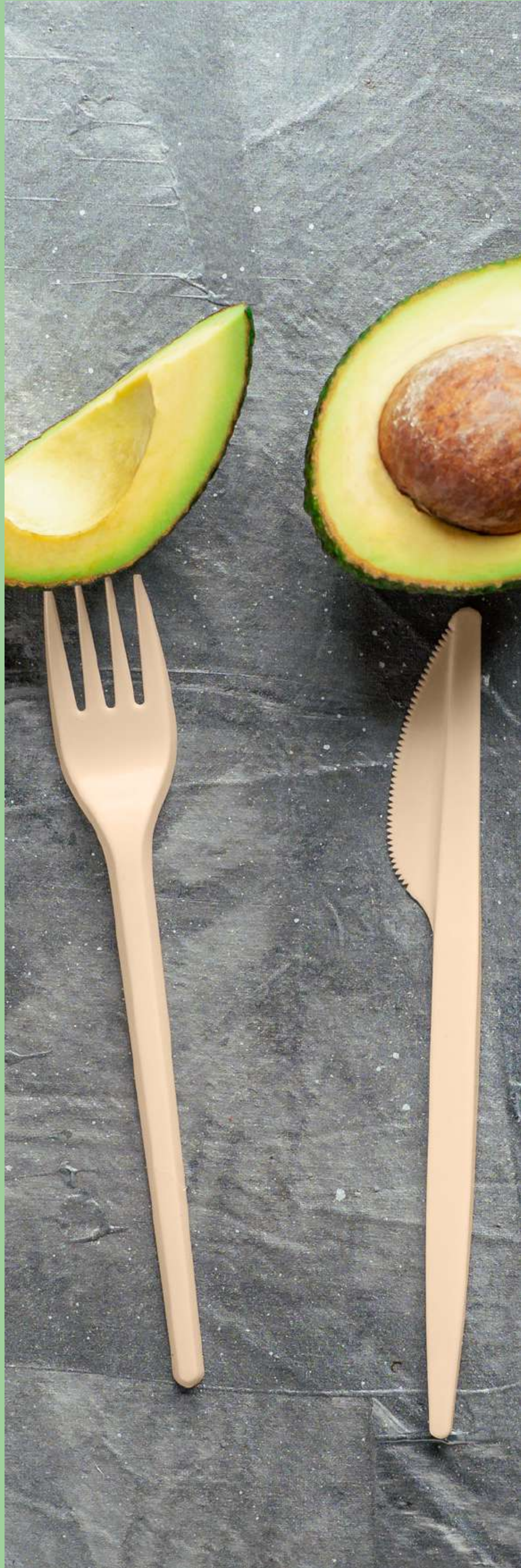

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