Seedling packaging made from biodegradable plastic

Image CNPq/Disclosure

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ENVIRONMENT

Is there really biodegradable plastic?

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In 2023, global plastic production reached approximately 413.8 million metric tons. Of this total, around 50% is single--use disposable plastics, such as packaging, bags and bottles, which quickly turn into waste.

Plastic production has an alarming environmental impact. Only 9% of all plastic generated worldwide is recycled, while the majority ends up in landfills (around 50%), is incinerated (19%) or disposed of inappropriately in the environment (22%).

Every year, around 11 million tons of plastic reach the oceans, posing a direct threat to marine life, as many animals ingest plastics as food, causing suffocation, poisoning and malnutrition, with an estimated death toll of more than one million marine animals.

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When decomposing, plastic releases harmful chemical substances that contaminate terrestrial ecosystems and aquifers, also impacting climate change, as its production and degradation releases greenhouse gases, CO2 and methane, which aggravates global warming.

And microscopic plastic particles have been detected in drinking water and various foods, leading to the involuntary ingestion of microplastics. Research indicates that the average human being consumes about 5 grams of plastic per week - the equivalent of the weight of a credit card.

Among the alternatives for dealing with plastic pollution are biodegradable plastics.

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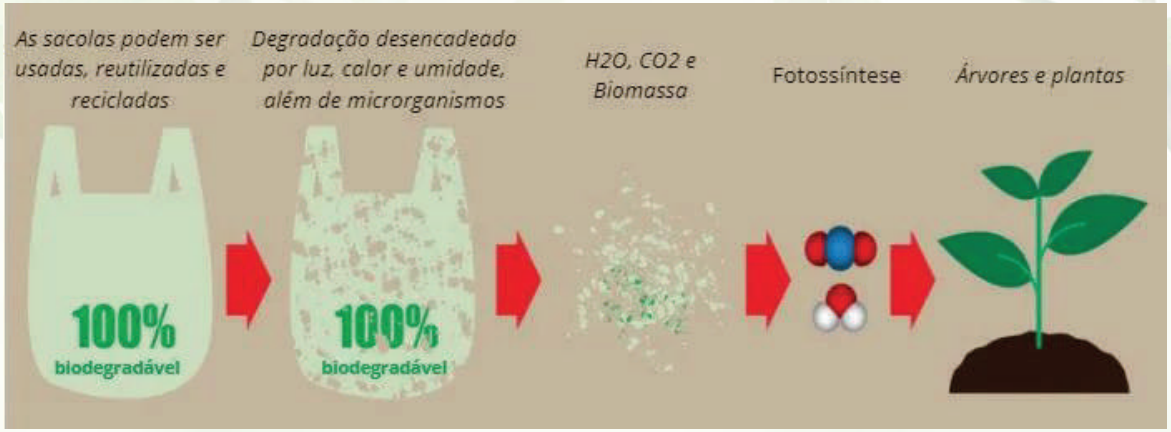
What is Biodegradable Plastic?

Biodegradable plastic is a material that, under suitable conditions, can be decomposed by microorganisms, such as bacteria and fungi, transforming into natural substances, such as water, carbon dioxide (CO2) and biomass, without leaving toxic residues in the environment.



It must be disposed of correctly. According to Bianca Maniglia, a professor at IQSC/USP (the Chemistry Institute of São Carlos at the University of São Paulo), "Not all plastics labeled as biodegradable decompose in natural environments; many require industrial composting."

"This creates confusion and can sometimes be used as a greenwashing strategy," she warns, referring to the practice of making products appear more ecological or sustainable than they actually are.

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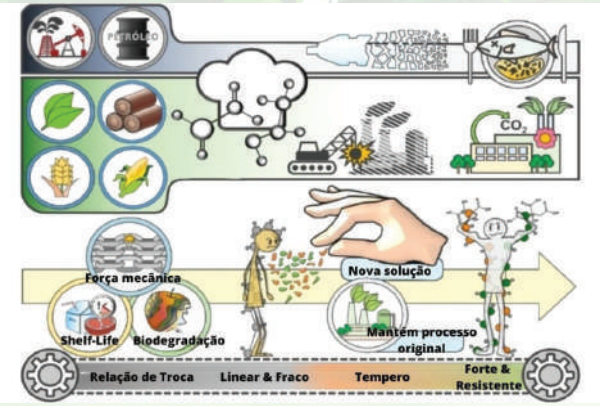
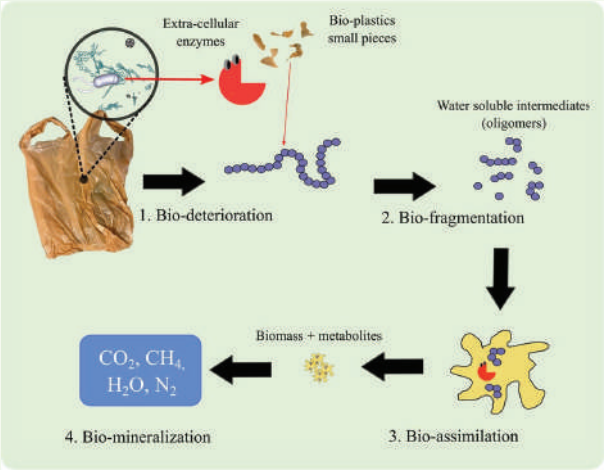
What is biodegradable plastic made of?





They are made from renewable raw materials (such as cornstarch, sugar cane or vegetable oils) or derivatives of synthetic polymers modified to facilitate their biodegradation, while conventional plastic is produced from petroleum, does not decompose easily and accumulates in the environment for years.

For a polymer to be considered biodegradable, it must be degraded by microorganisms existing in nature in a natural or controlled environment (for example, in industrial composting). The process must result in safe products, without toxicity to the environment.

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Which products already offer biodegradable plastic options?

Food packaging (cups, cutlery, knives, plates, plastic films).

Cosmetic bottles (such as shampoos).

Compostable bags, used in general retail and in the collection of organic waste (garbage bags).

Medical products (such as sutures and medicine capsules).

Plant pots and seedlings.

Soil cover films (in agriculture).

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What are the main types of biodegradable plastic?

PLA (Polylactic Acid) is made from sources such as cornstarch or sugarcane. It can be used in packaging and disposable utensils.

PHA (polyhydroxyalkanoates) is produced by bacteria from sugars or oils and is used in medical applications and packaging.

PBS (polybutylene succinate) is obtained by fermentation of biomass and is used in films and bags.

PBAT (polybutylene adipate terephthalate) is a synthetic polymer that combines biodegradability with flexibility and is used in compostable bags.

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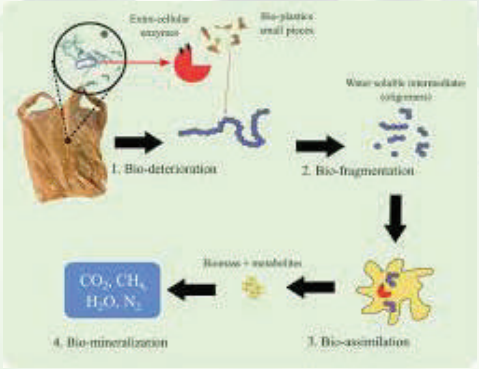
How does the plastic biodegradation process work?



Biodegradation occurs when microorganisms begin to attack the small polymer chains that are already of adequate size and under favorable environmental conditions (temperature between 37ºC and 55ºC, humidity, soil type, pH of the environment, presence or absence of oxygen).

The process occurs in stages:

- Fragmentation: the plastic material is broken down into smaller parts due to exposure to environmental factors such as UV light, heat, humidity and oxygen, in addition to the action of enzymes produced by microorganisms.

- Biostabilization: microorganisms metabolize the fragmented polymers, breaking their chemical bonds through specific enzymes.

- Assimilation: the products resulting from biofragmentation are absorbed by microbial cells.

- Mineralization: the degraded organic compounds are completely converted into simple substances, such as mineral salts, water, carbon dioxide and ammonia, for example. The degradation time can vary from weeks to years, depending on the type of plastic and environmental conditions. Cups or forks made with PLA derivatives, for example, degrade in approximately 1 month.

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Do biodegradable plastics degrade if thrown on the street?

When biodegradable plastics are discarded on the street or in nature, without suitable conditions, they can remain in the environment for long periods, causing negative impacts similar to those of conventional plastics.

In order to act, microorganisms need specific environmental conditions that can be efficiently controlled in industrial composting facilities.

"Since we do not always have ideal conditions, biodegradable plastics must be collected and destined for reuse through mechanical, chemical or mechanochemical recycling, or for incineration or combustion," says Lucia Helena Mei, professor of materials science at FEQ/Unicamp (School of Chemical Engineering at the State University of Campinas).

The choice of the most appropriate and sustainable process will depend on greenhouse gas emissions. When biodegradable plastic burns, it releases CO2, contributing to the greenhouse effect if the gas is not captured and/or transformed into another non-toxic product," she adds.

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What are the impacts of biodegradable plastics on the environment?

Positives:

- Reduced decomposition time compared to conventional plastic.

- Less accumulation of plastic waste in landfills and ecosystems.

- Reduced use of oil as a raw material.

Cons:

- If disposed of incorrectly, they may not biodegrade as expected.

- They may compete with food production, as they use agricultural raw materials.

- Their production may require high energy and water consumption.

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Is biodegradable plastic a solution to the plastic waste problem?

Biodegradable plastic can be one of the alternatives to overcome this problem, provided it is disposed of properly and undergoes several existing processes to treat plastic waste in general.

Therefore, according to researcher Bianca Maniglia, biodegradable plastic is not a complete solution.

According to her, it can reduce the persistence of waste in the environment, but it has limitations, such as the dependence on specific conditions for biodegradation and the limited infrastructure for industrial composting in many countries, in addition to not solving the problem of excessive consumption and inadequate disposal.

“I believe that the real solution requires an integrated approach, including reducing plastic consumption, encouraging reuse, efficient recycling and developing alternative materials,” says Bianca.

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What is the difference between biodegradable and oxo-biodegradable plastics?

The distinction between biodegradable and oxo-biodegradable plastics lies in the degradation process and the environmental impacts that each one generates.

Biodegradable plastics can be decomposed by microorganisms, such as bacteria, fungi and algae, resulting in natural substances, such as water, carbon dioxide (CO2) and biomass, without leaving toxic residues. This degradation occurs under specific conditions, such as in soil, aquatic environments or industrial composting facilities.

Oxo-biodegradable plastics are polymers derived from petroleum, such as polyethylene and polypropylene, which contain pro-degradant additives. These additives accelerate the fragmentation of the material when exposed to oxygen and UV light. However, this process generates microplastics, which can remain in the environment and affect ecosystems.

Unlike biodegradable plastics, oxo-biodegradable plastics do not completely decompose into biomass, which reduces their potential environmental benefit.

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Another point of concern is the so-called "green plastics" (PE or green polyethylene), which, although produced from renewable raw materials such as sugarcane, are not biodegradable and have the same potential for environmental accumulation as conventional polyethylene (PE), requiring attention to be paid to their proper disposal.

Microorganisms that can biodegrade it have already been found, but research into this process needs to advance, according to Lucia Helena Mei, professor of materials science at FEQ/Unicamp (School of Chemical Engineering at the State University of Campinas).

Source: Bianca Maniglia, professor at IQSC/USP (Chemistry Institute of São Carlos at the University of São Paulo) and one of the USP researchers responsible for developing biodegradable plastics based on raw materials of plant origin and agro-industrial waste; Lucia Helena Innocentini Mei, professor of materials science at FEQ/Unicamp (School of Chemical Engineering at the State University of Campinas), co-author of the book "Polymeric nanocomposites - Synthesis, characterization and properties" and co-organizer of the book "Bioplastics: biodegradable & biobased"