# MICROBIAL DEGRADATION OF PLASTIC

## PLASTIC

The word “plastic” refers to a series of (usually synthetic) polymers, made up of chains of carbon-based monomers. It is one of the most common and used materials in the world, since it is light, inexpensive, durable and resistant. The most common types of plastic are polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), polyurethane (PUR), polyethylene or polyethene (PE) and polyethylene terephthalate (PET).

*free picture at https://upload.wikimedia.org/wikipedia/commons/e/e6/WasteFinalDeposited.jpg*

## DISPOSAL OF PLASTIC WASTE

There are different ways to dispose plastic waste: storing it in landfills is the least convenient, given that plastic requires an extremely long time to degrade into the environment, from 100 to 1000 years. Moreover, the substances composing waste are not reused in any way, causing a waste of materials and energy [1].

## RECYCLING

New objects are produced from waste through recycling.

Thermosetting plastics can only be ground and used as aggregates for new products, e.g. concrete or asphalt; thermoplastic materials, instead, can be given a new shape when heated and moulded.

The main advantage of this disposal method is the production of plastic from plastic itself, without using petroleum.

## WASTE-TO-ENERGY

This method allows to obtain electricity from waste: in the majority of waste-to-energy plants, garbage is burnt in order to heat water, which steam is used to run turbines. A large part of the process consists in managing the remaining – both solid and volatile – substances, some of which are toxic. This represents the major disadvantage of waste-to-energy, whereas its main advantages are the reduction of the amount of waste that is landfilled and the possibility to use the energy produced from plastic.

*Free picture at https://upload.wikimedia.org/wikipedia/commons/a/ad/Oxodegradable_plastic-Logo.jpg*

## BIODEGRADABLE PLASTICS AND BIOPLASTICS

Plastic polymers are very resistant to environmental factors; biodegradable plastics contain additives that make them less resistant to sunlight and oxydation.

Given that fungi and bacteria are capable of decomposing organic molecules, attempts are being made to produce plastic polymers (called “bioplastics”) that are based on natural polymers, e.g. cellulose, starch, lignin etc., in order to make them more suitable for microbial degradation [3],[4].

The best feature of these materials is the possibility to compost: they degrade in non-harming substances in a few weeks time.

Nevertheless, these “eco-friendly” plastics also have some disadvantages, for example there are less resistant to mechanical stimulation, or some of them release methane – a powerful greenhouse gas – while degrading.

## BIOREMEDIATION

One of the most recent ways to dispose plastic waste is bioremediation, which is the removal of polluting substances from an area through microorganisms.

While recycling and using bioplastics can be efficient methods to prevent waste from being landfilled, bioremediation can solve the problem of environments that are already polluted.

Microbial degradation can be studied in various ways, of which each one leads to different results and has its own pros and cons, e.g. the reproducibility of experiments or the reliability of results [5].

## BIOREMEDIATION: POLYURETHANE AND ENDOPHYTIC FUNGI

In 2008 a group of researchers from Yale University tested the ability of various microorganisms to degrade polyurethane (PUR).

59 endophytic fungi were grown on solid PUR medium. In the first assay, 18 of these organisms produced a halo of clearance on the surface of the growth medium, therefore, they have been screened in other assays.

In the first one, all 18 fungi could degrade solid PUR medium in test tubes.

The five most active fungi were further examined in other assays.

These other experiments showed that *Pestalotiopsis microspora* (E2712A) and *Pestalotiopsis microspora* (E3317B) are the quickest to degrade PUR as the sole carbon source in liquid cultures and the only two that are able to grow in anaerobic conditions.

Afterwards, it was discovered that the activity is extracellular (since a cell-free filtrate can break down the polymer) and also induced by the exposure to PUR - because the fungi which have not been grown on the polymer cannot degrade it.

The enzyme responsible for degradation is probably a serine hydrolase, given that the activity is stopped by a serine-hydrolase inhibitor.

These organisms, especially *Pestalotiopsis microspora*, can be one of the solutions to the issue of plastic waste disposal. In the future, other organisms could be found to be capable of clearing polymers that are even more resistant and dangerous than polyurethane [6].

## BIOREMEDIATION: PET AND BACTERIA

As with polyurethane, various studies have been carried out about microorganisms which can degrade polyethylene terephtalate.
In 2016, one of the most sognificant experiments was performed by Dr. Yoshida and his team, who screened 250 plastic samples to identify PET-degrading microorganisms. In this way they discovered a new species, *Ideonella sakaiensis*, which was able to degrade a film of 0.31 mg/cm$^2$ per day.
Two enzymes are involved in the degradation activity: ISF6_4831 produces mono(2-hydroxyethyl) terephtalic acid through hydrolysis. The second enzyme, ISF6_0224, transforms mono(2-hydroxyethyl) terephtalic acid into terephtalic acid and ethylene glycol, two non-harming substances [7].

REFERENCES

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