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What happens to plastic in the soil?

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Abstract

Can you think of life without plastic? Plastic is currently one of the most common materials. It's used for most containers and it's even in your clothes! But what happens to this plastic? Some gets recycled but a lot of it gets thrown away. That means it often ends up in the environment where it can break down and change.

We wanted to see what happens to different types of plastic when we exposed them to different types of soil. We put small disks of plastic in different environments for 32 days. We then compared the plastics exposed to soil to plastic that was not exposed to soil to see how the surface and other properties changed. We also wanted to see whether any bacteria grew on the plastic. Our data proved that all plastics change when exposed to soil. But they experience different changes because they have different properties.

Introduction

Plastic is everywhere. Because it is cheap and durable, it has been extremely popular. Unfortunately, there is a huge amount of it present in the environment. Globally, plastic production exceeds 8,300 million metric tons. Approximately 80% of this plastic ends up discarded in a **landfill** or in the environment.

Once plastic enters the environment, it undergoes **weathering** and aging. These processes break the large plastic pieces down into **microplastics**. Scientific research shows that these tiny pieces of plastic can be harmful to ocean life. But not all plastic ends up in the ocean – a lot also ends up in the soil. For a long time, people thought that plastic was **nonbiodegradable** in the soil. That means that living organisms such as bacteria cannot break it down. However, new evidence shows that there are chemical, physical, and biological processes that do break down plastics in the soil. These processes break the plastics down into microplastics.

We conducted an experiment to see how different types of plastics change when in the soil for a specific amount of time. We believed that the type of plastic would be the main factor that determines how a plastic changes in the soil. To test our **hypothesis**, we exposed three different types of plastic to different soil conditions.

Microplastics are tiny pieces of plastic that are a concern for ecosystems both on land and in the water.

Source: NOAA

Methods

Our experiment exposed three types of plastics to three types of soil. The plastics we used were high density polyethylene (HDPE), linear low density and low density polyethylene (L/LDPE), and polyethylene terephthalate (PETE). To simulate microplastics, we used a machine to cut each plastic into 3.4 millimeter sized disks. We placed the disks in three different environments. The first one was wastewater treatment **sludge** collected during the treatment process. The second environment contained fresh soil mixed with water, and the last environment had aged soil mixed with water.

We filled three **Erlenmeyer flasks** with the soil from each environment. We added 10 plastic disks to each flask. We also set aside one set of disks without any soil contact as a **control** group. We covered the flasks and let them sit for 32 days. During this time, we shook them to make sure the disks and soil interacted.

After 32 days, we removed the disks from the flasks and rinsed with pure water. We then used a **scanning electron microscope** to see how the plastics had changed physically. We also looked at the bacteria that had grown on each plastic. Then we used a **mass spectrometer** to analyze the ratio of carbon **isotopes** in the plastics. We compared the amount of carbon-13 to the more common carbon-12. Then we compared the levels of these isotopes to the same type of plastic that wasn't exposed to soil.

Results

All plastics exposed to soil and sludge changed during the 32-day period. With the scanning electron microscope we observed bacteria and **biofilms** on the plastic disks (Fig. 1). We noticed that bacteria and biofilms preferred the PETE and HDPE instead of L/LDPE. We also observed surface changes in the plastics. L/LDPE had small pits, while HDPE had cracks that widened and deepened. PETE developed large ridges and indentations.

Our carbon isotope analysis showed an increase in the heavier carbon-13 isotope when exposed to soil and sludge for HDPE and PETE. L/LDPE showed very little change. This means that of the three plastics HDPE and PETE were changed chemically, but L/LDPE was not.

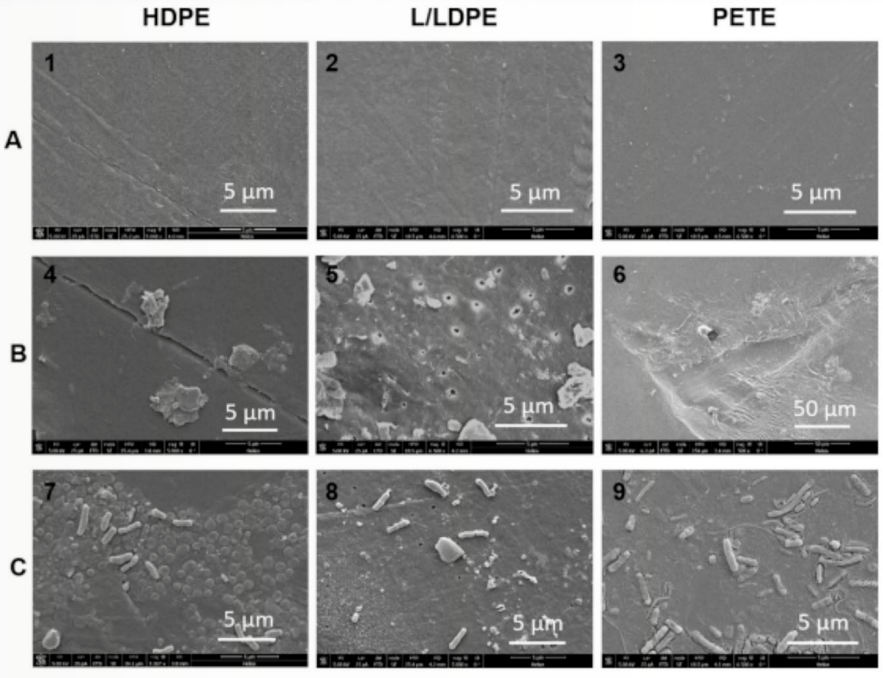

Figure 1:
Scanning electron microscope images of each plastic type.
A. Shows plastic disks not exposed to soil. For the plastic exposed to soil and sludge:
B. Shows surface changes.
C. Shows microorganisms and biofilm.

Which plastics experienced a physical surface change when exposed to the soil?

Discussion

Our experiment proved that plastics break down and change in soil. That is why we observed physical changes on the surface, changes in carbon isotopes, and the growth of bacteria and biofilms on the plastic. We also learned that plastics don't behave the same when exposed to soil and sludge. That's because each plastic has different properties. Some of the plastics are flexible (such as L/LDPE), while others are harder to deform (such as HDPE). Because we exposed all three plastics to the same soil and sludge, we can tell that these properties are important.

Our study gave us an idea of what can happen to plastic when exposed to soil and sludge. But not all soils are the same. That means we need to do more research to see how soil characteristics affect different types of plastic. We also need to discover the different processes that cause the plastic to break down and change. These experiments will help us to understand more about what happens to plastic when exposed to soil.

Conclusion

Our study proves that plastic breaks down and changes in soil. That means that over time, more microplastic will form. To reduce these microplastics in the environment, we need to reduce the amount of plastic in the soil. There are several things you can do to help.

- Reduce the amount of disposable plastic that you use. Swap out disposable water bottles for a reusable one.
- Prepare your own food and/or avoid food in plastic packaging.
- Use reusable grocery bags when you go to the store.
- Make sure that if you do use disposable plastics, you recycle them!

Using less and recycling more will prevent plastic from getting into the soil.

Glossary of Key Terms

Biofilms – a community of one or more types of microorganisms that can grow on a surface. Microorganisms that form biofilms include bacteria, fungi, and protists.

Control – a sample or group of samples that are not included in the tested variable and remain unchanged or unaffected.

Erlenmeyer flask – a type of glass container that has a flat bottom, a conical body, and a cylindrical neck. It's named after the German chemist who invented it in 1860.

Hypothesis – a proposed explanation made on the basis of limited evidence as a starting point for further investigation.

Isotopes – atoms of the same element that have the same number of protons and neutrons. For example, carbon-12 and carbon-13 are isotopes of carbon. They both have six protons and six electrons. But carbon-12 has 6 neutrons, while carbon-13 has 7 neutrons, making it slightly heavier than carbon-12.

Landfill – a place to dispose of garbage and other waste material by burying and covering it with soil.

Mass spectrometer – a device used to identify chemical compounds.

Microplastics – small plastic pieces that measure less than five millimeters.

Nonbiodegradable – not able to be broken down by living organisms.

Scanning electron microscope – a device that scans a surface with a focused beam of electrons to create an image.

Sludge – sediment collected and broken down during the wastewater treatment process. Most solids are removed and it becomes a form of dirty water.

Weathering – the breaking down and changing of a material.

Check your understanding

1. Which type of processes can break down and change plastic when it is in the soil?

2. Why did we use a set of plastic disks that were not placed in soil?

3. Why do we think that the different types of plastic changed differently in the soil?

4. We believe that the reduction of plastic in the environment is one way to minimize the impact of microplastics. To what extent do you think it is possible for our current society to reduce the amount of plastic used in everyday life? Explain your answer.

5. Recycling is a great way to reduce the amount of plastic in the soil. But not all plastic products can be turned in for recycling in the same way. In a group, research which plastic products can be recycled in your area and where they can be deposited for recycling. Then create a poster that shares this information with your community.

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