LESSON 3

What happens to plastic when you throw it away?

Age 11-14

60 minutes

Curriculum links

- Investigate what happens to plastics when disposed
- Describe and understand alternatives to plastics
- Working scientificall to compare plastics to alternatives, through degradation tests

Resources

Slideshow 3:
What happens to plastic when you throw it away?

Activity Overview 3a:
Design a biodegrade test

Student Sheet 3a:
How long will it take to degrade?

Student Sheet 3b:
Biodegradable plastic bags academic paper

Student Sheet 3c:
Design a biodegrade test

Student Sheet 3d:
Dr Imogen Napper's study

External Link:
Inspiring Stories: Imogen Napper

Extension or home learning

Complete the home learning exercise on Student Sheet 3d: Dr Imogen Napper's study.

Lesson overview

In this chemistry Key Stage 3 (KS3) lesson, students investigate rates of decay. The lesson is focused on students designing their own investigation. Included are teacher resources allowing students to test how a conventional plastic bag decays compared to a compostable bag (using a potato as a substitute), in different conditions.

Lesson steps	Learning outcomes
1. How many questions can you think of? (5 mins) Students are shown a picture of a plastic bag in the ocean. They must try and generate as many of their own questions about this image as they can.	• Recognise that most plastic ends up in either landfill o the sea
2. Where does it go? (5 mins) Students learn the possible journey plastic can take using a fl w diagram.	• Recognise that most plastic ends up in either landfill o the sea
3. Sources of plastic pollution (5 mins) Students are introduced to sources of plastic pollution using an infographic. Students are challenged to redraw the image from memory.	• Recognise that most plastic ends up in either landfill o the sea
4. Timeline (10 mins) Students order objects in order of the length of time it takes them to decay.	• Order materials based on the time they take to degrade
5. What are the alternatives? Academic paper (10 mins) Students analyse an academic paper to find alternatives to oil-based plastic.	• Describe alternatives to using plastics
6. Biodegrade test (20 mins) Students investigate what factors increase decay.	• Create an investigation on how to increase the speed of decay
7. Unintended consequences? (5 mins) Students evaluate the alternatives to plastics and balance the advantages with disadvantages.	• Describe alternatives to using plastics

TEACHER GUIDANCE 3 (page 1 of 4)
WHAT HAPPENS TO PLASTIC WHEN YOU THROW IT AWAY?

Step	Guidance	Resources
1 5 mins	Step 1 invites students to generate their own line of enquiry about plastic in the ocean. · On slide 2, students are shown a picture of a plastic bag in the ocean. As a settle activity they write as many questions as they can think of into their book. · Coordinate the sharing of students' questions. · At this point you will notice some common themes and can inform students about the lesson journey and which questions we will seek to answer in more detail during the lesson. · Follow on by sharing the learning outcomes, linking these to the questions previously raised.	**Slideshow 3:** Slides 1-3
2 5 mins	Most students will have recently drunk from a plastic bottle. tep 2 informs students about the end life of this everyday commodity. · Show the diagram on slide 4 detailing where manufactured plastics go. · You may want to ask students "what does this diagram tell us?" and "Are you surprised? How do you feel about this information?" **More information about how plastic can end up in the environment is available in our Plastic Clever Schools student workbook, page 5: https://plasticcleverschools.co.uk/wp-content/uploads/2023/06/PCS_-_SECONDARY_Student_Workbook_Feb_2023_SCREEN_AW.pdf**	**Slideshow 3:** Slide 4
3 5 mins	Students have an appreciation for where most plastics end up. In this step, students identify what are the main sources of this plastic waste through the 'flash diag am activity'. · Print off a copy of slide 5. Remember not to show this slide on the board as this will reveal the 'sources of waste diagram' that students need to draw in this 'flash diag am' activity. · The 'flash diag am activity' is where students work in groups to reconstruct a picture from memory. · Put the students into groups and give each group a few blank sheets of A4 paper. · Explain the activity to students. As a group, students will be re-drawing a diagram on their sheet of paper. All the students in a group will get to see the diagram, but there are some catches. 1. Only one group member is allowed to see the diagram at a time. 2. Students cannot write or draw anything while they look at the diagram.	**Slideshow 3:** Slide 5 **Print:** Slide 5

Step	Guidance	Resources
	3. Each group member is only allowed to see the diagram for a short period of time, and this time will get shorter after each viewing. Station yourself so that class cannot see the diagram, but there is room behind you where students can stand and "view" the diagram.	
4 10 mins	Students now consider how long they persist there through predicting how long it takes different objects to degrade. · students to draw timeline in their books- predict how long they estimate different materials take to degrade. Reveal the answers and ask students to correct their timeline using a different coloured pen. · **Using slide 8, explain that when plastics degrade, they break down into microplastics** Note that these values given are estimates. As many of these materials are relatively new, it is impossible to know accurately how long they will take to degrade, given different conditions.	**Slideshow 3:** Slides 6-8 **Student Sheet 3a:** How long will it take to degrade?
5 10 mins	Students now recognise how plastics enter the wider environment and the time taken for different materials to degrade. Now students explore alternative materials to synthetic plastics. · Using slide 9, pose the question "Plastic persists in the environment. What are the alternatives?" If this does not elicit a desirable response, ask students "What sorts of things, that you can find at home, degrade quickly?" Students ought to recognise that perishable foods degrade quickly. · Next, direct students to find out what scientists are doing by completing Student Sheet 3b, supported by slide 10. · Review Student Sheet 3b comprehension questions using slide 11. · Many students will have misconceptions about the differences in how plastics and bioplastics degrade. Address this common misconception on slide 12.	**Slideshow 3:** Slides 9-12 **Activity Overview 3a:** Degradation test **Student Sheet 3b:** Biodegradable plastic bags academic paper

Step	Guidance	Resources
	Go further by making it physical. Hand post-it notes to students. Challenge them to tear them into the smallest pieces possible. Explain that this is what happens to plastic. The post-it has not changed chemically - it has just become smaller. In contrast, natural polymers – such as starch - can be biodegraded by living decomposers, such as fungi and bacteria, which chemically change them into a new substance with different properties.	
6 20 mins	Students recognise that there are alternatives. Step 6 introduces students to Dr Imogen Napper and her work on investigating how fast materials degrade. Students will then replicate this research themselves. · Using slides 13 and 14, introduce Dr Imogen Napper by asking a student to read her comments. · Hand out Student Sheet 3c. · Explain that students will have to compare how plastic and a potato (proxy for bioplastic) decompose in different conditions. · Slide 15 has a graphic which explains factors affecting rate of decomposition. Depending on the class, you may want to talk through this in detail, or just direct them to the graphic to help them with their investigation. · Students will need to leave their samples for a week or more to see substantial results. Once they have prepared their samples get students to return to their seats and ask them to predict what might degrade most. The plastic or the potato? · Get students to vote with a 'hands-up': "which materials, plastic or bioplastic, is better for the environment?	**Slideshow 3:** Slides 13-15 **Student Sheet 3c:** Design a biodegrade test **Video:** Inspiring stories: Imogen Napper
	This video is hosted on YouTube and you may need to unblock this service, liaising with your IT department. The link for the video is: Inspiring Stories: Imogen Napper htt_s://youtu.be/8D0nBs9TiyI	

TEACHER GUIDANCE 3 (page 4 of 4)
WHAT HAPPENS TO PLASTIC WHEN YOU THROW IT AWAY?

Step	Guidance	Resources
7 5 mins	 Students should conclude that bioplastics are the better alternative. However, step 7 challenges students to consider unintended consequences of using the technology. · Direct students to the opinion on slide 16. It reads: "Bioplastics need lots of starch from plants. This takes up way too much land, which may result in forests being cleared for farming. It is also unethical because many people go without food." · Ask students whether they agree or disagree with this opinion. The teacher can then chair a small debate on students' opinions. · A useful debate model is ABC (Agree, build, challenge), where students must respond with either: "I Agree" "I want to build on that" or "I want to challenge that"  The statement on slide 16 is deliberately provocative. A switch to bioplastics does not necessarily mean deforestation and famine, but the increased use of any natural resource will place pressure on habitats and supply chains.	**Slideshow 3:** Slide 16
+ 20 mins	 Complete the homework sheet on Dr Imogen Napper's study	**Student Sheet 3d:** Dr Imogen Napper's study

Design a biodegrade test

Age 11+
(adult supervision)

20 minutes

Details

What you need per group

- Half a potato
- Part of a plastic carrier bag
- Cork borer
- Knife
- Cutting tile
- Ruler
- 4x Petri dishes
- Pen to label dishes
- Balance (to share)
- Student Sheet 3c

Equipment to change conditions:

- Soil
- Salt water
- Oil

Safety and Guidance

Precautions

Students may cause injury with knives and cork borers. Remind students and demonstrate how to conduct investigation safely.

Count the knives and borers handed out and count the knives and borers returned.

Students should be careful not to ingest rotten potato. Encourage students to wash their hands after handling.

Rotting p tato has the potential to breed fungus and bacteria. Ensure that samples are disposed of at the end of the activity

Overview

In this activity students will compare how plastic and potato (a proxy for starch-based bioplastic) degrade in different conditions. Note that results cannot be gathered in the same lesson.

Preparation

- Ask technicians to supply you with individual trays containing the essential equipment.
- In separate trays, or on top of the technician trolley, have a selection of optional equipment for students to choose from.

Running the activity

1. Use the borer to remove 4 cylinders of potato.
2. Cut all 4 pieces of potato into the same length.
4. Place each potato cylinder into a petri dish.
5. Cut out 4 squares of plastic carrier bag to the same size.
6. Add a plastic carrier bag square to each of the 4 petri dishes.
7. Change the environment for each petri dish (temperature, oxygen availability).
8. Leave your samples for a fi ed time.

Expected results

Students are likely to predict that the potato (naturally polymer made of starch) will biodegrade more easily than the conventional plastic bag (man made polymer made of hydrocarbons derived from oil). Students will notice that by adjusting availability of microbes, oxygen, or changing the temperature, they can increase the appearance of decay in the potato.

How long will it take to degrade?

Put these objects in order of the time it takes for them to degrade

Aluminium Can

Fishing Line

Plastic Bottl

Polystyrene Cup

Nappy / Diaper

Cigarette butt

Rubber boot sole

Sanitary pad

Plastic straw

0 years

800 years

STUDENT SHEET 3b

Biodegradable plastic bags academic paper

Scientists put their findings in writing to share. These are called publications or academic papers. Below is a group of scientists who share their ideas on a possible solution to the plastic problem. Read the extract and answer the comprehension questions.

Starch based bio-plastics as alternative packaging materials

Due to the negative environmental impacts of synthetic plastics, the development of biodegradable plastics for both industrial and commercial applications is essential today. Researchers have developed various starch-based composites [bioplastics] for different applications.

The present work investigates the corn and rice starch-based bioplastics for packaging applications. Various samples of bioplastics are produced, with different compositions of corn and rice starch, glycerol, citric acid, and gelatin. The tensile [strength] properties were improved after adding rice starch. However, water absorption and water solubility were reduced.

On the basis of these results, the best sample was analysed for thickness testing, biodegradability properties, SEM, hydrophilicity, thermogravimetric analysis, and sealing properties [visual inspection under a microscope, strength, and ability to make a seal] of bioplastic. The results show the suitability of rice and corn-based thermoplastic starch for packaging applications.

Marichelvam et al. (2019)
Corn and Rice Starch-Based Bio-Plastics as Alternative Packaging Materials, Fibers 2019, 7(4), 32; htt_s://doi.org/10.3390/fib704003_

Comprehension Questions

1. What is meant by synthetic plastics?

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2. Name the natural polymer they are using in their bioplastic.

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3. Which two foods do they obtain the starch from?

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4. Overall, does the text suggest that bioplastics are useful? Explain why.

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STUDENT SHEET 3c

Design a biodegrade test

How to make the most disgusting potato

Essential Equipment	Optional Equipment
• Potato	• Soil
• Plastic carrier bags	• Salt water
• Cork borer	• Oil
• Knife	
• Cutting tile	
• Ruler	
• Petri dishes	

Method

1. Use the borer to remove 4 cylinders of potato.
2. Cut all 4 pieces of potato into the same length.
3. Place each potato cylinder into a petri dish.
4. Cut out 4 squares of plastic carrier bag to the same size.
5. Add a plastic carrier bag square to each of the 4 petri dishes.
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Potato & plastic sample	How have you changed the conditions?
1	
2	
3	
4	

Samples	Observations
1	
2	
3	
4	

Summary Questions

1. What factors increase the rate of degradation?

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2. From your investigation, which factor(s) caused the most degradation?

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3. Explain why this might have happened?

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4. Would you recommend using starch-based (bio) plastics? Explain why.

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Dr Imogen Napper's study

Deterioration of compostable versus conventional carrier bags

Dr Imogen Napper studies ocean plastics at The University of Plymouth. Imogen has compared lots of different types of plastic to see in what conditions they break down best. Her findings will help us reduce the time plastics persist in the environment.

Imogen has tested compostable and conventional plastic carrier bags. These materials were exposed to open air, buried in soil, and submerged in seawater. One was kept in laboratory conditions as a control.

Imogen removed the bags after 3 years. She cut them into equal sized squares. Then Imogen hung a weight from the plastic and measured how much they stretched. The more the plastic stretched the more they had degraded.

1. What was Imogen's independent variable (what did she change)?

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2. What was Imogen's dependent variable (what did she measure)?

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3. What was Imogen's control variable (what did she keep the same)?

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Environment	How much the bags stretched with 60g weight	
	Compostable bag	Conventional bag
Open air	120mm	100mm
Buried in soil	240mm	60mm
Submerged in sea water	120mm	100mm
Lab conditions	100mm	90mm

4. Which bag showed the most degradation?

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5. Which environment degraded the bags the most for compostable and conventional bags?

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6. How could you improve this investigation?

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