Teaching unit

“Traces in the environment - What contributes to the ecological footprint of a liquid detergent?”

Worksheets for use in elementary school classes

These worksheets are based on a one-week research course for elementary school students, which is part of the Forscherwelt or Researchers’ World education initiative. The teaching concept and program were developed under the guidance of Prof. Dr. Katrin Sommer, Chair of Chemistry Didactics at Ruhr University Bochum, Germany, with the support of Henkel experts.
The experiments are suitable for third or fourth grade students.

Introduction

What does the life cycle of a detergent have to do with our environment?

Normally, the word "path of life" makes you think of a human being. A human being is born as a baby, grows up to become an adult and will leave the world again sometime after a hopefully long and beautiful life.
On the path of life a person leaves traces in his environment.

With a detergent it is not so much different: A detergent is created by mixing many individual raw materials. It is filled into its packaging, transported, used and finally disposed of. All this also leaves traces in the environment.

We want to go in search of traces. We ask: What does a detergent consist of? How is it packed? What traces does its transport leave behind? What happens during washing? And what happens to the empty packaging?

1. What washes in detergents?

Washing laundry is part of everyday life. But what do detergents consist of? How do they work?

Today you will learn about an important ingredient of detergents. Researchers call this ingredient "surfactant". Surfactants are made either from crude oil or renewable raw materials.

Surfactants work in a similar way to soap. They ensure that dirt stains can be washed out of a piece of clothing easily. Surfactants are also the reason why detergent foam.

We now want to have a look at the effect of surfactants.

1.1 Surfactants change the surface tension

1. Fill a glass vessel with water and carefully place three drawing pins flat on the water surface with the tip pointing upwards.
2. Drop 1-2 drops of liquid surfactant into the water with a pipette.
3. Observe what happens and take notes:

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1.2 Surfactants and the distribution of dirt in water

You will receive two glass jars with screw caps.

1. Fill them halfway with water.
2. Put a small spatula tip of soot in both glasses with the help of a small spatula.
3. Now use a pipette to drop two drops of surfactant into one of the two glasses.
4. Carefully close the jars with the screw caps and shake both jars for about 15 seconds.
5. Place the glasses side by side. What do you observe? Please take notes:

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1.3 Washing of oil stains

Now you should test whether a surfactant can remove oil stains well. Proceed as follows:

1. Drip four drops of olive oil from a dropper bottle onto each piece of cloth you receive, with four drops of oil in the middle. Wait a minute until the oil is well distributed.
2. Fill two screw-cap glasses half with warm water from the tap.
3. Drip 5 drops of surfactant into one of the screw-cap jars.
4. Put a piece of cloth into each of the glass jars and screw the lids tightly.
5. Shake both screw-cap glasses for two minutes and then take out the two pieces of cloth. Dab them dry briefly with a piece of kitchen paper and hold them against the light.
6. Compare the two pieces of cloth: What happened to the oil stain? Please take notes:

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2. It's all a question of dosage

When you do your laundry, remember that the detergent ends up in the wastewater and thus in the environment. Therefore, it is important to use only as much detergent as absolutely necessary.
The right amount of detergent depends on how "hard" the water is. On a detergent package you will find information about how much you should take.

But wait a minute - hard water? What is that? We have to answer this question first.

2.1 Different sorts of water

Examine two different water samples: sample A) and sample B). Find out the difference!

1. Take a pipette and drip 0.5 mL of the water sample A) onto a tablespoon.
2. Hold the tablespoon over a tea light until the water has evaporated.
3. Now drip 0.5 mL of water sample B) onto a second tablespoon.
4. Hold the second tablespoon also over a tea light until the water has evaporated.

What do the two tablespoons look like after drying? Please take notes:

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2.2 What happens with liquid detergent in soft and hard water?

1. Fill 500 mL of water sample A) into a large beaker.
2. Add 8 mL liquid detergent and stir the liquid for 5 minutes with a glass rod.
3. Repeat steps 1 and 2 with water sample B).

Please take notes:

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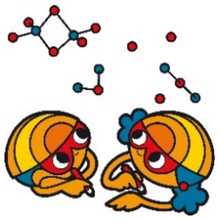
2.3 Foam

1. Fill an empty PET bottle with 100 mL water and mark the fill level with a waterproof felt pen.
2. Repeat this step until the bottle is filled with 1000 mL of water.
3. Empty the bottle at the end.
4. Now your class is divided into two groups.
   a. Group 1 fills 200 mL of water sample A) into their bottle.
   b. Group 2 fills 200 mL of water sample B) into their bottle.
5. Now fill 1 mL of liquid detergent into your bottle.
6. Shake the bottle vigorously for 30 seconds.

Compare your bottle with the bottle of the other group. What do you notice?



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3. Washed too hot?

The hotter the washing water, the higher the electricity consumption. This is not only expensive, but also bad for the environment. This is because electricity generation often produces carbon dioxide (CO_2), which is a greenhouse gas.
It is good for the environment if we save electricity and wash our laundry with as cold water as possible.

But: will the laundry also be clean with cold water? Give it a try.

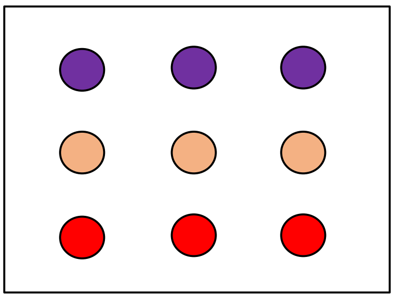
3.1 Stain some fabric

Before you can investigate how well the detergent washes, you first need to systematically apply stains. Specialists call this "soiling." You should stain a piece of white cotton fabric with beetroot juice, cocoa and ketchup.

Make sure that:

- each type of stain is applied to the piece of fabric three times in total
- the stains do not overlap
- a similar quantity of each staining type is used
- the fabric is tagged accordingly.

1. Label your piece of cloth with your name first.
2. For each stain, apply a certain amount of dirt:



- 3 times ca. 0,5 mL beetroot juice
- 3 times ca. 0,5 mL cocoa
- 3 times ca. spatula-tip of ketchup

Let the stains dry for about 10 minutes.

3.2 Laundry experiments

We divide the washing trials into different groups – pay attention to which group you are assigned to and mark your trial in the table below.

1. Write the number of your trial on your piece of fabric.
2. Pour 750mL of water at the right temperature into a beaker together with a stir-fish. Add your soiled piece of fabric and place the beaker on a magnetic heat stirrer.
3. Add 1 mL of liquid detergent with a pipette.
4. Choose a medium stirring speed and "wash" the fabric for 10 minutes.
5. Pull out the fabric, wring it out well.

trial/ Group no.	rounds per minute (RPM)	time (min)	temperature (°C)	liquid detergent (mL)	water (mL)
1	Medium	10	10	1	750
2	Medium	10	20	1	750
3	Medium	10	30	1	750
4	Medium	10	40	1	750
5	Medium	10	50	1	750
6	Medium	10	60	1	750

Rate your washing result and enter it in the table below. Use smileys: ☺ 😐 ☹

Compare your washing result at the end with those of the others.

stain	trial 1	trial 2	trial 3	trial 4	trial 5	trial 6
beetroot juice						
cocoa						
ketchup						

4. Greenhouse gas effect and CO_2

The greenhouse effect occurs when gases in the Earth's atmosphere capture the heat of the sun. Without the Earth's atmosphere, it would be much colder on Earth.

How is carbon dioxide related to the greenhouse effect?

Carbon dioxide (CO_2) is a natural gas - it is part of our air. We exhale CO_2 with every breath we take. CO_2 is also one of the gases that trap the sun's heat. Besides natural sources – do you know of other sources of CO_2?

Let's measure the greenhouse gas effect of CO2 in a simple experiment. You need:

Greenhouse gas (CO2) Source: lime + vinegar

- ➔ CO2 is released when an acid-like vinegar solution is added to lime (calcium carbonate). As soon as the vinegar hits the lime, it begins to bubble. The bubbles are CO2.

Heat source (which is the sun)

- ➔ We use a bright lamp bulb as heat source. Caution: the lamp must not be touched when the device is switched on.

Greenhouse (atmosphere)

- ➔ We use two beakers as containers (volume 2 L) - beaker 1 and beaker 2.

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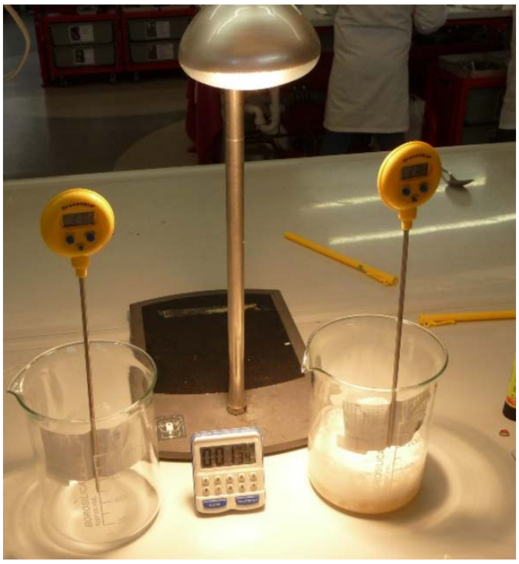
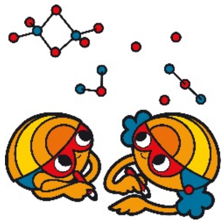
4.1 Measuring the greenhouse gas effect



1. Attach the digital thermometers to two beakers (beaker 1 and beaker 2) using adhesive tape. The tip of the thermometers should be 5 cm above the bottom of the cup.
2. Place the beakers 1 cm apart.
3. Weigh 10 g lime and pour the lime into beaker no.1.
4. Measure the temperature in the two beakers and enter the temperature values in the table below.
5. The temperature in both beakers should be about the same at the beginning.
6. Attach a lamp to a stand so that it is about 35 cm above the table. Place it so that it shines evenly on the two beakers.
7. Switch the lamp on.
8. Carefully pour 50 mL vinegar into the beaker with the lime.
9. Start the stopwatch and measure the temperature every 2 minutes. Enter the temperatures you measure into the table.

time (minutes)	temperature beaker 1, without CO_2-source (°C)	temperature beaker 2, with CO_2-source “greenhouse” (°C)
0		
2		
6		
8		
10		



What did you observe?

5. Packaging –- why, what material, how?

Every detergent needs packaging. Otherwise we could not transport the detergent at all. But which packaging is best suited for a liquid detergent?

Today, you are to study different packaging materials and their properties. You will be given containers made of wood, glass, cardboard, plastic and metal.

5.1 Form

➔ Examine the forms available to you and evaluate their characteristics with a view to

1. Stability (does the packaging tip over quickly?)
2. Stackability (can the packaging be stacked well / in a space-saving manner?)
3. Handling (is the packaging easy to grip and easy to open and close?)
4. Tightness (can the packaging be closed tightly so that no liquid escapes?)

➔ Use smileys to rate the containers: ☺ 😐 ☹

Stability: ______________

Stackability: ______________

Handling: ______________

Tightness: ______________

Stability: ____________
Stackability: ____________
Handling: ____________
Tightness: ____________

Stability: ____________
Stackability: ____________
Handling: ____________
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Stability: ____________
Stackability: ____________
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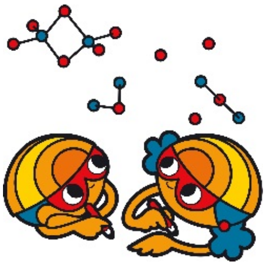
Stability: ____________
Stackability: ____________
Handling: ____________
Tightness: ____________



5.2 Material properties

➔ Examine the properties of the mentioned materials and enter the appropriate adjectives in the table.

material	floating/sinking behaviour in water *(floats, sinks)*	stability *(fragile, moderately stable, unbreakable)*	water resistance *(waterproof, water permeable)*	mouldability *(poorly formable, moderately formable, good formability)*
Wood				
Plastic				
Glass				
Card-board				
Metal				

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5.3 What did you learn about the different materials??

Match the statements in the speech bubbles to the different packaging materials!

Can be used over and over again

Is easy to recycle

Well suited for liquids

Suitable for packing fragile items securely

Is very light

Is almost unbreakable

Easy to transport

Easy to clean

Is produced from crude oil

Can't be reused often

6. Not all plastics are the same

There are packages made of many different types of plastic. They all end up together in the recycling bin. It is best for the environment if you can recycle the packaging. For this to work well, it is important to separate the different types of plastic well.

6.1 Get to know different types of plastic

You will get some plastic packaging made of different kinds of plastic. The chemists have very complicated names for them, but fortunately there are simple abbreviations. The abbreviation for the type of plastic is always under a recycling symbol.

Look for the recycling symbols and abbreviations on the plastic packaging you received.

Write down here the different abbreviations you have discovered:

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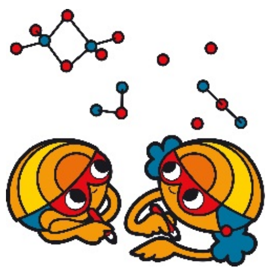
6.2 Float/sink behavior of plastic

Plastic floats on water, right? Study the swimming behavior of the different kinds of plastic you get.

1. Fill a beaker with water
2. Dip the first piece of plastic completely into the water and release it.
3. Observe what happens: does it float or sink to the bottom?
4. Mark your result in the table.
5. Repeat steps 2-4 with the other plastic pieces.

abbreviation	floats	sinks
PE		
PS		
PVC		
PET		



6.3 Float/sink process for the separation of plastics

You have learned which type of plastic sinks in pure tap water and which floats on water. What happens if you change the water by gradually adding salt? Try it out!

1. Fill a beaker (size "1 L") with 250 mL water.
2. Put the pieces of four different types of plastic into the beaker and stir briefly.
3. Now add a small spoonful of table salt, stir with a glass rod for about 30 seconds and let the mixture stand until the plastic pieces do not move anymore.
4. Repeat step 3 four more times. In total you have added five spoons of salt.
5. Write down your observation on the worksheet.

abbreviation	what happens if you add salt to the water
PE	
PS	
PVC	
PET	

6.4 Apply your knowledge of plastic separation now

You get a plastic mixture of different plastic particles.
Take advantage of the different floating/sinking behavior of the plastics to separate them from each other.
You may use different beakers, water and salt.

7. Water soluble films – alternatives to plastic?

Plastic packaging has a very big advantage, but it can also be a very big disadvantage: Plastic packaging has a very, very long shelf life. If plastic packaging ends up in the environment instead of in the bin, this is very bad.
Are there also packaging materials that are water-soluble? Couldn't they be used as packaging? Today we are getting to know two materials.

7.1 Water soluble starch film

1. Put 2.5 g corn starch, 20 mL water and 2 mL glycerine into a beaker.
2. Stir the mixture well with a glass rod.
3. Place the beaker on a heating plate and set the temperature control to 150°C. Stir the mixture well while it gets hot.
4. Write the name of your team and the letters "ST" on the back of a plastic lid of a plastic box.
5. Spread the mixture on the lid.
6. Allow the mixture to dry.

While the first film is drying, you can make a second film.

7.2 Water soluble PVA film

1. Heat 100 ml water in a beaker (60°C).
2. Pour the water into a tall plastic beaker.
3. Whisk the hot water with a hand blender and carefully add PVA (polyvinyl alcohol) powder.
4. After you have obtained a smooth mixture, spread the mixture on the back of another plastic lid.
5. Allow the mixture to dry.

8. Water soluble films

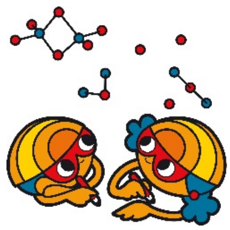
In the last hour, you've made two water-soluble films. Today, you can first examine the films you made yourself.

8.1. Comparison of the starch film with the PVA film

1. Cut your homemade starch foil into thumbnail-sized pieces.
2. Fill a small beaker with tap water.
3. Dip a piece of the starch foil into the water and stir briefly.
4. What do you observe? Write it down:

Now take your PVA film and repeat steps 1-4. Write down again what you observe:

8.2 Comparison of PE and PVA



In the next test you should compare plastic bags made of PE (polyethylene) and PVA (polyvinyl alcohol). You will need a plastic bowl, tweezers, a pipette, a beaker (100 mL), water, salt solution and detergent solution.

1. One of you grabs a PE bag with the tweezers and holds it over the plastic bowl so that the other one can fill 10 mL water into the bag with the pipette.
2. Repeat this step with the PVA bag and also 10 mL water.
3. Note your observation in the table below.
4. Then, together with your partner, investigate how the PE or PVA bags behave with 10 mL salt solution.
5. Write down your observation in the table again.
6. Finally, examine how the PE and PVA bags behave with 10 mL detergent solution.
7. Record the observation in the table again.

Enter your notes in the table:

bag	what happens with water?	what happens with saline solution?	what happens with detergent solution?
PE-bag			
PVA-bag			

Can liquid detergent be packaged with PVA film?