# Teaching unit

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

## Supplement for teachers

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.
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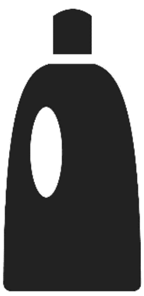
# Introduction

Ecological footprint, life cycle assessment, life cycle analysis, CO2 footprint: These are technical terms that all have in common that they are intended to describe the environmental impact of a product. In detail, there are certainly differences in terms of the system boundaries and the type of impacts that are considered. What they all have in common, however, is that their definition considers the entire life cycle of a product, from raw materials to disposal.
Since the exact definitions and scientific calculation methods are still difficult to grasp for children of primary school age, we will refrain from a detailed examination of the various technical terms in the following. Instead, we want to convey the basic principle that only a holistic view of the entire product life cycle allows us to assess whether a product is more or less environmentally friendly. For example, it is not per se true that an electric car is good for the environment. If it is powered by electricity from an inefficient lignite-fired power plant and has batteries whose raw materials were obtained with the help of child labor, the environmental benefit is at best doubtful.

In this series of lessons, we are guided by the life cycle of a liquid detergent. We start with an important ingredient, deal with its environmentally friendly use, investigate the greenhouse effect and then devote a great deal of attention to the subject of packaging.

### Lessons

1 What washes in detergents?
2 It's all a question of dosage
3 Washed too hot?
4 Greenhouse gas effect and $CO_2$
5 Packaging – why, what material, how?
6 Not all plastics are the same
7 Water soluble films – alternatives to plastic?
8 Water soluble films



# 1. What washes in detergents?

A brief introduction is given in this video:
https://www.youtube.com/watch?v=F7-ie4uWX04

### 1.1 Surfactants change the surface tension

Materials per group

- Three pins
- Small glass bowl or a beaker
- Pipette
- Liquid surfactant (e.g. sodium lauryl ether sulphate, alternatively detergent can be used)

### 1.2 Surfactants and the distribution of dirt in water

Materials per group

- Two glass containers with screw caps
- Pipette
- A spatula tip of soot (e.g. abrasion from a piece of coal)
- Liquid surfactant (e.g. sodium lauryl ether sulphate, alternatively detergent can be used)

### 1.3 Washing of oil stains

Materials per group

- Two glass containers with screw caps
- Pipette
- Dropper bottle with olive oil
- Two cotton rags (ca. 5x5 cm)

# 2. It’s all a question of dosage

To protect the environment, it is important to use only as much detergent as necessary. The correct detergent dosage depends on the water hardness. This is mainly determined by calcium and magnesium ions in the water. These minerals interfere with washing, as they can bind the surfactants and soaps contained in the detergent. This is why hard water becomes cloudy when liquid detergent is added and also foams less than soft water.

### 2.1 Different sorts of water

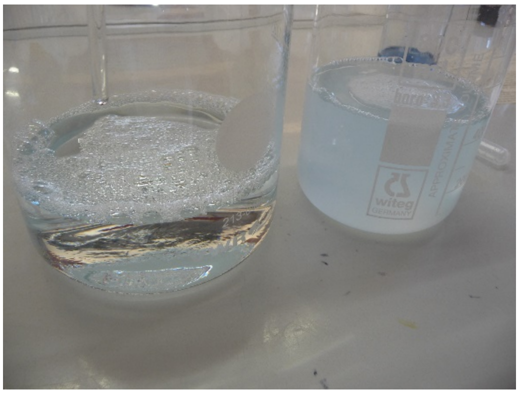
Materials per group

- Two tablespoons
- Tealight
- Matches
- Wooden clamp
- Two water samples with a) distilled water and b) hard water

The students shall receive safety instructions first and shall not work unsupervised.

### 2.1 What happens with liquid detergent in soft and hard water?

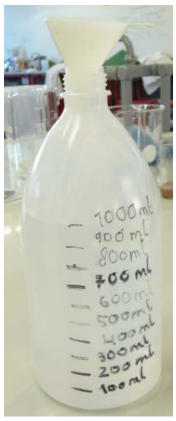
Materials per group



- Two 1 L beakers
- 500 mL distilled water
- 500 mL hard water
- 20 mL liquid detergent
- Pipette or small measuring cylinder
- Glass rod

### 2.2 Foam

Materials per group


- Two 1 L PET bottles with screw cap
- Funnel
- Water-insoluble felt-tip pen
- 100 mL Measuring cylinder
- 1 L hard water or 1 L distilled water
- 5 mL liquid detergent

# 3. Washed too hot?

### 3.1 Stain some fabric

Materials per group

- White cotton fabric piece (ca. 30 cm x 30 cm)
- 5 mL beetroot juice
- 5 mL cocoa
- 20 mL liquid detergent
- 1 tablespoon ketchup

### 3.2 Laundry experiments

Materials per group

- 1 beaker (1 L)
- Magnetic heating stirrer (if not available, can also be stirred manually)
- Pipette
- 5 mL liquid detergent
- Tempered water
- Thermometer

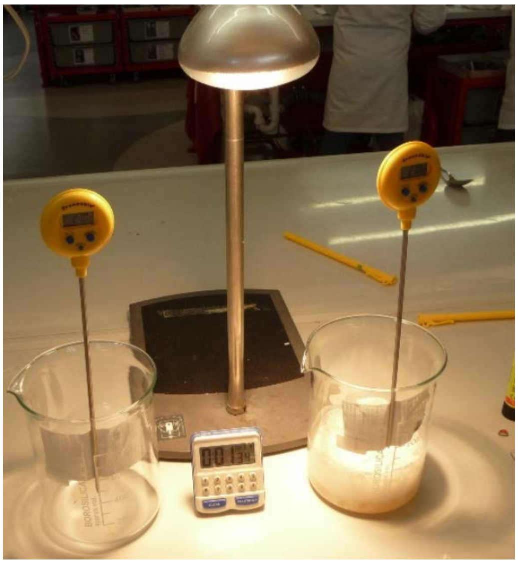
The washing trials are divided into different groups. If possible, at least two groups should wash under the same conditions.
The three types of dirt are chosen so that they belong in different dirt categories. Beetroot juice is one of the "bleachable" soils, cocoa contains protein and is removed especially with the help of detergent enzymes, and the same applies to ketchup, which contains many carbohydrates.

During the evaluation you will see that especially drinking chocolate is removed better at lower temperatures than at 60 °C. High temperatures can have a negative effect on both the protein-containing stain and the detergent enzymes.
The conclusion is that low washing temperatures can lead to good results with significant energy savings.

# 4 Greenhouse gas effect and $CO_2$

Put very simply, the greenhouse effect occurs when so-called greenhouse gases in the Earth's atmosphere "capture" the heat of the sun. Carbon dioxide, $CO_2$, is the best-known so-called greenhouse gas. It absorbs especially the wavelengths of sunlight, which make up the heat radiation. An atmosphere that contains a lot of $CO_2$ therefore absorbs more heat radiation and heats up faster than an atmosphere that contains less $CO_2$.
This effect can be simulated with a simple experimental setup. For this purpose, two containers (beakers) are needed, which represent two atmospheres: One with little and one with a lot of $CO_2$. The $CO_2$ is produced in one of the beakers in situ by adding vinegar to lime. $CO_2$ is heavier than normal ambient air and is concentrated in the lower part of the beaker.

Materials per group



- 2 high 2 L beakers
- 2 digital thermometers (0.1°C accurate)
- 1 lampshade with a 250W heat lamp
- 1 tripod with clamp for fixing the lamp
- Duc tape
- Timepieces
- 10 g powdered lime
- 50 mL household vinegar (5-6% acid)

In order to be able to measure the effect as well as possible, a few points must be taken into special consideration when setting up the apparatus:

The construction must be symmetrical, i.e. the beakers and thermometers must have the same distance from the lamp.
The initial temperature in both vessels should be as equal as possible; this can be achieved, for example, by preparing the apparatus the day before, so that the objects have time to adapt to room temperature.
The apparatus should be placed in a place which is protected from draught; any draught in the room, e.g. from an air-conditioning system, will interfere with the measurement.

https://www.youtube.com/watch?v=Ge0jhYDcazY

# 5 Packaging – why, what material, how?

Plastic's bad. Glass is good. You'd think. Plastic has fallen into disrepute as a packaging material. But plastic does not only have bad qualities.
In this lesson we will compare five different packaging materials and their properties. The properties are decisive for the areas of application and later recyclability of the materials.

### 5.1 Form

Materials per group

- Five different containers made of wood, glass, cardboard, plastic and metal.

### 5.2 Material properties

Materials per group

- 2-3 money coins
- 2-3 Small pieces of wood; e.g. wooden forks for French fries
- 2-3 glass beads (e.g. from handicraft supplies)
- 2-3 pieces of cardboard
- 2-3 small cut plastic packages (different types)

# 6. Not all plastics are the same

Depending on the application, different plastics are used in packaging. The plastics differ in their properties. In order for them to be recycled as well as possible, it is necessary to separate them from each other in the recycling process. In doing so, the different densities of the materials are taken advantage of.
In this lesson the children will learn about the most common plastics and their symbols. They will also learn how to use the different floating/sinking behaviour in water for separation.

### 6.1 Get to know different types of plastic

A good overview of the recycling codes can be found here:
https://en.wikipedia.org/wiki/Recycling_codes#List_of_resin_identification_codes_(RIC)_and_codes_defined_by_the_European_Commission

Materials per group

- Approx. 5-6 empty plastic packages of different types of plastic

### 6.2 Float/sink behavior of plastic

Materials per group

1 250 mL beaker or large drinking glass
Thumbnail-sized plastic pieces made of various plastic materials (PE, PS, PVC, PET).

### 6.3 Float/sink process for the separation of plastics

Materials per group

- 1 250 mL beaker or large drinking glass
- Thumbnail-sized plastic pieces made of various marked plastic materials (PE, PS, PVC, PET)
- Table salt
- Spoon spatula (or teaspoon)

### 6.4 Apply your knowledge of plastic separation

Materials per group

- 1 250 mL beaker or large drinking glass
- Thumbnail-sized plastic pieces made of various plastic materials (PE, PS, PVC, PET)
- Table salt
- Spoon spatula (or teaspoon)

# 7. Water soluble films – alternatives to plastic?

In limited applications, water soluble films can replace packaging plastics. For example, dishwasher tablets or detergent pods are offered in polyvinyl alcohol films. Starch-based packaging materials are also on the market, for example as filling material to secure fragile objects during transport.

## 7.1 Water soluble starch film

Materials per group

- Ca. 5 g corn starch
- mL Gycerin
- 1 250 mL beaker
- Magnetic heating stirrer or hotplate
- Glass rod for stirring
- Balance
- Spatula
- Measuring cylinder
- Plastic lid of a storage box

## 7.2 Water soluble PVA film

Materials per group

- 10 g polyvinyl alcohol (MW 70,000)
- mL Gycerin
- 1 250 mL beaker
- Magnetic heating stirrer or hotplate
- hand blender
- Balance
- Spatula
- Measuring cylinder
- Plastic lid of a storage box

After the two compounds have been applied to the plastic lids, they need about one day to dry.

# 8. Water soluble films

The water-soluble films produced in the previous hour can now be examined by the children. To do this, they must be carefully removed from the plastic lids.

## 8.1. Comparison of the starch film with the PVA film

Materials per group

- Self-produced films
- Small beaker
- Glass rod for stirring

## 8.2 Comparison of PE and PVA

Materials per group

- Plastic bags made of PE (polyethylene)
- PVA bags (fishing supplies)
- Tweezers
- Pipette
- Plastic bowl
- Beaker
- Concentrated table salt solution
- Liquid detergent

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# Links

https://www.cleanright.eu/en/laundry-room.html
https://www.youtube.com/watch?v=_6xlNyWPpB8
https://www.york.ac.uk/res/sots/activities/soapysci.htm
https://www.youtube.com/watch?v=cYOC8_jJcII