Teatime4Science

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| Authors | Karin Van den Eynde, Lies Van Nijverseel |
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# Lesson plan

## Method

Students participate in an interactive activity where they get familiar with the purpose of the Citizen Science project, they learn how to cooperate and how to help the project. They discuss possible reasons to join such projects. Then, they join the project and start participating.

## Introduction

As current global warming doesn’t only affect climate change directly, but also has an influence on the decomposition of all kinds of organic material because of the global rise in temperature, scientists are investigating this influence in several ways. One of these ways is the Tea Bag experiment, developed as an easy accessible, but accurate way to compare the effect of environmental conditions on decomposition.

To investigate the influence of global warming on decomposition, tea bags are buried in different soil types at different locations and dug up after three months to determine their weight loss.

The first tea bags were buried in 2010. Over the years the project evolved to a worldwide spread project with different sister projects that all have the same aim: to construct a global soil map and thus improve global climate models.

## Materials

Lesson plans can be downloaded on <http://www.teatime4science.org/publications/#lesson-plans> or watch photos from various burying locations <http://www.teatime4science.org/stories/pictures/> or other publications on the website <http://www.teatime4science.org/>.

## Concept

The measurement of decay rates of dead plant material was formely done by filling a plastic net bag with a certain amount of this material. The holes in the net would allow microorganisms to enter and consume the material, but the net would prevent the material from getting lost. The bags were buried in the soil to allow the microorgnisms to enter. After a certain amount of time the weight loss of the bag would give an indication of the speed of decay at the location it was buried. The Tea Bag experiment changed this method by replacing the net bags by tea bags: no need to prepare them yourselve, the content will always be the same, the bag is identical as well and anyone can do the experiment all over the world independently.

## Objectives

Students will learn:

* The process of decomposition of dead plant material into carbon dioxide, nutrients and soil.
* That decomposition depends on different environmental conditions.
* To discuss and reflect on the factors that affect decomposition/global change/sustainability by comparing their results.
* That contributing to scientific research doesn’t need to be complicated or dangerous.
* Raise their interest to join other citizen science projects in the future e.g. airbezen, curieuzeneuzen, zooniverse, …

## Subject

Decomposition of organic material in different soil types.

## Skills

Correct measurements, calculating weight loss, statistical comparison, orientation skills to determine the correct location of the bags after the experiment, studying soil types and microorganisms.

# Background

As mentioned before, the Tea Bag Experiment is based on the proces of decomposition. Therefore, this proces will first be clearified to the students.

## **What is decomposition?**

The process that breaks down [organic materials](https://en.wikipedia.org/wiki/Organic_substance)  into smaller organic pieces is called decomposition. After dying, remains of living organisms begin to decompose. Certain small animals help decomposition of organic materials. They are called decomposers. Decomposition never takes place in exactly the samen way, but the stages of decomposition are the same for all living organisms.

Through decomposition, plants and small soil organisms are provided with food to grow. Examples of decomposers are small animals such as beetles and earthworms, nematodes and unicellular animals and microorganisms such as bacterias and fungi.

When organic remains decompose, the weight decreases, since the gas carbon dioxide (CO2) is released into the atmosphere. Decomposition of plant remains, or "organic matter" is therefore a crucial process for life on our planet.

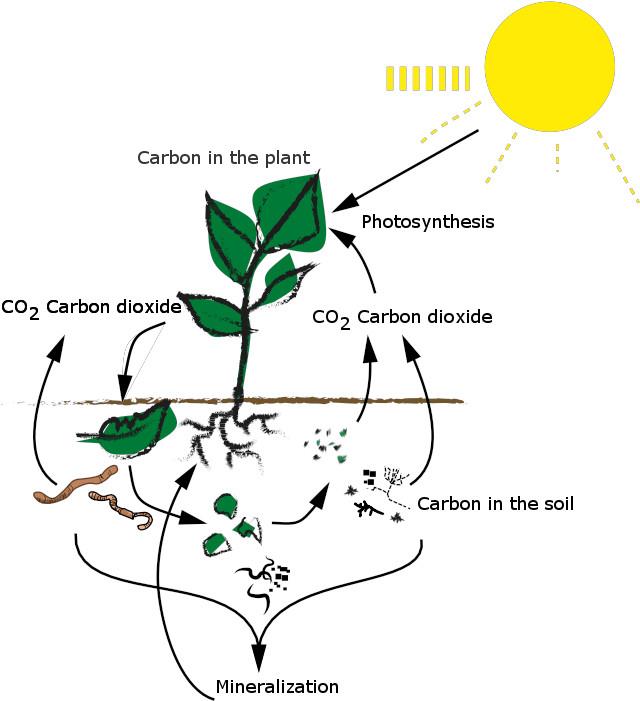


Figure 1: The carbon cycle. Photosynthesis fixes carbondioxide in organic molecules in plant materials. As organic materials perish, organic molecules decompose and carbon dioxide is released back into the atmosphere. The part that didn’t decompose is stored in the soil. It can be mineralized into nutrients for plants.

The decomposition rate depends on environmental conditions (humidity, acidity, the amount of nutrients in the soil, temperature). These factors affect the activity of the microorganisms: 1) how fit they are and 2) the amount of food they need. For example temperature: since decomposers are mostly small animals, they have difficulties or are unable to regulate their own temperature. Therefore, decomposition is slower in cold climates. This also means that in colder climates, less carbon dioxide will be released into the air, so the amount stored in the soil is bigger.

The chemical properties of the material that is going to be decomposed is a second factor to infuence the rate of decomposition.

The last factor to influence decomposition rate is the composition of the group of decomposers in each situation.

All organic materials consist of a mixture of materials that are easy to decompose (for example sugars) and materials that are difficult to decompose (e.g. wood/waxes). As different materials will decay at different rates, the whole decomposition process can be separated into two phases:

In the first phase all easy degradable material is decomposed, this process occurs quite fast, so the weight loss is fast as well. A part of this material might also be converted in a material which is more difficult to break down during decomposition.

In phase 2 only the difficult degradable part remains, so further weight loss is minimal. This recalcitrant material will become part of the soil.

The decomposition rates in both phases depend on the three factors mentioned above (environmental conditions, chemical properties of the plant materials and the composition of the decomposer community).

## **Decomposition and climate change**

The amount of carbon dioxide increased from approximately 315 ppm in 1960 to 410 ppm in January 2019.

Carbon dioxide is a greenhouse gas, which means that it contributes to the warming of the earth. Solar radiation warms the earth. Part of this radiation remains in the atmosphere and returns to the earth's surface instead of radiating out into space. The amount of greenhouse gas in the atmosphere determines how much of the earth’s warmth is retained in the atmosphere. This warming effect is called the "greenhouse effect". In this way more energy remains in the atmosphere, allowing the temperature to increase.

During the past century, human use of fossil fuels (such as oil and coal) have contributed considerably to increase carbon dioxide levels, and they are now far above normal levels. This results in further warming. Global warming is now one of the biggest challenges for humanity.

## Decomposition research

To understand and predict the emissions of carbon dioxide from different types of soils, it is important to know the decomposition rates in these different types of soils.

The soils will likely vary in terms of temperature, moisture and fertilization. Measuring decomposition in many different kinds of soils will help the researchers of the Teatime4science project to understand the role of decomposition in global warming.

A lot of researchers around the world have tried to measure decomposition. However they used different methods and materials in their experiments, which makes it impossible to compare results between all those experiments. Another problem is that a lot of methods for measuring decomposition rates require a lot of effort.

Recently, a new method was developed to investigate decomposition. The new method is called Tea Bag Index and uses tea bags with plastic mesh bags (Keuskamp et al., 2013). The tea inside the bags is plant material and decomposes just like all other plant material. By using tea bags, it becomes much easier to do experiments with exactly the same method. It will then become possible to compare the results. Based on the decomposition observed in the tea bags (the weight loss after 3 months), the Tea Bag index is calculated consisting of decomposition rate and a stabilizing factor.

## Tea bag method

The tea bag experiment uses two types of tea: green tea and red tea (rooibos tea). Green tea is made from materials that are easily decomposed by microorganisms while red tea is more wood-like, and therefore more difficult to decompose. By comparing the decomposition of these two different kinds of tea, it becomes clear that decomposition of for instance a wooden branch and a leaf is different.

Both tea types are buried for three months. Since the two tea types differ in material composition, the green tea with its easily degradable material will decompose faster than the red tea. Because of this, green tea will already be in the second phase of decomposition after three months. What is left of the green tea at this moment is the recalcitrant material plus the stabilized easy degradable material.

The red tea decomposes slower and after three months it will still be in the first phase of decomposition. This is why the different types of tea are indicative for the different phases of decomposition of organic material.

We will use this method and test which environmental conditions around us affect decomposition.

# Experiment

## Instructions

The work can be divided between the teacher and the students in the way that suits the students' age and educational purpose.

In the experiment, a total of 6 tea bags - 3 red and 3 green – will be dug at two different locations. They may also be burried at 3 locations, with two tea bags of each type, although the first option would be more interesting because of safety: tea bags might get lost or animals may have made holes in the bags. Furthermore, there may be small environmental differences that affect decomposition. By measuring three times at almost the same location, an average can be calculated, that will represent the main conditions and decomposition at this location.

The green and the rooibos tea bag should be 15 cm apart and the pairs of tea bags should be spaced about one meter from each other. Locations that are choosen should be preferably natural (a wet place along a river, the forest patch behind the school), but you can choose one location (not both) in a place strongly influenced by humans (e.g. the school garden).

## Materials

Research kit:  
• 6 Lipton Rooibos tea bags  
• 6 Lipton Green tea bags  
• Form to fill in the data (printable on website), to take to the location

Other material needed:  
• Scale (0.01 digits).   
• Waterproof marker pen, black.  
• Spade or spoon.  
• Sticks to mark where the tea bags are buried (such as barbecue sticks or straw).  
• Ruler.  
• A warm and preferably sunny spot indoors where the tea bags and soil samples can dry when they are dug up (such as a window sill). Or preferebally: an oven that can run for 48 h at 50°C, but not above 70°C.

## Preparations

1. Take 6 tea bags with green tea (Lipton Green Tea) and 6 tea bags with red tea (Lipton Rooibos tea) and the form to fill in the data for the experiment.

2. On the white side of the label, number the red tea bags with R1-6 and green tea bags with G11-16 with a black, water-resistant marker. Use "R" for red and "G" for green tea. Since the white side of the label is made of plastic the label will remain. The green or red side is made of paper and will disappear.

3. Using a scale, weigh all the teabags with an accuracy of at least 0.01 grams, and write it on the form in the column of “start weight”. Make sure the scale is placed on a stable, horizontal underground.

## Experiment

## Field activity

1. Choose two locations. At least one should be a natural soil that is not too much influenced by human activities. Provide a description on the form, and make a map of each location so that you can find back your tea bags after three months.

2. Look at Figure a when you do the following steps. In each location, dig 6 holes, 8 cm deep, and place a tea bag in each hole, according to figure 4. The distance between the Rooibos and green tea bags should be 15 cm, and the distance between the pairs 75 to 100 cm.

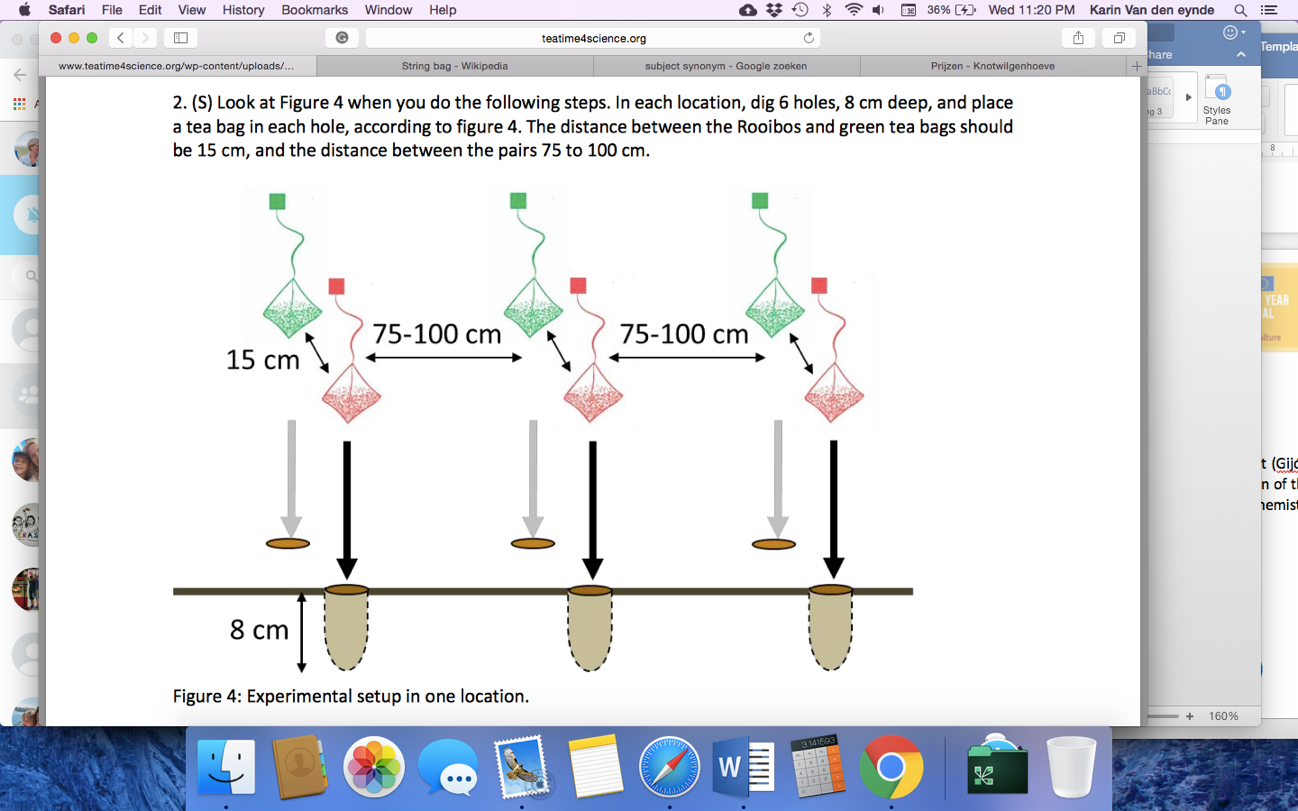


Figure a: distance between the tea bags.

4. Keep the label above the ground. Put back the soil and press it firmly with your hands.

5. Mark the place where you buried each tea bag with a stick and attach the label of the bag to this stick with tape. Draw a sketch to show how the tea bags are buried, and of other characteristics of the area (e.g. a tree or fence). This will make it much easier to find back the tea bags.

6. Fill in the form: date putting the bags in the ground, what kind of location did you use, etc.

7. If you decided to do additional GLOBE protocols to characterize the soil, it should be done now as well. They are strongly advised, as they will help the students to explain differences in decomposition between the locations.

8. Wait for 2-3 months. In warm, moist environments (e.g. the tropics) the tea bags need to be in the soil for 2 months. In cold or dry locations (e.g. tundra’s or deserts) the tea has to be in the soil for 3 months. It does not have to be exactly 3 months, it can be a week more or less, according to your own convenience. As long as you write down the exact dates.

## Retrieving tea bags

After 3 months:

1. Find back the tea bags.

2. Carefully dig up the tea bags. Do this CAREFULLY so that neither the labeling nor the tea bag is destroyed.

3. Carefully remove the soil and roots that are stuck to the tea bag. Put the tea bag in a (paper) bag or envelope. NOTE! Do not use water to clean the bag, and write down if something goes wrong or if you see anything strange on the tea bags (fungus, roots grown into the bag, holes in the bag etc.)

4. If you decided on any additional soil characterization, don’t forget to do them again, see if it has changed during the experiment.

## Classroom activities

In the classroom:

5. Dry the tea bags indoors in a warm (and preferably sunny) place for at least three days, or longer, until they are completely dry.

5. Carefully remove the remaining soil from the tea bags with your hands.

6. Open the tea bag, and take out the tea. You can put the tea in a cupcake holder. Take great care that you do not loose any material. Be careful that there are no soil particles from outside the bag falling into your tea material.

7. Weigh the tea.

8. The tea bags (with string and label) should be sorted as other waste and not with the green waste because the tea bag is made of plastic.

9. Fill in the rest of the form.

10. Go to www.teatime4science.org, select ‘data’ and ‘submit a single data point’. You have to fill in the form 6 different times, for each pair of tea bags. Do not submit data from bags that were broken. If at one location you only found the rooibos of one pair and the green of another pair, you can combine those two. Provide a short description of your location and write down any abnormalities under “Remarks”.

# Tips and Tricks

• As a quality check, it may be recommended that the teacher weighs all the tea bags him- or herself and then let the students weigh them again. It is also helpful if the teacher checks the weight of the tea bags recorded on the forms.

• The tea bags must be completely dry before they are weighed.

• Remember to have the scale stable, horizontal surface.

• Broken tea bags cannot be used because weight loss is than not solely due to decomposition. Be careful during retrieving the bags!

• Remember to mark the tea bags labels on the white side with a waterproof pen. Otherwise, the marking will be gone by the time the tea bags should be dug up! Therefore make also a good map of the area.

• Aim to have the tea bags buried for three months. This can vary between 65 and 100 days for the Tea Bag index to be calculated.

# Problems

The most common problems and possible solutions:

* The loss of a tea bag:

If one bag got lost, the data of the other bag, dug next to the first one can’t be used either. Both types are needed for calculations.

* The detachment of a label:

If it is clear which bag the label belongs to and the other bags still have their label, the data can still be used.

* A bag is found on the surface instead of buried when it is dug up:

These data cannot be used.

* Roots grew into the bag:

All roots should be removed carefully from the bag. Sometimes it is necessary to open the bag. Tea can’t get lost or mixed with the soil outside on the bag. Another container should be used to let the tea dry after picking out the roots. The tea weight is measured together with the empty bag, and the weight of the container should be substracted.

* Soil came into the bag:

Soil should be removed carefully and a note about this should be written in the comments section when submitting the data.

* There is a hole in the tea bag after digging it up:

This data cannot be used. Tea might have got lost from the hole. Weight loss might have a different cause then decomposition.

# References

**Project website address**

<http://www.teatime4science.org>