eBryo SoilSkin

RESEARCH GROUP ON EXPERIMENTAL BRYOLOGY
GRUPO DE INVESTIGACIÓN EN BRIOLOGÍA EXPERIMENTAL

ACTIVITY 1
A climate change experiment
Soil protection and conservation

Grade

- ESO: 1º, 2º, 3º y 4 º.
- Bachillerato de Ciencias: 1º y 2º

Estimated time

- **In the field:** approx. 40 mins
- **In the classroom:** approx. 1 h (preparation & main experiment), 2-3 days waiting time in between

Locations

- Schoolyard, garden, park, forest, field, any green area (urban or not) where biological soil covers can be collected
- Classroom

Materials

In the field:

- 2 rigid plastic containers for sampling biological soil covers (BSC) (recommended: 1L each)
- Plastic containers or bags for soil collection
- A pick mattock or hand trowel

In the classroom:

- 1.5-2 kg soil
- BSC communities
- Water
- 3 aluminum baking pans, approx. 13x25x6cm
- Plastic container, high-edge tray or any object that can be used as a platform for the aluminum pans. Do *not* use an object that you don't want to get wet.
- Small wedge, plastic container or any object that can be used to prop up one side of the aluminum pans to create a slope. Do *not* use an object that you don't want to get wet.
- 3 graduated beakers (recommended: 400 ml), or other container of similar capacity for water collection

- Graduated cylinder (recommended: ≥ 250 ml)
- Small watering can with water diffuser (recommended: 0.5 – 1 L)
- Digital scale
- Indelible marker
- Ruler
- Scissors, cutter or any other sharp object that can be used to make a hole in the aluminum pans
- Test area, a flat surface that can get wet

Background

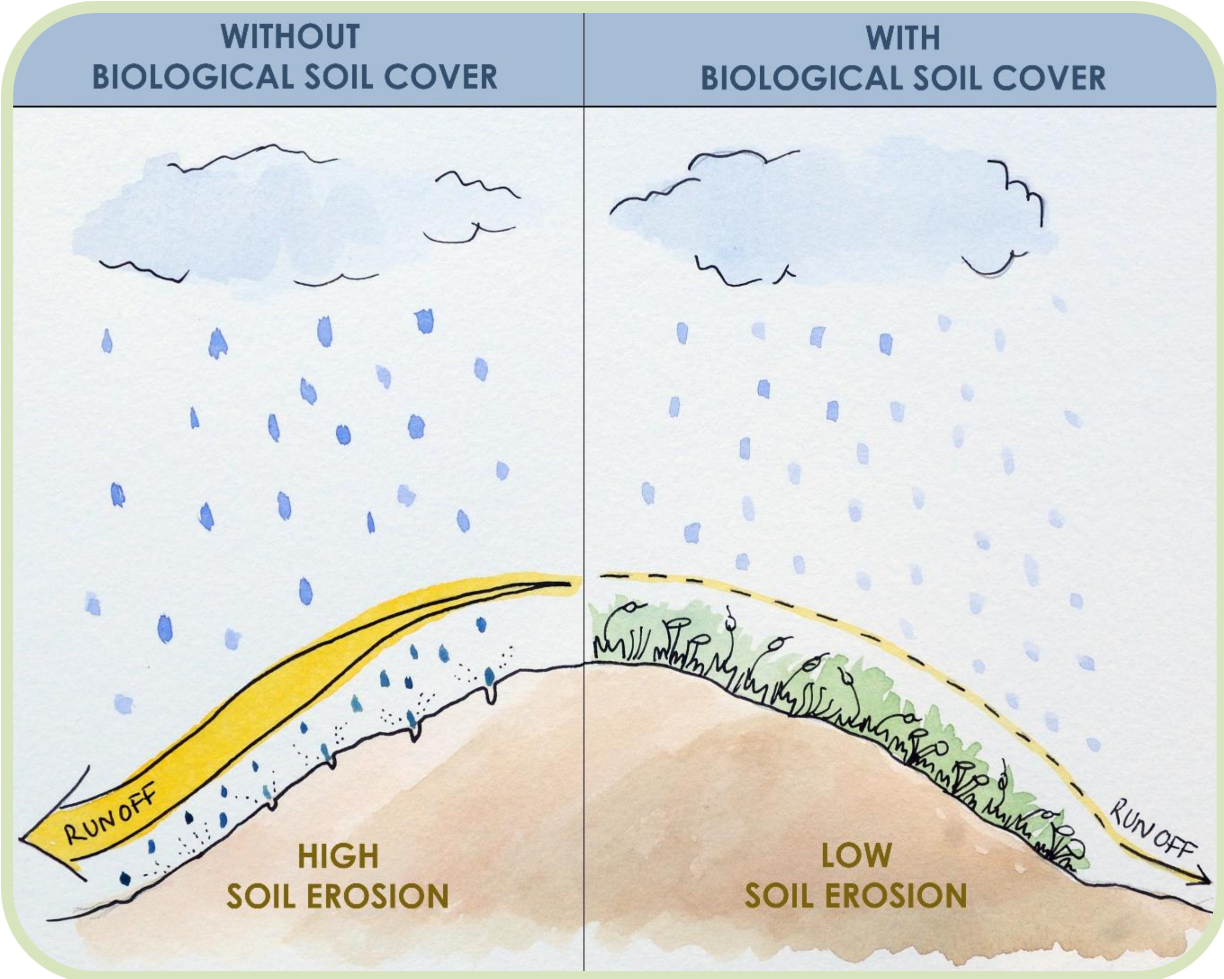
Soil provides critical support for maintaining life worldwide: it holds and filters water, stores nutrients, and offers a growing substrate for plants and a habitat for a great diversity of organisms. Soils are also extremely important for humans because they are the platform for man-made structures and constitute a source of food, fiber, bricks, antibiotics, etc.

Water has its major storehouses in the oceans, which contain around 97% of the Earth's water. A small amount of this water is available to travel through the water cycle processes, often changing state between liquid, vapor and ice. In its journey, to depart from the Earth's surface, water first evaporates (from oceans, streams and lakes, transpiration from plants, and evapotranspiration from soil and plants), then rises into the atmosphere and condensates to form clouds. Again, it falls down onto the Earth's surface as precipitation (rain, snow, hail). A small part of it may be taken up by plants and animals. The remaining can follow two paths in its return to rivers and streams and, ultimately, back into the oceans: infiltration and surface runoff. Water that infiltrates enters the soil, moves vertically into the ground and recharges groundwater aquifers. Here the soil acts as a filtration system cleaning up the water from dust, chemicals and pollutants. On the other hand, water that runs off over the soil surface may remove soil particles and aggregates, and transport them to distant areas causing soil erosion.

Soil erosion, then, is a process of soil loss, mostly from the surface, caused by different agents (not only water, also wind). During this process, soil particles and aggregates are detached, moved and deposited in different locations, which leads to a reduced ability of the soil to store water and nutrients, to soil compaction, and to a loss of biodiversity and fertile land.

These negative impacts of soil erosion can be modulated by the presence of biological soil covers (BSCs), which form a "living skin" over the soil surface favoring soil aggregation and reducing soil erosion. These BSC cover about 12% of the terrestrial surface and, beyond their role preventing soil erosion, they are involved in nutrient cycling (notably carbon and nitrogen), and in soil water balance. Thus, BSCs protect soils against erosion, also provide nutrients to the soil, and regulate the amount and timing of water entrance into the soil.

Biological soil covers (BSCs) are small-sized communities, and if sufficiently developed, they are usually dominated by mosses and lichens that grow on or within the top few centimeters of the soil surface. Mosses are tiny land plants that lack real roots, leaves and stems, while lichens are a symbiotic association between a fungal partner (mycobiont) and one or two unicellular photosynthetic partner(s) (photobiont). Both mosses and lichens depend on their water content to be metabolically active, but they lack the mechanisms to effectively control their water uptake or loss (poikilohydric organisms). In other words, they are "alive" and grow when they are hydrated, but they cannot control their water content, which depends entirely on the water available in the environment. However, they do not die when they dry out, they are able to wait in a physiologically inactive state (dormancy) until rewetted. Besides, they can delay water loss through diverse morphological adaptations (compact communities, hair points in mosses, etc.), and rehydrate quickly as they are able to re-distribute external water across their whole surface. Therefore, BSCs are considered "the sponges" of the ecosystems: they absorb water very quickly (in seconds) and release it gradually (in hours or days).


WITHOUT
BIOLOGICAL SOIL COVER
WITH
BIOLOGICAL SOIL COVER
RUN OFF
HIGH
SOIL EROSION
RUN OFF
LOW
SOIL EROSION

Description

In this activity you will evaluate the role of biological soil covers in preventing soil erosion and modulating soil water balance. To do so, you will simulate erosion caused by rainfall under three different scenarios with increasing abundance of BSC: bare soil (without BSC), moderately-developed BSC and well-developed BSC.

Objectives

- Understanding the role of biological soil covers in the water cycle.
- Demonstrating how rain water causes soil erosion by surface runoff.
- Comprehending how biological soil covers mitigate soil erosion by reducing runoff.

Key concepts students need to know before the experiment

- Importance and main characteristics of the soil
- Main characteristics of BSCs
- Water cycle
- Erosion and its consequences
- Principles of the experimental method in science

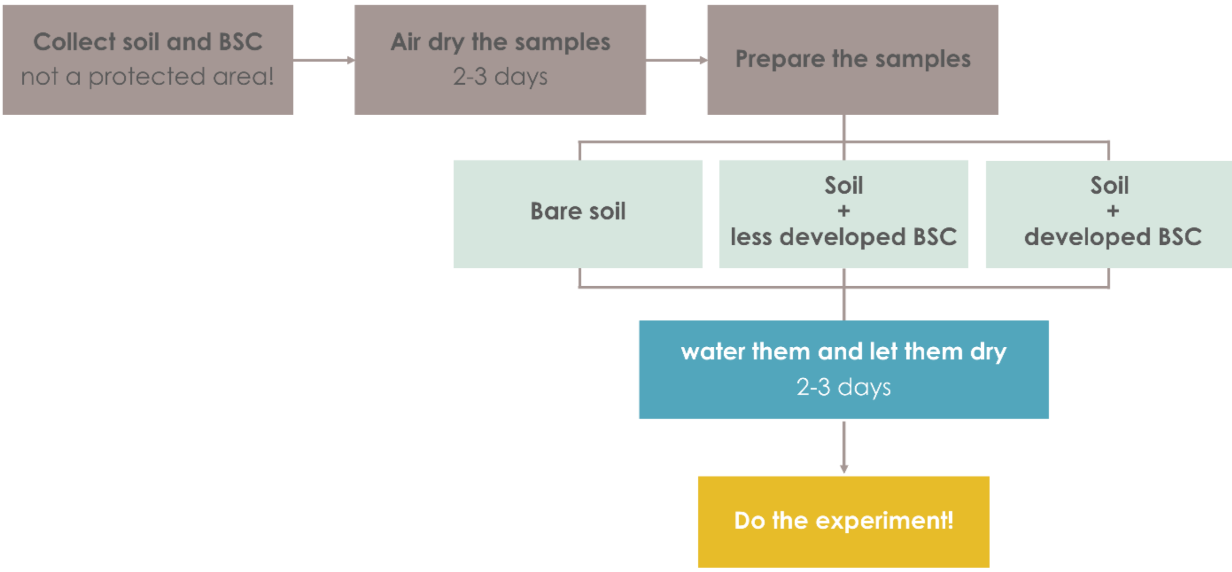
Directions for teachers

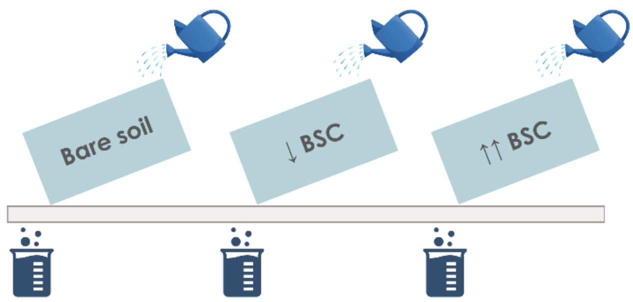
Planning the activity

- It is recommended that prior to realizing the activity the teachers have introduced to the students the key concepts that are addressed in it. Importantly, familiarizing students with BSCs, the elements they consist of, the importance of soil and its conservation, and the consequences of erosion.
- Sampling location: **Make sure the location you choose for collecting the samples is not a protected area**. Choose a location that is as undisturbed as possible in order to have a higher chance of finding more developed BSC communities (e.g. avoid areas where human presence is very high and the soil is being constantly stepped on). Note that there may be well-developed BSC communities in some urban parks, in areas that are not subject to recurrent trampling (i.e., walkways, paths, playing field grounds, etc.).
- After extracting the soil and BSC samples, **cover the area you have dug up** as much as possible, in order to minimize the impact on the soil and BSC communities. Avoid unnecessary digging and excessive sampling.
- The activity can be repeated more times by changing a different parameter each time or in groups, where each group can either test a different hypothesis about the effects of slope, BSC abundance/composition, rainfall intensity, etc., or evaluate the same factor to have more replicates of the same experimental design. Keep in mind that you may need to collect more samples and more materials accordingly.
- Remember that in the beginning of each experimental trial, **both the soil and BSC communities should be dry** so that the conditions are controlled and both the soil and the communities can absorb water. To dry the BSCs and soil place them in a well-ventilated location indoors and let them air dry. The process usually takes 2-3 days. If you want to speed it up, take the communities out of the containers and place them on a newspaper and/or in front of a fan.
- Once you prepare the samples (**step 7**), it is important that you water all three pans until they are saturated before letting them dry. This is important so that the communities you have just put over the soil integrate with it and any added water does not just flow through the gaps or cracks between them.
- When carrying out the experiment, it is important that you make sure you **drop the water slowly and evenly** over the soil, to simulate rain conditions as much as possible. This way you give the time necessary for the soil and the BSC communities to absorb some water, the same way it would happen under natural rainfall.

After the activity

- We would really appreciate if you could share with us photos of the activity you carried out. You can send them to lapielvivadelsuelo@gmail.com. You should attach an authorization to publish the images on the web page and twitter accounts of the projects as well as in the reports of the SoilSkin project. Note that for children under the age of 14 the authorizations should be signed by one of the parents or legal guardians while, for those between 14 and 17, the authorization needs to be signed by the parents or legal guardians and by the teenager himself. You can find a draft for the authorization on the web page of the project www.ebryo.com/soilskin/





*Please send photos and an authorization to publish the images to lapielvivadelsuelo@gmail.com

Activity

STEP 1: Collect your samples

WHERE?

Biological soil covers (BSCs) can be found practically everywhere, in a field, in a forest, an urban park, etc. For the needs of this activity, you will need to find an area where the BSCs are growing on a continuous surface that can be dug out and where you can find a community as well developed as possible.

Go to the nearest park, forest or any green area that is relatively undisturbed. Walk around and observe the soil closely. Look at the openings between the areas where grass grows. You will soon start noticing mosses and lichens growing all around. Aim for areas that are relatively protected from the wind and sun and try to find the best developed BSC community you can. Then find one that is notably less developed than the first one. These are the two BSC samples you will collect. Finally, you also need to find a space close to the communities where you can collect bare soil of similar characteristics.

Do not sample protected areas, as you may end up collecting rare or endangered species!

HOW?

First, using the mattock or trowel, collect the bare soil. Filling two 1L of soil should be enough. You can store the soil in plastic containers or bags. Avoid collecting soil that is very compacted and hard. Remove any big chunks, rocks, plants and other objects you find in the soil.

Then, proceed to collect the BSC samples: the well developed one and the moderately developed one. When you decide which part of the soil surface you want to collect, place the plastic container, upside down, over it and with the mattock/trowel “trace” the area around it as seen in the photos. Remove the container and carefully start deepening the traces you just made. Insert the mattock in the soil, at about 1-2cm under the community, as parallel to the surface as you can, and lift it carefully. Expect the soil to start breaking up. Try to keep it as intact as you can. Put the pieces gently in a container as if you were assembling a puzzle. Clear the sample of any rocks, dead leaves, other plants or other objects. In the same manner, collect the second sample (bare soil).



STEP 2: Now, do the experiment!

Make your hypothesis

Before starting anything else, you should define the set of hypotheses that you are going to test with your experiment. From what you know so far about erosion and the characteristics of BSCs, how do you think that the increasing development of BSC affects erosion? What do you expect to happen if you drop the same amount of water over the same amount of soil with different development of BSC?

Preparation

1) Fill one aluminum pan with bare soil until it is about 4 cm deep. This will be the **control sample** containing only bare soil.
2) Weight the pan with the soil using the digital scale and take the measurement.
3) Put the second aluminum pan on the scale. Add also bare soil, and on top of it place carefully the moderately developed BSC community, so that its overall (soil + BSC) **weight is the same** as the control sample.
    - Place the pieces of the community over the soil as if you were assembling a puzzle, filling any gaps and pressing lightly so that it integrates with the soil underneath as much as possible without destroying it. Avoid breaking it into smaller pieces.

4) Repeat step (3) for the third aluminum pan, placing now the developed BSC community on the bare soil.
5) On the control sample, using a marker, mark the level of the soil on the outer part of the narrow side of the pan. With the ruler, measure the distance of the mark from the bottom of the pan. Repeat this for the other two pans.
6) Using the scissors, poke a hole in the mark at the soil level in all three pans, no bigger than 1 cm in diameter. This will allow the water and soil to flow out of the pan, simulating surface runoff.

7) **Once you have prepared the three pans, water them until complete saturation, and let them dry for 2-3 days before following the next steps! This will stabilize the communities in the soil.**

Main Experiment

8) Once the communities and the soil have dried, place the pans on the object on a platform (any elevated surface), next to each other.
9) Place a wedge (or other object) under each pan so that it is tilted, forming a gentle slope, with the hole on the lower side.
10) Place one beaker in front of each pan, next to the platform, to collect the water running out from it (see the picture).

11) Using the graduated cylinder, measure a specified amount of water, between 200-300 ml and pour it in the watering can.
    - ***Indicatively:*** 200 ml water for 500 g of soil over a 13x25 cm surface is equivalent to the amount of water pouring down over one hour of moderate rainfall (approx. 6 mm of precipitation).
12) For the first pan, pour all of the water **slowly** over the pan surface, simulating rain. Make sure the hole is not blocked by any rock or other object, and the water is able to flow freely into the beaker.
    - Try maintaining a steady flow and pouring the water evenly over the whole surface of the pan. Avoid holding the watering can too close to the pan and dropping water only in one concentrated area.
    - Pay attention to how much you tilt the watering can and the intensity of the water dropping on the soil, as you will need to repeat the same for the rest of the samples.
13) Repeat steps (11) – (12) for the remaining samples.
    - Make sure that you are dropping the same amount of water each time, with the same intensity and rate as much as possible.
    - ***Suggestion****:* In case no water comes out of the pans with the BSCs, try adding more water until it starts flowing out of the pan. Register the amount of extra water you used.

14) Observe and compare the content of the three beakers. Measure the amount of water that has been collected in each beaker.

Discussion

- How does the content of the three beakers differ from each other?
    - What is the main difference between bare soil and soil with BSCs? Are the results in accordance with your initial hypothesis? Where do you notice more intense erosion and water runoff?
    - Do you notice any difference between the amount of soil and water that comes out of the pan with the less developed BSC and the pan with the more developed community? What did you expect to see and what do you observe? How high the difference between them? What is the ecological significance of this?
- What are your overall conclusions about the role of BSC communities in surface runoff and the water cycle?

You can also try…

- The experiment can be repeated many times, changing and testing a different parameter each time (see below some examples). Alternatively, the experiment can be carried out in groups, and each group could test a different value of a given parameter.
    - What do you expect to happen when you increase or decrease the slope inclination of the samples?
    - What about increasing the intensity of the “rain” (watering rate)?
    - Try collecting communities from different areas or habitats. How do they behave?
    - Try removing half of the BSC in each community. What do you think will happen? Do the results differ?

Fun facts

- Did you know that there are more living individual organisms in a tablespoon of soil than there are people on the Earth?
- Did you know that some mosses can increase more than multiply by 10 their weight when they become hydrated? Think about it, it is the equivalent of a 20 Kg child drinking a 200 L bathtub!
- Did you know that some mosses survived after spending more than 1500 years frozen under the Antarctic ice?
- Did you know that lichens can survive unprotected in the harsh conditions of the space? Maybe they could even survive on Mars!

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