ECHO

ENGAGING CITIZENS IN SOIL SCIENCE:
THE ROAD TO HEALTHIER SOILS

Deliverable 2.3
"Handbook of agreed methods to assess soil health"

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Short description of the deliverable

This document serves as a comprehensive collection of agreed methods for assessing soil health, forming part of the Citizen Science Soil Health Toolbox available via the ECHO App. Designed with a divulgative tone, it is intended to be accessible to citizen scientists.

The document compiles detailed methodologies for evaluating the eight soil health indicators outlined in the Mission Soil Implementation Plan. This information is crucial for users of the ECHO toolkit and App, ensuring they can correctly implement the protocols.

Once formatted into factsheets, this guide will help citizens conduct soil sampling, evaluate on-site indicators, and prepare samples for submission. Off-site indicator analysis of submitted samples will be conducted by ECHO experts, providing citizens with reliable and scientifically robust results.

Versioning and contribution history

Version	Date	Modified by	Notes
1	16/09/2024	Celine Laurent, Claudia Cappello and Tanja Mimmo (UNIBZ)	Draft version
2	25/10/2024	Celine Laurent, Claudia Cappello and Tanja Mimmo (UNIBZ), Virpi Virjamo (UEF), Alba Peiro (IBERCIVIS)	Draft version
3	21/11/2024	Celine Laurent, Claudia Cappello and Tanja Mimmo (UNIBZ)	Draft version
4	22/11/2024	Manuel Pulido Fernández (UEX), Roy Neilson (HUTTON), Alba Peiro (IBERCIVIS)	Revision
5	29/11/2024	Celine Laurent, Claudia Cappello and Tanja Mimmo (UNIBZ), Wiktoria Witek (AgroHorti Media)	Final Version

Foreword

Soil is a vital, yet often disregarded, resource that supports life on Earth by providing the foundation for agriculture, forests, and various other natural ecosystems. However, soil degradation is a growing concern around the world, and can have severe consequences for our planet, such as reduced crop yields, increased greenhouse gas emissions, and decreased biodiversity. The ECHO project aims to prevent this by bringing together citizens and volunteer scientists from around Europe to work towards a common goal of protecting and preserving our soils, thus contributing to the transition towards healthy soils of the European Union (EU) Mission: “A Soil Deal for Europe”.

ECHO will generate new data on the health status of EU soils, complementing existing soil mapping and monitoring in EU Member States and Scotland, including the EU Soil Observatory (EUSO). The project will develop and deploy 28 tailor-made citizen science initiatives taking into account different land-uses, soil types, and biogeographical regions, as well as stakeholder needs. With 16 participants from all over Europe, including 10 leading universities and research centres, four SMEs, and two Foundations, under the coordination of the Free University of Bolzano-Bozen, ECHO will assess 16,500 sites in different climate and biogeographic regions to achieve its ambitious goals.

The project aims to engage citizens in protecting and restoring soils by building their capacities and enhancing their knowledge. Citizens will thereby not only actively contribute to data collection but also promote soil stewardship and foster behavioural change across the EU. ECHOREPO, a long-term open access repository with a direct link to the EUSO, will enable citizen science data available for exploitation not only by scientists but also by citizens, policy makers, farmers, landowners and other end-users, providing added value to existing data and other relevant soil monitoring initiatives. ECHOREPO will thus provide valuable information about the state of soil health in various regions, and help citizens make informed decisions about land use and conservation.

We believe that ECHO will have a significant impact on soil health and citizen engagement across Europe and become an important step towards protecting and preserving our soil for future generations. By working together, we can ensure that our soil remains healthy and productive, and that we continue to enjoy the many benefits it provides.

Contents

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1 Soil health assessment

In ECHO, you will assess soil health by focusing on eight key indicators described in the Misson Soil Implementation Plan[1], helping you to better understand the condition of your soil. This section provides a step-by-step guide for proper sample collection, which will be used to evaluate all eight soil health indicators. Specifically, you will collect information both directly in the field and through laboratory analysis to evaluate:

1. Presence of pollutants and soil nutrients
2. Soil organic matter
3. Soil structure and soil texture
4. Soil biodiversity
5. Soil pH
6. Vegetation cover
7. Landscape heterogeneity
8. Forest cover

As a citizen scientist, you will receive the ECHO toolkit from your ECHO Ambassador, with each kit designed to collect a single soil sample, and containing all the materials needed for soil sampling, including containers and clear instructions (**Figure 1**). The toolkit is designed to include everything necessary for accurately analysing the soil health indicators evaluated in ECHO, except for a container with a small amount of tap water, which you will need to bring on the sampling day for the soil texture assessment (see section 2.8). Videos showing all the procedure are available on our ECHO YouTube channel (https://www.youtube.com/@ECHOsoilproject-v6w). Additionally, you can explore detailed information evaluated using the ECHO kit by consulting factsheets for each indicator, which are available for download through the ECHO app.

Detailed content of th ECHO toolkit:

- ECHO leaflet and field instructions;
- Protective gloves;
- A metal trowel;
- A wooden spoon;
- A 15 mL plastic tube containing distilled water;
- A paper strip;
- A 5 mL plastic tube containing preservation solution*;
- A small biodegradable plastic bag;
- A large biodegradable plastic bag with a QR code.

[1] https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/soil-deal-europe_en

(*) The preservation solution is not harmful, and a datasheet from the company provides full details about it. However, handle the tube carefully, wear gloves for safety, and avoid drinking the solution. Keep the kit out of reach of unsupervised children to prevent accidental ingestion.

Figure 1: Content of the ECHO citizen science toolkit

Figure 2 outlines the entire process, from selecting your sampling site to assessing soil health. The soil analysis will be conducted in two phases: by you in the field, where you will evaluate on-site indicators, and by experts in the laboratory, using the soil sample you send us to assess off-site indicators.

***Figure 2**: Workflow for soil health assessment: a summarised step-by-step and visual guide to help you navigate the ECHO process*

2 On-site activities

2.1 Selecting the sampling site and time

You will choose your own sampling location, but before collecting soil samples, it is important to contact the ECHO team or your ECHO Ambassador for guidance.

It is best to avoid sampling when the soil is too wet, such as after heavy rainfall, or too dry, such as during summer heat waves. In colder regions, don't sample when soil is frozen and covered with snow in winter and usually saturated by water in spring. Rather, it is recommended to collect samples in the summer months for more representative results

Please note that one ECHO kit is designed for a single complete sampling. The materials inside are limited to one sampling. If collecting soil samples as a group of citizen scientists, please ensure that:

1. You complete one sampling, following all the required steps through the ECHO App, before opening another kit.
2. It is important to ensure that the distance between sampling sites is at least 50 meters.

Before collecting any soil samples, make sure you have the necessary authorization to sample the chosen site, especially if it is not your own property. If the sampling site is inaccessible (e.g., due to barriers or restricted zones) do not take any risks, and instead, choose an alternative site.

2.2 GPS coordinates

Once you have selected your sampling location, record the GPS coordinates using the ECHO App. The GPS coordinates saved on the map will indicate an area, not an exact point. If you are in an area without an internet connection, you can save the coordinates offline. If you need help with recording your GPS coordinates, contact us in advance or reach out to your ECHO Ambassador.

Your coordinates will only be shared once you have given authorization through the ECHO App, and they will only be used for the duration of the sampling.

2.3 Vegetation cover, forest cover, landscape heterogeneity

You will need to take and upload photos of the area around you to the ECHO App as shown in Figure 3. These photos should show the vegetation cover, forest cover, and the landscape at your location.

Try to take clear, high-quality pictures that really capture the surroundings. If you are unsure about anything, feel free to reach out to us or your ECHO Ambassador for help.

The ECHO App will ask for permission to access your camera so you can take the photos. Once you give permission, the app will only use the camera for sampling, and your photos will be shared for that purpose only.

Conduct a thorough walk around the site to identify any potential sources of contamination or disruptions, such as nearby roads, traffic, and industrial facilities. Additionally, if you have any prior knowledge of the area, include relevant details about waste disposal sites, agricultural activities, pesticide use, standing water, or indications of recent flooding. Please provide any other pertinent information that can help describe the surrounding landscape in the comments. The more comprehensive the information, the better.

Figure 3 Error! Reference source not found. gives you some examples of photos to u pload on the ECHO App.

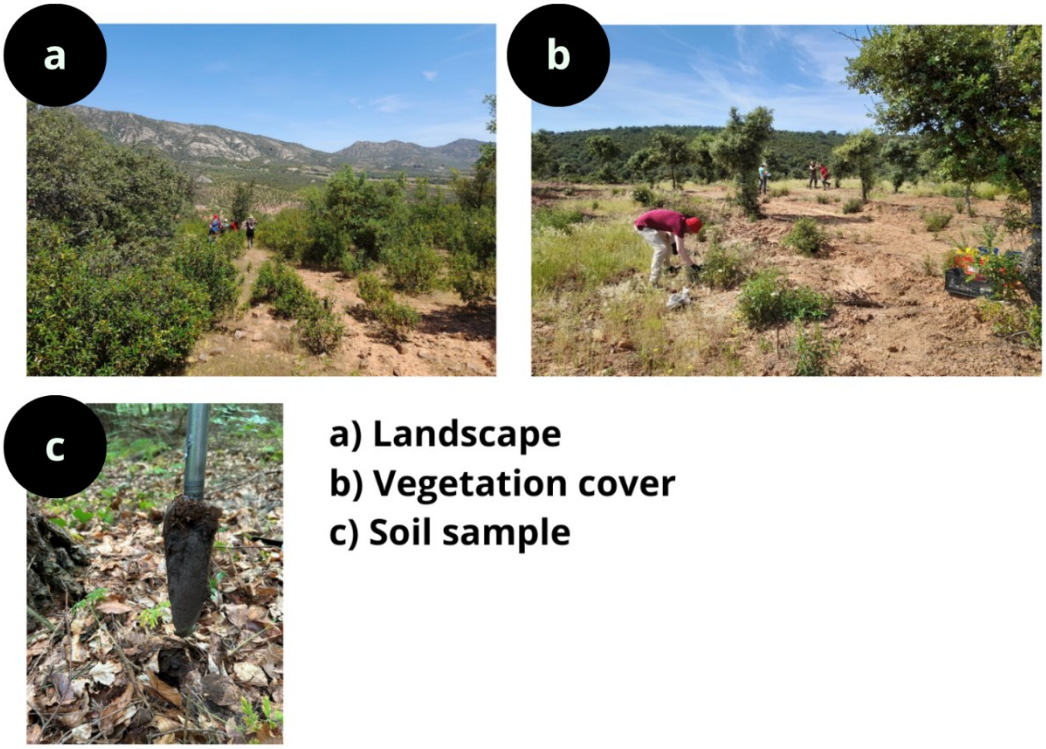

Figure 3: *Examples of photos to upload on the ECHO App*

2.4 Soil digging procedure

For ECHO, it is important to carefully follow this procedure to prepare the sampling site and to collect the exact volume of soil needed for analysis.

Here is how to proceed with soil sampling (**Figure 4**):

1. Use the trowel to carefully rake away the litter and/or the upper soil layer, including dense grass, roots, vegetation residues, and stones. If you encounter roots or rocks in the topsoil that make digging difficult, feel free to move a few meters away* and collect the soil sample from a new location.
2. Use the trowel to dig a 30x30x30 cm soil pit. The length of the trowel blade (excluding the handle) is 15 cm, so dig to a depth of 30 cm by measuring two times the length of the blade. Remove soil from the pit and begin assessing the different soil health indicators.
3. Leave all the soil you collect during digging on one side, without mixing it. Try to keep the soil structure intact as you collect it, for the first analyse of soil structure.

(*) Always keep in mind that if collecting soil samples for ECHO as a group of citizen scientists, the distance between sampling sites must be at least 50 meters.

Figure 4: *Soil digging*

2.5 Soil structure

Using the soil you have just collected from the 30x30x30 cm soil pit, you will conduct a Visual Evaluation of Soil Structure[2,3] (VESS) (**Figure 5**).

How to perform the VESS method:

1. From the soil sample left on one side (section 2.4), gently open the soil block;
2. Break the soil into smaller aggregates;
3. Evaluate the aggregates using your hands:
4. Do they crumble easily?
5. Can you break them with one hand?
6. Does it take strength to break them with one hand?
7. Does it require considerable effort to break larger aggregates?
8. Assess soil structure according to the VESS grid available on the ECHO App;
9. Record soil structure on the ECHO App.

[2] https://ahdb.org.uk/knowledge-library/how-to-assess-soil-structure

[3] Ball, B. C. *et al*. Field assessment of soil structural quality – a development of the Peerlkamp test. Soil Use Manag **23**, 329-337 (2007). https://doi.org/10.1111/j.1475-2743.2007.00102.x

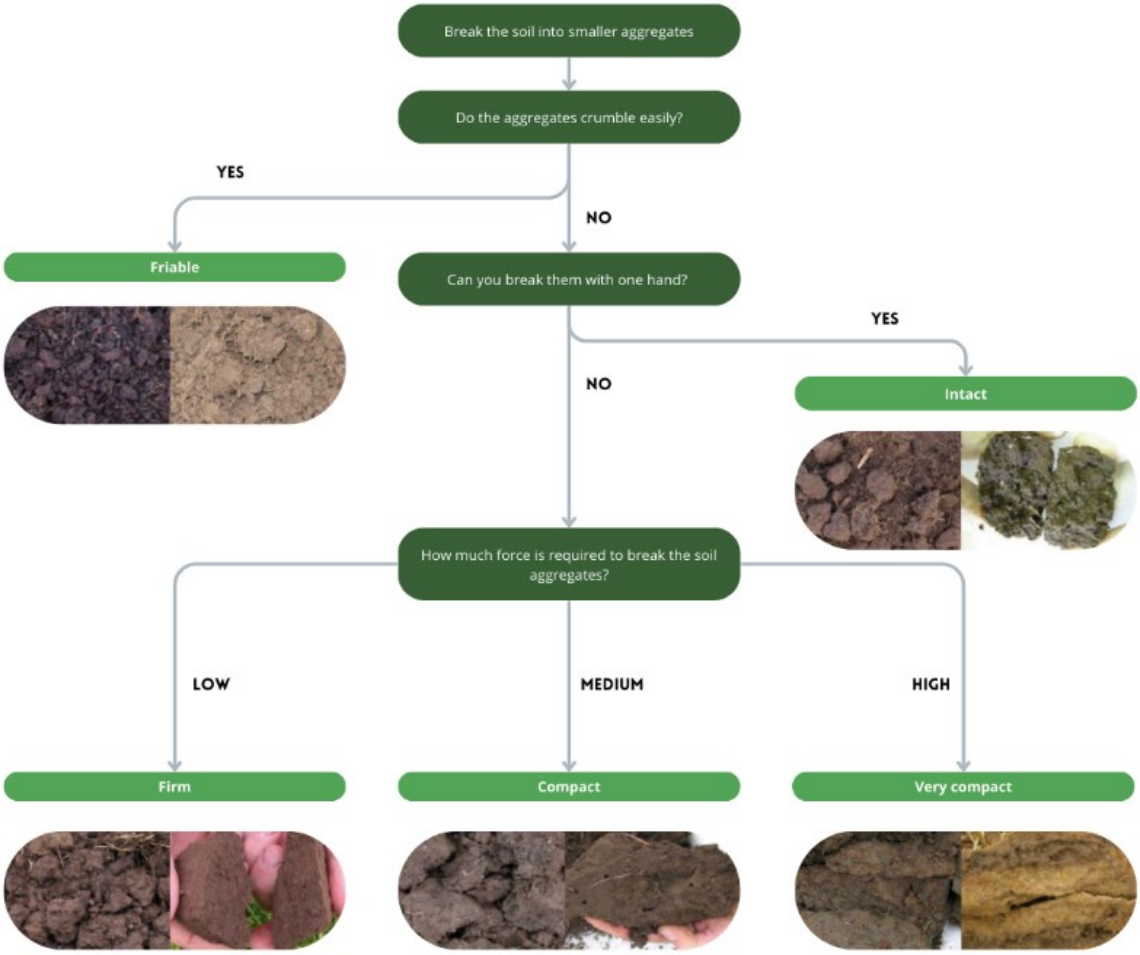

Figure 5: *Reference grid to use for the visual evaluation of soil structure (adapted from Agriculture and Horticulture Development Board)*

2.6 Soil biodiversity in terms of earthworms

In ECHO, you will assess soil biodiversity on-site by counting earthworms, as their presence can reveal much about the soil structure and quality. However, numbers of earthworms are only relevant when you identify the species present. Following the process detailed below helps ensure an accurate earthworm count while preserving the soil for further testing.

Here is a clear step-by-step guide to help you with the earthworm count:

1. Take the soil sample that you have already left on one side (section 2.4) and carefully break it apart by hand.
2. Place any earthworms you find on the soil surface next to the pit. *Be aware that some earthworms will react to light and try to move away (surprisingly quickly!).*
3. Count the earthworms and record the number in the ECHO App.
4. Gently return the earthworms to the soil.
5. Leave aside the soil sample you removed from the pit for further analysis.

Additionally, check for the presence of other animals such as slugs, snails, spiders, woodlice, millipedes, centipedes, beetles, ants and moles, and add this information to the "Observation box".

2.7 Presence of pollutants

Visually inspect the sampling site for plastic, metal debris on the ground. Look for visible fragments that may be on the surface or embedded in the soil.

How to observe the presence of pollutants:

1. Use the hole you dug for the soil sample to check for fragments, like large pieces of plastic or metal, within the soil.
2. Observe the visible debris and record the number and the size in the ECHO App.
3. Add further comments in the ECHO App that you think may be useful to understand possible sources of contamination.

2.8 Soil texture

In ECHO, you will assess soil texture by conducting the "texture-by-feel method" (**Figure 6**). By testing how the soil feels when you moisten and manipulate it, you can classify the soil as sand, silt, clay, or a combination of these, which provides important information about soil texture and its ability to retain water and nutrients.

How to perform the "texture-by-feel method":

1. Remove any plants and roots, then disaggregate and mix the soil sample previously taken and well-mixed from the 30x30x30 cm pit, breaking it into smaller pieces to ensure it is evenly mixed.
2. Follow the decision-making flowchart provided for the next steps, also available in the ECHO App.
3. Record soil texture on the ECHO App.

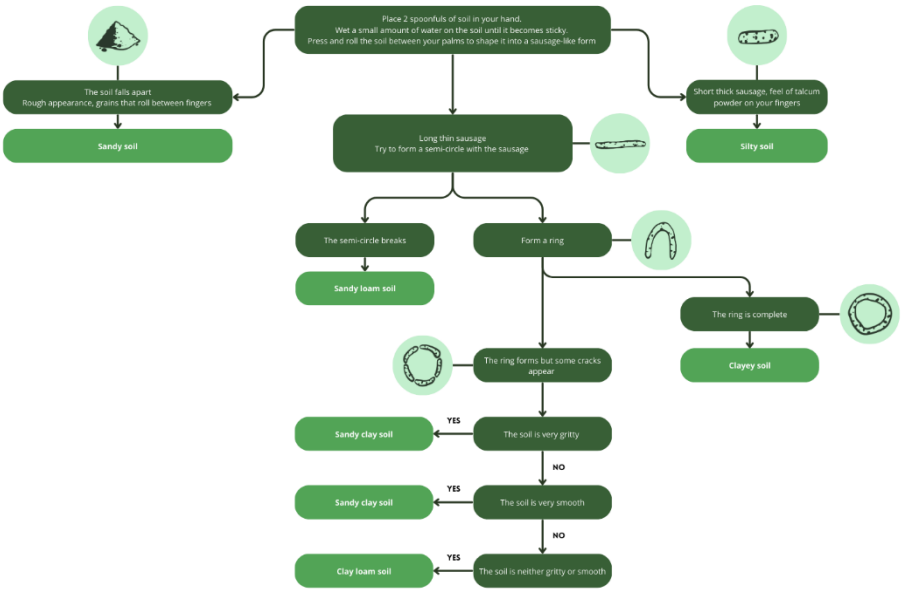

Figure 6: *Decision-making flowchart to determine soil type according to the "texture-by-feel method" (modified after USDA soil quality guide)*

2.9 Soil organic matter

In ECHO, you will evaluate the content of soil organic matter (SOM) by comparing soil colour to a colour chart provided through the ECHO App.

Steps to assess SOM content:

1. Take a spoonful of the mixed soil sample.
2. Compare the soil sample to the colour chart (**Figure 7**) available on the ECHO App.
3. Select the corresponding SOM content value on the ECHO App.
4. At some sampling sites, soil organic matter can be much higher than 5% with no mineral soil at 30 cm depth (e.g., peatland, or former peatland). Organic soil can be recognized by the intense dark colour, comprising of decomposing vegetation and lack of sand, clay or other mineral soils. Organic soils differ from mineral soils in their biological and structural features and defining soil texture is not possible. Thus, check the "Other" box on the ECHO App instead of selecting a value.

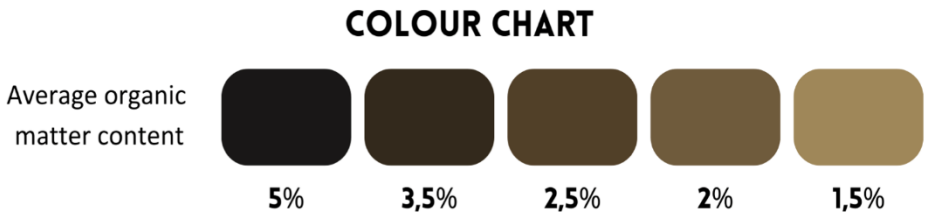

Figure 7: *Soil colour chart to assess soil organic matter content*

2.10 Soil pH

In ECHO, you will use a simple method to analyse the pH of your soil sample using pH paper strips (**Figure 8**).

How to measure soil pH using the paper strip method:

1. Using the wooden spoon, collect the mixed soil sample and add it to the plastic tube that is pre-filled with distilled water, until the mixture reaches 14 mL.
2. Securely close the tube and shake it gently for 30 seconds to ensure the soil and distilled water are well mixed.
3. Place the tube upright, ensuring it is not lying flat, and allow the mixture to settle for 5 minutes.
4. Dip the coloured end of the pH paper strip into the solution for 30 seconds.
5. Remove the paper strip and compare its colour to the pH colour chart available on the ECHO App.
6. Record the pH value in the ECHO App.

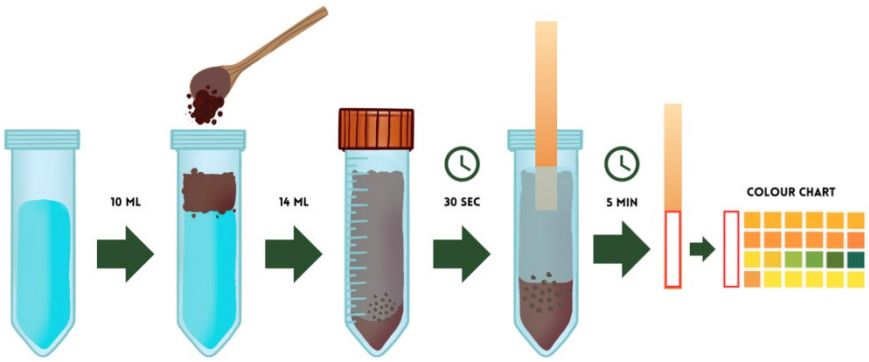

Figure 8: *Step-by-step process for soil pH measurement*

3 Off-site activities

In addition to on-site activities, we ask you to send a small soil sample for off-site laboratory testing, as these require more specialised laboratory equipment. Specifically, the laboratory will analyse your soil sample for two indicators: soil microbial diversity (bacteria and fungi, see 3.1) and heavy metals and soil nutrients (see 3.2). Your role in collecting and sending the samples is crucial for the overall site evaluation.

3.1 Soil biodiversity in terms of bacteria and fungi

The soil sample for biodiversity analysis in terms of bacteria and fungi must be stored in a preservation solution to prevent degradation during shipping to the UNIBZ laboratories. The provided plastic tube already contains this solution and is ready to be filled with soil. **The**

preservation solution is not harmful, and a datasheet from the company provides full details about it (available via the ECHO App). However, handle the tube carefully, wear gloves for safety, and avoid drinking the solution. Keep the kit out of reach of unsupervised children to prevent accidental ingestion.

How to collect a soil sample for off-site soil biodiversity assessment (**Figure 9**):

1. Put on gloves and keep them on throughout the entire procedure for your safety when using the preservation solution and to prevent contamination of the sample.
2. Take the small plastic tube that contains the preservation solution.
3. Open the tube and use the wooden spoon to collect the mixed soil, filling the tube to the top, until the mixture reaches 5 mL.
4. Close the tube carefully and shake it gently for 15 seconds to mix the soil with the preservation solution, ensuring that all the soil is in contact with the solution.
5. Place the small plastic tube in the plastic bag marked with the QR code from your toolkit.

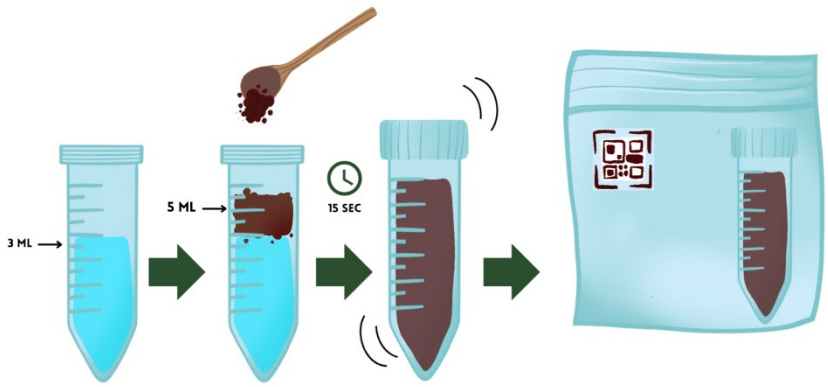

Figure 9: *Procedure to collect a soil sample for off-site biodiversity assessment*

Once your sample arrives for analyses, we will extract the DNA from your soil sample, send the extract to a company for sequencing analyses, and then analyse the results to find out the bacteria and fungi communities of your sample.

3.2 Heavy metals and soil nutrients

Please use the small plastic bag (the one without QR code) for collecting the soil sample for this analysis (**Figure 10**).

How to collect the soil sample for off-site heavy metals and soil nutrients assessment:

1. Open the small plastic bag and start collecting soil with the wooden spoon;
2. Fill the plastic bag completely (6 full spoonfuls of soil) and close it carefully;
3. Place the plastic bag containing the soil sample into the larger plastic bag already containing the sample tube for biodiveristy analysis, and marked with the QR code, and seal the bag.

Figure 10: *Procedure to collect soil sample for off-site heavy metals and nutrients assessment*

4 Site cleanup and sample shipment

The activities you need to carry out on-site for the ECHO project are now complete. Remember to close the soil pit, ensuring it is not left open. Also, make sure to collect all the materials you have used.

Once you have collected the two soil samples for off-site indicator analysis (the tube for soil biodiversity and the plastic bag for heavy metals) and placed inside the larger plastic bag marked with the QR code, they are ready to be sent to the laboratory for analysis (**Figure 11**).

To do this, find your nearest ECHO Ambassador via the ECHO App, or through any other channel that is best for you, and schedule an appointment to hand over the bag containing both samples. To find your nearest ECHO Ambassador, simply search on the ECHO App through the list of Ambassadors available in your area.

The ECHO Ambassador will then scan the QR code on the plastic bag and will plan the shipment to the UNIBZ laboratory with the ECHO partners. Upon arrival, ECHO experts will scan the QR code to confirm receipt and proceed with the next steps. Your sample will be assigned a specific code that allows you to access your results through ECHOREPO. The results will be available once the analysis is complete. Using this code, you can access your data in ECHOREPO. Once the results are ready, you will receive detailed instructions on how to retrieve them.

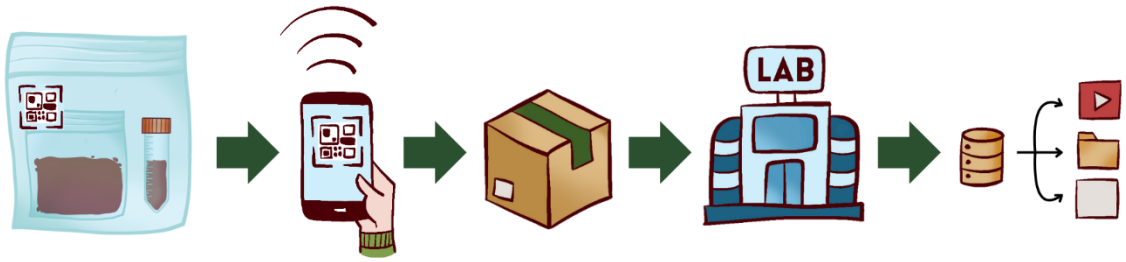

Figure 11: *Sample shipment process*

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