ERASMUS+ KA220-SCH - Cooperation partnerships in school education

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Promoting STEAM through participatory urban regeneration

2024-1-IT02-KA220-SCH-000251173

Laboratory

Digging into Soil Secrets

Co-funded by
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FREELAND laboratories follow the structure of Inquiry Based Learning, in 5 steps (orientation, conceptualization, investigation, conclusion and discussion), and for each step we suggest activities and methodological approaches that are engaging for the students, such as brainstorming, hands-on, creative works. The activities described in the laboratory are suggestions that teachers can adapt or replace with similar activities suitable to students' age and school type.

Laboratory	**Digging into Soil Secrets**
Duration:	2,5 hours outdoors & 3-4 hours indoors
Tools:	7 Printed worksheets, Pen and notes, Materials indicated in the worksheets
Technologies:	Mobile phones for photos and videos
Subjects:	Science (Biology), Maths, Art, Civic education
Students' age	Any
School type	Any
Disciplinary contents:	This laboratory is about soil properties evaluation by using simple hands-on methods. **What is soil:** Soil is the upper surface on earth which is made of mineral components (i.e. clay, silt, sand), organic matter, air and living organisms (roots, microorganisms, arthropods, other animals) and it is influenced by abiotic (climate, weather), biotic (plants, animals) factors and human activities. **Soil functions:** Soil plays fundamental environmental functions that provide services to ecosystems and humans. For instance, plants grow on soil, therefore a healthy and fertile soil guarantees plant production (provision service). Soil characteristics regulate nutrients and water cycles and (trap) some pollutants (regulatory services), and host microorganisms able to degrade the organic matter facilitating nutrients availability for plants. Soil supports plants and biodiversity (diverse plant species, fungi, animals), soil formation (support services). Finally, soil protects archeological remains and it hosts green spaces (cultural, recreational services).

This laboratory aims at assessing the soil characteristics by using the “underwear test” to assess soil health and simple methods to assess soil properties.

Soil properties in brief:

Soil physical characteristics (texture, structure) are both unique properties of the soil that affect the behavior of soils, such as water holding capacity, nutrient retention and supply, drainage, and nutrient leaching.Soil structure is the arrangement of soil particles into groupings. These groupings are called peds or aggregates, which often form distinctive shapes typically found within certain soil horizons. For example, granular soil particles are characteristic of the surface horizon. Soil aggregation is an important indicator of the workability of the soil. Generally, only the very small particles form aggregates, which includes silicate clays, volcanic ash minerals, organic matter, and oxides. There are various mechanisms of soil aggregation.

Mechanisms of soil aggregation

- Soil microorganisms excrete substances that act as cementing agents and bind soil particles together.
- Fungi have filaments, called hyphae, which extend into the soil and tie soil particles together.
- Roots also excrete sugars into the soil that help bind minerals.
- Oxides also act as glue and join particles together. This aggregation process is very common to many highly weathered tropical soils and is especially prevalent in Hawaii.
- Finally, soil particles may naturally be attracted one another through electrostatic forces, much like the attraction between hair and a balloon.

	The presence of earthworms is generally associated with good fertility soils, even though they represent only a small part of the biological universe in the soil. The tunnels dug by earthworms allow rapid water circulation, ensure aeration in conditions of high water content, and represent the preferred route for deep root development. One of the main functions of soil is to store moisture and supply it to plants between rainfalls or irrigations. When soil is saturated, all the pores are full of water, but after a day, all gravitational water drains out, leaving the soil at field capacity. Plants then draw water out of the capillary pores, readily at first and then with greater difficulty, until no more can be withdrawn and the only water left is in the micro-pores. The soil is then at wilting point and without water additions, plants die. The amount of water available to plants is therefore determined by the capillary porosity and is calculated by the difference in moisture content between field capacity and wilting point. This is the total available water storage of the soil. Poor structure, low organic matter, low carbonate content and presence of stones all reduce the moisture storage capacity of a given texture class. Clays store large amounts of water, but they need significant rain to be able to supply water to plants. On the other hand, sands have limited water storage capacity, but most of it is available to plants when it rains. Soil chemistry also is important in determining soil fertility. Macroelements such as Nitrogen (N), Phosphorus (P) and Potassium (K), but also Calcium (Ca), Magnesium (mg) and Sulphur (S) are the most abundant elements in plants, although also microelements (such as Zinc, Iron, Manganese, Boron, Copper, Silicium) are important for plant growth. pH influences the mobility of certain elements in water and their availability to plants, thus,

	plant growth, as well as microbial activity. A pH between 6 and 7.5 is considered optimal for plant growth. The presence of carbonates is of considerable importance also due to the role that calcium ions play in determining the physical and chemical characteristics of soils. Calcium contributes to the formation of stable structural aggregates and to maintaining pH values between neutral and sub-alkaline, thanks to its high buffering capacity.
Learning objectives:	Students will be able to ● Observe the soil and make simple analysis to assess soil fertility ● Learn pedological terminologies ● Reflect on sustainable use of soil. ● Discuss scientific results and make relationships between diverse disciplines, in connection to the characteristics of the soil

For each phase of the IBL we provide a description of the suggested activities.

Orientation

Duration:	10 minutes outdoors or indoors
Tools:	No specific tools
Technologies:	No
Subjects:	Science (Biology)
Method:	Brainstorming

The teachers take the students outdoors to the neglected space, which should have some soil, and invite them to observe the soil.

"What is the soil? Where is it?/Can it be found underneath sealed surfaces such as asphalt?"

"Is the soil a living ecosystem?"

"How would you define "soil fertility/healthy soil"?

Students should recall their prior knowledge and express their own opinion to answer questions and the teacher should introduce the definition of soil.

Conceptualization

This phase concerns the creation of the question/s to be answered by an investigation.

Duration:	20 minutes outdoors or indoors
Tools:	No specific tools
Technologies:	No
Subjects:	Science (Biology)
Method:	Brainstorming

"Is the soil fertile in this site?" "In the case the soil is not healthy, how can it be improved?"

Following orientation, the teacher introduces the concept of soil fertility.

"Soil fertility is the ability of a soil to sustain plant growth and agricultural production. A fertile soil has nutrients available to plants (chemical fertility); it is not compacted (physical fertility) and it is rich in organisms (micro- and meso-organisms such as arthropods) which enable degradation and decomposition of organic matter (biological fertility)". In general, forest soil is dark, rich in organic matter, rich in microorganisms and fertile.

Investigation

The investigation includes hands-on activities to answer the question posed in the Conceptualization *"Is the soil fertile in this site?"*

Duration:	30 minutes indoors, 2 hours outdoors
Tools:	For each group: white cotton underwear, one shovel, a plastic bag, measuring tape, a marker, pen and note

	Activities and materials are indicated in the following worksheets: ● Worksheet: Underwear test ● Worksheet: Living organisms ● Worksheet: Soil structure ● Worksheet: Aggregate stability ● Worksheet: Soil texture ● Worksheet: Water holding capacity ● Worksheet: Color, Carbonates and pH ● Worksheet for the students
Technologies:	Mobile phone to take pictures
Subjects:	Science (Biology), Chemistry, Civic education
Method:	Hands-on laboratories

Planning and performing the activity

Note:

1. Teachers should make a field visit to the area prior to the laboratory taking place with the students in order to plan the sampling spots of the area (eg. spots with different soil cover such as. lawns or open areas, stepped areas, woody areas etc.). If there are various spots that are worthy to be compared because of their different characteristics, students can be divided into groups and each group is assigned to a specific spot. If only one spot is investigated, each group can carry out specific laboratories.
2. Worksheet 1 “underwear test” allows the evaluation of the level of degradation of white cotton underwear by soil microorganisms which is linked to soil fertility. The test is nice and successful when a few underwear can be compared. Then, besides the underwear test, students can collect soil samples to investigate all other characteristics. Worksheets 2-7 allow assessing specific aspects of soil fertility.
3. Print the worksheets (Appendix) to carry out the different laboratories and activities

Conclusion

This phase concerns the analysis of the qualitative data gathered in the investigation.

Duration:	1-2 hours
Tools:	Pencils and notes
Technologies:	PC or notebook
Subjects:	Science, Civic education
Method:	Report of the observations Draws of student's ideas of improvements/design projects

In Science students gather all the results obtained from the investigations on soil and describe the characteristics of the soil in the plots. They make comparisons and find out relationships between soil characteristics and soil use or cover.

Soil Property	**Evaluation (Descriptive)**
Biological fertility (earthworms)	
Biological fertility (roots)	
Physical fertility (texture, structure)	
Physical fertility (water holding capacity)	
Chemical fertility (e.g., pH, carbonates)	
Colour	

Is the soil fertile?

____
____
____
____

Discussion

In this phase students reflect on the findings. They are able to answer the original question and reflect on it.

Duration:	1 hour indoors
Tools:	Pen/notes/Powerpoint
Technologies:	PC
Subjects:	Civic Education
Method:	Brainstorming, group work

Circle time or brainstorming can be useful to involve the students in the discussion phase which will finally answer the initial question. Based on the results obtained by the analysis of the data, each student will be able to tell the characteristics of the soil and make a bibliographical research to propose how to possibly improve it (e.g. What kind of soil amendments/What species of plants (among some suggestions) can improve soil quality?). This information can be added as additional information in the 3D model.

Students should be able to exactly indicate what they would like to add or change in the area and present their design projects or sketches of ideas, or verbal description for the 3D modeling platform.

Outcomes:

- 3D visualization of the project (one student group will recreate the place virtually with the support of the **Platform**).
- Report or presentation or video, that can be evaluated by teachers following the school's evaluation grid.

Additional reading materials:

- Soil Management https://www.ctahr.hawaii.edu/mauisoil/a_factor_ts.aspx
- Soil Texture - Hand Texturing Method https://wiki.ubc.ca/Soil_Texture_-_Hand_Texturing_Method
- Soil color - Munsell charts https://www.msn.unipi.it/wp-content/uploads/2022/11/TAVOLE-MUNSELL-per-colori.pdf
- Water Holding Capacity calculation http://bettersoils.soilwater.com.au/module2/2_1.htm
- Manuale di autovalutazione del suolo (italian) https://www.mase.gov.it/portale/documents/d/guest/lifecarbonfarm_manuale_autovalutazione_suolo-pdf

Appendix:

Worksheet: Underwear test
Worksheet: Living organisms
Worksheet: Soil structure
Worksheet: Aggregate stability
Worksheet: Soil texture
Worksheet: Water holding capacity
Worksheet: Color, carbonates and pH
Worksheet for students

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Worksheet: Underwear test

This test was developed by the University of Zurich and Agroscope as a citizen-science initiative to investigate soil health and raise awareness on the importance of soil protection. Living organisms in soil degrade organic matter. Cotton is organic fiber so it can be degraded. The more the fabric degrades, the more life in soil is active, indicating a good soil health.

Instructions:

1. Select a plot of land to perform the test.
2. Dig a hole 20 cm deep and bury a pair of white cotton underwear (if possible 100% cotton), leaving the elastic exposed.
3. Cover them thoroughly with the excavated soil, compacting it over the underwear, and place a marker (a rock or a stick) to help you find the burial site again after a few months.

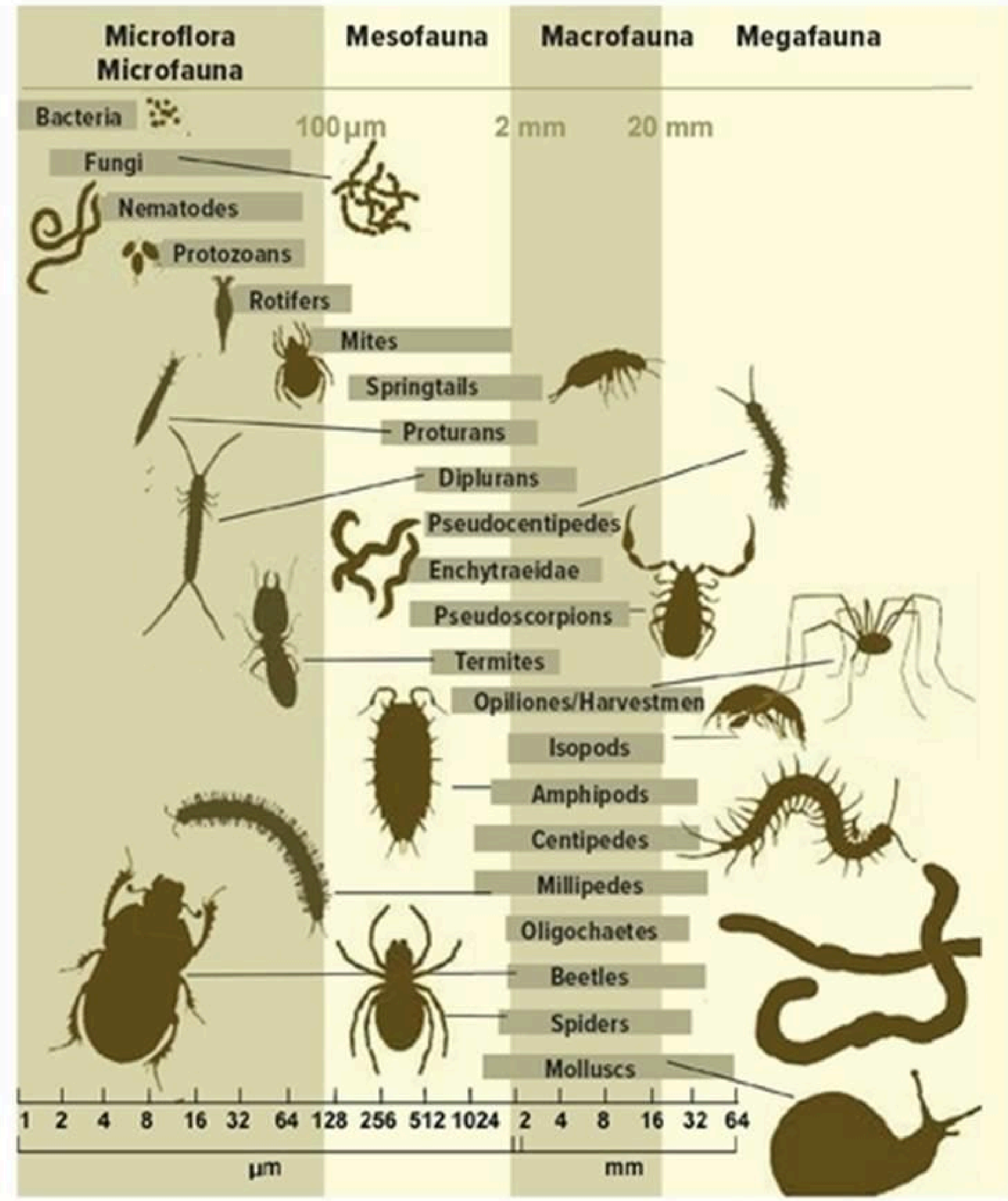

After 2/3 months, unbury the underwear and make observations on the state of degradation.


Worksheet: Living organisms

Dead organic matter is relatively rich in energy, making it the primary resource attracting soil organisms involved in decomposition. The central role in this process, ultimately leading to mineralisation into basic nutrients, is carried out by the **primary decomposers** – soil bacteria and fungi. Their efficiency depends on various factors, including the availability of specific enzymes, their relative size, their capacity to penetrate the soil matrix, their motility, and other specialised adaptations.

Soil engineers (such as earthworms, termites, ants, and certain insect larvae) play a structural role: by creating burrows and channels, they enhance the distribution of organic residues throughout the soil profile, enabling access for other organisms, allow rapid water circulation, ensure aeration in conditions of high-water content, and represent the preferred route for deep root development. Therefore, the presence of earthworms is generally associated with good fertility soils, even though they represent only a small part of the biological universe in the soil.

Litter transformers (medium and large organisms such as millipedes, isopods, insect larvae, enchytraeids or potworms) feed on plant debris, fragmenting it and transforming it into structured excrements (e.g., faecal pellets). Finally, smaller organisms such as **microarthropods** (mainly mites and springtails) and a wide variety of nematodes predominantly consume fungi and bacteria, further regulating microbial activity.



Categorisation of soil organisms based on effective diameter of the body, which is related to functioning in the soil ecosystem. Source: Miko et al. (2019). © Ladislav Miko

Instructions for earthworm count:

Method 1: The simplest and quickest method to assess their number is to count the earthworms present in a 20x20x20 cm clod.

Method 2: Mustard method: create a solution by mixing ground mustard powder with water, such as 25 ml of mustard in 0.75 liters of water or 40 grams in 4 liters. Pour the solution onto a marked square-foot (or 35cm x 35cm) area of soil, allowing it to soak in. Earthworms will emerge from the soil within minutes to avoid the irritant; collect and count them for about 10 minutes after the area is saturated.

Evaluation of biological fertility	**Description**
Good	More than 8 earthworms
Fair	4-8 earthworms
Bad	Less than 4 earthworms

Roots observations:

Observe the same clod and assess the visible roots.

Evaluation of biological fertility	**Description**
Good	Roots are present until the deepest part and they are well distributed
Fair	Root development is limited horizontally or vertically
Bad	Few roots or roots with great restriction of development. Thick roots or crushed between soil units.

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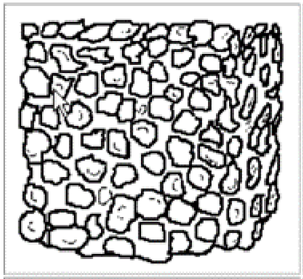
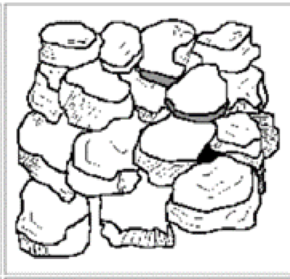
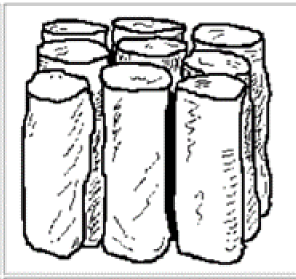
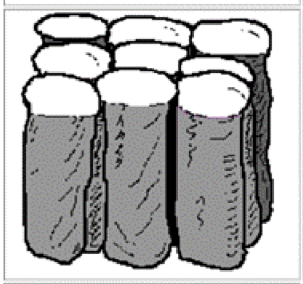
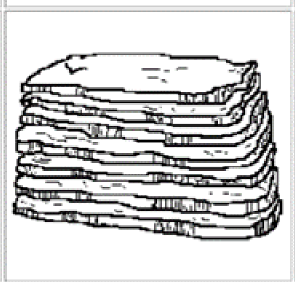
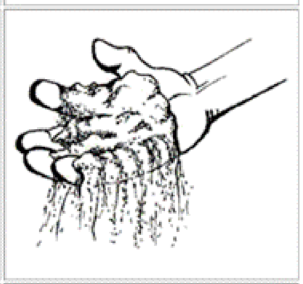
Worksheet: Soil structure

Soil structure is the arrangement of soil particles into groupings called peds or aggregates. They often form distinctive shapes within certain soil horizons. For example, granular particles are characteristic of the surface horizon. Soil aggregation is an important indicator of the workability of the soil.

Instructions:

Take a soil clod (about 20*20*20 cm) and place it on a table/plastic film. Apply a gentle force to break the macro-aggregates.

1. Observe their shape and assign a shape among the following images of the scheme. Pay attention to the size!

		
Granular: Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.	**Blocky**: Irregular blocks that are usually 1.5 - 5.0 cm in diameter.	**Prismatic**: Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.
		
Columnar: Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.	**Platy**: Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.	**Single Grained**: Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.

Source: A Methodology of a Visual Soil - Field Assessment Tool - to support, enhance and contribute to the LADA program. Des McGarry. https://www.ctahr.hawaii.edu/mauisoil/a_factor_ts.aspx

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2. Separate the aggregates into three size-classes: (approximately > 60 mm, 20-60 mm, < 20 mm (use the hand as a reference or a ruler). Distribute them from the biggest to the finest



Assign a score:

Evaluation	Description
Good	Good distribution of smaller, friable aggregates, with no significant number of clods
Fair	The soil contains a significant percentage of both large clods and small, firm, friable aggregates
Bad	Soil dominated by the presence of extremely firm clods, with few small, friable aggregates

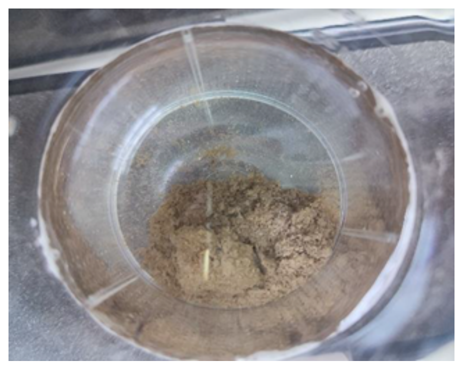
Worksheet: Aggregate stability

The disintegration and dispersion test measures soil stability when exposed to rapid wetting. The test is qualitative and must be performed on soil aggregates previously air-dried which are submerged in water. Two phenomena are observed: **disintegration**, which is the breaking of the aggregate into its micro-aggregates, and **dispersion**, which represents the disappearance of any form of aggregation between the elementary soil particles (sand, silt, and clay).

When soil is rich in organic matter, only the disintegration of the aggregate into micro-aggregates is observed (without dispersion of particles).

Materials

- 1 Petri dish or a small transparent jar
- Water
- One soil aggregate



Instructions:

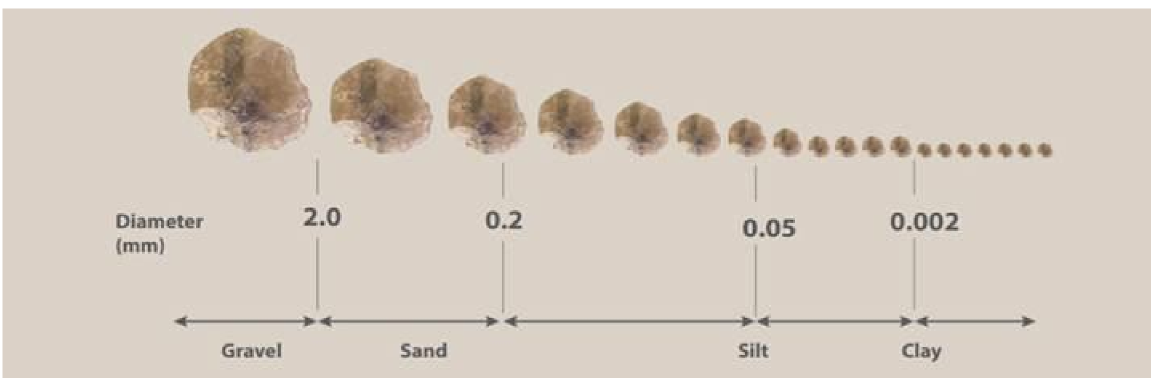
1. Fill the Petri dish or the jar with water
2. Pour the aggregate into the water and observe what happens to it (it should be submerged)
3. After 10 minutes, assess according to the following table

Evaluation	Description of stability
Very good	No dispersion (although the aggregate may break)
Good	Slight dispersion evidenced by a slight milkiness of the water adjacent to the aggregate
Fair	Moderate dispersion with noticeable milkiness
Bad	Strong dispersion with considerable milkiness and approximately one-half of the initial aggregate volume dispersed outward
Very bad	Complete dispersion of the initial aggregates of clay, silt, and sand grains

Worksheet: Soil texture

Soil texture is a key property as many other soil characteristics depend on it (such as water retention capacity, permeability, plasticity, and the ability to provide nutrients to plants). It refers to the distribution of the soil's mineral particles: sand, silt, and clay. Clay particles, as well as other particles of similar size, are important components of a soil. Soils that contain large amounts of sand particles and soils that contain large amounts of very small particles are mainly different for the surface area. The total surface area of a given mass of clay is more than a thousand times the total surface area of sand particles with the same mass. In soil fertility, coarser soils generally have a lesser ability to hold and retain nutrients than finer soils. However, this ability is reduced as finely-textured soils undergo intense leaching in moist environments.

Particle Type	**Diameter (USDA classification)**
Sand	0.005 mm < diameter < 2 mm
Silt	0.002 mm < diameter < 0.05 mm
Clay	diameter < 0.002 mm



Materials required for each student group:

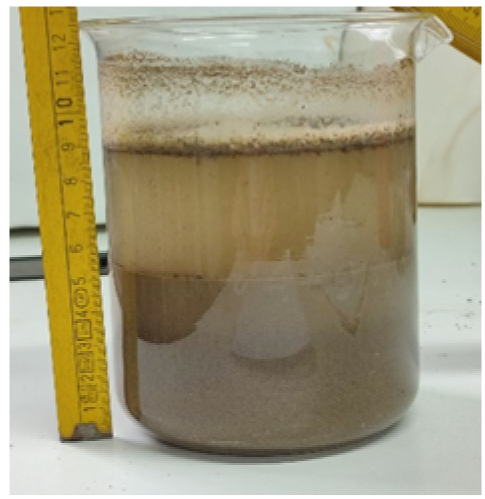
- 500 g soil sample (dug from 5-20 cm of depth with the shovel and placed in a plastic bag)
- 1 plastic tray
- ½ liter of water
- 1 transparent and cylindric jar (300 ml capacity)

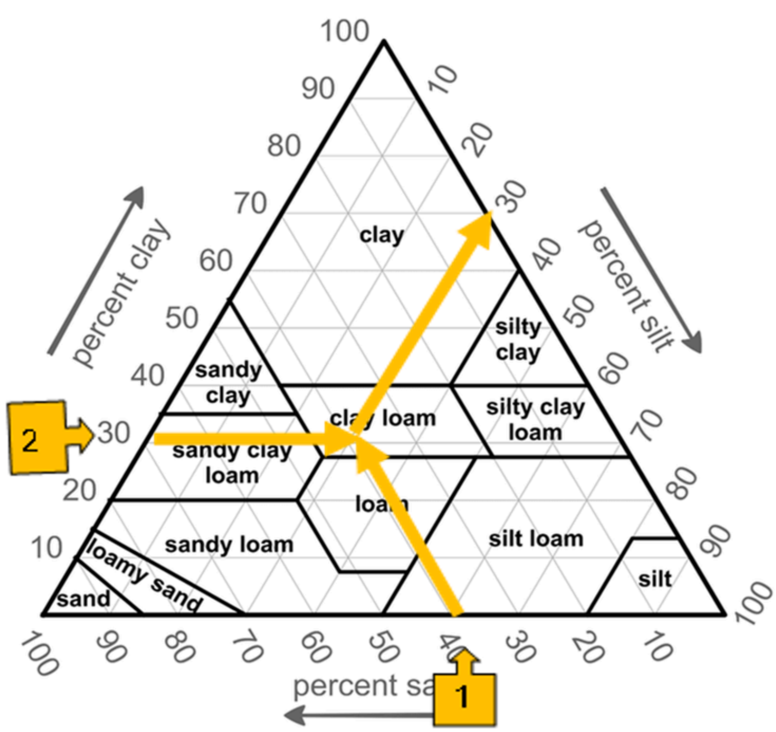
Instructions:

1. Place a small amount of soil (about 200 g) in the tray.
2. Determine the soil texture using the worksheet provided below (*), by taking a nut of soil in your hands and wetting it a little bit to manipulate it **(optional)**.

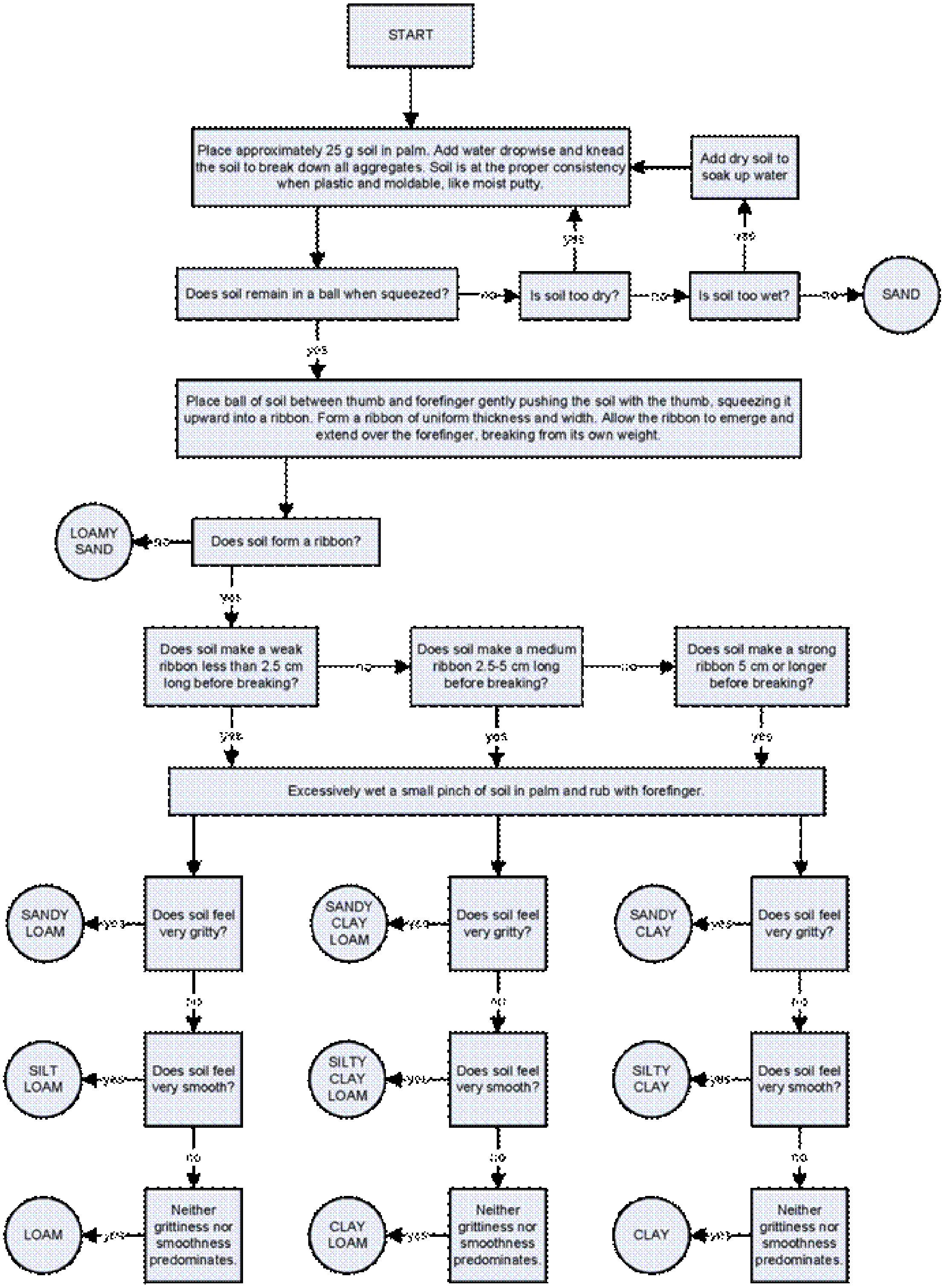
3. Place approximately 100 g of soil into the 300 ml clear glass jar, add 200 g of water, close the lid tightly and shake well until all the soil is suspended in the water.
4. Let the jar sit undisturbed for 72 hours.
5. After 72 hours, using a ruler, mark the height of the sediment layers (sand - at the bottom, silt - middle layer, and clay - upper layer).
6. Measure the total height and calculate the percentage of each sediment layer in relation to the total.
7. Use the soil texture triangle to identify the soil texture.

	Height of the deposited particles (cm)	**%**
Clay		
Silt		
Sand		
Total		





(*) Alternative method for the determination of the soil texture by hand



Worksheet: Water holding capacity

Measuring Soil Water Holding Capacity by knowing the soil texture

1. Establish the depth of the root zone, either by observing the depth to which roots of plants have extended, or by noting the depth to a restrictive layer.
2. Use the following table to calculate the water holding capacity of the soil layer in the root zone, depending on the texture.

Water holding capacity (mm/cm depth of soil) of main texture groups. Figures are averages and vary with structure and organic matter differences.

Texture	Field Capacity	Wilting point	Available water
Coarse sand	0.6	0.2	0.4
Fine sand	1.0	0.4	0.6
Loamy sand	1.4	0.6	0.8
Sandy loam	2.0	0.8	1.2
Light sandy clay loam	2.3	1.0	1.3
Loam	2.7	1.2	1.5
Sandy clay loam	2.8	1.3	1.5
Clay loam	3.2	1.4	1.8
Clay	4.0	2.5	1.5
Self-mulching clay	4.5	2.5	2.0

Source: Department of Agriculture Bulletin 462, 1960

(source: http://bettersoils.soilwater.com.au/module2/2_1.htm)

For example, 25 cm of clay loam has on average an available water of 1.8 mm water per cm of soil, so it can store 45 mm of available water.

N.B. The unit of measure is “mm” which means that 1 mm of water over 1 meter square surface corresponds to 1 L.

The water holding capacity of a soil is calculated by summing the capacity of each layer in the root zone.

Worksheet: Color, carbonates and pH

Colour of the soil (little wet):

Color is measured in the wet and dry state of the soil. A standard soil color chart should be used. The reference color chart is the Munsell color chart or an equivalent. The cost of the evaluation is included in the purchase of the chart. Alternatively, the "Soil Color Chart" app is available online. Link to Munsell color charts: https://www.msn.unipi.it/wp-content/uploads/2022/11/TAVOLE-MUNSELL-per-colori.pdf

Chemistry: carbonates and pH

The carbonate content in the field can be assessed by observing the effects of a few drops of concentrated hydrochloric acid (HCl 1 Normal - "1N") on the soil. Hydrochloric acid dissolves carbonates, releasing CO2, which produces both audible and visible effervescence with varying intensity depending on the amount of carbonates present in the soil.

Materials

- Petri dish
- Hydrochloric acid (HCl 1 Normal - "1N")

Instructions:

Pour a few drops of Hydrochloric acid on the soil aggregates and observe what happens.

Field description	**CaCO3 (%)**	**Estimated reaction by hearing**	**Estimated reaction by sight**
Non-carbonatic	0.1	None	None
Very slightly carbonatic	0.5	Barely perceptible and audible	None
Slightly carbonatic	1	Moderately perceptible and audible	Slight effervescence limited to barely visible individual grains
Slightly carbonatic	2	Moderately and clearly audible even far from the ear	Generalized effervescence visible only from very close distance

Carbonatic	5	Very evident and clear	Moderate effervescence; visible bubbles up to 3 mm in diameter
Heavy carbonatic	10	Very evident and clear	Violent effervescence; visible bubbles up to 7 mm in diameter

pH evaluation

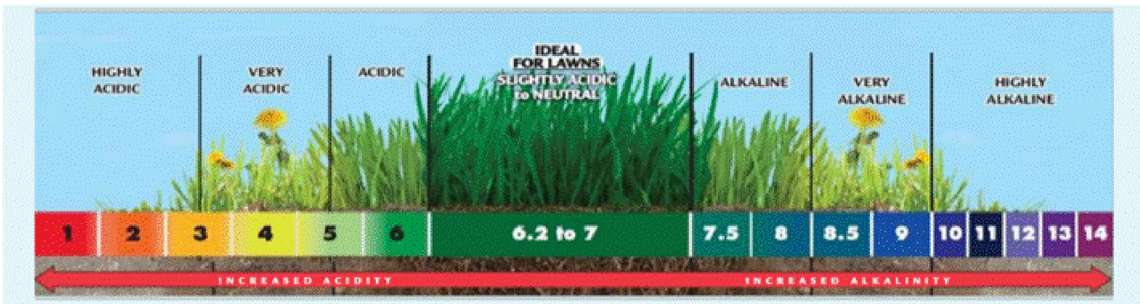
pH can be assessed in the field through colorimetric tests or a portable pH meter. It is an indicator of soil acidity or alkalinity. It influences plant growth, microbial activity, and the solubility of soil minerals. A pH between 6 and 7.5 is considered optimal for plant growth.

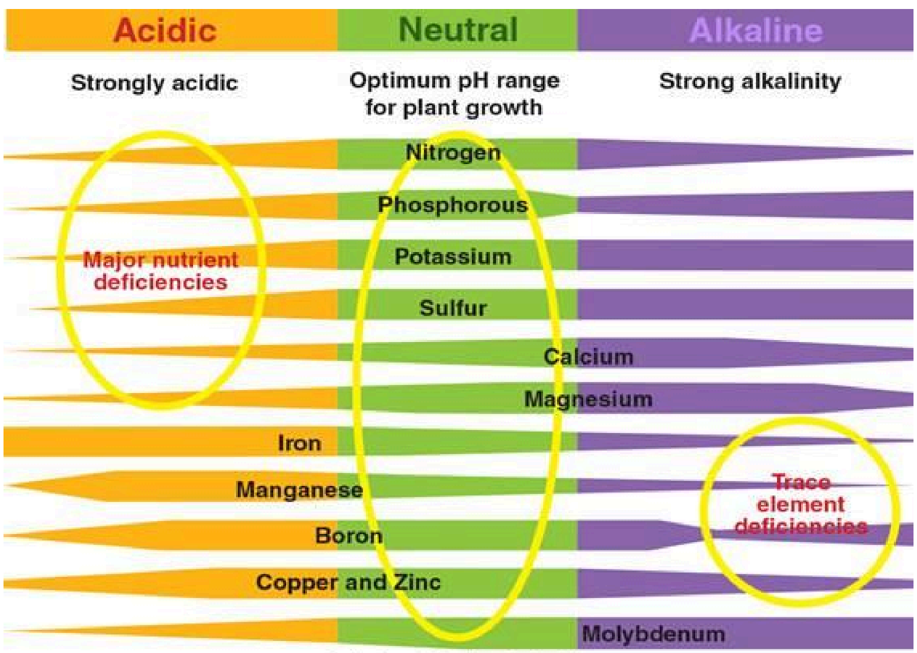
Materials:

- A small jar with a lid (100 ml)
- 30 g distilled/deionized water
- 30 g soil
- litmus paper

Instructions

1. Pour the soil into the jar with the water (1:1)
2. Shake vigorously many times until the soil is dispersed into the water
3. Let the soil settle for 2 minutes.
4. Estimate the pH by dipping litmus paper into the supernatant;





Soil pH and Nutrient Availability
(Source: Bluedale - http://www.bluedale.com.au)

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Worksheets for students

Names of the team:

____

Name of the locality/Town: _______________________________________

Date of observation: _________________________________

<u>Underwear test – Description form for site and soil</u>

Composition of the underwear fabric (read the label): _____________________

Date of underwear burying: _______________________

Name of the burying site (locality)/Town: ___________________________________

Description of the site:

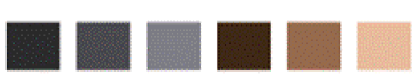
- ☐ Plot covered by grass/lawn
- ☐ Plot with dense trees
- ☐ Plot with spare trees
- ☐ Plot within a field for crops
- ☐ Other:

Soil depth of burying (e.g. 0-20 cm; 0-15 cm): _______________________

Have you seen any living organisms while excavating (e.g., ants, arthropods, earthworms), Which ones?How many?

____

What is the colour of the soil when it is moist? (take some soil in your hand and wet it with a little bit of water. Choose the colour closer to this scale)



Biological fertility - Observation of living organisms

Arthropods

Have you seen any arthropods (insects, arachnids, crustaceans, myriapods) in the soil? If Yes, can you tell what you have noticed? (You can use Google Lens or other Apps to identify them).

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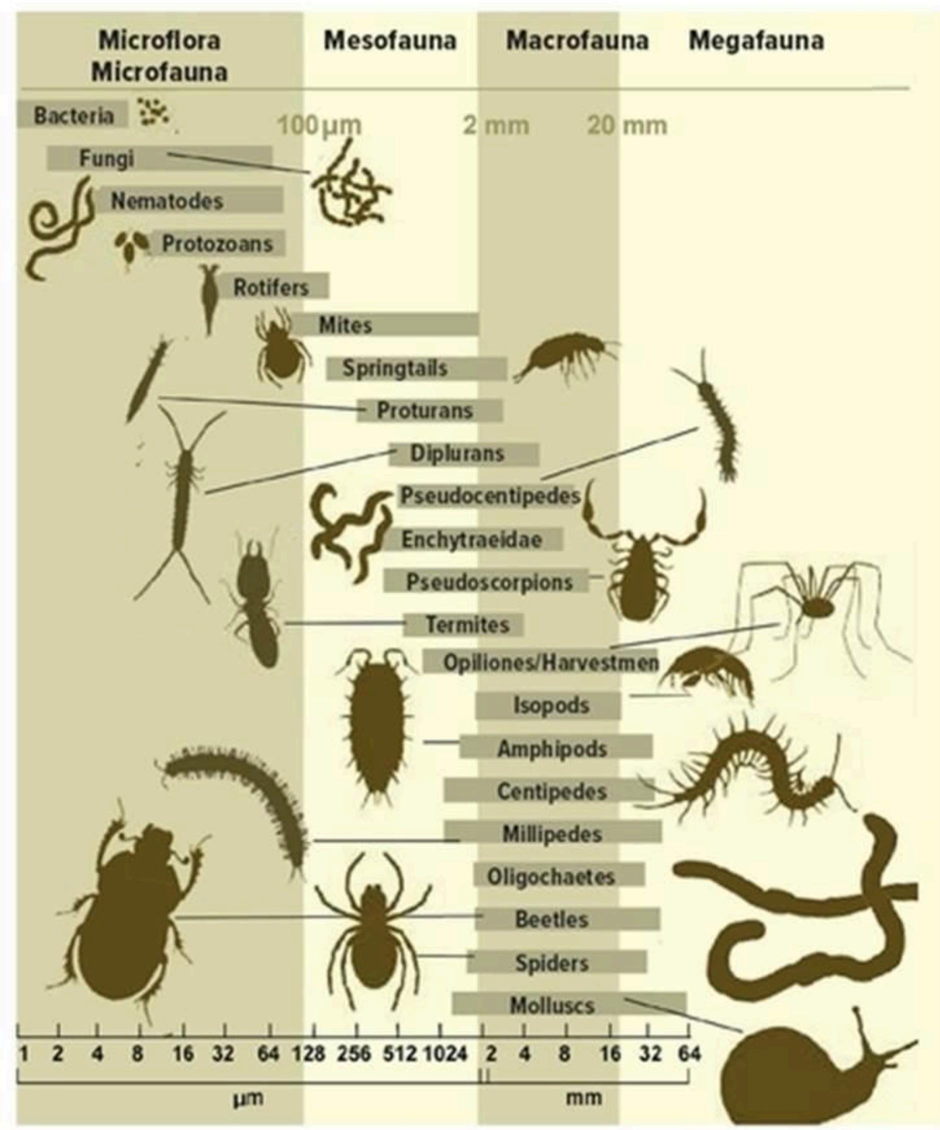

Categorisation of soil organisms based on effective diameter of the body, which is related to functioning in the soil ecosystem. Source: Miko et al. (2019). © Ladislav Miko

Earthworms

Count the earthworms in your clod to assess the biological fertility

Evaluation of biological fertility	Description
Good	More than 8 earthworms
Fair	4-8 earthworms
Bad	Less than 4 earthworms

Roots

Observe the hole of soil and assess the visible roots to assess the biological fertility.

Evaluation of biological fertility	Description
Good	Roots are present until the deepest part and they are well distributed
Fair	Root development is limited horizontally or vertically
Bad	Few roots or roots with great restriction of development. Thick roots or crushed between soil units.

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How would you evaluate the presence of living organisms?

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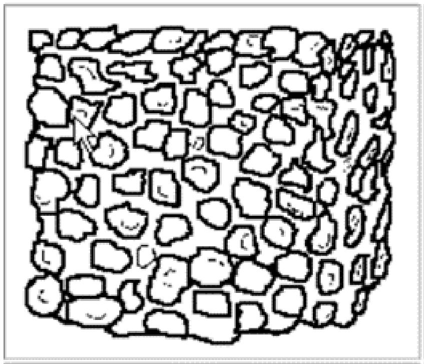
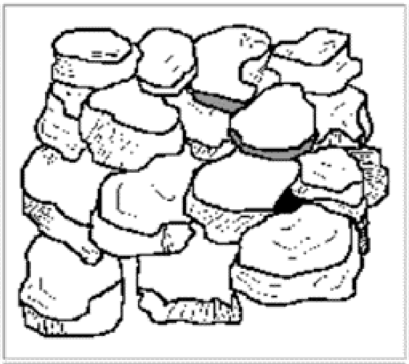
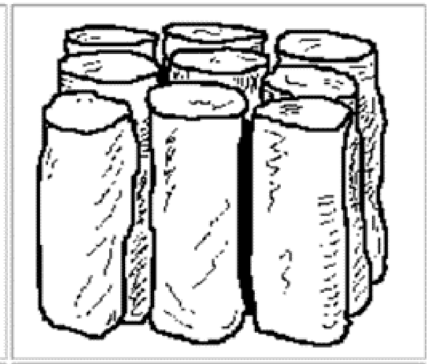
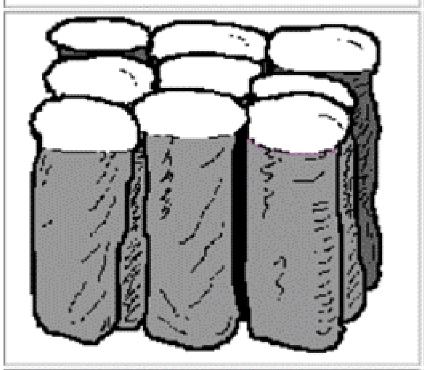
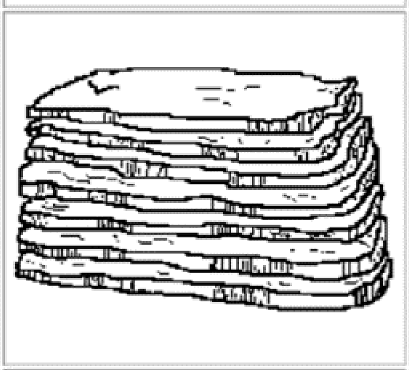
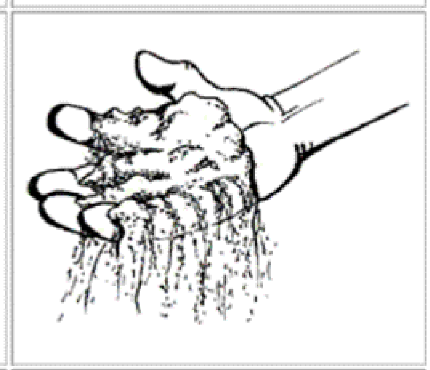
Physical fertility - Soil structure

What structure does the soil have? (Take a soil clod and place it on a table/plastic film. Apply a gentle force to break the macro-aggregates. Observe their shape and assign a shape among the following images. Pay attention to the size of the aggregates!

		
Granular: Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.	**Blocky**: Irregular blocks that are usually 1.5 - 5.0 cm in diameter.	**Prismatic**: Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.
		
Columnar: Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.	**Platy**: Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.	**Single Grained**: Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.

Source: A Methodology of a Visual Soil - Field Assessment Tool - to support, enhance and contribute to the LADA program. Des McGarry. https://www.ctahr.hawaii.edu/mauisoil/a_factor_ts.aspx

Then, Separate the aggregates into three size-classes: (approximately > 60 mm, 20-60 mm, < 20 mm (use the hand as a reference or a ruler). Distribute them from the biggest to the finest.

Assign a score:

Evaluation	Description
Good	Good distribution of smaller, friable aggregates, with no significant number of clods
Fair	The soil contains a significant percentage of both large clods and small, firm, friable aggregates
Bad	Soil dominated by the presence of extremely firm clods, with few small, friable aggregates

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How do you evaluate the structure of your soil?

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Physical fertility - Aggregate stability

Submerge an aggregate in water and observe what happens to it.

According to this table, how do you evaluate the aggregate stability of your soil?

Evaluation	Description of stability
Very good	No dispersion (although the aggregate may break)
Good	Slight dispersion evidenced by a slight milkiness of the water adjacent to the aggregate
Fair	Moderate dispersion with noticeable milkiness
Bad	Strong dispersion with considerable milkiness and approximately one-half of the initial aggregate volume dispersed outward
Very bad	Complete dispersion of the initial aggregates of clay, silt, and sand grains

Note: Two phenomena are observed when you put a soil aggregate in water: **disintegration**, which is the breaking of the aggregate into its micro-aggregates, and **dispersion**, which represents the disappearance of any form of aggregation between the elementary soil particles (sand, silt, and clay). When soil is rich in organic matter, only the disintegration of the aggregate into micro-aggregates is observed (without dispersion of particles).

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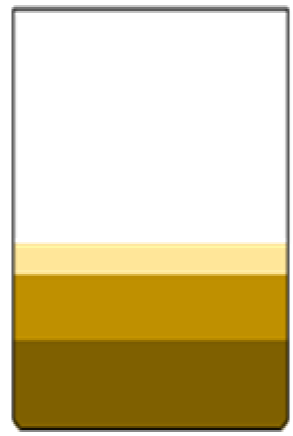
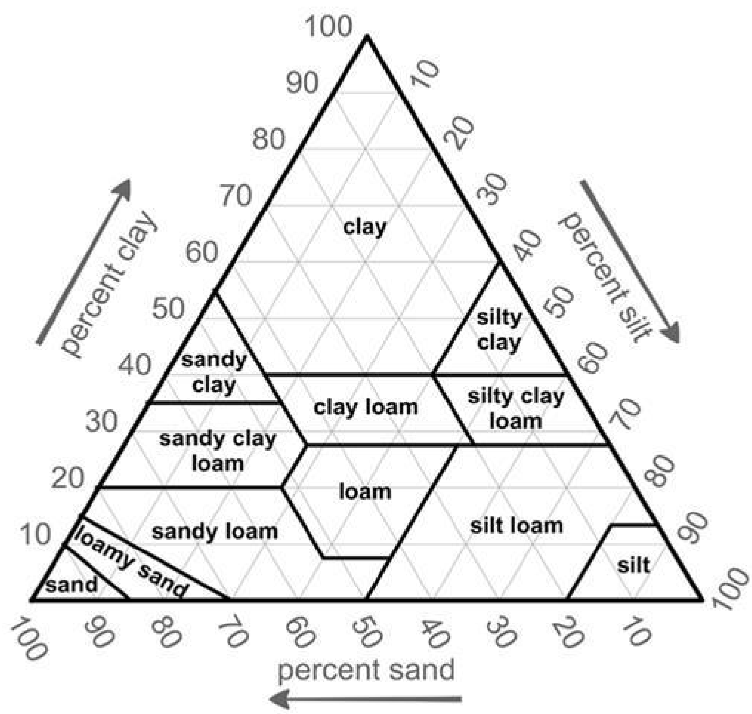
Physical fertility - Soil texture

Date of the readings (after 72 hours): ______________________________

	Height of the deposited particles (cm)	**%**
Clay		
Silt		
Sand		
Total		100%



Once that you have identified the percentage of the particles, use the triangle of texture to define it. Start from Sand, follow the grey oblique lines towards clay to reach the value of clay (horizontal line). Automatically you will also know silt percentage.



What is the soil texture of the sample? ____

Water holding capacity (WHC)

After defining the soil texture, use the following table to calculate the water holding capacity of the soil layer in the root zone, depending on the texture.

1) For such texture, consider the average "available water" (AW), expressed in mm of water per cm depth of soil. AW is the water that plants can absorb.

Water holding capacity (mm/cm depth of soil) of main texture groups. Figures are averages and vary with structure and organic matter differences.

Texture	Field Capacity	Wilting point	Available water
Coarse sand	0.6	0.2	0.4
Fine sand	1.0	0.4	0.6
Loamy sand	1.4	0.6	0.8
Sandy loam	2.0	0.8	1.2
Light sandy clay loam	2.3	1.0	1.3
Loam	2.7	1.2	1.5
Sandy clay loam	2.8	1.3	1.5
Clay loam	3.2	1.4	1.8
Clay	4.0	2.5	1.5
Self-mulching clay	4.5	2.5	2.0

Source: Department of Agriculture Bulletin 462, 1960

(source: http://bettersoils.soilwater.com.au/module2/2_1.htm)

2) Set the soil depth (SD), for instance 25 cm (at which most herbaceous plants develop roots)

$$WHC = AW*SD$$

How much is the Water Holding Capacity of your soil? ____________________________

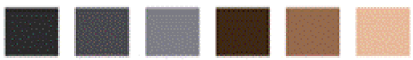
N.B. The unit of measure is "mm" which means that 1 mm of water over 1 meter square surface corresponds to 1 L. The water holding capacity of a deep soil is calculated by summing the capacity of each layer.

Chemical fertility - Color, carbonates and pH

Colour of the soil (little wet):

Color is measured in the wet and dry state of the soil. You can use Munsell color charts: https://www.msn.unipi.it/wp-content/uploads/2022/11/TAVOLE-MUNSELL-per-colori.pdf

Or, simplifying, chose the closer color to your soil:



Chemistry: carbonates and pH

Field description of the soil	CaCO3 (%)	Estimated reaction by hearing	Estimated reaction by sight
Non-carbonatic	0.1	None	None
Very slightly carbonatic	0.5	Barely perceptible and audible	None
Slightly carbonatic	1	Moderately perceptible and audible	Slight effervescence limited to barely visible individual grains
Slightly carbonatic	2	Moderately and clearly audible even far from the ear	Generalized effervescence visible only from very close distance
Carbonatic	5	Very evident and clear	Moderate effervescence; visible bubbles up to 3 mm in diameter
Heavy carbonatic	10	Very evident and clear	Violent effervescence; visible bubbles up to 7 mm in diameter

pH:_______________