FOREST LEARNING

Students

Year 11 Earth and Environmental Science

Practical Investigation of Soil

Image: M

Australian Curriculum Outcomes (Content)

ACSES020 - Conduct a practical investigation to examine soil types and component materials.

ACSES003 - Conduct investigations, including using map and field location techniques and rock and soil sampling and identification procedures, safely, competently and methodically for the collection of valid and reliable data.

NSW Syllabus for the Australian Curriculum

A student:

- Conducts investigations to collect valid and reliable primary and secondary data and information EES11/12-3
- Selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media EES11/12-4
- Analyses and evaluates primary and secondary data and information EES11/12-5

NOTE: Schools will need to complete their own risk assessments for the experiments contained in this lesson.

Table of Contents

Activity 1: Practical investigation to examine soil types and component materials

Introduction

Soil is composed of inorganic and organic components: minerals, air, water and plant and animal material. About 50% of the volumes of soil are mineral elements and organic particles. The rest of the volume is space. These small spaces transfer and hold water in soil. Oxygen and other gases also move through the spaces. The combination allows small animals, such as insects and worms and plant roots to move through soil to collect the water and nutrients.

If you were to cut vertically through soil, you could see it has three layers: bedrock, subsoil and topsoil. Each layer has various depths and plays an important role in growing crops.\

Activity 1.1 - Soil Profile Modelling (edible model)

Task A: Using the links below complete the following table to summarise the five layers of soil.

1. Source: Soil Horizons, Help Teaching.com
   URL: https://www.youtube.com/watch?v=yOWH83YF3Bc

2. Source: Queensland Government. How soils are formed.
   URL: https://www.qld.gov.au/environment/land/soil/soil-explained/forms

TABLE 1: Soil Horizons

Horizon	What is it made of?	Where is it on the Horizon scale?	One Interesting Fact
O			
A			
B			
C			
R			

Task B: Label the picture below to show the location of the soil horizons present in the photo.

https://www.google.com.au/search?q=soil+profile+horizons&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjo-Znrlp_VAhWFUbwKHQq6CXAQ_AUICigB&biw=673&bih=730#imgrc=38hClieQ2UtiMM:

Task C: Complete the steps below to create an edible soil profile.

Materials:

- ☐ Clear plastic short cups
- ☐ Prepared pudding – chocolate and vanilla
- ☐ Chocolate biscuits
- ☐ Green shredded coconut
- ☐ Chocolate chips
- ☐ Caramel chips
- ☐ Gummy Worms
- ☐ Spoons
- ☐ Serving utensil

Method:

1. Fill your cup (soil profile) with different ingredients representing soil horizons.
2. You must have at least four horizons.
3. Draw and colour your cup on this page to show what ingredients you used in each horizon (Table 2).
4. Label each horizon.
5. Use the table over the page to describe why you chose the ingredient and what it represents (Table 3).
6. Answer the questions over the page.

TABLE 2: Drawing of Soil Horizons in Cup

TABLE 3: Ingredients and why they were chosen

Horizon	Ingredient	Description of Horizon

Questions:

1. Describe in your own words what a soil horizon is:

2. What horizon typically has the most material?

3. What is organic material?

4. Describe the material found in the lowest layer of the soil profile:

5. Explain what the parent material in a soil profile is

Activity 1.2 – pH

Introduction

Soil pH refers to how acidic or alkaline a soil is. pH is vital to a soil's fertility as certain minerals are only readily available at specific pH levels. The majority of soils fall within the pH range of 5-8. The pH of a soil has a major effect on: nutrient availability to plant life, plant growth and yields, rate of reactions within the soil and microbial activity (both positive and negative pests).

Materials:

- ☐ Soil sample(s) from various locations around the school grounds, or other.
- ☐ White tile
- ☐ Stirring rod
- ☐ Universal indicator
- ☐ Barium sulphate powder
- ☐ pH colour chart

http://www.ga.gov.au/ausgeonews/ausgeonews201003/soil.jsp

Method:

1. Place a small soil sample on to a white tile.
2. Add a few drops of universal indicator solution and mix it thoroughly with the soil sample.
3. Sprinkle a small amount of barium sulphate powder onto the soil sample.
4. Observe the colour change in the barium sulphate and match this to the universal indicator colour chart to determine the pH.
5. Repeat steps 1-4 for the number of soils samples you have.
6. Design a table of results for your findings.

Task: Visit the link below and create a rough sketch (with key) of the distribution of soil pH types in Australia.

Source: Australian Government Geoscience Australia: Preliminary Soil pH map of Australia, March 2010.

URL: http://www.ga.gov.au/webtemp/image_cache/GA16735.pdf

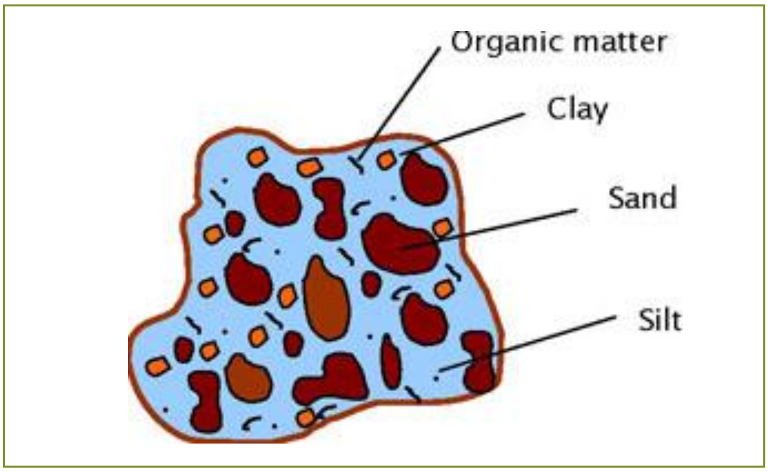
Key

Activity 1.3 – Texture

Introduction

Soil texture refers to the size and percentage of sand, silt and clay within a body of soil.

Soil texture impacts on many important features of soil including; soil structure (size, shape and arrangement of particles), the infiltration rate and movement of water through the soil, the amount of nutrients that are available, the degree of biological activity and penetration of roots.



http://agriculture.vic.gov.au/agriculture/farm-management/soil-and-water/soils/soil-structure-monitoring-tools

TABLE 4: Soil particle size classification.

Name	Diameter range of particle (mm)
Sand	0.02-2
Silt	0.002-0.02
Clay	Less than 0.002

Materials

- ☐ Soil samples
- ☐ Water
- ☐ Texture chart/ table 5

Method

1. Obtain a small soil sample in the palm of your hand.
2. Add a small amount of water and rub the sample with your fingers to break down any larger aggregates.
3. Add enough water so that your sample is moist and pliable but not runny
4. Use table 5 to help you assess your sample
5. Design a table of results for your findings

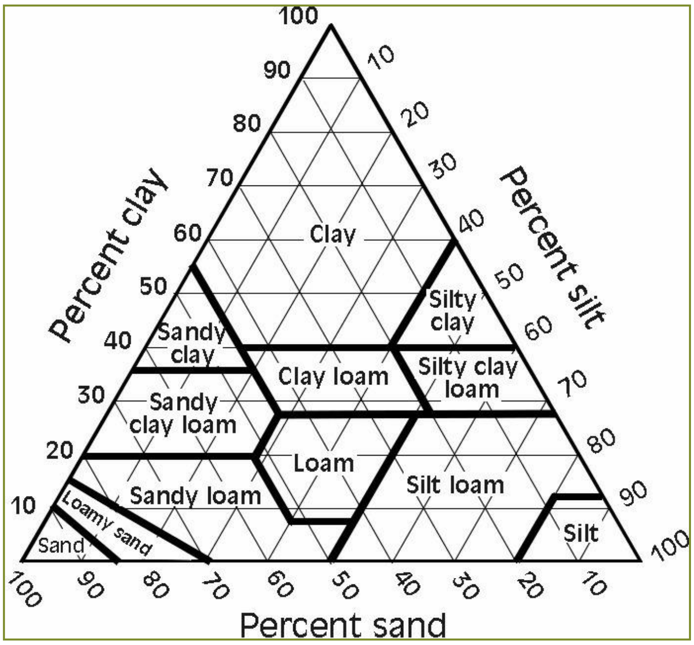


TABLE 5: Texture assessment

A) Rub the soil between your fingers	Is it gritty?	Go to B
	Is it slippery (sticks to your fingers)?	Go to C
	Is it sticky (but not to your fingers)?	Go to D
B) Roll the soil into a ball	Does the ball fall apart?	SANDY SOIL
	Does the ball keep its shape?	Go to B1
B1) Roll the ball into a thread	Does the thread fall apart?	SANDY LOAMY SOIL
	Does the thread not fall apart?	Go to B2
B2) Curve the thread into a ring	Soil can form a ring?	SANDY CLAYEY SOIL
	Soil cannot form a ring?	SANDY CLAYEY LOAMY SOIL
C) Gently roll the soil into a ball.	Soil is shiny/some shine?	SILTY SOIL
	Soil is not shiny?	SILTY LOAMY SOIL
D) Roll the soil into a ball. Place the ball onto a hard surface and gently press on it with the palm of your hand	The ball deforms easily?	CLAYEY LOAMY SOIL
	The ball does not deform easily?	Go to D1
D1) Roll the ball into a thread	Soil cannot form a thread?	SILTY CLAYEY LOAMY SOIL
	Soil can form a thread?	Go to D2
D2) Form the thread into a ring	The ring cracks?	SILTY CLAYEY SOIL
	The ring does not crack?	CLAYEY SOIL

Questions

1. Explain why it is important to know the different amounts of sand, silt and clay in a soil sample.

2. Explain why soils of different textures will have different permeability and infiltration rates.

Activity 1.4 – Simple Infiltration Rate

Introduction

Infiltration is the movement of water into a soil profile. The rate at which infiltration occurs is controlled by the properties of the soil, the level of soil saturation when rainfall starts and by the way in which humans have modified the landscape. The infiltration rate depends on soil texture (the size of the soil particles) and soil structure (the arrangement of the soil particles). Infiltration rates, in turn, control runoff rates and soil erosion, which are important because these processes influence the quality and quantity of our water resources.

A ring infiltrometer is used to measure basic infiltration rates.

By: Soil Physics at English Wikipedia - Transferred from en.wikipedia to Commons by Quedel using CommonsHelper., Public Domain, https://commons.wikimedia.org/w/index.php?curid=9076020

BASIC INFILTRATION RATES FOR VARIOUS SOIL TYPES

Soil type	Basic infiltration rate (mm/hour)
Sand	< 30
Sandy loam	20 - 30
Loam	10 - 20
Clay loam	5 - 10
Clay	1 - 5

An infiltration rate of 20 mm/hour means that a water layer of 20 mm on the soil surface will take one hour to infiltrate. (Food and Agriculture Organization of the United Nations)

Task: Read through the following method and design a table of results to record your data.

Materials

- ☐ 6 equal size buckets
- ☐ 6 equal size tin cans with both ends removed (or can use one and repeat)
- ☐ Sand
- ☐ Bag of potting mix "A" (any variety)
- ☐ Marker
- ☐ 6 plastic rulers
- ☐ Stopwatch
- ☐ 500ml measuring jug/ beaker
- ☐ Water

Method:

1. Fill 6 equal sized buckets with the following materials:

Bucket 1	Bucket 2	Bucket 3	Bucket 4	Bucket 5	Bucket 6
Sand	Sand	Potting mix A	Potting mix A	50/50 mix of sand and potting mix A *	50/50 mix of sand and potting mix A *

**Equal volumes of sand and potting mix A that have been thoroughly mixed prior to filling the bucket.*

2. Push a tin can into each of the buckets until it penetrates to a depth of 2-3cm into the soil.
3. Quickly fill one of the cans with water to the top depending on the size of your can.
4. With you stopwatch, time for 60 secs and then with a ruler measure how far the water level has fallen from the top of the can. Record the distance.
5. Repeat test for each bucket and record your results
6. Select 2 different soil sites (around your school, or on excursion etc).
7. Repeat steps 2-5.

Results:

Distance of infiltration in 60 seconds (cm)										
	Bucket 1 Sand	Bucket 2 Sand	Bucket 3 Potting mix A	Bucket 4 Potting mix A	Bucket 5 50/50 mix	Bucket 6 50/50 mix	Site 1 A	Site 1 B	Site 2 A	Site 2 B
Average time for infiltration										

Questions

1. Compare the infiltration rates of the different soils types you tested and explain the results you obtained.

2. Explain how and why your results might change if you were to place a number of bricks/weights on the soil samples for a significant length of time prior to the test.

3. Identify what "real life" scenario Question 2 trying to model?

Activity 1.5 – Organic Matter

Introduction

Organic matter is made up of dead animal and plant material that is decomposed by microorganisms to release nutrients and energy. Organic matter recycling is very important to soil fertility and impacts its structure, water holding capacity etc. Many factors in the environment affect the level of organic matter including; pH, management, texture and climate.

Materials

- ☐ Evaporating basin
- ☐ Soil sample
- ☐ Bunsen and matches
- ☐ Tripod and gauze mat
- ☐ Tongs
- ☐ Stirring rod
- ☐ Electronic beam balance
- ☐ Safety goggles,
- ☐ Fume cupboard

Method:

1. Record the mass of the evaporating basin or tare the scales to zero
2. Add the soil sample to the basin and record its mass
3. Carefully heat the soil sample in a fume cupboard (or very well ventilated room) whilst occasionally stirring the sample for a period of 20 minutes or more
4. Allow the sample to cool and reweigh the basin to calculate the mass of the burnt soil
5. Calculate the percentage of organic content of the soil by using the formula

Percentage organic content of soil

$$= \frac{\text{Mass of burnt soil}}{\text{Mass of unburnt soil}} \times 100$$

Students

Question

1. Explain why a soil that contains low organic matter will also have a low microorganism count and discuss why this is undesirable for a productive ecosystem.

Activity 1.6 – Bulk Density

Introduction

Access the following:

Source: Soilquality.org.au Fact Sheets Bulk Density Measurement

URL: http://soilquality.org.au/factsheets/bulk-density-measurement

Task A: Read the information under the heading background and complete the passage below.

Background

The soil ____________ density (BD), also known as dry bulk density, is the ____________ of dry soil (M_{solids}) ____________ by the total soil ____________ (V_{soil}). The total ____________ volume is the ____________ volume of ____________ and ____________ which may contain ____________ (V_{air}) or ____________ (V_{water}), or both (Figure 1). The average values of air, water and solid in soil are easily ____________ and are a useful ____________ of a soil's ____________ condition.

Soil BD and porosity (the number of pore spaces) reflects the ____________, shape and ____________ of ____________ and voids (soil structure). Both BD and porosity (V_{pores}) give a good indication of the suitability for ____________ ____________ and soil ____________ and are vitally ____________ for the soil-plant-atmosphere system (Cresswell and Hamilton, 2002; McKenzie *et al.*, 2004). It is generally ____________ to have soil with a ____________ (<1.5 g/cm^3) (Hunt and Gilkes,

1992) for optimum ___________________ of ___________________ and __________________

through the ________________________.

Bulk density measurements can be done if you suspect your soil is compacted or as part of fertiliser or irrigation management plans.

Watch the video Measuring Bulk Density

Source: Measuring Bulk Density Published on 14 Dec 2016 UWSP Soil Physics Final Project
URL https://www.youtube.com/watch?v=Rt1qD7Ldhng

Task B: As you watch the video create an equipment list and a flow chart that could be used to complete an activity to determine the bulk density of a soil sample

Materials

Method

Access the Soil Quality site

Source: Soil Quality for Environmental Health URL http://soilquality.org/indicators/bulk_density.html

Task C: In the space below outline the problems that can occur when soil bulk density is too high

Activity 1.7 – Porosity

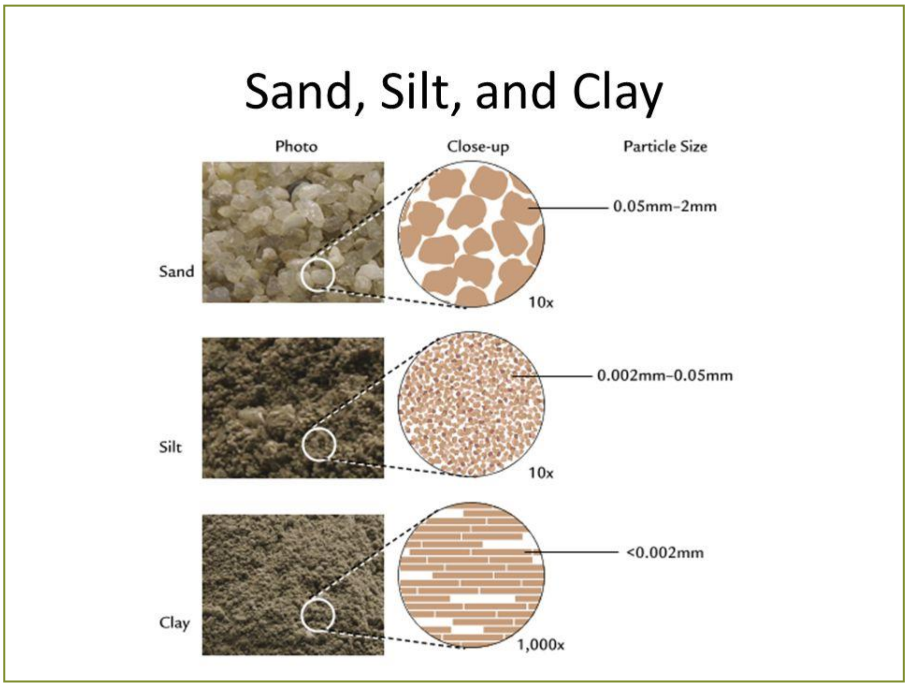
Introduction

Soils are made of particles that are different shapes and sizes. The space between the particles is called pore space. The amount of pore, or open space between soil particles is referred to as soil porosity. Pore spaces may be formed due to the movement of roots, worms, and insects; expanding gases trapped within these spaces by groundwater; and/or the dissolution of the soil parent material. Soil texture can also affect soil porosity.

Soil porosity is important for many reasons. A primary reason is that soil pores contain the groundwater that many of us drink. Another important aspect of soil porosity concerns the oxygen found within these pore spaces. All plants need oxygen for respiration, so a well-aerated soil is important for growing crops. Compaction by construction equipment or our feet can decrease soil porosity and negatively impact the ability of soil to provide oxygen and water.

Task A:

The diagram below shows the pore spaces in three soils: sand, silt and clay.
In the space below, make a hypothesis about which of the three soils will have the greatest porosity include a reason for the answer given.



Hypothesis

Task B: Before starting the activity, watch the following clip and answer the questions.

Source: GeoScience Video Porosity and Permeability

URL: https://www.youtube.com/watch?v=8mfBomrw0rs

1. What can ground water be used for?

2. Explain the source of most useable groundwater

3. What is porosity? Draw a diagram to explain your answer

4. Using a flow chart, summarise the experiment that shows how porosity can be calculated

5. Stop the video after the water is poured into the sand. Write a prediction about which will hold more water, the gravel or the sand

6. Outline how water is extracted from below the ground

7. Define the term permeability

8. Describe the permeability and porosity in an igneous rock

9. Identify which type of soil had the greatest permeability

10. Outline which rocks are the best suited for groundwater reservoirs

Task C: Soil Porosity

Materials

- ☐ 3 metric measuring cups
- ☐ 100 ml graduated measuring cylinder
- ☐ Water
- ☐ Marking pen
- ☐ Soil samples: sand, clay and small pebbles (can be obtained from various field locations such as a rock quarry, road cuts, stream beds, etc.)

Method

1. Fill one measuring cup to 200ml with sand, the second cup with 200ml of clay and the third with 200 ml with small pebbles.
2. Fill a graduated cylinder to 100ml with water.
3. Slowly and carefully pour the water into the first cup until the water just reaches the top of the sand. Pour slowly so no water spills out of the measuring cup.
4. Record exactly how much water was used.
5. Use the formula below to calculate the percent porosity for the sand:

Porosity = (Amount of water added to sample ÷ Total sample volume) x 100

6. Repeat the same procedure with the clay and the pebbles.
7. Record the results in the table below

Results

Soil Type	Total sample volume (mL)	Amount of water added to sample (mL)	Porosity (%)
Sand	200		
Clay	200		
Pebbles	200		

Conclusion

Write a summary using the results to compare the porosity of the three samples: sand, clay and pebbles

Activity 2: Forests and Soils

Background

Soils are an important component of a forest ecosystem and are partly responsible for controlling such processes as decomposition of organic matter, nutrient and water availability which in turn are important to the growth of the forest and its value as an ecosystem and economic commodity. The positive interactions between trees and soils help to ensure a thriving environment and have far reaching impacts in the environment.

Forests and their soils are estimated to store in total (taking into account the trees, soil and dead wood and litter) as much carbon as the atmosphere (1).

Forest establishment, including for sustainable forestry production, can positively improve the structure of soils and reduces the degree of erosion and landslides within an ecosystem due to their roots' ability to stabilise the soil.

Plantation productivity is closely related to soil properties and knowledge of soil characteristics by producers helps them make important management decisions when establishing a plantation.

Task: Visit the URL below and summarise the key points and relationships between making soil related forestry decisions.

Source: Queensland Government: Business Queensland (Scroll to the bottom of the page to find the heading "Plantation forestry rules of thumb").

URL: https://www.business.qld.gov.au/industries/farms-fishing-forestry/forests-wood/plantation-forestry/soil

TABLE 6: Soil related decisions in plantation forestry

1	

2	
3	
4	
5	
6	

FOREST LEARNING

Students

References

1. Soil Horizons Help Teaching.com, published 27th November 2017 https://www.youtube.com/watch?v=yOWH83YF3Bc Accessed on 12th July 2017.
2. Queensland Government. How soils are formed. https://www.qld.gov.au/environment/land/soil/soil-explained/forms Accessed 23rd August 2017
3. University of Hawaii at Manoa. Soil Nutrient Management for Maui County https://bit.ly/2vKChgk Accessed 21st July 2017.
4. AusGeo News Preliminary Soil pH map of Australia http://www.ga.gov.au/ausgeonews/ausgeonews201003/soil.jsp Accessed on 21st July 2017
5. Australian Government Geoscience Australia: Preliminary Soil pH map of Australia, March 2010 http://www.ga.gov.au/webtemp/image_cache/GA16735.pdf accessed on 19th July 2017
6. Agriculture Victoria http://agriculture.vic.gov.au/agriculture/farm-management/soil-and-water/soils/soil-structure-monitoring-tools Accessed 16th July 2017.
7. Agriculture Victoria; Victoria resources online, Accessed on 17th July 2017
8. http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_texture_qrg Food and Agriculture Organization of the United Nations https://bit.ly/2qXJgh6 Accessed 20th July 2017.
9. By Soil Physics at English Wikipedia - Transferred from en.wikipedia to Commons by Quedel using CommonsHelper., Public Domain, https://bit.ly/2HZhgRE
10. 2015 International yeas of Soil http://www.fao.org/soils-2015/news/news-detail/en/c/285569/ Accessed on 10th July 2017.
11. Soilquality.org.au Fact Sheet Bulk Density http://soilquality.org.au/factsheets/bulk-density-measurement 2017 Accessed 23rd July 2017
12. Measuring Bulk Density https://www.youtube.com/watch?v=Rt1qD7Ldhng December 2016 Accessed 23rd July 2017
13. Soil Quality Bulk Density http://soilquality.org/indicators/bulk_density.html September 2011 Accessed 23rd July 2017
14. Earth Science Week Soil properties http://www.earthsciweek.org/classroom-activities/soil-properties 2017 Accessed 17th of July 2017
15. Rainmachine Zones Soil https://support.rainmachine.com/hc/en-us/articles/228001248-Soil-Types 2013-2017 Accessed 17th of July 2017
16. GeoScience Video Porosity and Permeability https://www.youtube.com/watch?v=8mfBomrw0rs July 2015 Accessed 23rd July 2017
17. Queensland Government Business Queensland https://www.business.qld.gov.au/industries/farms-fishing-forestry/forests-wood/plantation-forestry/soil Accessed on 18th July 2017

Commons License