Department of Primary Industries

Stage 3 Science and Technology unit

Teacher's Handbook and Learning Sequence

NSW Department of Primary Industries Schools Program

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Acknowledgements

The Investigate competition and this resource are an initiative of the NSW Department of Primary Industries Schools Program.

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Education and Regional Services: Jo Hathway (Project Officer, Education), Michelle Fifield (Education Officer, Schools) and Megs Dunford (Project Officer, Education).

This resource draws heavily on the following publications:

- *Managing for healthy soils AgGuide* from the NSW Department of Primary Industries
- *Soil Explorer Workbook* from Local Land Services
- *Read your Soil* from NSW Agriculture (now NSW DPI) – all of the illustrations are from this resource.

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About this resource

Background and aims

This resource was written for the 2019 Investigate: soils science and technology competition - an initiative of the NSW Department of Primary Industries. The competition is open to all NSW Stage 3 students and teachers and a new theme and unit of work are available each year.

Soil is a living, changing material that is made up of minerals, organic matter, water, air and living creatures. It is the basis of our food production systems as well as a vital player in the world's ecosystem, performing services including filtering water, neutralising pollutants and converting and recycling raw organic matter.

This learning sequence and investigation will assist students in understanding the value and vulnerability of soils. It is the start of ensuring that our students grow into informed consumers of the food we produce.

Students will observe that different soils are more suited to food production. They will assess the soils' characteristics and discuss how these are likely to affect plant growth. They will also make recommendations about how the soil can be improved.

Students will prepare a scientific report that aligns with outcomes from the NSW Science and Technology, English and Geography syllabuses.

Investigate provides authentic learning experiences to support students' development of science, technology and communication skills. Real-world content guides the application of these skills in a meaningful learning context. By participating in the Investigate competition students will understand that science plays an important role in their lives every day.

Intended audience

This Teacher's Handbook and Learning Sequence are intended for teachers of Years 5 and 6 students working towards Stage 3 outcomes in the Science and Technology K-6 syllabus. The activities in this unit assist students to achieve outcomes in the Living World, Built Environment and Information strands and in the skills areas of Working Scientifically and Working Technologically. Cross curricular links are made to Geography, English and Mathematics outcomes.

Table of contents

NSW Syllabus links

Science and Technology	
ST3-1WS-S	plans and conducts scientific investigations to answer testable questions, and collects and summarises data to communicate conclusions
ST3-4LW-S	examines how the environment affects the growth, survival and adaptation of living things
ST3-5LW-T	explains how food and fibre are produced sustainably in managed environments for health and nutrition
English	
EN3-1A	communicates effectively for a variety of audiences and purposes using increasingly challenging topics, ideas, issues and language forms and features
EN3-2A	composes, edits and presents well-structured and coherent texts
EN3-3A	uses an integrated range of skills, strategies and knowledge to read, view and comprehend a wide range of texts in different media and technologies
Geography	
GE3-1	describes the diverse features and characteristics of places and environments
Mathematics	
MA3-1WM	describes and represents mathematical situations in a variety of ways using mathematical terminology and some conventions

Literacy learning progressions			
LiS7– LiS8	InT5– InT6	UnT7–UnT9	CrT8–CrT10
Numeracy learning progressions			
IRD5			

Why soils?

Soils are a complex, invaluable part of sustaining life on Earth. To those who study soils they represent a fascinating, endless investigation of the impacts of human activity and ways of managing food and fibre production. To those who work them they are an enduring partner in their pursuit, whether it is agriculture, gardening, mining, land rehabilitation or construction to name just a few. But to perhaps the majority of people soils are just the dirt beneath our feet.

So we are pleased that you are introducing your students to the value and complexity of soils. It is important that students begin to understand the role that soils play in our lives and just how important it is that we care for them.

This learning sequence will support students working towards the Living World strand of the NSW Science and Technology syllabus and particularly the Growth and survival of living things theme. This understanding will also prepare them for the agricultural outcomes ahead of them in the Technology Mandatory syllabus in years seven and eight.

While researching this learning sequence we have come across quite a few great activities and resources. A list of these is included at the end of this resource for you to use as extension activities or ways of expanding on the value of implementing this resource in your stage 3 program. Some of these are used in this learning sequence and our sources are referenced (though some activities appear in multiple locations). This resource draws extensively on the Read your Soils resource developed by NSW Agriculture (now the NSW Department of Primary Industries).

Preparation

We suggest you read through this document in advance as some activities require pre-planning. Have a look at the student learning journal (even if you don't plan to use it) to see what sort of data you will be collecting and to see the template for the report. The learning journal is provided in both Word format and pdf so you can adjust it to suit your needs.

For this unit of work you will need access to two different soils. It would be great if you can compare different gardens or backyards but you could also use soil from school gardens, home gardens, potting mix, sand, or soil from a nearby farm. You will need about a bucket of each so that there is enough to plant a seed in to observe the growth of the plant in different soils and enough for students to carry out some soil assessment activities.

You could also assess soils from different parts of the landscape for example on the top of a hill, in a valley or in a creek bed. Later in the program students will consider the effect landscape has on soil and food and fibre production.

If you collect your soils without the students present, take a photo of the site and record some observations including approximate percentage of grass cover, land use, how difficult it is to dig (giving an indication of soil compaction and texture) and whether there was evidence of plant roots or animal activity in the soil.

If you have easy access to where you collected the soil there are a couple of extra soil assessments that you will be able to do with students. You will not be disadvantaged in the competition if you are unable to complete these.

You will also need to decide on a plant to grow. Choose something that germinates fast and it would be great to grow something that you can transplant into a larger pot or garden to share the fruit with students at a later stage. Good options include tomato or snow peas.

We have provided an optional learning journal for students to record the steps and findings of their investigation. These do not need to be submitted for judging in the competition and you may choose to have students record their findings in their workbooks instead.

The competition entry is a scientific report. Details of what we are looking for are in the judging rubric and you can choose your own way of presenting the report. Keep in mind though that when judging a number of entries, a clear and well organised report presents you a better opportunity for judges to find the necessary information.

Icons

The following icons are used in this document to help you navigate the activities and to act as a checklist so you can easily find where you are up to.

Discussion

Videos

Activities

Record results and discussions

Thinking and planning activities

Extension or optional activities

Biosecurity and soil

What is Biosecurity?

Biosecurity helps to keep NSW and Australian ecosystems, agriculture and communities safe by keeping out and controlling animal and plant diseases and pests such as weeds and pest animals and insects, such as aphids.

How does biosecurity work?

Biosecurity includes measures to:

- prevent new pests, diseases and weeds from entering our country and becoming established
- manage established pests, diseases and weeds to eradicate them where feasible or lessen their impact
- ensure an appropriate preparedness and response capacity that is internationally recognised and meets our trading obligations and international treaties
- maintain or improve the status of Australia's biosecurity systems.

Why is biosecurity important?

- Australian flora and fauna are unique; by protecting them we protect our natural biodiversity, distinctive ecosystems and heritage.
- Australia's domestic and international markets demand products that are free of pests, diseases and contaminants.
- Biosecurity helps to keep food and other products from our primary industries safe from diseases such as Salmonella and pathogenic E. coli. Biosecurity also protects people from diseases that can be passed from animals to humans (called zoonoses), such as Hendra virus and Avian Influenza.

How does biosecurity relate to soils?

Pests, disease and weeds can all be carried in soil. Bringing soil from another site on purpose or accidently (for example when carried in tyre tread) can spread biosecurity threats from one site to another.

Biosecurity is a shared responsibility

Government, industry and the people of NSW working together to protect the economy, environment and community from the negative impacts of animal and plant pests, diseases and weeds for the benefit of all people in NSW.

Learning sequence

Define the problem

Discuss with students their current knowledge about soil(s). Record on a KWHL chart all the information that students currently know about soil and growing food and fibre.

The following logos and images may help to start the conversation (available online if you would like to display them on the SmartBoard). What do they tell you about soils and the role that they play in our life?

View the video 'How soil is created' from 59 degrees Academy (https://youtu.be/ZcAmpVJgwJI). Note: this video is made in the UK. At the end the presenter discusses issues of soil protection and the impact of farming. While the statistics are specific to the UK, soil degradation is a world-wide issue.

Discuss the video with students:

- What surprised them in the video?
- Does this change the way they think about soil?

Record student responses.

Complete the Apple as the Earth's soil activity with students. This activity can be found on various websites, the link below takes you to the Soil Science Association of America version and includes a link to a video of a teacher completing the activity if you prefer to view that. It was also included in the 2014 Science Week package and they suggest giving students playdough so they can follow along with you – making it more hands-on for them.

https://www.soils.org/files/sssa/iys/apple-as-world-soil.pdf

Discuss the 'What we would like to know' section of the KWHL chart and record students' responses.

Discover what your soils are like.

Recall that in the apple activity only part of the 1/8th of the Earth's surface that is available for agriculture is suitable to growing food and fibre.

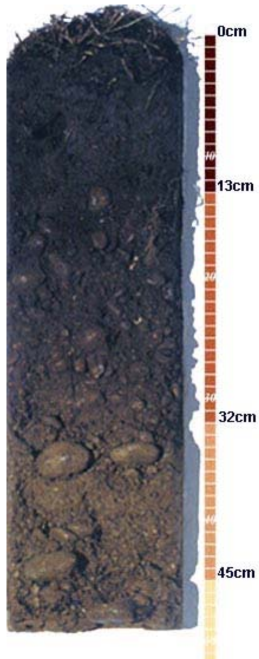
Consider the following images of soil profiles found on Tocal. These images and descriptions are available on the Tocal Virtual Farm (accessed from the Soils story map) – these images are also hyperlinked to the online version.

Windmill paddock profile description

- 0cm: Dark grey-brown loam. Abundant plant roots, well drained, pH 4.7
- 40cm: Dark grey-brown loam. Plant roots common, worm channel below 22cm, well drained, pH 5.9
- 85cm: Dark grey-brown loam. Lucerne roots at 85-90cm, well drained, pH 6.1

View paddock profile description

- 0cm: A horizon. Dark brown loam. Slight gravel content, plant roots common, good drainage, hard surface soil, large piece of charcoal at 6cm, pH 5.5
- 13cm: B1 horizon. Brown sandy clay loam. Heavy gravel content, plant roots common, good drainage, pH 6.2
- 32cm: B2 horizon. Yellowish brown light medium clay. Heavy gravel content, massive structure, plant roots are few, fair drainage, pH 6.1
- 45cm: C horizon. Rock



Discuss: How are they different? Ask students to suggest what is different in the soils that makes one more suitable to growing food and fibre than the other? Consider the soil description and information that is recorded on the side of the profiles – the differences will give students a hint about what to look for in their soils. Write a testable question or aim for this investigation – you may need to guide this discussion.

Optional: The soils on Tocal have been surveyed and mapped so that farm managers can make informed decisions. This soil map and information about the implications on farm management are available on the Tocal Virtual Farm soils map available at https://Trade.maps.arcgis.com/apps/MapSeries/index.html?appid=52054dd7557c48489bd4ac0a25aae525 .

Consider the soils that you have collected for students to use in this investigation. Ask students to record their observations about the different soils. Ask them to predict which soils will be better for growing plants for food. Record student discussions and predictions.

Set up the soil trial

Plant seeds or seedlings in pots in the different soils – remember to keep some of the soil for the soil assessments.

Remember that in a fair test there is only one variable. If students are to be asked to draw conclusions about the quality of the soil for growing plants, all other variables including sunlight, water and temperature should remain the same for each individual plant. Ask students to suggest ways that you can ensure that this investigation reflects the rules for a fair test (more information about fair tests and what you can expect of your student in planning this investigation is in the skills continuum of the NSW Science and Technology syllabus (2017)).

Record the set up for the Investigation including how students have determined that this will be a fair test.

As a class decide how often you will record observation of plant growth and how you will assess plant growth. Over the next few weeks observe the growth of the plants in different soils and record plant growth and student observations about what is happening.

During this time you will also be undertaking some investigation of the soils. These activities are the sorts of tests that farmers and agronomists carry out to assess the suitability of soils for different production systems.

You may choose to spend a day completing all of the assessments or spread them out over a few days or weeks.

We have provided instructions and images to assist your completion of the activities but individual findings will vary across different soils.

For those new to soil assessments it can be hard to determine soil characteristics. Comparing different soils will be really useful for students to be able to make decisions on the features of soils. For example, it may be difficult for students to determine the texture of clay on a scale of gritty to sticky but comparing it to garden soil or sandy soils will help students to feel how sticky the clay is.

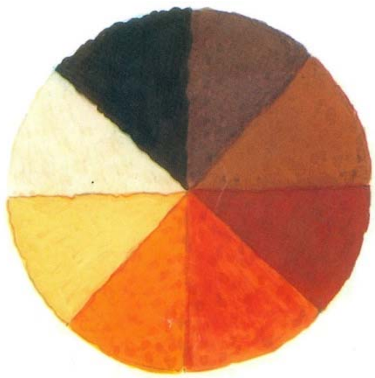
The soil assessments

Food production depends on healthy soils. A basic understanding of what soils are made up of, how they vary and how that informs soil management is important for all of us.

Note: the charts that are used in this section are included in the student learning journals. If you have decided not to use the journals – or have printed them in black and white - the charts are included in the appendix for you to print for student reference.

Colour

The first and easiest soil assessment is to look at the colour of the soil. While many students probably use the same colour pencil to colour soil, in reality there is a huge variety of soil colours. In fact one of the activities we came across while researching this resource is to complete a soil painting – using only soil for colour variation. If you are lucky enough to have access to a range of soils you could try this.



colour

Pale colours generally indicate low fertility. Darker colours usually indicate high levels of organic matter. Red colours indicate the presence of oxidised iron (rust) which means the soil is well drained and well structured. White, pale grey and pale green colours may indicate waterlogging. Mottled soil colours may indicate intermittent waterlogging.

Soil scientists use a Munsell Soil Colour chart(https://munsell.com/color-products/color-communications-products/environmental-color-communication/munsell-soil-color-charts/) to help them describe the colour of soil. This helps to ensure consistency between scientists and locations. For our purposes however the image above provides a general guide for most soils you are likely to encounter.

Have students record the colour of each of the soils you are using and what that could mean for how the soil performs in the trial. Make sure the soil is dry for this.

See what is in your soil

Soil organisms

Soil organisms play an important role in keeping soils healthy, they convert organic matter into nutrients that are accessible to plants and they aerate the soil.

They range in size from microscopic bacteria through to insects and earthworms and larger animals that make their home in the soil. Soil organisms have not always been well understood and some past land uses and farming practices have had serious detrimental impacts on soil organisms. Fortunately soil conditions can be altered to increase the amount of soil organisms.

Watch all or some of the following videos.

The Soil Food Web: This is a slightly technical video about the role of decomposers in the food chain. It runs for 7 mins https://www.youtube.com/watch?v=ZcAmpVJgwJI&feature=youtu.be

Dead Stuff: the secret ingredient in the food chain. This is a shorter video highlighting the role of 'pond scum' and other decomposers to their role in the food chain. It runs for 3.50 mins. https://www.youtube.com/watch?v=KI7u_pcfAQE

The Living Soil: This 360° video is a great immersive introduction to the life in soils. It runs for 3.11 mins and can be watched on any tablet through the YouTube app. https://www.youtube.com/watch?v=-dhdUoK7s2s

An accurate measure of soil organisms can really only be assessed in a laboratory.

If you do not have access to the soil sample site skip to the image on the next page and use it to stimulate discussion about the role of soil organisms and possible ways to protect them.

If you have access to the site you may be able to observe the activity of some larger soil organisms.

Lay out a shovel full of soil and see if you can find animals or evidence of animals. Look at the soil through a microscope (the soil sample needs to be fresh). The following field trial is used as a way of monitoring activity of soil organisms across growing seasons and from year to year.

Cotton strip trial

Note: This test will only be effective for soils in situ.

Cut strips of white cotton or calico approximately 5cm wide and 20cm long. You will need at least three per site you wish to assess. Label the end of the strips with the name of each site.

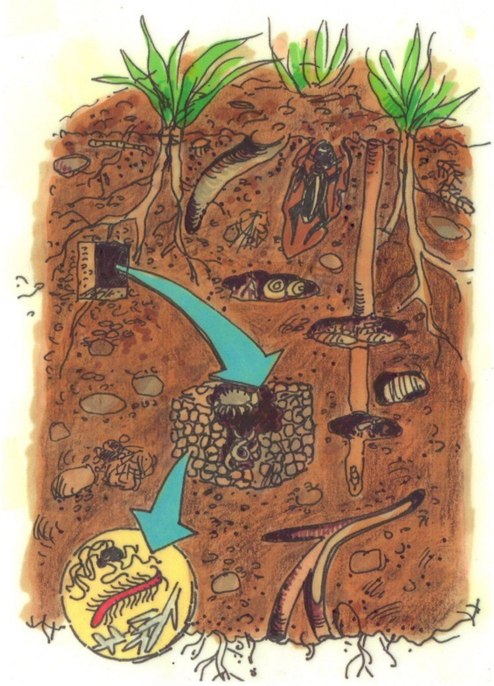
Push the shovel into the soil about 15 cm deep, take the shovel out and fold a cotton strip over the end of the shovel. Push the shovel back in the soil and remove the shovel leaving the cotton strip in the soil with one end visible above the ground cover (so you can find it again). Leave the strips in place for about four weeks. You many need to label them or put up a sign to ask people not to touch or remove them.

When the strips are removed soil organism activity will be evident in the decay of the strip. If there is no decay there is limited soil organism activity.

Record your observations and comparisons between the sites/soils. Consider what impact your results would have on plant growth in your soils. Use the image below to stimulate discussion and record some of the discussion points.

Soil animals

- The presence of soil organisms in a soil implies an available source of organic matter as food.
- You may see larger organisms such as earthworms, beetles, ants and slaters in your soil. Their presence is indicated by tunnels, holes, shells, webs, mucus and casts.
- A dark, moist, crumbly soil with an earthy smell indicates smaller soil organisms, such as bacteria, fungi and protozoa, are also in the soil.
- If there is no sign of biological activity check the soil pH. Most soil organisms do not like soil that is too acid or too alkaline.



One of the quirkier of the soil organisms are dung beetles. They play an important role in agriculture. This five minute video provides a good accessible overview of dung beetles. Why isn't the world covered in poop? - Eleanor Slade and Paul Manning (https://www.youtube.com/watch?v=uSTNyHkde08)

Soil chemistry

Soil chemistry is a complex area of study. Farmers often have regular soils tests carried out in a soil testing laboratory to see how their management practices are affecting the sustainability of their production enterprise. The soil test results are used to make decisions about fertiliser use and providing minerals which are lacking to optimise plant and animal production on the farm.

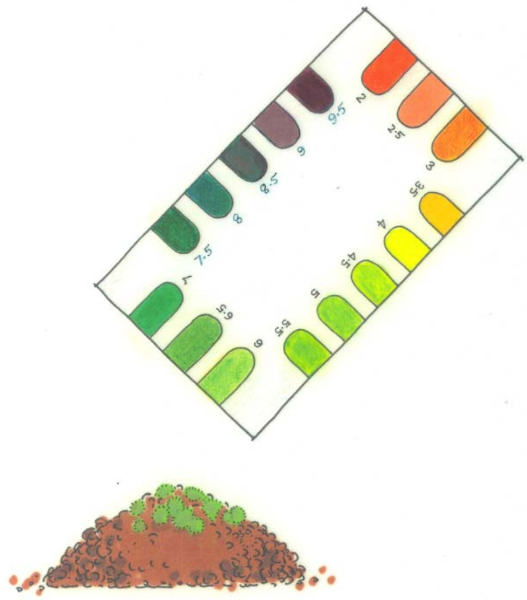
pH

One test that is easily carried out on your soil sample is soil pH. Again if you have access to an agriculture or science department they will most likely have a soil pH kit you could use. If not, nurseries and rural supply stores often sell them.

The testing process is quick, the kit comes with easy to follow instructions and is a great visual activity for students to do.

Soil pH

- Soil pH can be easily checked using a simple field pH kit. Test both topsoil and subsoil because they often vary.
- For most agricultural plants, the ideal soil pH range is 6 to 8 on the field kit colour card.
- Above 8, the soil is alkaline and may be deficient in some nutrients.
- Below 6, the soil is acid. Aluminium and manganese toxicity may affect plants. Treatment with lime may be needed.
- Soil pH can indicate the available nutrients in the soil. If a soil is too acid or too alkaline nutrients become unavailable to plants.



Record the pH of your soil samples.

Soil structure

Soil texture

Read and discuss this passage (from Managing for Healthy Soils) with students.

‘Soil is a complex mixture of mineral particles that come from weathered rocks, water that contains dissolved nutrients vital to plant growth; air (supplying oxygen to plants and soil organisms); living organisms of all sizes (including bacteria and fungi) and organic matter (the remains of plants and animals).’

As you saw in the previous activity the relative quantities of each affect the colour of your soil.

The relative quantities of different sized particles have an impact on the texture of the soil, affecting its ability to hold water and minerals and its ability to support plant growth. The following two soil assessments will determine the texture of the soil.

Jar test

A graphic representation of this test is in the appendix. Do this for both soils.

For each soil half fill a small jar (ideally with straight sides) with soil. Top the jars up with water and shake them. Leave them in a light location for 24 hours. During this time the sand will settle first followed by the silt and finally the clay. If the water is still particularly cloudy, wait another 24 hours for more of the clay to settle.

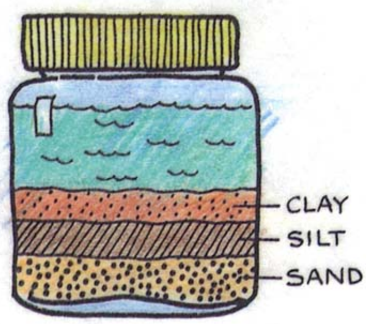
Don’t move the jars to measure as this could affect your results. By measuring the depth of the layers compared to the overall depth of the settled soils you will be able to calculate the percentages of each.

Use the following calculation:

Measure the overall depth of the soil (A).

Measure the depth of the sand layer (B).

Measure the depth of the sand and silt layer and subtract the sand layer (B) leaving you with the silt measurement (C).

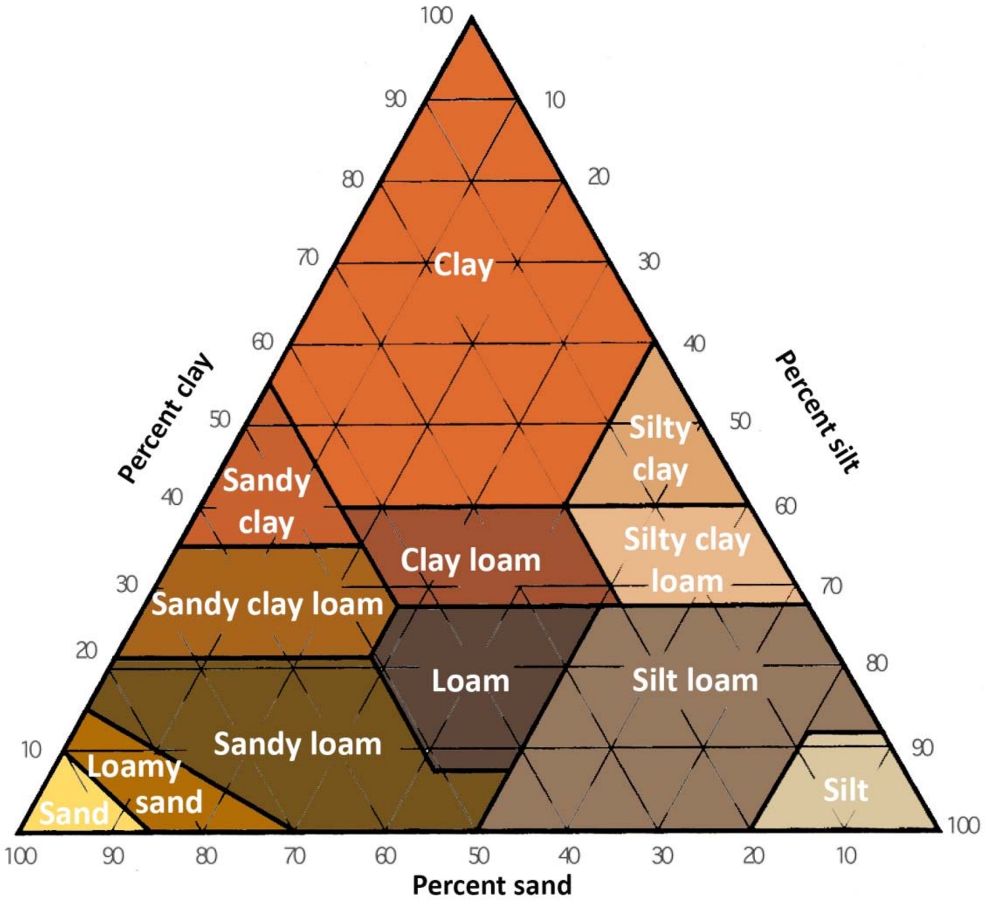


Subtract the depth of the sand and silt layer (C) from the overall depth to leave you with the clay measurement (D).

For each measurement (B, C and D) divide by the overall depth (A) and multiply by 100 to calculate the relative amount of sand, silt and clay in the soil – expressed as a percentage eg if the overall soil depth is 12cm and the sand layer is 3cm then 3 divided by 12 is .25 and multiplied by 100 means the soil is 25% sand.

You may also be able to estimate the amount of organic matter – it will be floating on top of the water. We will discuss organic matter in more detail in a later section so take note of whether there is any organic matter floating.

Using the percentages and the graph below classify each of the soils by texture.



Ribbon test

A graphic representation of this test is in the appendix.

Take a small handful of soil. Gradually add water until you can form a ball with the soil. If you cannot form a ball the soil has a high sand content – or you have added too much water. Work the soil well (like plasticine).

Once you have formed a ball roll the soil into a cylindrical shape and start to press a ribbon over your forefinger with your thumb. When the ribbon breaks measure the length of the ribbon. The longer the ribbon, the higher the clay content in your soil. Have a few students try this test and compare results.

Talk about how the soil feels; gritty is sand, silky is silt or loam and sticky is clay. This will be easier to determine if students are able to compare the texture of different soils.

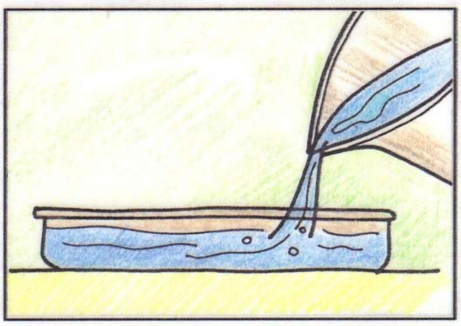
The Managing for healthy soils AgGuide provides the following rule of thumb – the ideal soil as far as texture goes is probably loam or clay loam. Discuss this with students in light of your results and ask students to record the implications that texture may have on the soil trial you currently have underway.

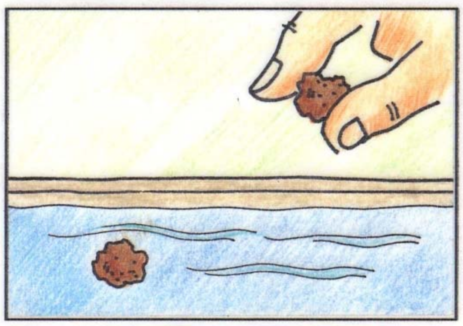
Soil stability

Sometimes soil structure is naturally unstable. (Soil structure is the most important of all soil features. It is 'the size, shape and arrangement of soil aggregates (crumbs) and voids.) There are two potential problems for soil stability – dispersing soil and slaking soil. To assess whether your soil is a dispersing soil or a slaking soil place a couple of small crumbs into a shallow dish of rain water (or distilled water), leave it to sit and watch what happens.

A visual guide to this test is included in the appendix.

Record the results for what happens to each soil straight after putting the soil in water, after one minute and after ten minutes. Check the soil again 24 hours later as some soils take longer to display dispersing and slaking characteristics.





Slaking soil

If you have a slaking soil the soil will crumble (and you may notice air bubbles come out of the soils when it is first placed in the water) and collapse – but the water around the soil is clear. This means that this soil has poor stability and is prone to erosion. Slaking soils do not have enough organic matter to assist with binding the soil particles together.

Dispersing soil

If you have a dispersing soil the water around the clumps will go cloudy. Dispersing soils also have poor stability and are prone to erosion but in dispersing soils it is because they have too much sodium attached to the clay particles. They are known as sodic soils.

Dispersing soils should not be disturbed - the roots and ground cover will help to stabilise the soil, reducing erosion. Adding gypsum can assist a dispersing soil.

Organic matter

Organic matter has come up a few times in the assessments you have carried out. It is made from plants, animals, and bacteria that were once alive and plays an important role in the healthy soils.

Organic matter can be a complex part of managing healthy soils but as general rule of thumb Australian soils are low in organic matter and adding organic matter is beneficial for food and fibre production.

Organic matter effects can be evident in the colour of soil and you may have seen some floating on top of the water when you did the jar test for soil texture. Whether or not you have observed organic matter in your soils, consider the following important roles that organic matter plays in soils:

- Providing food to plants
- Reducing soil erosion
- Retaining soil moisture
- Improving nutrient supply to plants
- Improving soil structure
- Retaining air in the topsoil
- Reducing problems of acid or sodic soils
- Reducing soil diseases, weeds and pests.

This demonstrates that organic matter can combat many of the issues that we have considered in the earlier assessments.

Consider the image below (also available in the appendix) and discuss with students how the litter layer can be used in gardens to improve organic matter content of soils.

How can this litter layer be encouraged in your garden?

Litter layer

- This layer is found on the surface of the soil.
- It is made up of fresh and decomposed organic material such as leaves and other plant litter.
- The decomposed organic matter gives this layer its dark colour.
- It is usually very fertile because soil organisms feed on the organic matter and release nutrients into the soil.

Record your observations and recommendations for organic matter in your soil.

Soil profile

If you are using soil from the school ground you will be able to see any changes in the top part of the soil profile. Dig a hole wide enough for students to see the soil on the side of the hole. Continue digging (or have students take turns!) until you can see a change in the colour of the soil – this will most likely be when you reach the bottom of the topsoil and start to dig through the subsoil. This can be an obvious change or a more subtle change – that in itself tells you something about your soil.

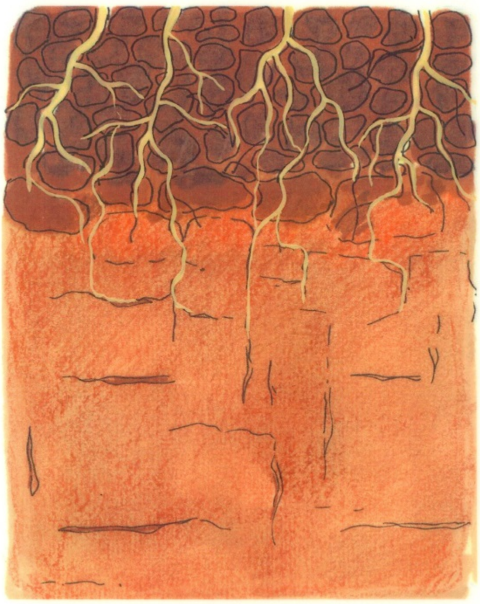
If you are able to contact a high school agriculture department you may be able to borrow a soil auger which will enable you to dig deeper and, if you lay out each auger-load in a line, you will be able to see more of the profile. In this case keep a sample (about two cups full) of each of the different sections to use for the soil assessments. This way you will be able to see how the soil characteristics change through the soil profile.

The images below (from NSW DPI's Read your Soil resource) describe the features of the topsoil and the subsoil. Essentially the topsoil is where most of the plant growth occurs – and is most commonly assessed for food and fibre production. The subsoil is a reflection of the soil's parent material and has an impact on drainage of water through the soil profile.

Topsoil

- Topsoil is usually darker compared with subsoil layers because of the accumulation of organic matter. It may have a lower clay content.
- Higher levels of soil nutrients are usually found in this layer.
- Most biological activity and root growth occurs in this surface layer.
- The depth, texture and structure of the topsoil largely determines how much air and water can enter the soil.
- A deeper topsoil can store more organic material, nutrients and water.
- Topsoil depths vary but are relatively shallow (10-20 cm) in Australia.

Subsoil



- Subsoil beneath the topsoil can be many metres deep.
- It has less organic matter, lower biological activity and lower nutrient concentrations.
- Subsoil is often paler with more clay than the topsoil.
- Subsoil is usually wetter due to infiltration and less evaporation. It is a reservoir of water for plant roots.
- Subsoil texture largely determines drainage characteristics of the soil.
- A mottled or grey coloured subsoil indicates poor drainage, while a red subsoil indicates good drainage.

Record your observations of the topsoil and subsoil. Are they freely draining with evidence of plant and animal activity?

More information about the soil profile is available in the following video: https://www.youtube.com/watch?v=vqtdFaclWf0 .

If you do not have access to the soil profile for your soil you can include a discussion of the impact of the soil profile in your scientific report based on the video and the images above.

A note about landscape

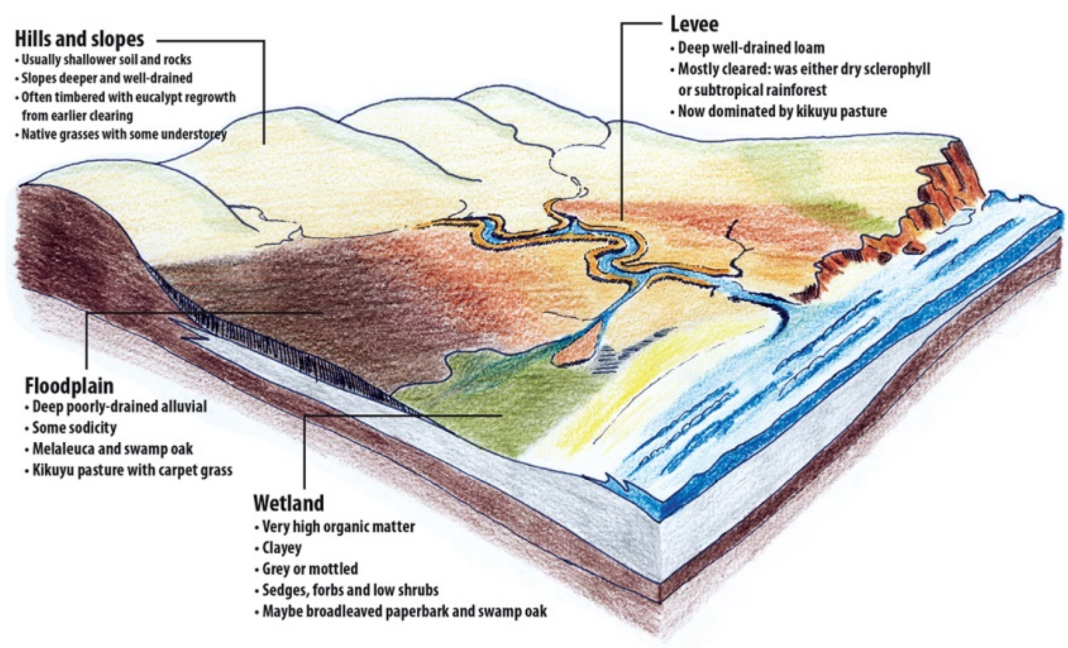
Soil moves across a landscape, carried by water and wind. Even human and animal activity can move significant amounts of soil. This affects the soil profile in different parts of the landscape with a general movement of soil downhill. This movement, taking soil (particularly topsoil) from the upper slopes down into the valleys, forms deeper soils in the valleys and shallower soils on the hills and upper slopes. Revisit the images of the two soil profiles from Tocal. View paddock is from one of the higher hills on Tocal and Windmill paddock is a river flat.

Some farming practices including clearing trees (whose roots bind the soil together) and over-grazing grasses (that protect the topsoil from erosion and over-cultivation (intensive ploughing and harvesting) can drastically change the soil profile.

The following video demonstrates the role that ground cover can have on preventing soil erosion. It is 17.23 minutes long so you may like to skip parts but it will give students some ideas for their report (https://www.youtube.com/watch?v=d-3ZF6Gi3Ec).

If you have sampled soil from your school grounds or garden have a look at the surrounding landscape. Is the school – or at least the location of your soil samples— located on top of a hill, or in a valley, or somewhere in between? If you are a metropolitan school, the effect of landscape on your soil is probably long since lost amongst construction and landscaping activities.

The image below (from Managing for Healthy Soils) illustrates the effect of landscape on soils. Discuss with students whether landscape has had an impact on the soils you used in the trial and assessments (a larger version of this image is in the appendix).



Include a comment in your report whether the soil in your garden is from the natural landscape or soil that has been brought in for the garden – and the impact that has on the potential to grow food and fibre there.

Results

At the completion of the trial period discuss the results with students. Which plant grew better? How can you tell? Discuss the possible reasons for these results (based on the soil assessment results). Record these discussions.

Preparing your report

The student learning journal includes a template for a scientific report. You can use this to guide your report whether you plan to submit a written report or use another format.

The results and discussion sections of the report should include observations about how the plants grew in different soils as well as a note about each of the assessments and observations that you were able to complete. These included all or some of:

- Colour
- Organisms / animals
- Texture
- pH
- Stability

- Organic matter
- Soil profile

Consider each of the assessments that you have carried out on your soils and possible remedial actions for each if they were determined to be not ideal. Are they realistic options for your garden or growing situation (that is represented by the soils you have trialled)? How might that have impacted on the growth of the plants?

There is some helpful information about soil health on the NSW DPI website including the role of earthworms and dung beetles, organic matter and garden soil - https://www.dpi.nsw.gov.au/agriculture/soils/structure.

Discuss ways that you can ensure these conditions are suitable to support healthy soils. Consider these areas where land managers can have an impact:

- Soil disturbance – overworking soil exposes soil organisms to light, reduces soil moisture, breaks up soil structure and can expose the soil surface to erosion
- Amount of organic matter in the soil —farmers can retain or increase organic matter through sustainable cultivation practices including: direct drilling, retention of stubble from the last crop and green manuring
- Soil structure – soil compaction reduces spaces in the soil available for water, air and living things
- Fertiliser, herbicides and pesticides can make the conditions unsuitable for soil organisms if they are used incorrectly.

Remember that sustainable agriculture aims to produce food and fibre without destroying the potential to produce food and fibre into the future – from the same area of land. This applies to your school garden as well as to farms.

This short video from Gardening Australia gives a recipe for creating excellent soil for a vegetable garden. You may not have access to all of the resources they use in preparing the garden bed but it provides some ideas for students to consider. View online at https://www.abc.net.au/gardening/factsheets/making-perfect-vegie-soil/9432374.

Other useful soil resources and references

Resources and references

Tocal Virtual Farm

https://www.dpi.nsw.gov.au/education-and-training/tocal-virtual-farm

Soil test in a jar from the Natural History Museum Los Angeles Country available online at https://nhm.org/site/sites/default/files/for_teachers/pdf/Soil%20Test%20in%20a%20Jar.pdf

Managing for Healthy Soils AgGuide from the NSW Department of Primary Industries (available for purchase online https://www.tocal.nsw.edu.au/publications/list/farm-management/agguide-managing-for-healthy-soils)

Soil Explorer Workbook by Local Land Services produced in 2014.

Read Your Soil resource developed by NSW Agriculture (now NSW Department of Primary Industries).

Soils Ain't Dirt http://www.maroochycatchmentcentre.org.au/catchment/wp-content/uploads/2013/10/Soils-Aint-Dirt.pdf

Science News for Students - The dirt on soil

https://www.sciencenewsforstudents.org/article/dirt-soil includes a useful soils glossary.

Videos

Dust watch (4.32 mins)

https://www.youtube.com/watch?v=vbL1IxOX8Qo&t=166s

59 degrees academy

- Soil food web https://youtu.be/ZcAmpVJgwJI (7 mins)
- How soil is created https://youtu.be/vbgM54TXdnk (5.27 mins)

Dead stuff: The secret ingredient in our food chain - John C. Moore (3.50 mins)
https://www.youtube.com/watch?v=KI7u_pcfAQE

Soil profile (1.43 mins)
https://www.youtube.com/watch?v=vqtdFaclWf0

The Living Soil: How Unseen Microbes Affect the Food We Eat (360 video, 3.11 mins) https://www.youtube.com/watch?v=-dhdUoK7s2s

Why isn't the world covered in poop? - Eleanor Slade and Paul Manning (5 mins) https://www.youtube.com/watch?v=uSTNyHkde08

Soil erosion demonstration https://www.youtube.com/watch?v=d-3ZF6Gi3Ec with outlets for topsoil and subsoil. 17.23mins

Life in the soil
https://www.youtube.com/watch?v=XapUm5n1zuM&t=26s up to 1min 45sec (then goes on to suggestions for improving gardens)

Building a living soil profile (6.04mins) - very American but good for building garden soil https://www.youtube.com/watch?v=NEz-_Ld_bjc

Why do rivers curve? https://www.youtube.com/watch?v=8a3r-cG8Wic (related to the soil erosion videos) 2.56 mins

Making perfect vegie soil
https://www.abc.net.au/gardening/factsheets/making-perfect-vegie-soil/9432374 3.56 3.56 mins

Websites

The National Association of Conservation Districts (America)
http://www.nacdnet.org/general-resources/stewardship-and-education-materials/2019-life-in-the-soil-dig-deeper/

> Including a story book about children exploring soils
> https://www.globe.gov/documents/348830/35487706/Soil+Book_FINAL2017.pdf/6b84e020-6215-41a5-82c7-dd9155efcdbf

Dig Deeper - Soil Science Society of America
https://www.soils4kids.org/home

Includes activities https://www.soils4kids.org/experiments including Dirt Puddings for soils profiles

For teachers who would like some help in guiding student investigations we found this website to be fantastic:
https://plantingscience.org/content/article/2-uncategorised/77-teacherroadmaps

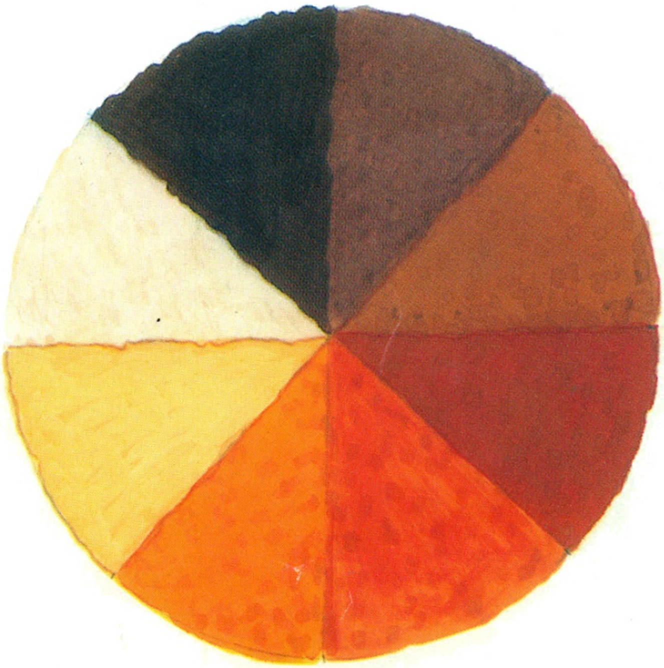
Marking rubric

Category	3	2	1	0	Score
Aim	The aim clearly conveys the purpose of the investigation and connects it to real world examples.	The aim conveys the purpose of the investigation	An aim is included but does not convey the purpose of the investigation	No aim included	/3
Hypothesis	The hypothesis states expected outcomes supported by scientific understanding	The hypothesis states expected outcomes	The hypothesis does not state expected outcomes	No hypothesis included	/3
Variables	All variables are correctly identified	Variables are identified	Variables are incorrect	Variables are not included	/3
Materials	All materials are listed	Some materials are listed	No materials are listed	Materials not included	/3
Method	Clearly identifies all the steps of the trial and lists the soil assessments carried out.	Describes either the trial or the soil assessments	Provides a general outline of the trial	Method not included	/3
Diagram	A clear diagram with labels that adds value to the report	A clear diagram with labels	A clear diagram is included	No diagram is included	/3
Results	Results for both the soils trial and assessments are discussed and graphs / tables / images are included	Results for both the soils trial and assessments are discussed	Results for either the soils trial or assessment are discussed	No results included	/3
Discussion	A clear discussion of the results with implications of the results and questions for future trials	A discussion of the results with implications of the results	A discussion of the results is included	No discussion included	/3
Conclusion	Clearly stated findings of the trial and assessments, referring back to the hypothesis and suggested improvements	Clearly stated findings of the trial and assessments, referring back to the hypothesis	Clearly stated findings of the trial or assessments	No conclusion included	/3

Quality and effort evident in the report	Superior effort has been put into the report	Average effort has been put into the report	Some effort has been put into the report	Little effort has been put into the report	
	5	3	1	0	/5
Teacher ranking					
Effort and achievement of personal best	The student(s) have put their best work into the investigation and report	The student(s) have put some work into the investigation and report	The student(s) have put limited work into the investigation and report	The student(s) did not put in any effort	
	5	3	1	0	/5
Achievement of the outcomes / aim of the project	The student(s) has learnt a lot about soils, food and fibre production and science in everyday life	The student(s) has learnt a couple of things about soils, food and fibre production and science in everyday life	The student(s) has limited learning about soils, food and fibre production and science in everyday life	The student(s) has not achieved the outcomes / aim of the project	
	3	2	1	0	/3
Total and judges' comments					/40

Appendix

Soil charts and guides.

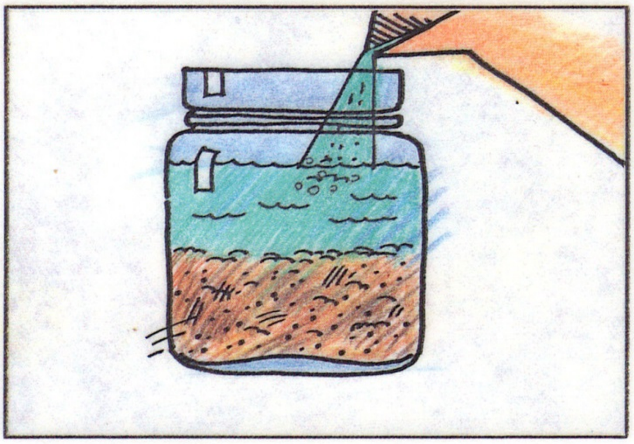


colour

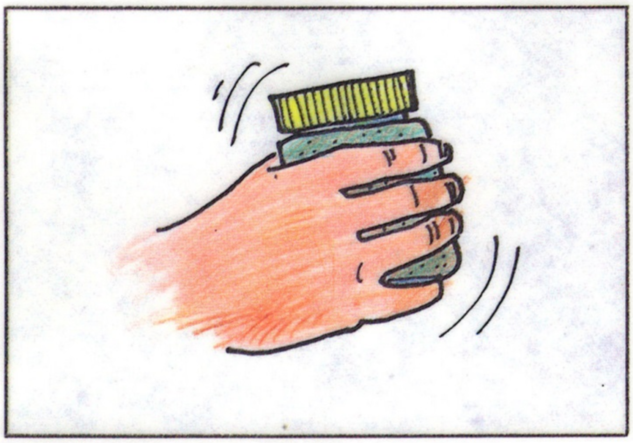
Pale colours generally indicate low fertility. Darker colours usually indicate high levels of organic matter. Red colours indicate the presence of oxidised iron (rust) which means the soil is well drained and well structured. White, pale grey and pale green colours may indicate waterlogging. Mottled soil colours may indicate intermittent waterlogging.

See what is in your soil

1. Half fill a jar with soil.

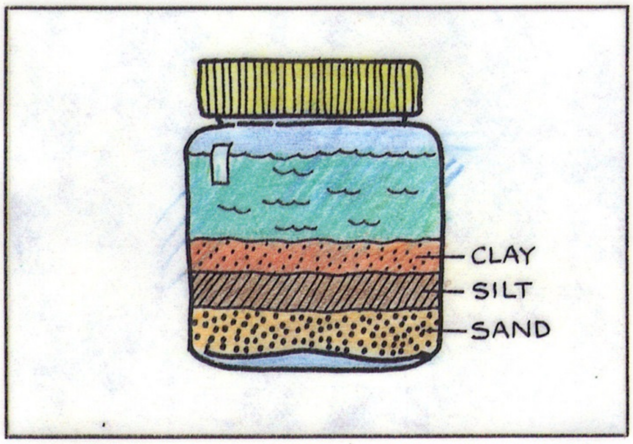


2. Top it up with water.

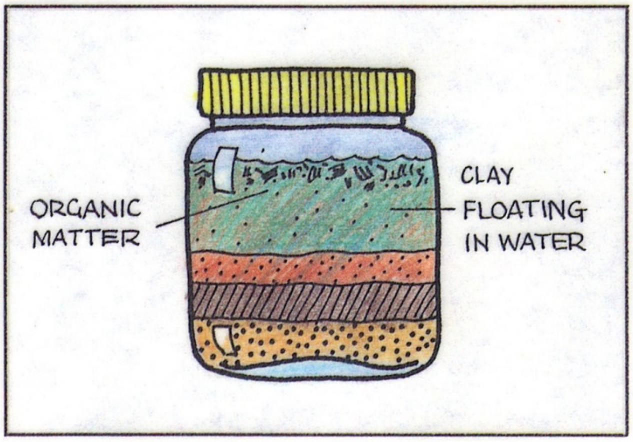


3. Put the lid on and shake well.

4. Leave for a few hours.

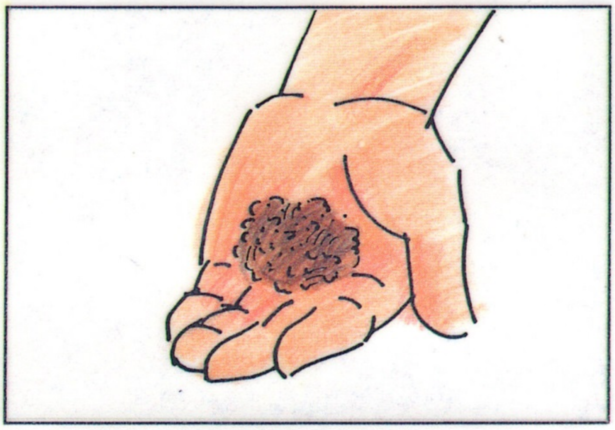


5. Soil particles settle in the following order: sand, silt and clay. The heaviest particles are sand and the lightest particles are clay.

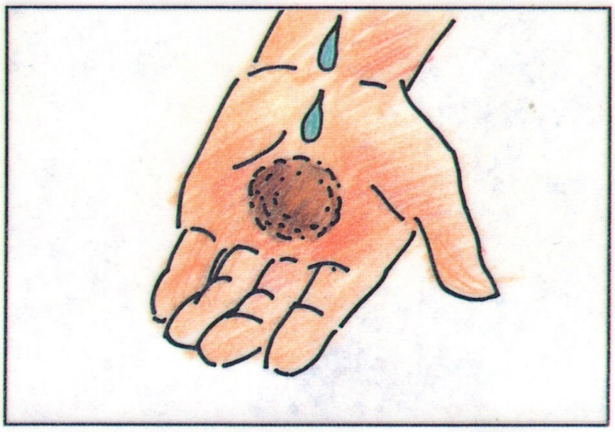


6. If the water doesn't clear, clay particles are still floating in it. Brown material floating on top of the water is organic matter.

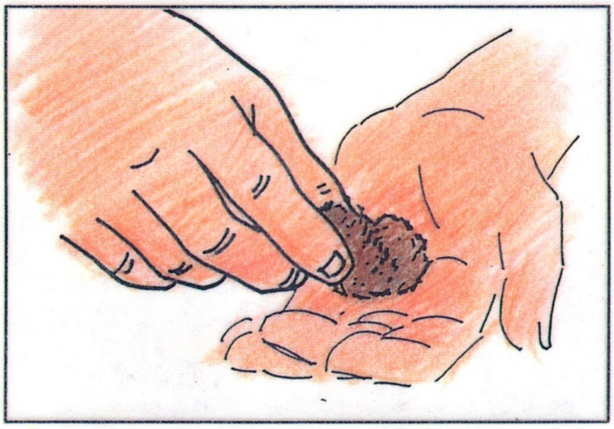
Feel your soil texture



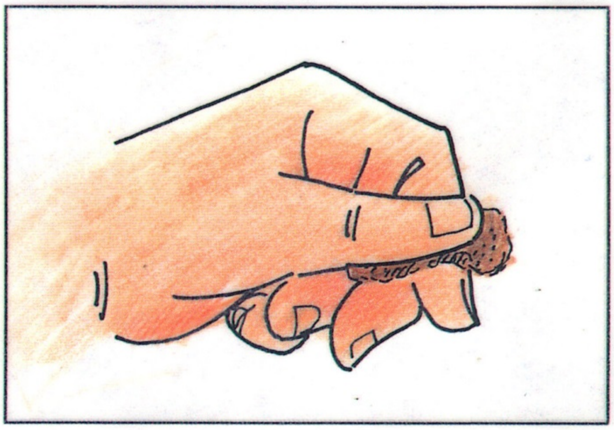
1. Take a small handful of soil.



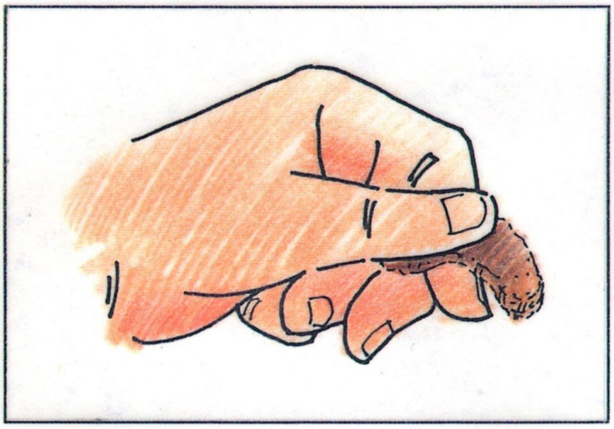
2. Add enough water to make a ball. If you can't make a ball, the soil is very sandy.



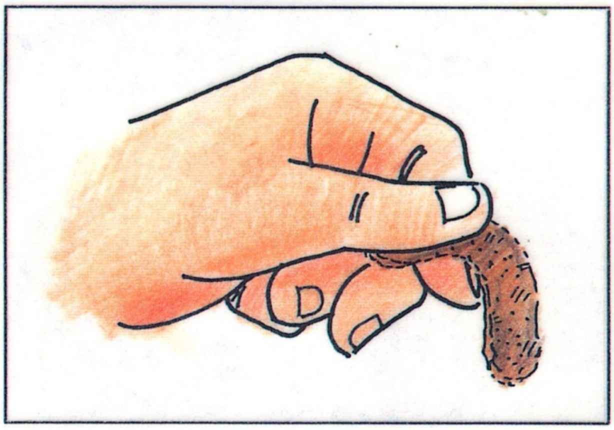
3. Feel the ball with your fingers to find out if it is gritty (sand), silky (silt) or plastic/sticky (clay).



4. Reroll the ball and with your thumb gently press it out over your forefinger to make a hanging ribbon.



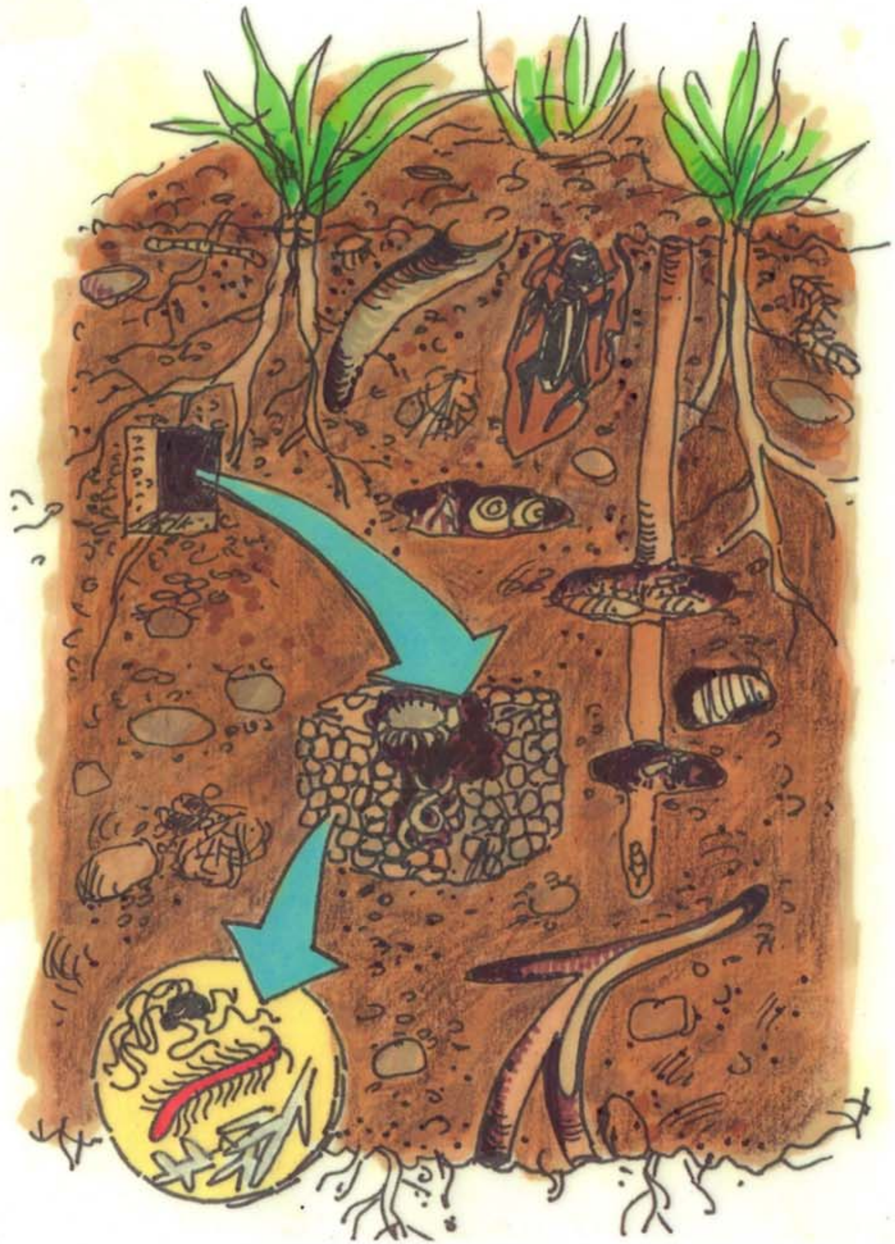
5. If you can make a short ribbon your soil texture is loamy, a mixture of sand and clay.



6. The longer the ribbon the more clay is in your soil.

Soil animals

- The presence of soil organisms in a soil implies an available source of organic matter as food.
- You may see larger organisms such as earthworms, beetles, ants and slaters in your soil. Their presence is indicated by tunnels, holes, shells, webs, mucus and casts.
- A dark, moist, crumbly soil with an earthy smell indicates smaller soil organisms, such as bacteria, fungi and protozoa, are also in the soil.
- If there is no sign of biological activity check the soil pH. Most soil organisms do not like soil that is too acid or too alkaline.

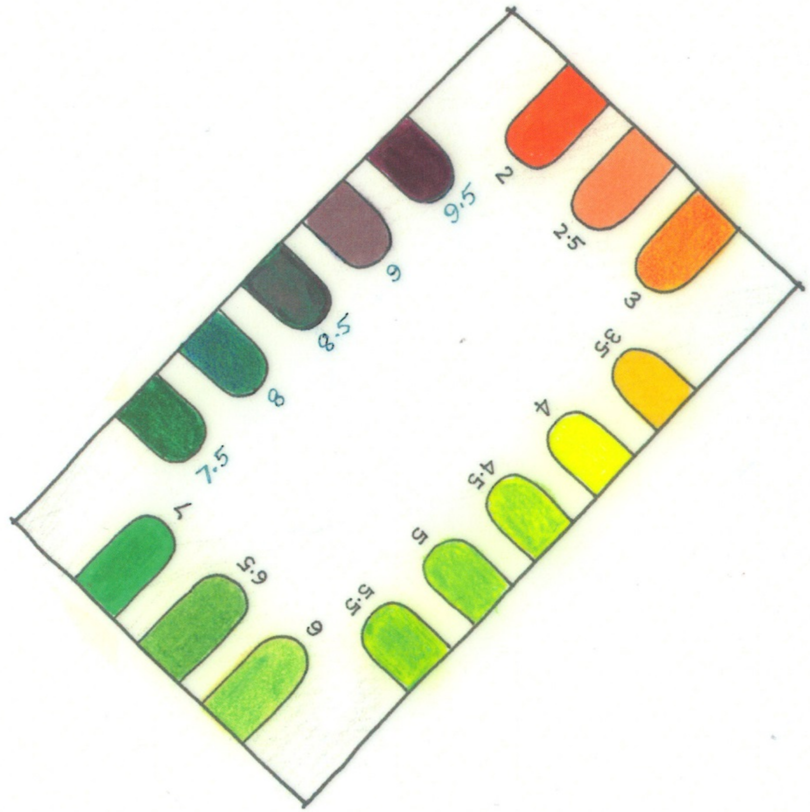


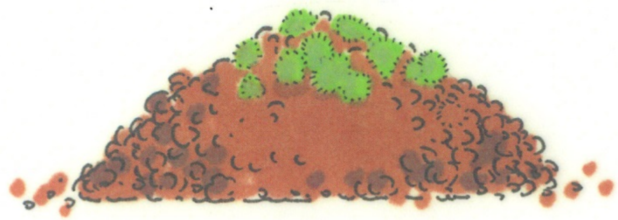
Litter layer

- This layer is found on the surface of the soil.
- It is made up of fresh and decomposed organic material such as leaves and other plant litter.
- The decomposed organic matter gives this layer its dark colour.
- It is usually very fertile because soil organisms feed on the organic matter and release nutrients into the soil.

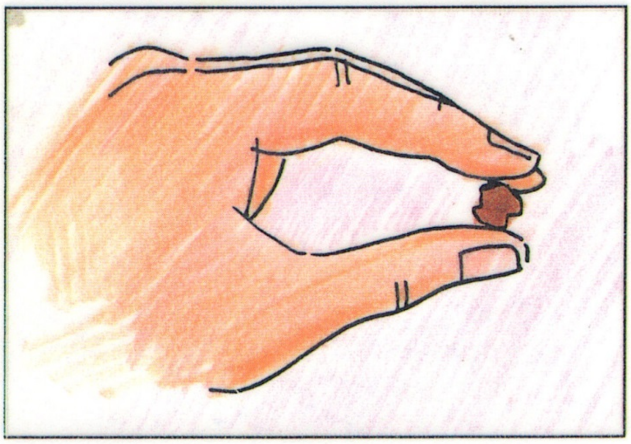
Soil pH

- Soil pH can be easily checked using a simple field pH kit. Test both topsoil and subsoil because they often vary.
- For most agricultural plants, the ideal soil pH range is 6 to 8 on the field kit colour card.
- Above 8, the soil is alkaline and may be deficient in some nutrients.
- Below 6, the soil is acid. Aluminium and manganese toxicity may affect plants. Treatment with lime may be needed.
- Soil pH can indicate the available nutrients in the soil. If a soil is too acid or too alkaline nutrients become unavailable to plants.

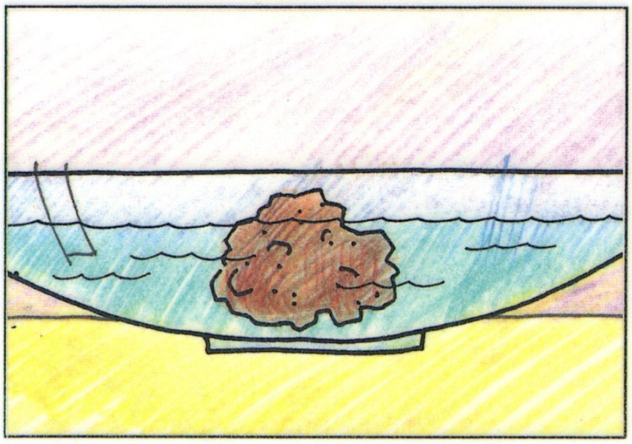




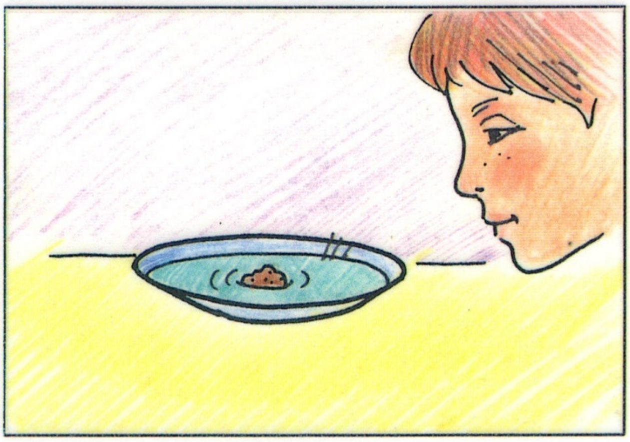
See if your soil slakes



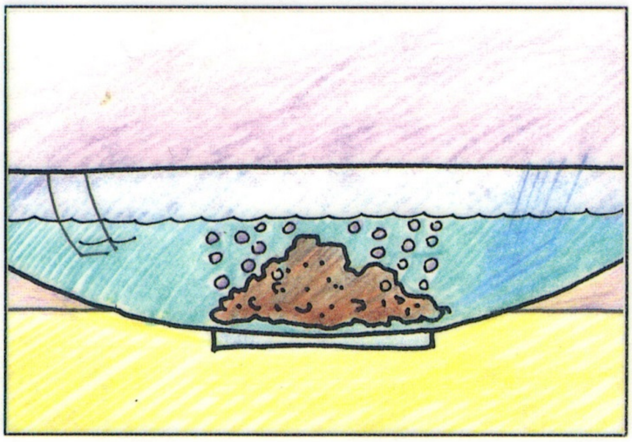
1. Take a small lump of soil, about as big as a marble.



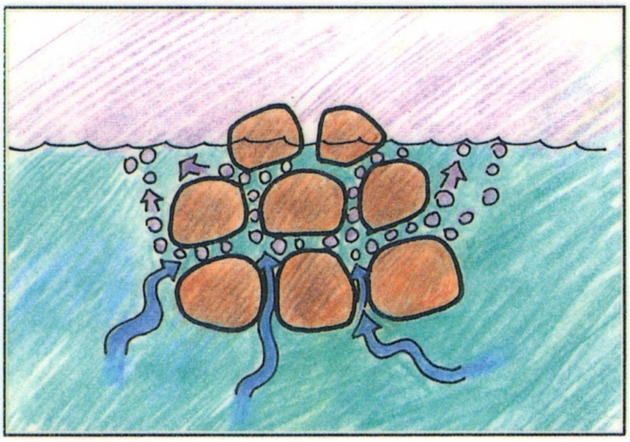
2. Place it carefully in a saucer of water.



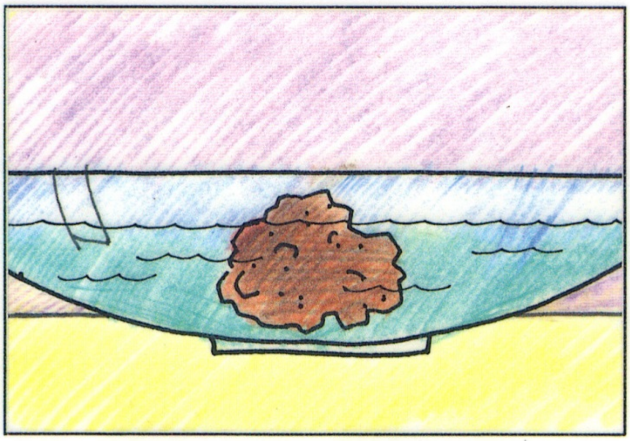
3. Watch to see whether anything happens.



4. If small bubbles appear in the water, and the lump collapses, your soil has slaked. It has no humus or decaying organic matter to hold the soil particles together.

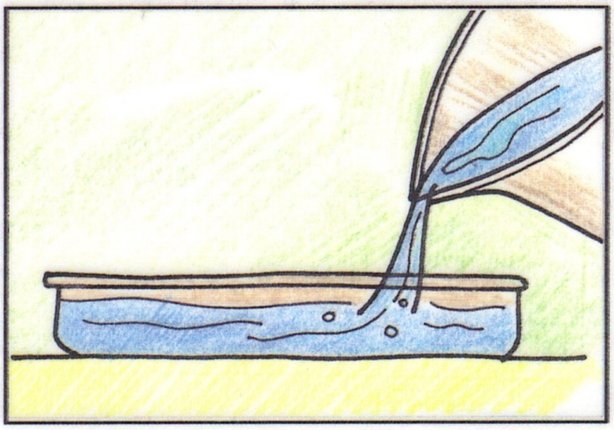


5. When soil slakes, water rushes into the air spaces in the soil, forces the air out (as bubbles) and explodes the soil particles. Slaking occurs when soil is cultivated without any organic matter going into the soil.

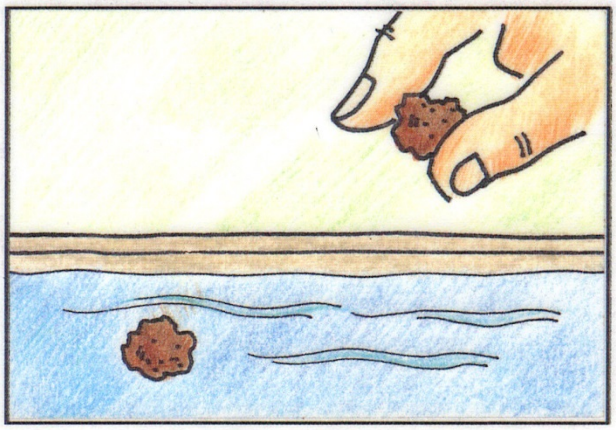


6. If nothing happens to your soil lump, it has enough organic matter in it to hold it together. It has good structure.

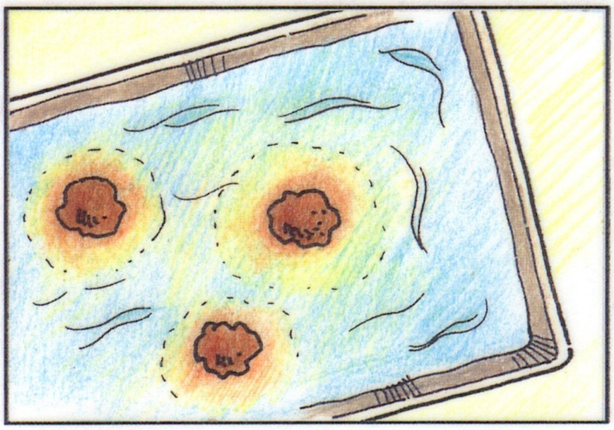
Does your soil disperse?



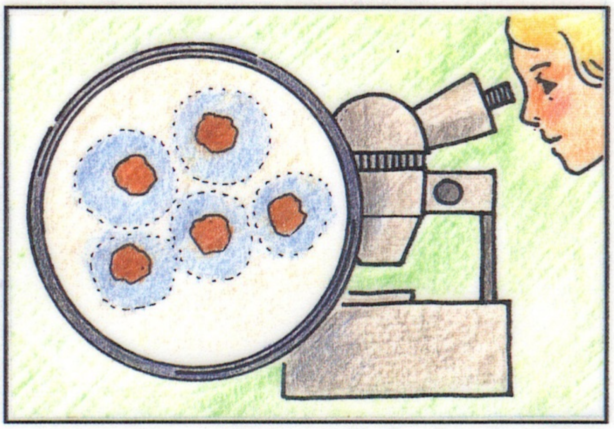
1. Pour some rainwater or distilled water into a dish placed where it will not be disturbed for several hours. (Do not use town water.)



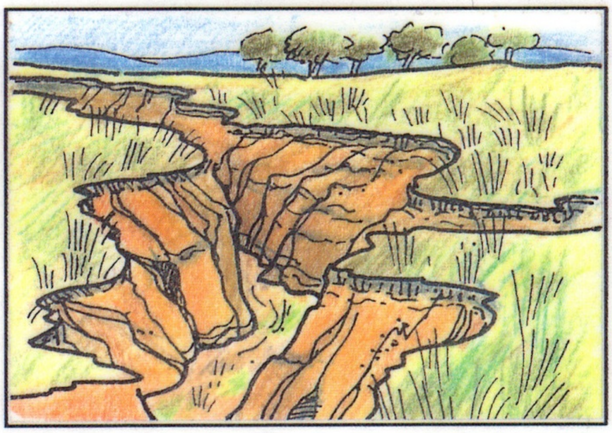
2. Drop several small lumps of dry soil into the water one at a time.



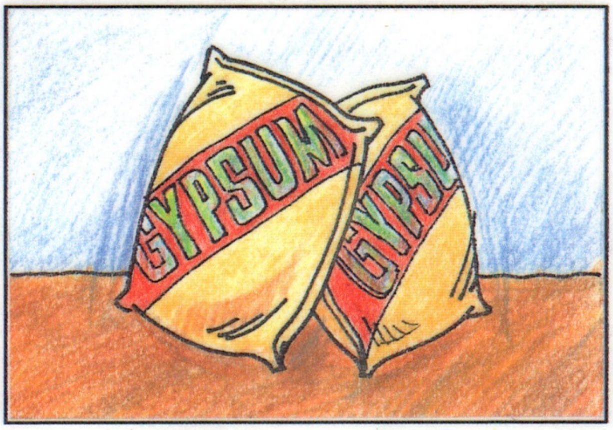
3. Check after 10 minutes whether the water around the soil has started to go cloudy. If it has, this means that the soil has started to disperse, and possibly indicates that the soil is sodic. Look again after 30 minutes, and again after 2 hours, to further check for cloudiness around the soil.



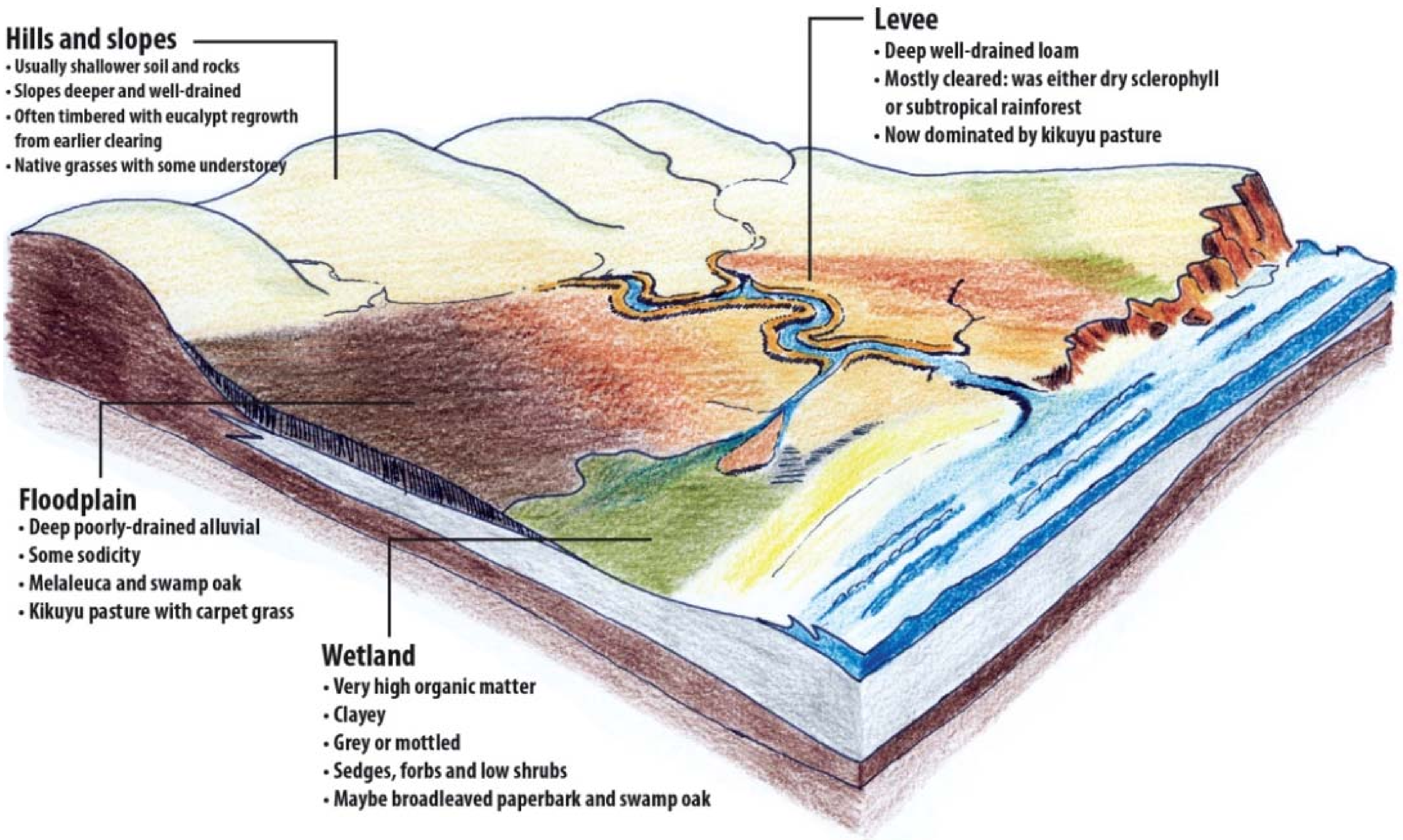
4. Sodic soil has sodium attached to the clay. When the clay is wet, the sodium attracts a water shell around each clay particle, preventing the particles from joining together. The separated (dispersed) clay particles make water look muddy or cloudy.



5. Sodic soil is a problem because it erodes easily. The individual clay particles are easily washed away by water, leaving huge gullies. The eroded particles settle into a hardsetting, crusted topsoil. It is difficult for water, air or plant roots to move through this soil.



6. Gypsum can help manage sodic soils in two ways. In the short term it provides a moderately saline soil solution which prevents dispersion. In the long term, the sodium in the clay is replaced with calcium from the gypsum. The calcium makes the soils less likely to separate into individual particles.


Hills and slopes
• Usually shallower soil and rocks
• Slopes deeper and well-drained
• Often timbered with eucalypt regrowth from earlier clearing
• Native grasses with some understorey
Levee
• Deep well-drained loam
• Mostly cleared: was either dry sclerophyll or subtropical rainforest
• Now dominated by kikuyu pasture
Floodplain
• Deep poorly-drained alluvial
• Some sodicity
• Melaleuca and swamp oak
• Kikuyu pasture with carpet grass
Wetland
• Very high organic matter
• Clayey
• Grey or mottled
• Sedges, forbs and low shrubs
• Maybe broadleaved paperbark and swamp oak