SOIL

It's Precious,
It's underfoot

Experiential Learning for School Students

RUSA SPONSORED OUTREACH ACTIVITY

SOPHIA COLLEGE FOR WOMEN
(Empowered Autonomous), Mumbai

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FOREWORD

Welcome to the wonderful world of soil! This activity book aims to inspire young minds to uncover the magic of soil and its importance in nourishing life - the very foundation of our planet's ecosystem. We should realize that 'Soil' is more precious than 'Oil'.

Through fun activities, games, and experiments, young readers will discover the fascinating science of soil, explore different textures and colours, meet the tiny creatures that live beneath, and learn about the water cycle, among other things. Children can create soil art and crafts to uncover its many wonders.

The play-way tone, simple language, and engaging illustrations make this book on 'Soil' an engaging read for young minds. Best wishes to the authors and readers!

Dr. Rita Mukhopadhya
Genomics Scientist and Educator
Former Scientist, Bhabha Atomic Research Centre

PREFACE

One of the most important resources on earth which we tend to overlook since its everywhere around us is ‘soil’. We often forget that soil is the living skin of our planet which has its own science. It combines physics, chemistry and biology. Science as you know is best understood by doing and not by reading. This manual is a compilation of simple experiments for middle school students, from classes 6 to 8, to understand the many characteristics of this amazing resource and appreciate the importance of preserving it for the future. All the experiments are designed to be performed using very simple, easy to find material that would be easily available in most schools or can be adapted using similar material even at home.

The teachers are encouraged to let the students understand through these experiments that there are no ‘correct results.’ Since soil varies from place to place the students should be allowed to explore, compare and draw their own conclusions based on their observations.

A unique feature of this manual is that it is written in a conversational style making science more approachable for the students. It is simple enough for the students to enjoy reading on their own and to explore further with the help of a teacher or parent.

The section ‘In conversation’ highlights the many important topics that are connected to understanding, valuing and appreciating the important role that soil plays in our life and why it is so important that we do not lose this very valuable life-giving resource.

These experiments will be demonstrated by students of Sophia College for Women (Empowered Autonomous) in a few local schools. Video recordings of these experiments being performed by the students will be available on the college YouTube channel for students of schools where live demonstrations are not possible.

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INTRODUCTION

What is soil?

To answer this question, Lyla, a young environmentalist in her teens, asked her group of young friends who called themselves 'Junior Scientists', to write down any one thing that would describe soil. Given below is what they wrote. Which of the following attributes do you feel are true about soil?

a. It is the top layer of the earth's crust.
b. Soil takes thousands of years to form.
c. Healthy soil contains minerals as well as organic matter.
d. It contains water too.
e. It helps anchor plants and supports their growth by supplying nutrients and water.
f. An incredible number of organisms live underground, inside the soil.

'Each of you is correct!' exclaimed Lyla.

'Believe it or not, soil enriches our lives,' said Lyla. To prove this, she led the Junior Scientists to a park where they were advised to walk barefoot.

'This feels really good,' said Richi.

'I feel connected to all those creatures that are living inside the soil,' said Bablu.

'Exactly,' said Lyla. 'This exercise of walking barefoot or 'earthing', not only strengthens our bond with Mother Earth but it also imparts a profound feeling of well-being. Unfortunately, we hardly get to see bare soil open to the elements, in our cities. Everywhere there is rampant concretization. But not so in the rural areas. It is a common sight to see the tribals there walking barefoot. This possibly increases their immunity too.'

History of Soil

'Shall we discuss the **history of soil**?' asked Reema.

'I was just about to do that,' said Lyla. 'Believe it or not, it takes about 100 to 500 years or more for an inch of topsoil to form.'

'That's cool! It means that the soil I am holding in my fist began forming when my great, great, great, great, great grandmother was alive!' proclaimed Richi.

'Yes indeed.'

'Our predecessors realized the value of soil,' continued Lyla, 'and in order to conserve this precious natural resource, they came up with the idea of establishing **sacred groves.'**

'What are sacred groves?' Reena looked puzzled.

To explain this, Lyla told the Junior Scientists **a story about Mother Earth being revered in different ways:**

'In the forests of India, there are several sacred groves. These are dense clusters of native trees where no one is allowed to cut even a single branch. People have to remove their footwear and walk barefoot in some of these groves. Each of these sacred groves is in reverence to a deity connected with Mother Earth. 'That is such an interesting bit of information,' commented Richi. 'I have begun to look upon soil in a different light.'

'So, soil has a history,' Richi quipped, trying to sound worldly wise.

'In fact, soil also serves as a graveyard for history,' Lyla added, amused by the puzzled expressions of the Junior Scientists.

'You mean the bones of prehistoric animals and the seeds of ancient plants that may have been buried in soil for millions of years?' asked Richi.

'Spot on!' clapped Lyla. 'Fossils of dinosaurs and other prehistoric creatures have been extracted by paleontologists from soil.'

‘What about the ancient coins and tablets buried under the rich soil along the banks of the River Indus?’ Richi proclaimed brightly. ‘That is how the history of the Mohenjo-daro and Harappan civilizations was discovered. That too is history, isn’t it?’

‘Brilliant!’ Lyla lauded. ‘I almost forgot about that.’

‘And now that we have immersed ourselves in this **brown gold - soil**, let’s look into its **Physics, Chemistry and Biology**,’ suggested Lyla.

‘Yippee!’ Rumi exclaimed exuberantly, performing a jig. ‘And we would also like to do some **experiments** related to the Physics, Chemistry and Biology of soil, please.’

THE PHYSICS OF SOIL

Covering the earth,

The textured soil,

Has physics of its own,

Well defined!

THE PHYSICS OF SOIL

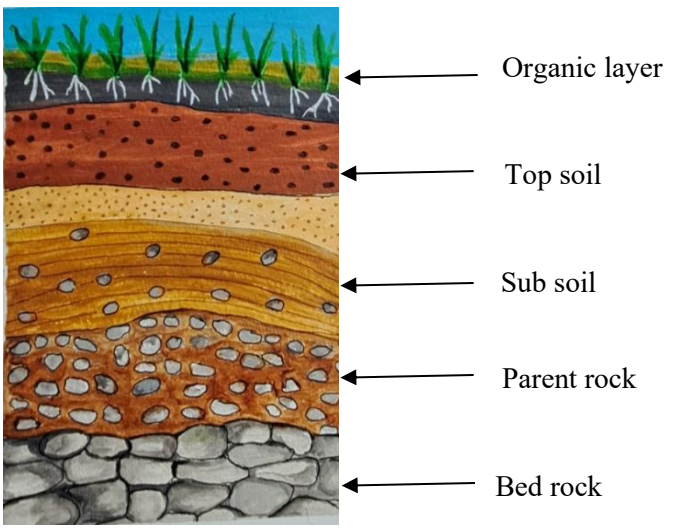
INTRODUCTION:

'**Soil has a 'profile!**' announced Lyla as she began her discussion on the Physics of soil.

'Where do you get to see the profile of soil?' Richi, ever curious, wanted to know.

'At a construction site, when the earth is dug deep, to lay the foundation of a building or where a well is being dug. The cut part of the soil shows up in different layers.'

Lyla led the Junior Scientists to a construction site.



'The topmost layer is the darkest,' Rumi observed.

'Yes, that is called the **topsoil**,' Lyla informed. The topsoil has humus which serves as good manure to the plants that grow in it. In fact, it is the topsoil which is the living layer, what with insects, crabs, snails and so many others in it.'

'I can even see the roots of trees in this topsoil,' Bablu pointed.

‘This topsoil is the most productive, that is why so many animals live in it and plants need it too.’

‘How, do you think, this topsoil is formed?’ Lyla quizzed.

‘Tell us, please, tell us its story,’ the Junior Scientists pleaded in unison.

‘By a process called weathering. Strong winds, temperature changes, constant movement of water over the rocks as in the case of rivers and ocean waves, cause rocks to break up. Even the roots of trees can cause rocks to crack up. Imagine yourself being taken millions of years back in time, when the earth’s crust of mere rocks was just formed. What a different earth that would be, with hardly any soil and no plants at all. Microbes and algae were the first living organisms to colonize this soil using the minerals in the rocks. As they lived and died, they added organic matter to the soil permitting other complex organisms to survive.

And there is yet another process that can produce healthy soil. Any guesses?’

The children all looked wide-eyed.

‘Here is the story. Have you seen and felt moss – the velvety green furry growth on bricks, walls and even tree trunks during the rains? It can be considered as a living fossil, as it was present millions of years ago, when other plants had yet to evolve. This moss has rhizoids to anchor it, not roots. Besides anchoring, the rhizoids help to absorb water and nutrients, but many also secrete acids which over a period of time, can dissolve rocks and produce soil!’

‘And that is not all, new soil is formed where mangroves grow. But that is another story. More about that under the section on Mangroves.’

‘But coming back to the soil profile, what about the layer below the topsoil? It appears lighter. Is it because it doesn’t contain humus as there are no earthworms to break down the dead plants?’ queried Reema.

‘Spot on! This lower layer of soil is the **subsoil** where living organisms are **not** found, but it contains minerals like silica, iron, chalk. The minerals vary from place to place. The subsoil also holds water.

Below the subsoil you can see the **parent rock**.

And much deeper is the **bed rock** which is extremely hard. It is from the parent rock that the upper layers of soil are formed.’

‘So now, may we perform some experiments, please?’

EXPERIMENT 1: Observing the components of soil

What you will require:

A fistful of soil

A transparent glass of water

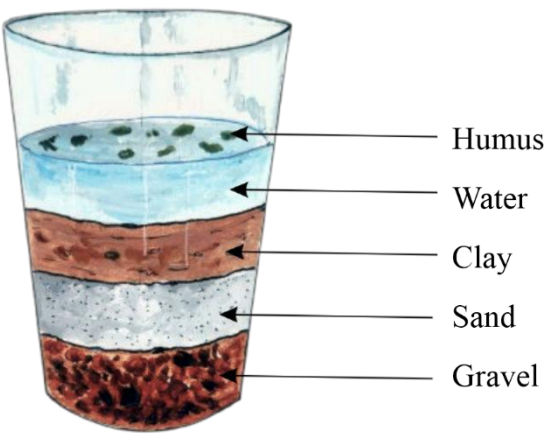
What you have to do:

Place the soil in the glass of water. Swirl it a bit, and allow it to settle.

What do you see?

Your Observations: Draw what you see in the glass.

Probable Observations:



The soil would have separated out into 4 different layers. The heavy particles of gravel would have settled at the bottom. Above that you would

see a brownish layer of sand, and above the sand will be a darker layer of clay, since clay particles are lighter than sand.

Right on top would be clear water with some very tiny leaf pieces floating on it. The leaf pieces are the organic matter in soil, the humus which the earthworms and millipedes and others produce from dead leaves. So, you get to see nature's laboratory here in this glass!

Were your observations different from the expected one? If yes, think why it was so!

FOR THE TEACHERS: The above experiment can be repeated with different samples of soils taken from different places, e.g. beach, mangroves, garden, forest and the school compound.

NOTES AND THOUGHTS:

EXPERIMENT 2: Testing the heating capacity of different types of soil.

What you will require:

Equal quantities of different soils, sand, silt, clay and loam, in 4 small pots (you can also make your own pot out of recycled plastic by using the cut base of a plastic bottle). Try and keep the same amount of soil in each pot using a cup to measure.

One thermometer

What you have to do:

Insert the thermometer in the 4 pots kept indoors to exactly the same depth and note the temperature of each. They should all show the same temperature.

Next, all 4 pots need to be put out in the sun for 1 hour.

Again, insert the thermometer to the same depth. Note the temperature in each.

Your Observations: Note down your observations in the following table (the type of soil label can be changed depending on what is used):

Type of soil / Temperature	Sand	Silt	Clay	Loam
Temperature indoors				
Temperature after 1 hour in the sun				
Difference in temperature				

Which soil sample got heated the fastest? ……

Which soil sample got heated the slowest? …….

Why do soils get heated to different extent? Discuss with your teacher.

Does the presence of moisture in the soil control its heating capacity?.....

Have you ever experienced walking barefoot on the beach during the afternoon when the sun is overhead? How did the sand feel? ……..

Would it feel just as hot if you walked barefoot on other types of soil like silt or clay at the same time, when the sun is overhead? ……..

NOTES AND THOUGHTS:

EXPERIMENT 3: Comparing the permeability of different types of soils.

What you will require:

Three transparent plastic cups / cut plastic water bottle of equal length

Three larger cups / glasses to hold the above

Three different types of soils - sandy, loamy and clayey

A watering can filled with water

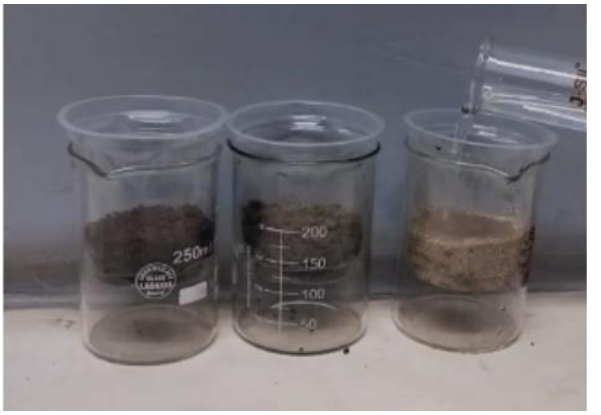
What you have to do:

Make holes at the bottom of the smaller plastic cups.

Fill up half of each cup with equal amounts of sandy, loamy and clayey soils respectively.

Keep these cups in the larger cups.

Pour water into each of the 3 cups to the same height and measure the time it takes for the water to drain out into the larger cup



Your Observations

Measure the time taken for water to drain out or note the amount of water collected in each of the larger cups after a fixed time

	Type of soil	Time taken for water to drain out	OR	Amount of water collected in larger cup after a fixed time
Cup 1				
Cup 2				
Cup 3				

Which soil allowed water to drain through it fastest? …….

Which soil took longest for the water to drain through it?.....

Probable Observations:

Sandy soil will allow the water to drain fastest as it is the most permeable. Clayey soil is the least permeable. This is why paddy is grown in clayey soil, as it requires to be standing in water while growing.

The loamy soil, you will find, gets the second rank, allowing water to drain through it, neither very quickly nor very slowly.
Water through silt (mixture of sand and clay) takes more time than sand but less time than clay.
Water through loam (mixture of sand, clay and silt) takes slightly more time than silt.
So, you see, different crops require different soils as their needs are different.

- Wheat and gram grow best in a mixture of clayey and loamy soil but not standing in water like paddy.

- Lentils and pulses require plain loamy soil.
- Where there is black loamy soil, cotton is grown.

FOR THE TEACHERS: Game to demonstrate permeability of different types of soils (Classroom activity). Please check in the last section, 'In conversation'.

Factors that determine permeability: Discuss with students

- Particle size: Coarse grained soil has higher permeability than fine grain such as clay.
- Void ratio: Permeability increases with higher void ratio, that is the ratio of void space to solid particles.
- Impurities in soil: Particulate impurities may clog the pores and decrease the porosity.
- Degree of saturation: The permeability will reduce if there are air pockets in the soil.
- Adsorbed water: Clay particles can hold a layer of adsorbed water on its surface which reduces the void area for passage of water.

NOTES AND THOUGHTS:

EXPERIMENT 4: To show how plants prevent soil erosion

What you will require:

Some grass scooped out along with the roots and surrounding mud

Two identical trays

What you have do:

Fill both trays with some soil.

In one tray transplant the grass with its roots and clinging soil, dabbing it in carefully.

Wait for three days, for the roots in the tray to settle.

Pour some water in both tray on the next two days.

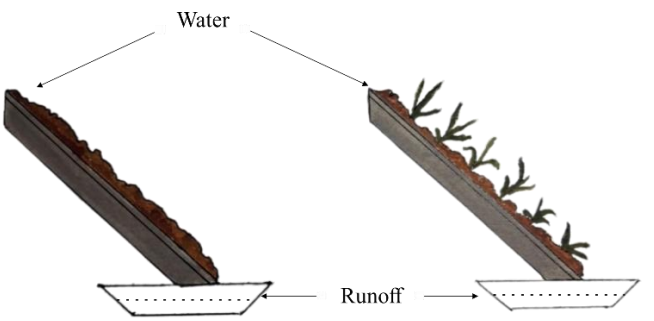
Pour very little water in both trays on the third day.

On the fourth day, tilt both trays at an equal angle over the sink and simultaneously pour water, very gently, from a watering can.

Your Observations:

Was the run off from the tray with the grass clear water?……..

Was the run off from the tray without grass muddy?…….



Draw the colour of the run off in each case. Can you explain why there is a difference in run off from the two pans? Think, think!

FOR THE TEACHERS:

The reason that grass/plants reduce soil erosion is that the roots bind to the soil particles and physically prevent them from getting washed out. In addition, the foliage reduces the impact of the rain water directly on the soil so that water can get absorbed instead of draining away.

NOTES AND THOUGHTS:

EXPERIMENT 5: Mapping the soil.

What you will require:

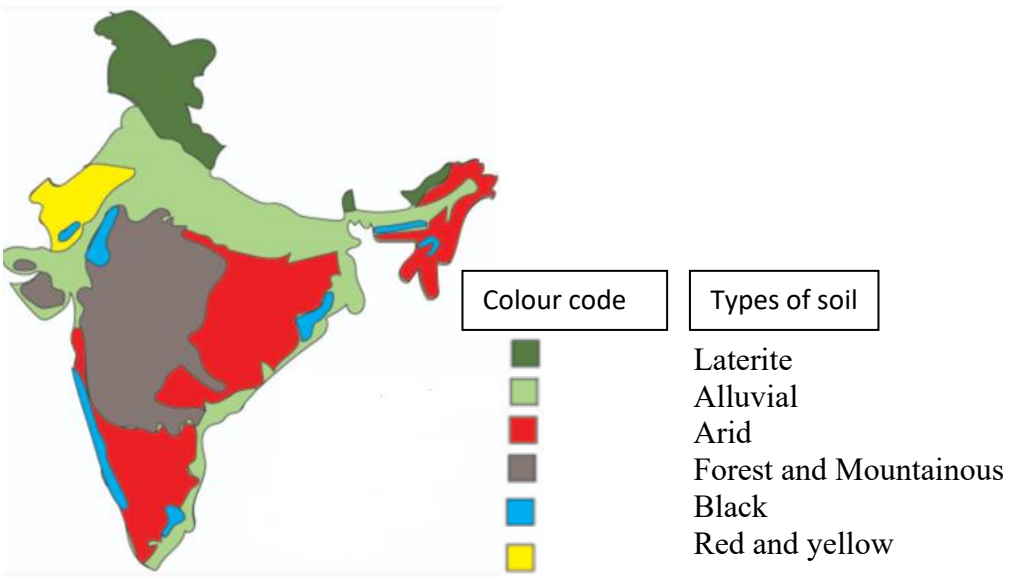
A map of India which had been marked according to the different types of soils found in different regions.

What you have to do:

Using the map mark the following types of soil found predominantly in each region by matching the column of colour code and type of soil.

a) Mountainous and forest soil b) Alluvial soil c) Laterite soil d) Black soil e) Arid soil

Your Observations: Match the correct soil type with the colour code provided on the Map of India using geographical information you know.



https://currentaffairs.adda247.com/major-soil-types-of-india-map/

EXPECTED OBSERVATION: *Check the answer at the end of the book*

FOR THE TEACHER: Discuss the following with the students:

Arid soil: Is dry and not fertile at all; its natural flora consists of cacti and scrub. They can support the growth of climate smart plants like millets and barley.

Alluvial soil: Is most fertile and supports tall grass interspersed with trees.

Laterite soil: Exists as a shallow layer on plateaus and mountain slopes and can support ground hugging plants only.

Mountainous soil: Varies depending on the environment. Upper slopes are often rocky while lower slopes and valleys may have more fertile loamy soil.

Black soil: Is fertile and can hold moisture. It can support the growth of cotton, millets and a number of fruits.

NOTES AND THOUGHTS:

THE CHEMISTRY OF SOIL

Salts of all kinds,
In the soil you will find,
Its richness, its quality,
Soil Chemistry defines!

THE CHEMISTRY OF SOIL

INTRODUCTION

`Now that we have had fun learning about soil physics, we are looking forward to immerse ourselves into **soil chemistry**,' Richi told Lyla one day.

'Actually, the chemistry of soil varies depending on its location and how it was formed. Also, since different rocks are made of different chemicals, these could affect the quality of the soil,' Lyla told the Junior Scientists.

'What about the fragrant aroma that soil gives off after the first showers of rain?' Reema shot the question.

'That heady aroma which uplifts our spirits is called petrichor, released by certain bacteria in the soil, The petrichor released by soil is due to the chemical geosmin secreted by soil bacteria called Actinobacteria. When water drops fall on a porous surface it traps tiny air bubbles. These bubbles shoot upwards and burst, releasing an aerosol spray containing the chemical geosmin into the air, which then reaches our nose."

Lyla informed the group. 'The release of petrichor is also a signal to animals living in and around the soil to adjust their life cycle behaviour to the seasonal changes.'

'Does that mean that different organisms living in the soil are also responsible in determining its chemistry?' asked Bablu.

'Spot on!' exclaimed Lyla. 'We shall discuss how these organisms affect the chemical nature of soil when we tackle the biology of soil later.

EXPERIMENT 1: Review of literature to find out chemical composition of each type of soil.

What You will require:

Books on soil

Internet connection

What you have to do: Complete the observation table on the basis of survey of literature you do using books and internet.

Your Observations:

Soil type	Chemical composition
Laterite	
Volcanic soil	
Black cotton soil	
Clay	
Sand	

Expected Observations:

Check the answer at the end of the book

FOR THE TEACHERS:

Look out for types of soil around you for students to observe

NOTES AND THOUGHTS:

EXPERIMENT 2: To determine the acidity or alkalinity of different soil samples.

What you will require:

Soil samples from different areas

Tiny pots (the cut base of plastic water bottles would also do)

A water spray

Strips of universal indicator

What you have to do

Collect different samples of soil from different places.

Small amounts of these soils can be placed in tiny pots, and sprayed with water to moisten them.

Insert universal indicator strips in each pot and note the pH of each sample and record it in the table below.

Acidic…….……Alkaline

Your Observations

Type of Soil	No. 1	No. 2	No. 3	No. 4
pH				

Do you think the pH of soil affects the growth of plants? …….

…… ….

Do you think pH controls the colour of vegetables …….

Have you ever been to the vegetable market and wondered why some cabbages are green while there are other cabbages which are purple and even reddish in colour?

Interesting!

Cabbages have a pigment called anthocyanin in them. When the cabbage is grown in acidic soil the pigment takes a red colour. In soil with neutral pH it remains purple while it turns yellowish green in alkaline soil.

FOR THE TEACHERS:

What is pH?

pH is a measure of the acidity and alkalinity of a solution. It is the measure of Hydrogen ions (H^+) concentration. The pH scale ranges from 0 to 14. Every step is not simply an increase in the concentration. Every step means 10 times more or less H^+. Acidic solutions have more H^+ while alkaline solutions have less. Water is in the middle and is neutral. The lower the pH value number the more acidic is the solution since pH = - log [H^+].

Some everyday examples are

pH	H^+ ions relative to pure water	Example
1	1,000,000 times more	Stomach acid
3	1,000 times more	Vinegar
7	Balanced (neutral)	Water
9	100 times fewer	Baking soda
13	10,000,000 times fewer	Bleach

Making your own pH indicator: Take red cabbage and grind or boil in minimal water. Strain the fluid using a muslin cloth to get a clear solution. Take small pieces of filter paper and dip in this solution. Dry the paper completely and you have your own pH indicator papers.

NOTES AND THOUGHTS:

EXPERIMENT 3: Determine if a sample of laterite soil has magnetite properties.

What you will require:

Sample of laterite soil

A bar magnet

A sheet of paper

What you have to do:

Spread a thin layer of the soil sample on the sheet of paper

Pass one end of the bar magnet gently over the soil

Your Observations:

Did the soil particles jump and cling onto the magnet? …….

Draw a sketch of your results.

Probable observations:

The soil particles may or may not jump on to the magnet.

Some laterite soils contain the oxide of iron hematite (iron (III) oxide), which is non-magnetic while other laterite soils contain magnetite (iron (II, III) oxide) which, as the name suggests, is magnetic.

If the soil jumps to the magnet, it contains iron oxide magnetite. If not, then your sample may be containing hematite which is also iron oxide (iron (III) oxide) which is not magnetite.

NOTES AND THOUGHTS:

EXPERIMENT 4: To demonstrate the different metallic ions in soil through a flame test.

What you will require:
Different soil samples (very small quantities)
A Bunsen burner
Some dilute hydrochloric acid
A clean wire (like a nichrome wire loop)
Some borax/boric acid

What you have to do:
Dip the wire loop in the hydrochloric acid and then rinse it to ensure no impurities are adhering to the wire.
Rinse it in distilled water.
Make a tiny loop at one end of the wire.
Dip the loop in borax/boric acid and heat it in the Bunsen flame till it turns into a transparent bead.
Touch the hot bead to the soil sample and re-heat in the outer, hotter part of the flame (the blue part).
Note the colour of the bead.

Your Observations: Each metallic ion shows its own characteristic colour in the flame.

On the basis of the colors you observed note below the elements present in the soil sample

No	Soil type	Colour of flame	Metal present
1			
2			
3			
4			
5			
6			

Probable Observations: Note these colours of different elements that could possibly be present in the soil sample.

Orange-red – Calcium
Persistent yellow – Sodium
Green – Barium
Bright red – Strontium
Blue-green – Copper
Deep blue – Cobalt
Yellowish-brown – Iron

FOR THE TEACHERS:
A simple qualitative test to detect metals in a sample is the flame test, though not all metals emit color. The principle of the test is that when metal ions are heated, they gain energy and shift to higher energy levels. However, they are unstable at this new energy level and return to the lower energy level by releasing energy in the form of light. Each metal gives out a characteristic light which helps identify the metal. Use of goggles is recommended during this experiment.

NOTES AND THOUGHTS:

EXPERIMENT 5: Exploring the effect of adding 1. Banana peels 2. Crushed egg shells to the soil of potted plants.

What you will require:

Four pots / cut base of plastic bottle with equal numbers of freshly sprouted beans and the same type of soil

Banana peels

Washed egg shells

What you have to do:

Begin by taking photographs of all 4 plants.

Dry the banana peels for a day or two.

Chop them into small pieces.

Crush the egg shells into powder.

Place the chopped banana peels on the soil of one plant, the crushed egg shells in another plant, both banana peels and crushed egg shells in the third plant. The fourth plant will have neither banana peels or crushed egg shells.

Keep all four plants in sunlight and water daily.

Take photographs of all four plants after 2 weeks and compare the growth by measuring the shoot length and leaf formation.

Your observation

	Observation
Control plant	
Plant + banana peel	
Plant + crushed egg shells	
Plant + banana peel + crushed egg shells	

FOR THE TEACHERS: The banana peel acts as natural fertilizers by supplying important nutrients to the plants such as potassium, phosphorus and calcium that improves root development and flowering. Calcium from the egg shells prevents plant rot and also neutralizes any acidity in the soil. Other kitchen waste, like onion and potato peels and the green stems of coriander which would normally be discarded, can also fertilize the soil and boost plant growth.

This experiment can be done as a project with the class.

NOTES AND THOUGHTS:

EXPERIMENT 6: Demonstration of soil acting as a natural filter for impurities.

What you will need:

Some sand, gravel and soil samples

Dirty coloured water (tea or diluted food dye)

Column or funnel

What you have to do:

Layer first the gravel, followed by sand and then soil in the column / funnel. Pour the coloured water slowly over this column and collect the filtrate. Check for the clarity and colour of the filtrate.
(If you want to see which of these layers performs which function then the 3 materials should be put in 3 different funnels).

Your observation:

Probable Observation:
You will see that the filtrate appears clear and the colour is lost. Can you explain why this happens?

FOR THE TEACHERS:

The filtrate will look clear because the gravel and sand will physically block large particles from flowing through. It will also have lost most of the colour.

This is due to a phenomenon called adsorption. Organic particles and dyes stick to the surface of the soil particles and do not flow through. Fine clay and organic carbon in the soil provide charged surfaces to which dissolved and colloidal organic material will also bind.

NOTES AND THOUGHTS

THE BIOLOGY OF SOIL

In the ecosystem of the soil

Many life forms make a home

Each with a Biology of its own!

THE BIOLOGY OF SOIL

INTRODUCTION:

There are many organisms that play a role in keeping the soil healthy. Of these the earthworms are very important. 'You will be amazed to know this,' Lyla told the Junior Scientists one day 'that productive soil can contain up to a million earthworms per hectare. Earthworms make tunnels in the soil helping to mix it, create air spaces and allow water to seep in. They also eat the dead plant material which is broken down by their digestive system. The cast excreted is rich in nutrients like nitrogen and phosphorus that acts as a natural fertilizer for plant growth.'

'Wow! I will now look upon earthworms with renewed respect,' declared Richi very solemnly and Lyla broke into laughter.

'Now that we are going to look into the biology of soil, may we please begin with an experiment?' pleaded Reema.

'Of course, would you Junior Scientists like to play the role of earth detectives?' asked Lyla, amused by their bright-eyed, eager faces.

EXPERIMENT 1 – Becoming an earth detective.

What you will require:

A measuring tape

Some string

Equal-sized sticks as pegs

Notepad and pencil

What you have to do:

Mark out a square quadrat, five feet by five feet in an open unconcreted area, using the string and the pegs. Note down the organisms you observe in the quadrat.

Repeat this in different areas.

Your Observation: List and draw the organisms you observe**.**

Probable Observations:

In addition to the organisms you see, you may come across some intriguing stories in each of the different quadrats. Here are some possible observations:

- A funnel-shaped, coin-sized depression in dry, sandy soil which is actually a trap made by the larva of an antlion who is waiting inside for an unwary ant to tumble in and provide the antlion its next meal.
- A wasp dragging a spider that has been paralyzed by her venom. The spider is pushed into her burrow to serve as ready food for her babies that hatch inside.
- The hard, dried-up woody pod of a Wild Almond tree, caked in mud, but when you gently shift it with a stick, you see several off-white termites who have created that muddy covering on the pod. This is how they begin decomposing the pod. Ultimately, all of the pod will turn into soil.
- You may see a lot of leaf litter which when playfully shifted with a stick, will reveal a snake-like creature with legs – a skink.
- These are only some of the many macrofauna around soil.
- There are other smaller creatures that can only be seen through a microscope, the microfauna.

FOR THE TEACHERS: Encourage the students to be observant. The observations may depend on the type of soil. Encourage the students to draw the observations.

NOTES AND THOUGHTS:

EXPERIMENT 2: **Detection of respiration of microorganisms in soil.**

What you will require:

About 100 g of soil samples collected from different areas, in paper pouches

2 Plastic jar with airtight lids

2 small tubes

Lime water (prepare saturated calcium hydroxide solution and then decant the clear liquid from the top) / Or

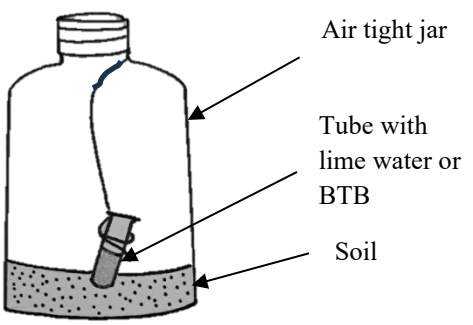
A solution of bromothymol blue (BTB) (made by dissolving about 10 mg / 100 ml of water. Adding 1 – 2 drops of sodium hydroxide makes the solution clearly blue so that the colour change is easily visible)

Thread

What you have to do:

Put about 100 g of soil in one jar and moisten it. The other jar is without soil (or you can take soil that has been sterilized by heating.)

Put 10 ml of lime water/ BTB in the 2 tubes and hang them in each of the jars as shown in the diagram below. The jars should be stoppered and sealed to make them air tight.



Keep the jars in a warm area or in a water bath at 30ºC for quicker results.

Your observation:

What happened to the limewater / BTB solution?

Probable Observation:

The lime water turns milky. The living microorganisms respire by taking in oxygen and releasing carbon dioxide (CO_2) to produce energy. The released CO_2 reacts with the lime water as shown in the following reaction to give calcium carbonate ($CaCO_3$), which is a white precipitate and makes the lime water turbid or cloudy.

The carbon dioxide is released due to respiration of soil microorganisms. The following equation represents the reaction.

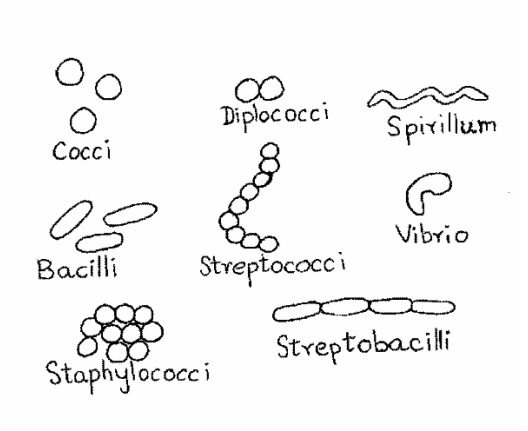
$CO_2 + Ca(OH)_2 \rightarrow CaCO_3$ (white precipitate) → causes the limewater to turn milky/cloudy

If bromothymol blue is used the colour will change from blue to green to yellow.

- **Blue** at pH > ~7.6
- **Green** near neutral
- **Yellow** below ~6

CO_2 from soil dissolves in water → forms carbonic acid → pH drops → colour changes.

FOR THE TEACHERS: The following microorganisms are often present in the soil which cannot be seen with a naked eye. However, their presence can be proved indirectly by measuring their respiration as suggested in this experiment.



NOTES AND THOUGHTS:

EXPERIMENT 3: Observations on rate of germination of peas/mung in different types of soil

What you will need:

Some green peas /mung beans

Equal quantities of clay, loam, sand and silt soil

Four small pots (the cut base of plastic water bottles may be used, with a hole at the bottom)

What you have to do:

Place the 4 different soils in each of the 4 pots.

Insert 4 to 5 seeds in each of the pots.

Water the seeds mildly and place in the sun.

Note the changes that take place on each day, for at least 15 days.

Your observations:

Sketch, take pictures and measure the height of the sapling on each day.

Also note on which day the a) cotyledons appear, b) the first leaves appear.

DAYS	OBSERVATIONS
1	
2	
3	
4	
5	
6	
7	

8	
9	
10	
11	
12	
13	
14	
15	

Make your inferences about which soil is the best for growing the seeds.

FOR THE TEACHERS:

This experiment can be considered as a group project.

NOTES AND THOUGHTS:

EXPERIMENT 4: Observations on the formation of compost from dead leaves by detrivores / decomposers

What you will need:

2 pots (or cut base of plastic water bottles) with a tiny hole in the bottom

Healthy soil in each

Vermicompost

6 equal sized dead leaves

What you need to do:

Add some of the vermicompost to the soil in one of the pots only.

Embed 3 leaves in each of the pots.

Sprinkle water in each of the pots to keep the soil moist, for 10 days.

Your observations: Note carefully the difference between the status of the leaves in the two pots. Have they decomposed?

Draw what you see on the 10^{th} day after setting up the experiment.

Probable Observations:

Note the difference in the 2 pots: the pot containing leaves but no vermicompost may still have the undecomposed dead leaves in it but the pot that had vermicompost will have no leaves left.

FOR THE TEACHERS: The experiment could be done as a Group project.

NOTES AND THOUGHTS:

IN CONVERSATION

The more we discuss
The more we learn.
Gossiping about science
Is nothing but fun

Some interesting and Important Facts about Soil

'There are several very interesting stories about soil' Lyla got the Junior Scientists together one day.

'We would love to hear them all,' cried the Junior Scientists in unison.

'May be not all but I will tell you some that I think you will find interesting,' continued Lyla.

'While carrying out the experiment to observe the microfauna in soil, you must have observed fungal mycelia,' she told the Junior Scientists.

'But what are mycelia?' Reema wanted to know.

'They are long strands of fungal hyphae that form a mesh. They cover miles and miles of soil. And what's more, they are entangled around the roots of trees too.

'This seems like something out of a science fiction book,' Richi commented. 'But it's true, the fungi pass messages from one tree to another. Thus, the many trees in a forest form what is known as the Wood Wide Web (www)

‘Indeed, nature can be stranger than fiction,’ Reema commented.

‘The fungi help pass messages by secreting certain chemicals’, Lyla continued with her story. ‘For instance, new seedlings may not grow healthily if in the shade of other trees. If there happens to be a mature tree nearby, sometimes called a `mother tree’, it sends its own nutrients into the soil for the benefit of the baby seedlings. By doing so, the mother tree may deplete its resources and at times may even die.’

‘A story most intriguing’ was Richi’s conclusion.

‘There is yet another fascinating story,’ Lyla told the children.

‘What’s that?’ they all asked, with mounting curiosity.

‘Soil serves as a safe deposit vault for thousands of seeds. That is why soon after the first showers of rain you see tiny specks of green raising their little heads, on the ground – the seeds that were lying dormant all the while suddenly awaken, and germinate, after receiving the magic touch of rain droplets.’

‘I just can’t stop marveling at all the secrets that soil has inside it,’ Richi waxed eloquent.

The Secrets of Natural Farming

By now, the Junior Scientists were most convinced about soil being a very precious natural resource. So, Lyla took them to Bhimji’s farm during her holidays. Bhimji’s methods of farming were very different – he practiced **natural farming,** which meant **interfering as little as possible with Nature.**

They were most intrigued by the lush, dense growth of fruit trees, other native trees, interspersed with Tulsi plants and even crops such as millets. ‘Growth of such healthy fruit is due to maintaining a healthy soil through natural farming!’ remarked Lyla.

The kind old man took them around his farm, imparting many useful tips on the way.

'You see,' Farmer Bhimji told them, 'I never till the soil since that would break the delicate fungal mycelia inside the soil and also, it could damage the many burrows and homes of underground creatures as well as the delicate root hairs of plants. In fact, many rural tribes also do the same as they believe that soil is one of the most valuable components of Nature. To till the soil would mean scratching Mother Earth.'

'But why do you grow so many Tulsi shrubs around the periphery of your field and also among the crops, Farmer Bhimji?' Richi asked, looking puzzled.

'Tulsi can retard the reproductive process of pest insects that destroy plants,' was the answer.

'What about all these weeds?' Richi shot her next question. 'Don't you remove them?'

'I don't find it necessary at all. The weeds are actually seasonal plants which ultimately dry up and get decomposed, serving as green manure to the soil,' Farmer Bhimji replied calmly. 'What's more, I do not grow the same crop year after year, I believe in **rotating crops of different varieties** in my fields. This is because **monoculture would exhaust the soil of nutrients** and make it ineffective to support good, healthy crops in the long run. By rotating different species of crops, the soil gets to recover whatever nutrients had been absorbed by the roots of the previous crop.'

'That is so clever of you, Farmer Bhimji!' all four children exclaimed, while Lyla smiled from ear to ear.

Companion plants

'Talking of manure,' Bhimji continued, 'as you can see, my fruit-bearing plants are interspersed by vines of pulses. The roots of these leguminous plants have in them certain bacteria that can convert the nitrogen in the air spaces in the soil into nutrient-rich nitrates.'

‘That means the pulses are companions of your fruit plants!’ concluded Rumi. ‘And these companions are ensuring that your fruits grow healthy too by providing nitrates!’

Farmer Bhimji’s eyes twinkled smilingly.

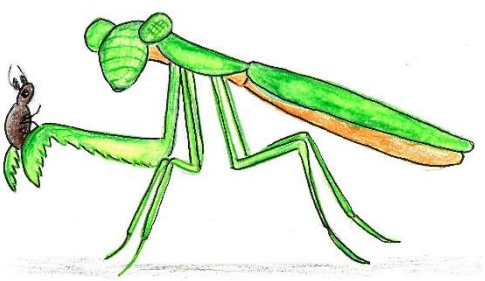
‘Just look at the size of those tomatoes and there – the custard apples!’ added Lyla.

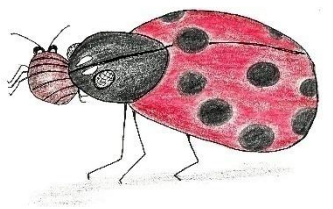
Farmer Bhimji pointed to the dead leaves that went ‘crunch, crunch’ under their feet as they walked. ‘Nature provides so much manure in the form of dead leaves and twigs which decompose, recycling the elements into the soil,’ he commented. ‘In fact, after harvesting my crops, I **do not burn the stubble**. The stubble serves as mulch, protecting the soil from losing its humidity and later even this mulch decomposes, returning its nutrients back to the soil.’

The children became thoughtful for a while, taking in all that Farmer Bhimji had mentioned.

‘But what if, in spite of all those Tulsi Plants, your farm gets invaded by some pests?’ Bablu suddenly blurted. ‘Would you use pesticides then?’

‘Any form of chemical pesticides is absolute **TABOO** on my farm. The chemicals get leached into the soil making it poisonous. This same poison would then get absorbed by the roots of my plants. It would be present in the milk of my cows who browse on the weeds and grass. Nature has its own living pesticides – Praying Mantids, Ladybird Beetles, Garden Lizards, Frogs – they all feed on the pest insects!’





Indeed, the Junior Scientists were most intrigued by all of Farmer Bhimji's ways of natural farming. 'We want to have our own natural farm one day,' Richi announced as they bid Farmer Bhimji goodbye and left for home.

Soil and Climate Change

'Healthy Soil can play a great role in mitigating climate change,' Reema read in a book on 'Soil' one day. 'What does soil have to do with climate change?' wondered Reema.

'Soil is a huge reservoir for carbon sequestration,' said Lyla. 'This means that when trees are cut, the carbon dioxide absorbed by trees and stored in the soil is released into the air. Carbon dioxide is one of the chief greenhouse gases that are responsible for global warming.'

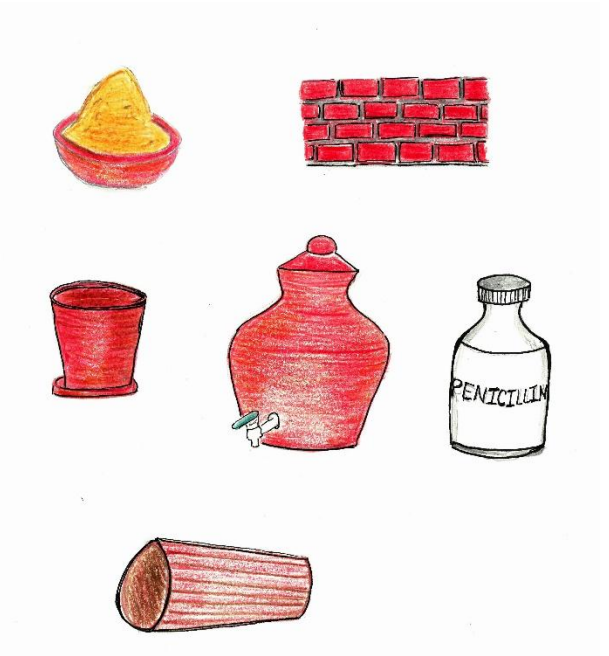
'You mean, taking care of soil and protecting its fertility would ensure that a good amount of vegetation would grow and that in turn, would help the planet to cool down and absorb more water, channeling it into the soil,' Richi spoke her thoughts.

'Brilliant!' exclaimed Lyla. 'The healthier the soil, the more the biodiversity it can support, and the greater its ability to mitigate climate change. It's a vicious circle – owing to climate change, there are floods, landslides, soil erosion and water logging. These can have a negative impact on the soil'.

'So, we must maintain healthy soil to ensure a healthy planet,' concurred the Junior Scientists.

The Many Uses of Soil

Besides growing plants, Lyla told the Junior Scientists, we use soil in a number of ways. Some of them are shown here in this illustration. Can you label each illustration? The list below is given in a jumbled order.



Bricks, Multani Mitti, medicines like Penicillin, clay pots for growing plants, a mandar, matka for drinking water.

The children managed to label all of the illustrations correctly. Can you think of any more uses?

'Now I have to tell you about something that might amaze you,' said Lyla. 'Many animals enjoy feeding on soil.'

'Have you seen animals tasting mud? Have you come across several butterflies gathered in a damp patch of mud, with their straw-like proboscis extended, as though sucking the juices from the soil? Those butterflies are actually **mud-puddling.** Do you find that mind-boggling?

Butterflies, especially male butterflies, tend to suck sodium salts and some other nutrients from wet mud. These salts improve their virility. Also, they transfer some of these salts to the female butterflies when they mate to help them produce healthy eggs.

‘In fact, many herbivorous animals too are able to identify places in the wild that serve as salt licks – they too lick the soil,’ Lyla continued.

‘This is because the soil in certain areas has many minerals that help build up strong bones and muscles. Elephants, deer, gaur and other herbivores go crazy when they come across salt licks,’ Lyla concluded.

Wetlands, most special

One day, Lyla led the Junior Scientists to a marshy area, where the sea met a creek, during low tide. ‘This is a Wetland,’ she told them. ‘Wetlands, as the name suggests, are those regions where water plays a primary role in controlling the animal and plant life. Mangroves, marshes, mudflats, are all wetlands.’ To their great delight, they got to see several marine marvels in and around the pools of water - like Fiddler Crabs, Hermit Crabs, Sea Anemones, Squids and even octopuses. There was a thick patch of mangrove trees.

‘Do you see how the mangrove trees here have roots growing upwards straight out of the mud?’ declared Lyla. ‘This is because the soil is very slushy and water-logged so these pencil-like roots breathe air from above the ground.

‘Mangroves also produce dense entanglements of cable roots and stilt roots which trap the sediments brought in by the sea or river during high tide,’ Lyla continued.

On returning home, Richi looked up wetlands on the net and got inspired into composing the following rhyme:

Wetlands – a combination of water and land

Find them confusing? Then go through this rhyme!

Depending on their location and climatic situation

They’re of various types, you will soon understand.

Bogs** have freshwater containing **peat

Which is plant matter decomposed partially.

***Swamps** are predominantly forested,*

*While **marshes** are home to grasses*

***Mudflats** or **tidal flats**, all coastal **wetlands**,*

Have sediments brought here, by tides or rivers grand.

So now you will surely agree,

wetlands – though diverse may be

Are nothing but miracles of Nature,

Each having their own unique features

'Bravo!' applauded the other Junior Scientists and Lyla, on hearing her recite it the next day. 'That was really cool,' Rumi had the last word.

Permafrost

'Today, I will tell you the story of another kind of soil that can take you back in time,' Lyla announced to the Junior Scientists the next day – '**permafrost.** It is soil comprising of sand, gravel and ice, that has remained frozen for thousands of years. At least for a minimum of two successive years. Its depth may vary from 1 meter to 1000 meters. About 22.8 million sq km of the northern hemisphere is permafrost. It has within it, microbes, partly decomposed organic matter and fossils too.'

'But isn't the permafrost melting everywhere owing to global warming?' enquired Reema. 'True. It is melting, and releasing methane from the partially decomposed organic matter that was earlier trapped inside. Methane being a greenhouse gas, can, in fact, aggravate global warming.'

Playtime with soil:

'Now that you have learnt and experienced so much about soil, we can play some games,' declared Lyla one day.

'Yippee!' exclaimed Bablu, dancing a jig. 'Which game? What game?'

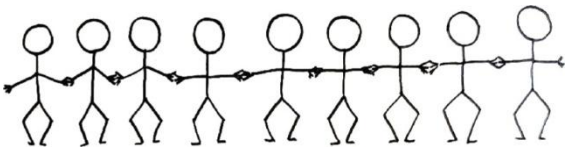
Game 1: Soil permeability to water

Lyla looked thoughtful. 'Let's play a game of **soil permeability to water**. But we need twelve children for this.'

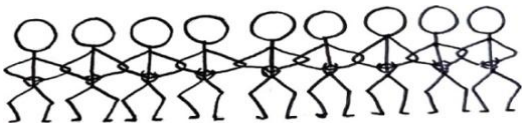
'Not to worry, we shall go call some of our friends,' said Richi. The four Junior Scientists ran in different directions and came back in a jiffy, with eight of their friends who were just as excited for the game.

'Now,' said Lyla, 'I want nine of you to stand facing the same direction with your fingertips touching, to represent **sand**. Two students who are not in the line can opt to represent water – they have to pass through the spaces between the children who represent sand. The last student plays the role of timer, measuring how long this takes, using a stop watch.

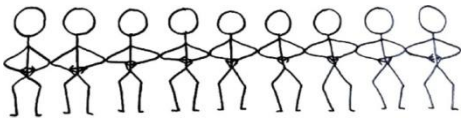
Sand



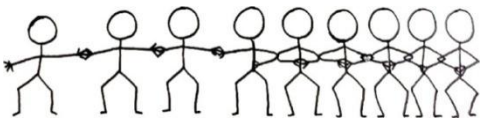
Clay – The above game was repeated but this time the 9 students had to stand with arms intertwined



Silt – Once again the game was repeated with students standing with hands on hips, and only elbows touching.



Loam – Since loam is a mixture of all 3 types, some students had to stand with finger tips touching, some with elbows touching, and some with arms intertwined. The 2 students representing water had to pass through the spaces again.



In which case would the 2 students representing water be able to pass through quickest?.....

In which case would the 2 students representing water be able to pass through slowest?.....

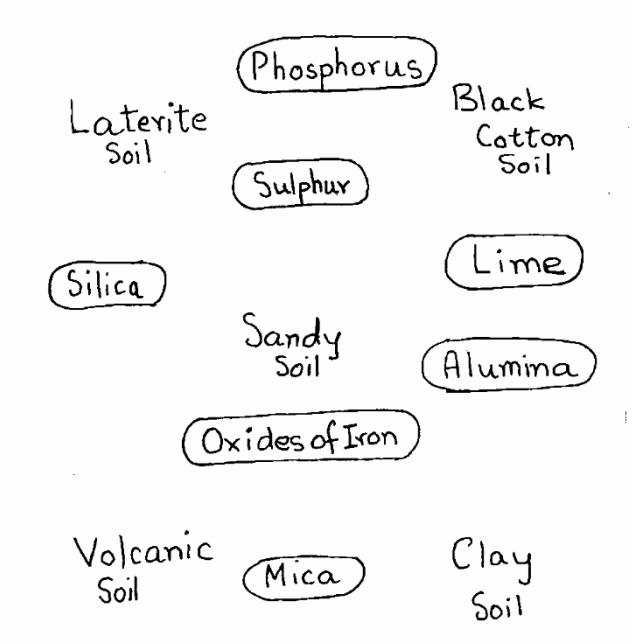
Game 2: Revisiting Types of soil

Lyla produced samples of 1. Laterite, 2. Volcanic soil, 3. Black Cotton Soil, 4. Clay and 5. Sand

The Junior Scientists were next shown the following table which indicated the chemical composition of each soil sample:

Soil type	**Chemical composition**			
Laterite	Oxides of iron	Aluminium oxide		
Volcanic soil	Phosphorus	Sulphur		
Black cotton soil	Lime	Alumina	Iron	Potash
Clay	Silica	Alumina		
Sand	Silica	Mica		

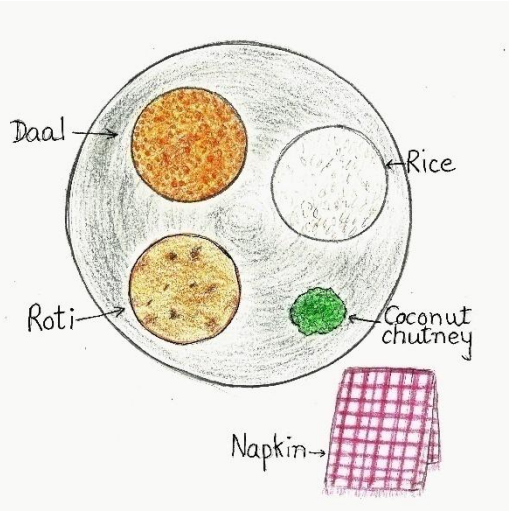
After this, Lyla gave each of the Junior Scientists the following maze. 'I want each of you to connect the type of soil with its composition, in a limited time.' You can start at the count of three.



Game 3: A guessing game!

Game after game, the Junior Scientists enjoyed themselves. One day Lyla laid out the following on her dining table:

A plate with a 'vati' of daal, some rice, a spoonful of coconut chutney, a chapatti and a cotton napkin by the side.



'I want each of you to guess which soil is required for each of these items,' she told them.

To make it easier for them, Lyla gave the following hints:

a. Wheat requires lots of water and fertile soil, with a balanced mixture of soils of large particle size, very fine particle size and medium particle size.
b. Cotton requires volcanic soil.
c. Rice needs to stand in soil with water while growing.
d. Pulses require soil rich in organic matter.
e. Coconut grows in pervious soil with large particle size.
Check answers at the end of the book

Game 4: A game to know the underground creatures better

a. S**oil charades** can be great fun, with each child miming out the role of one of the underground creatures with the rest of them guessing which creature.

Enact the following creatures: an earthworm, a mole cricket, a snail, a millipede, a frog.

b. Can you guess which of the following creatures live inside the soil, either to hibernate or to enjoy a snug home, away from predators?

Honey badgers, slow loris, millipedes, pangolins, pit vipers, mongoose, frogs, shrews, pagoda ants, desert fox, wood-borer beetles, snails, mole crickets.

Check answers at the end of the book

Game 5: Soil degradation

'Humans,' began Lyla the next day 'in the course of their various activities like cutting down forests to create farmlands or making way for infrastructure, have, in many places degraded the soil. This has succeeded in aggravating climate change. The carbon in the soil gets emitted as carbon dioxide. Here, in this teaser which I have created for you, is a list of these activities. Can you tap your grey matter and fill in the missing letters? You may take the help of the hints given below.'

1. CO _ _R _ TI _ A _ I _ N
2. S _ _ _ E _ O _ I _ N (2 words)
3. C H _ _ P _ N _ T _ E _ S (2 words)
4. M _ N _ C U _ _ R _
5. C _ _ M _ C _ L P _ _ T _ _ I _ _ S (2 words)
6. M _ _ I _ G
7. D _ M _ I N _ _ I V _ R _ (2 words)

Hints:

1. Covering the soil with a man-made substance
2. Soil being blown off or carried away
3. People do this to clear the ground for other purposes
4. Growing the same crop year after year
5. Something dangerous is added to the soil
6. Searching for minerals in the soil
7. Creating huge bunds across rivers to form a reservoir of water

Students can role play how soil is affected by the activities in the above list.

Check answers at the end of the book

PHOTO FEATURE ON SOIL

The Kaas Plateau of Satara district in Maharashtra has a very thin layer of lateritic soil. This enables it to support the growth of a variety of the most exquisite ground-hugging flowers, especially during the monsoon. For this reason, Kaas has been declared by UNESCO as World Heritage Site.

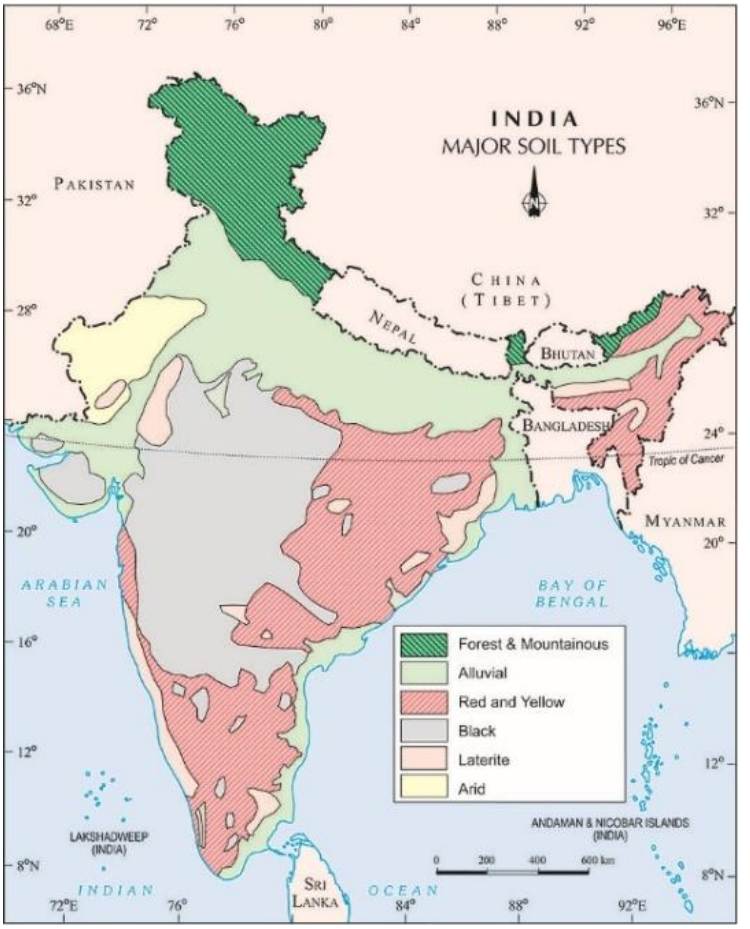
A Fluffy Tit butterfly `mud-puddling'

Photograph of an unusual termite mound which was considered as a deity, in a temple in Nerur near Goa. This perhaps suggests that preservation of soil and soil organisms is considered a sacred activity

ADD PHOTOGRAPHS OF INTERESTING FEATURES OF SOIL TAKEN BY YOU

Answers to quiz questions

Answer to question on page 17



Answer to question on page 22

Soil type	Chemical composition			
Laterite	Oxides of iron	Aluminum oxide		
Volcanic soil	Phosphorus	Sulphur		
Black cotton soil	Lime	Alumina	Iron	Potash
Clay	Silica	Alumina		
Sand	Silica	Mica		

Game 3 from page number 57 - Daal – loamy soil; chapati – mixture of clayey and loamy soil; rice – clayey soil; coconut chutney – sandy soil (mixed with some loamy soil); napkin – black loamy cotton soil

Game 4 from page number 57 - Honey badgers, millipedes, pangolins, mongoose, frogs, shrews, desert fox, snails, mole crickets

Game 5 from page number 58 - 1. Concretization; 2. Soil erosion; 3. Chopping trees; 4. Monoculture; 5. Chemical pesticides; 6. Mining; 7. Damming rivers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