No Soil, No Us,

Know Soil, Know Us!

Soil, as we know, is often considered as dirt! We forget that this dirt is nothing but a mixture of organic matter, minerals, liquids, gases and living organisms that support life on Earth. When it comes to understanding nature of various soils, one is always astonished to find the differences in the properties and uses of soils found in India. This learning unit aims at getting a broader sense of the basic differences in the soils and their unique properties that contribute to any country's richest natural resource.

Time Needed: 4 sessions of 40-50 minutes
Type of Tasks: Indoor + Outdoors
Expected Learning outcomes:
At the end of this learning unit, students will be able to gain knowledge on,
1. differences in the unique properties of red, lateritic, clayey and black soils viz. Porosity, water retention, carbonate content etc.
2. effects of black and red soils on agriculture, man-made constructions and their roles in reducing certain natural disasters like floods.
3. some physical properties of their local soils through observations and
4. enhancement of communication skills via interactions with people.

Task 1: Value of Soil in Your Locality
Soil, as known, understood and used by local people is different at different places. Let us try and collect some information on the various types of soils that are present in your localities. Given below are a few questions. Discuss these questions among your friends, teachers and elders in the vicinity. You can do this task in groups of 2-3 students.
Meanwhile, other students from your groups can collect 3 soil samples in the school campus. Soils from garden, roadside, open ground, banks of a pond etc can be collected.
Collect two samples of the same soil.

- One just from the surface.
- Other one by digging a pit of 1-2 ft deep(using a shovel)-Sub surface soil.

Some of you may be familiar with farming/gardening or construction activities. Some of you may not be. Given below are two sets of questions. Depending on your background, you may collect answers for any one of the two sets.

SET A (for students familiar with farming/ gardening/construction)

1) Describe the soil in your locality? (think of properties like colour, texture)

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2) Is the soil fertile or it need specific fertilizers to grow plants? What crops do well in this soil?

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3) Some soils have an ability to let water pass through their pores (porosity) and some soils retain water. Have you seen any canals/ water reservoirs build in the soil in your locality? Does this soil hold water in it for a long time?

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4) Certain varieties of soils soften a lot during rainy seasons and then contract during dry seasons. As a result of this, soils develop cracks. Have you seen any road/building floor in your locality developing cracks or potholes? If yes, what could be the reasons for it?

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5) Often, the nature of soil changes in a span of few years due to various reasons like agriculture, deforestation, industrialization etc. Do you find any changes in the nature of soil in your locality? Also, is the soil known to be polluted due to any sources of pollution nearby?

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6) At many places, colored soils called geru, khadiya, chuna, or any other coloured soils are used for painting houses or pottery or making rangoli. Is the soil in your locality used for making any kind of colors or pigments?

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7) At many places, soils are used to make water filters. Have you seen water filters made out of soil in your locality?

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SET B (for students NOT familiar with farming/gardening/construction)

Certain properties of soil : water holding capacity, chemical nature of soil, stickiness, particle size, porosity. Considering these properties, collect answers for following questions.

1) If you want to set up a large garden for growing fruits and vegetables, what type of soil will you prefer? What different properties of soil will you consider?

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2) You are given 4 different samples of soils viz. red soil, shadu mati (natural clay), black soil and sandy soil. You have to make a *diya*/small pot using any of these soils. Which soil will you use and why?

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3) We often hear of structures like tunnels collapsing down, occurrences of landslides due to multiple reasons such as heavy rainfall, deforestation in the nearby places, etc. Do you think soil underneath and around also plays a role in it? In what ways?

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4) Sand and clay are generally mined for construction industries, or bauxite or haematite for metal extraction or silica for electronics Is any soil in your vicinity used for extracting any metals or materials for industry?)

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Task 2: Let us observe whatever you have collected.

Let's try to understand that there is variation in soil at different locations and with also with depths.
Material needed: 3 paper or plastic bags, funnel, 3 filter paper, tap water, litmus paper or turmeric paper, lemon juice or vinegar.

Soil colour: Colour of the soil changes depending on how much organic matter is present and the kind of minerals it contains. Look at the soil samples and see if it is red, black, or grey. Is it black even when dry?

Soil Colour:	**What it may be telling**	**Where such soil is usually found**
Red	Presence of iron	Found in Coastal Areas
White	Presence of calcium carbonate	Found in dry area
Black/grey (Dry)	Presence of Humus	Agriculture or Forest land
Black Wet	Saturated with water	Found on coast near water body

Soil Texture: Soil texture is best understood in wet soils. Hence, use wet soil to check it's texture.
Take 1-2 pinch of soil on your hand. Pour 2-3 droplets of water on it and feel the soil in between your fingers.

Do you feel hard particles/ slippery but non-sticky/very soft and sticky particles of the soil? Based on size, soil particles are classified as gravels, sand, silt and clay.

Note their colours, texture (fine, coarse, pebbles), containing lot of biological matter (decaying plants, leaves, insects), and fill in characteristics in table below.

Sr. No	Soil Texture	Presence of Sand, Silt, Clay	Particle size
1	Rough to touch	Soil is sandy	Larger particle (visible to naked eye)
2	Smooth or floury	Silt is present	Medium particle size (particle visible to naked eye on keen observation)
3	Feels sticky	Clay is present	Smaller particle size (particles not visible by naked eye)

Soil	Visual Characteristics (colour, texture, presence of plants/insects matter)			
		Color	Texture	Presence of plants/insects
S1	Surface soil			
	Sub-surface soil			
S2	Surface soil			
	Sub-surface soil			
S3	Surface soil			
	Sub-surface soil			

Note: Use the same soil samples in the same sequence for Task 3- Part B.

Soils that Change Lives and thus Histories
Story 1

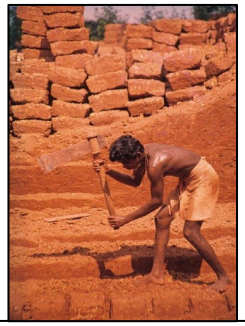
Dr. Franscis Buchmann, a surgeon in East India Company, when visited Angadipuram in Malappuram district in Kerela in 1807, reported a very unusual observation to the British Government. He saw a red-yellow soil about which he writes:

"What I have called the indurated (Hardened) clay..... is one of the most valuable materials for building. It is diffused in immense masses, without any appearance of stratification and is placed over the granite that forms the basis of Malayala (Kerala). It is full of cavities and pores and contains a large quantity of iron in the form of red and yellow ochres. ... while excluded from air, it is so soft, that any iron instrument readily cuts it, and it is dug up in square masses with a pick-axe, and immediately cut into the shape wanted with a trowel or a large knife."

"It, very soon after, becomes as hard as brick, and resists air and water much better than any bricks that I have seen in India..."

Laterite blocks mined in Goa (Source: Directorate of Mines and Geology, Goa, www.dmggoa.goa.gov.in/laterite.php)

In Kerala, this soil was known as "*chenkallu*". Dr. Buchmann called it Laterite, based on the Latin Word "letritis" meaning bricks. Laterite has the peculiar property of being soft when freshly cut from below the ground level and becoming very hard as it dries. On drying, it can be used as construction material (without firing in a furnace like clay bricks) just like stones and bricks. Therefore, mining of Laterite for making construction stones has been a commercial activity in such areas. Many historical building (including parts of Konark Sun temple in Orissa) have been made using laterite blocks which have survived centuries of rains and air. On a given land, therefore, its top layers exposed to air are much harder than the wet layers below the surface.



Cutting of Laterite stones in Angadipuram, Kerela, www.newworldencyclopedia.org /entry/Laterite

Laterite is formed after several years of rainfall on high lands common in Karnataka, Kerala, West Maharashtra, Central Odisha and Assam and in many other parts of the world. When soluble minerals dissolve in rainwater and get washed away, insoluble iron and aluminum compounds remain. The iron compounds give the soil yellow to red colour. This soil cannot hold water due to high porosity. Therefore, it is not highly suitable for agriculture. Iron rich varieties of laterite are also mined as iron ore while aluminum rich varieties are mined as aluminum ore in the name of bauxite.

Now let us try answering a few questions:

Q1. Have you found any soil in your locality having this property of being soft when wet but becoming permanently hard on drying? The soil becomes so hard that even pouring water over it cannot make it soft again.

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(This students may answer based on their experience. They may also think of clay here. But it would be important to differentiate clay from laterite, because clay become soft on becoming wet whereas laterite doesn't.)

Q2. Why do you think Dr. Buchmann found the red soil so interesting that he wrote about it to the British Government?

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(There may be variety of answers here. Students may try to recollect that East India Company was trying to find material resources in India that can be traded/sold to make money. This will help students realize that many scientific discovery become public or known to the world because of their economic importance).

Q3. Do you think the kind of soil in a region can affect the life of people living there? Is laterite soil good for the people living there or bad?

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(Here also multiple answers are possible. It is likely that economic value of the laterite soil

may make people rich. It is also possible that lack of agriculture make things problematic because there is lack of food. It is also possible due to mining, peoples' houses and forests are lost. Let students think about these. For example, mining of bauxite-rich laterite has displaced many tribes in Niyamgiri hills in Odisha, whereas in Angadipuram, mining of Laterite has become a source of income for the local residents. It also affects the groundwater level and quality of water in an area. For example in calcite rich soils, groundwater has a lot of calcium and carbonante ions which makes it hard water, whereas in laterite soil, you rarely find Calcium and magnesium ions, and hence the water the soft. Groundwater may have some iron which precipitates as it is exposed to air.)

Q4. Is it easy to make canal or a water reservoir in an area with the laterite rich soil? Will you need some other type of soil to make canal/water reservoir?

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(Due to high porosity, this soil cannot hold water. So unless other type of soil is brought, one cannot make a canal or a reservoir in such areas. Even in the laterite rich zone, small regions may hold water in rainy season. Humus or small deposits of fine soil carried from other regions may get deposited in localized regions and hence cause water logging in rainy seasons. However, large scale water holding becomes challenging in these regions.)

Soil deposited by the rivers during the 2018 floods in Kerala was acidic in nature and it needed to be treated with laterite or loamy soil before agriculture use.

Task 3: Some chemical properties of soil and soil porosity

Note: Use the same samples collected in Task 2 for this task.

Part A

Soil Acidity/Basicity: (This part can also be done after porosity test)

Take 10 gm (or two spoonful) of soil in a beaker and add about 20 ml (or one test tube) of water. Stir it. Use this slurry for these tasks. Use a litmus paper to check if it is acidic or basic.

Carbonate content: Now take a spoonful of soil and add few drops of lime juice or vinegar. Is there any effervescence (evolution of a gas in form of tiny bubbles)? In most cases, effervescence indicates presence of carbonate minerals in the soil and the gas evolved is Carbon Dioxide

Soil + Vinegar $\longrightarrow$ Carbon dioxide (effervescence)

Part B

Porosity Test

- Stir the soil slurry with a spoon or spatula. Pour this slurry into the funnel kept over a beaker/test tube. Is water passing easily through the soil? (surface and sub-surface soil)

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- Determine how many ml of water passes through the funnel per minute. Also, calculate relative drainage rate per minute. Does it decrease with time?

  Here, let students find relative drainage rates. No need to actually calculate the rate of percolation using formula.

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- Add more water over the funnel and measure the rate again. Does it decrease? Is there any difference in the rate with change in soil sample (with depth)?

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Record the observations in the table below.

Soil	Physico-chemical Characteristics (stickiness,porosity,acidity/basicity, presence of carbonates)				
		Stickiness	Porosity	Acidic/Basic	Carbonates
S1	Surface soil				
	Sub-surface soil				
S2	Surface soil				
	Sub-surface soil				
S3	Surface soil				
	Sub-surface soil				

Q. What does these above observations of soil in funnel tell you about the porosity of soil in your school area? Will these observations be consistent when you observe the soil during the rainfall?

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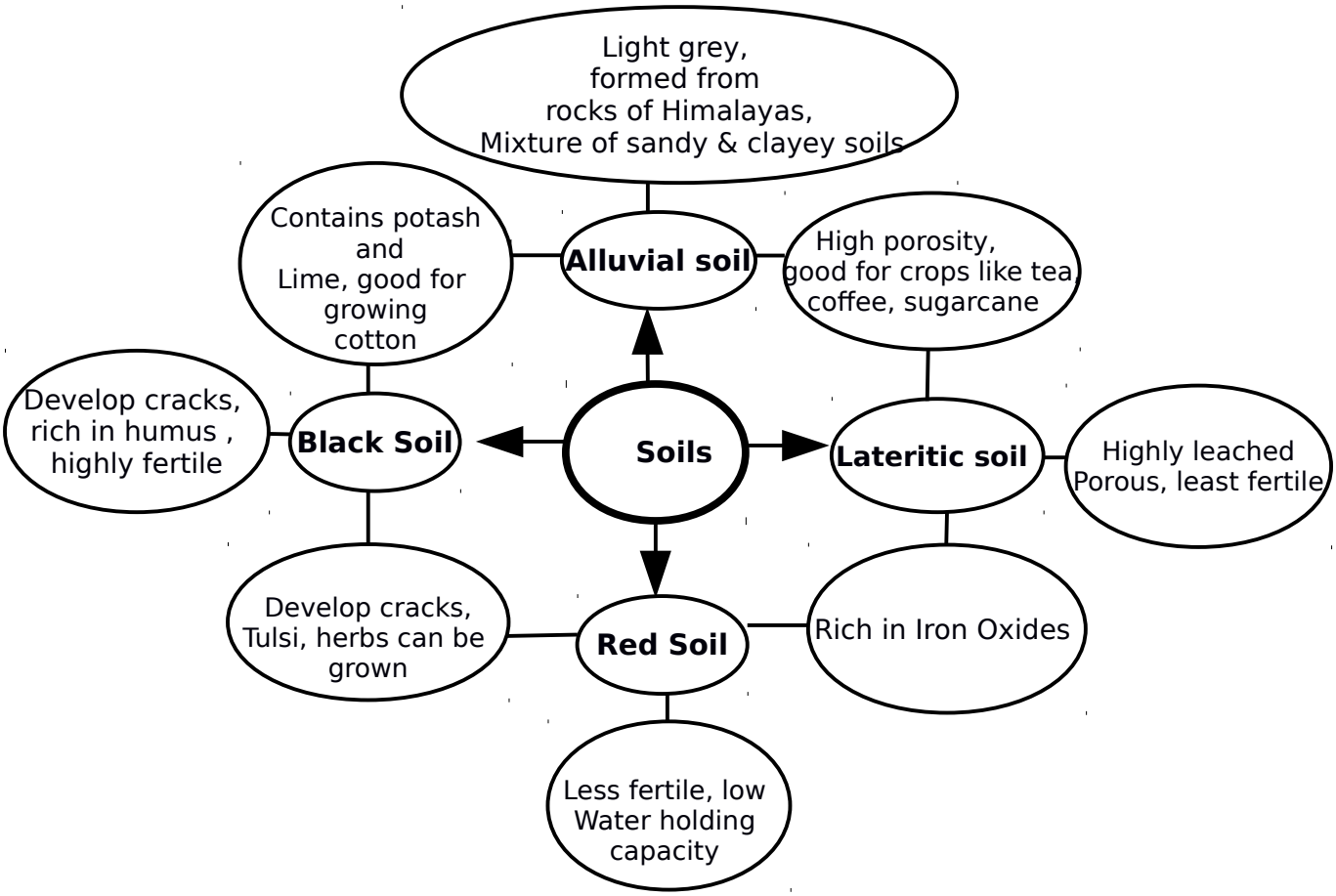
(Generally, if puddles form very fast, that means water does not pass through very easily. Hence the porosity of soil is very low. If puddles don't form even after a lot of rain, then the porosity of soil is high).

Study the given concept map of different types of soils.



Q. Have you seen such a soil or pictures of dry land with big cracks in it? Where?

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(Students may have seen such picture in TV, newspaper, internet or in real life. Let them write whatever they want. You can try to recollect if any road or building cracked or sunk with the cycles of summers and winter. The soils which are highly rich in carbonates, such as those found in the foothills of Himalayas also, show shrinkage over years due to dissolution of carbonate minerals. This phenomenon is different from swelling and shrinkage of black soils.)

Now a memory game... Try to remember:
In summers, does the soil in your school area cracks? Yes ☐ No ☐
In monsoon, do puddles form within few minutes of rain or after a lot of rain?
Does it tell anything about soil porosity?

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About your soil samples:

Since now you have observed the colour, texture, porosity, and recollected its behaviour in rains/summers, can you tell if soil in your school is:

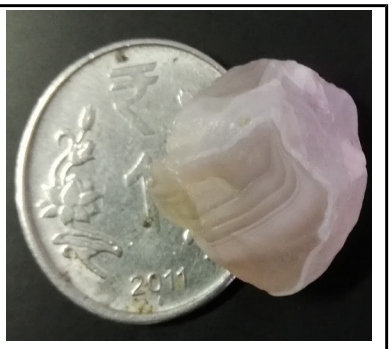
a. Laterite b. Red Soil c. Black Soil d. Alluvial soil e. Any other type_____

Story 2: Diversity in soils over short distances.

Dr. Pradeep Sarkar, an earth scientist from Pune while walking with his friends in the small hills of *Belhe* and *Alkuti* villages of Ahmednagar district (Maharashtra) noticed huge black boulders of rocks (called Basalt) which had beautiful crystals in them. Some of the large crystals were white to cream colored, and some of the smaller crystals were brownish in color. The brown colouration they thought could be caused by action of water, soil minerals or living organisms on the white crystals. The detailed observation of surrounding rocks gave them a different cluster of varied minerals. There, minerals had shades of green, some of which were opaque and some beautifully crystallized, in the cavities of the main rocks.

Their knowledge of earth science indicated that some of these minerals are found in some other parts of the world as well but are not found in all soils of India.

Further, within ~5 km of that area, they also found layers of red and green colored clayey rocks showing angular and blocky structures (common in black basaltic rocks). This was surprising because that region is made of igneous rocks (black basalt), and such layer of red and green soil could not come from physical breaking of the basalt rocks. One of the fellows told *“This red patch (known as Red bole) could be so because of iron and magnesium rich minerals (Fe_2O_3 and MgO) remaining as a result of chemical weathering of the basalt rocks”*. Dr. Sarkar further explained that these layers of red boles have commonly been seen in the Deccan Plateau of southern India, formed due to chemical changes as water flowed through the transition zone between two rocks.

		
Quartz crystals (Amethyst) found in the cavities of basalt	*Zeolite mineral found in the cavities of basalt*	*Banded agate found as nodules in volcanic rocks*

A small kid who was passing by them got fascinated by the rocks these people were holding in their hands. He thought to himself, *"What wonderful structures are shown by these crystals! I could actually collect a lot of them and make a necklace out of them for my sister*!". Smiling at Sarkar, he went back on his way.

Q5. Do you find such color variations and crystals in the rocks and soils in your surroundings?

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Q6. How the colour of crystals affects the color of the soil in the area?

Photo showing layer of red bole marking the base of basalt

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The mineral crystals are formed under high temperatures and pressures thus giving them the form. When these minerals undergo weathering, there is a change in the chemical content of the minerals, further leading to change in the rock color.

Further extensions:

Task 4: Soil of a different place

As we have seen above, soils have different properties and affect the local environment in different manners:

1) Water holding capacity affects the nature of plants and animal that can stay around.

2) Porosity affects how it regulates the flow of water through it.
3) Hardness and swelling behavior affects the strength of building and structures over it.
4) Moreover soil type a locality may change drastically over very short distances as well as with depth.

With this background, let us try exploring the soils in and around our school.

Repeat Task 1 (part 2 and 3) with soil around your home or another area about 1-2 km away from your school.

Try to find out if any location nearby has been dug or there is an exposed profile of soil (near roadside construction it may be easier to find). Do you see different layers of soil? Collect samples of soils from the different layers and repeat the above.

Q. Do you see variations in soils? What kind of differences did you observed in different soils in your surrounding?

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(In general, variation in soils are observed over few kilometer or sometimes on two sides of road. The idea of variation in soil may be linked to diversity of vegetation/ plants or animals or other organisms or human factors like construction of buildings or roads)Also try to find if the soil is natural soil of that area or has been brought and added to that region from somewhere else (For example, old broken construction material is dumped at many sites and in some places fertile soil is brought and added for growing some plants (transported top soil).

Task 5: Make a Chart

Make a chart highlighting the finding about the soil in and around your school as discovered in this learning unit.

References:

1. Buchannan F (1807). A journey from Madras through the countries of Mysore, Canara, and Malabar. East India Co., London, 2, 440-441.

2. Sarkar P. et al (2016). Petrography of Megaporphyritic Lava Flow from Belhe-Alkuti area, Ahmednagar district, Maharahtra, India, JGSR vol. 1,no2, pp.105-110.