Soil 4 Youth

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LESSON PLAN: Protecting our Soils

Introduction:

Soil is a non-renewable resource that is crucial for the world's food production, making high levels of erosion around the world very concerning. This lesson plan consists of two main activities: 1) the "Apple Talk", demonstrating the limited amount of topsoil in the world, and 2) a demonstration of erosion under different soil conditions.

Prescribed learning outcomes (PLO) are content standards for the provincial education system; they are the prescribed curriculum. The "Protecting Our Soils" lesson plan will help students to achieve the following BC PLOs[1]:

- Earth Science 11 – Surface Processes and the Hydrosphere (F1-F3)
- Geology 12 - Surface Processes and the Hydrosphere (F1, F4)
- Geography 12 – Themes and Skills (A2-A4); Gradational Processes (C1-C3); Weather and Climate (D2, D5-D7); Biomes (E3); Resources and Environmental Sustainability (F1, F2)

Learning Objectives:

- Recognize soil as a valuable, non-renewable resource
- Describe the negative impacts to water and soil quality by water erosion
- Describe how vegetation and organic matters helps in the prevention of erosion

Materials

- Apple
- Knife (pocket knife or paring knife)
- 4 large plastic water/juice jugs
- Fine textured soil: silt/clay (topsoil from the garden centre will work) – for 3 jugs
- Coarse textured soil: sand (gather from beach or can be found at garden centre) – for 1 jug
- Grass (seeds or turf) – overlays fine soil in 1 jug
- Leaf litter or mulch – overlays fine soil in 1 jug
- 4 clear containers to collect water (Suggestion: small plastic water bottles cut in half)
- See figures 2 and 3 for set up.

[1] Please consult the appropriate Integrated Resource Package (IRP) to identify the PLOs. A catalogue of the BC Curriculum Documents (including IRPs) can be found here: http://www.bced.gov.bc.ca/irp/all.php?lang=en#

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Bridge/Intro:

- Take a good look at this apple. This apple came from a tree, but it tells a story about the soil as well. To generate fruit, that tree took carbon dioxide from the atmosphere to photosynthesize and create sugars. That tree also took water and nutrients up from the ground – from the soil – through its roots. The nutrients from the soil were needed to make this apple...and the nutrients in the apple then enter our bodies when we eat the apple.
- I can also use this apple to tell another story about the soil...then, use “apple talk” as a demonstration of the limited land available for food production

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Apple	World	Story
Whole	Planet Earth	Hold the apple out so the class can see it. *"This apple represents our planet."*
3/4	Water	Cut the apple into quarters. Hold out 3/4 in one hand. Ask the class: *"What do these 3/4 represent?" (Water.)*
1/4	Land	Set the three "water" sections aside and hold out the remaining quarter. Ask the class: *"What fraction of the apple remains?" (1/4.) This 1/4 represents the total land surface."*
1/8	Uninhabitable & Non-Arable Land	Slice the land (the remaining 1/4) in half, lengthwise. Hold out one of the pieces. Ask the class: *"What fraction of the apple is this?" (1/8.) This 1/8 represents the half of the Earth's surface that is inhospitable to people and to crops: the polar regions, deserts, swamps, and high or rocky mountains."*
1/8	Habitable Land	Set that 1/8 aside and hold out the other. *"This 1/8 represents the other half of the Earth's surface. These are the areas on which people can live, but cannot necessarily grow food."*
3/32	Habitable Land, but Non-Arable Land	Slice this 1/8 crosswise into four equal pieces. Hold out 3/32 in one hand. *"These 3/32 represent land on which people can live, but cannot grow food. Some of it was never arable because it's too rocky, wet, cold, steep or has soil too poor to produce food. Some of it used to be arable but isn't any longer because it's been developed—turned into cities, suburbs, highways, etc., so it can no longer be farmed. Governments have earmarked other areas, such as parks, nature preserves and other public lands to remain undeveloped forever."*
1/32	Arable Land	Set 3/32 aside and hold out 1/32. *"So, only 1/32 of the Earth's surface has the potential to grow the food needed to feed all of the people on Earth."*
Remaining peel	Topsoil	Carefully peel the 1/32 slice of Earth. Hold up the peel. *"This tiny bit of peel represents the topsoil, the dark, nutrient-rich soil that holds moisture and feeds us by feeding our crops.*

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Figure 1. Apple bridge-in

Pre-test:

- Only this tiny area of our entire planet represents the part of Earth that supports crop growth. That is where our food comes from! And everyone has to eat. How much of our food comes from the soil? *A: sources have varied responses, but between 97-99.7%. Humans obtain more than 99.7% of their food (calories) from the land and less than 0.3% from the oceans and other aquatic ecosystems (FAO, 2004)*[2].

[2] FAO Food Balance Sheets. FAOSTAT, Food and Agriculture Organization of the United Nations, 2004. Available online: http://faostat.fao.org/site/368/default.aspx#ancor

- Wow, so we really need this soil – this topsoil is very important to feeding the world. How old is the soil beneath our feet? *A: 10,000 years old in BC and Canada.*
- That's a long time. And this soil is considered "young" in soil terms – there are soils in other parts of the world, such as Australia and South America that are hundreds of thousands and in some cases millions of years old! So, if we're talking about this topsoil as an important resource, would it be considered renewable or non-renewable? *A: non-renewable...like fossil fuels, it takes a long time scale to truly "renew" its sources. An inch of soil takes between 200 - 1000 years to form.*
  (Note: It's true that there are "man-made soil" mixtures out there. But while those soil mixtures might be used in a backyard garden, they can hardly be applied to a larger agricultural field.)

Bridge into activity...

- How many of you have thought of soil as a non-renewable resource before? It often isn't, and so soil can be managed very poorly, resulting in the loss of our very limited and precious topsoil! Two key types of erosion: wind and water.
- Soil erosion is arguably one of the most serious environmental and public health problems facing human society. Each year about 10 million ha of cropland worldwide are lost due to soil erosion, thus reducing the overall cropland available for food production.
- Some impressive stats: As a result of erosion over the past 40 years, 30% of the world's arable land has become unproductive. Excessive erosion is estimated to affect more than 1/3 of the global total of cropland, outside of the humid regions. In Africa, Europe, and Australia soil loss rates average 5 - 10 tons/ha/yr. In North, Central, and South America, loss rates average 10-20 tons/ha/yr. Losses are highest in Asia, averaging 30 tons/ha/yr. To put these numbers into some perspective, please consider that average rates of natural soil formation are on the order of 0.5 - 1.0 tons/ha/yr! Overall soil is being lost from land areas 10 to 40 times faster than the rate of soil production.
- We're going to look at some examples of different soils and predict how susceptible they are to erosion.

Activity: Erosion Demo

Figure 2. Four juice containers filled with a) bare soil (fine), b) bare soil (coarse), c) mulch on fine soil, and d) grass on fine soil.

Figure 3. “Runoff” collected after pouring water over each of the four jugs (be sure to moisten soil to saturation first, then start collecting runoff).

- **4 soil combinations are shown, and participants must match the collected runoff to the soil they think it came from**
- Go through the answers, and ask participants about the reasoning behind their choices

Fine textured soil – no vegetative cover: Runoff is very cloudy. Runoff contains mineral fine sediment, organic matter, nutrients. (Answer: C in Figure 3)

Fine textured soil – covered with mulch: Runoff is moderately cloudy. Mulch helps to slow infiltration of water, reduces particulate matter. (Answer: A in Figure 3)

Fine textured soil – covered with growing grass: Runoff is relatively clear. Note the roots. (Answer: B in Figure 3)

Coarse textured soil – no vegetative cover: Runoff is lighter colour, slightly cloudy. Most water went through this soil due to poor water retention. Runoff does not have any organic matter and fine sediment particles but could contain nutrients. (Answer: D in Figure 3)

Activity Debrief:

- If we cut too many trees in a forest near a river or creek, or a farmer's field is left completely bare over the winter in a region with abundant rainfall, which of these samples would most resemble that situation? Those sediments/nutrients end up in nearby streams, which can be very problematic environmentally.

Show photos of eroded landscapes, and discuss water quality and eutrophication. Talk about how nutrients are actually beneficial in the water for fish and other organisms, but when there is excess, it throws the ecosystem off-balance, resulting in algae blooms and subsequently dead zones (depleted of oxygen) after algae decompose. Talk about how widespread this problem is, and how protecting and properly managing soil for food production is extremely important, since it can have impacts very far away (use Mississippi River dead zone example. See article entitled "Fertilized World" published in the "National Geographic". Available at http://ngm.nationalgeographic.com/2013/05/fertilized-world/charles-text).

Figure 4. Soil erosion from agricultural runoff. Photo credit: Sanibel Sea School (http://sanibelseaschool.org/classroom/eutrophication)

Figure 5. Nutrients are transported to rivers and lakes through agricultural runoff, such as from this dairy farm. Photo credit: Smithsonian Science (http://smithsonianscience.org/2009/08/bottom-dwelling-creatures-in-the-chesapeake-bay-need-more-oxygen-study-finds)

Figure 6. Excessive nutrient inputs (nitrogen and phosphorus) can lead to eutrophication and subsequently, algal blooms in waterways. When these organisms decompose they deplete oxygen in the water, causing dead zones, and can also release toxins into the environment. Photo credit: Hans Schreier, UBC.

- Looking at the content of the run-off, is it the big or small particles that are easiest to erode? Note: Organic matter actually acts as a cement in the soil, which can make larger particles that are harder to erode away.
- Let's say this (bare soil example) is a farmer's field, after harvest. The soil is bare, and the wet winter months are approaching. What could we do here to help prevent water erosion? Wind erosion? Why would those things help, exactly? *A: add organic matter, cover crop, mulching, wind breaks/hedgerows.*

- Optional/additional: What is another way that we are losing our agricultural land, other than erosion, that we didn't really talk about? (Development of arable land due to urbanization)

Take-away message:

Fertile topsoil is a very important resource; it is the basis for food and fibre production in the world. However, only a very small part of the Earth is made up of topsoil, and the threat of erosion puts this amount of topsoil at risk for being reduced even further. Erosion removes topsoil, takes nutrients out of agricultural land, and can cause water quality problems. Lucky for us, there are ways to protect land from erosion with smart management! Organic matter additions, dead mulches, living vegetative cover, and hedgerows can all help to reduce erosion and save our precious topsoil.