Module 3 Lesson B: Carbon in Soils: – Hands-On Activity B1, B2, B3

Instructions Worksheet
Grouping: Pairs or small groups (3–4)
Time: 35-45 minutes

Instructions Worksheet – Activities B1, B2, B3

Lesson Overview: In this lesson, you will explore how carbon moves through soil systems by doing three hands-on activities. These activities demonstrate how soil builds carbon, maintains it, and also how carbon is consumed (released) in soil. You will investigate soil organic matter (the "build/maintain" part of carbon in soils), measure soil respiration (the "consume" part, where microbes release carbon as CO_2), and create a "compost cake" to see how we can turn organic waste into soil (a circular way to build carbon in soil). Work with your team, follow safety guidelines, and have fun discovering the role of soil in the carbon cycle!

Activity B1: Soil Organic Matter – How Much Carbon is in Our Soil?

Resource**: Follow the USDA NRCS Soil Quality guide for SOM* **- Soil Organic Matter** *and watch the Soil Organic Matter demo videos for guidance [YouTube: Activity B1_Overview; Test***].*

Objective: Determine the relative amount of organic matter in different soil samples by using soil color as an indicator. Soil organic matter (SOM) is the carbon-rich material (decayed plant/animal matter) that gives soil a darker color. You'll estimate %SOM in soil samples and discuss what that means for soil health.

Materials (per group of 3–4):

- Soil samples from **two different locations** (e.g. garden soil vs. sandier or depleted soil). Collect a cup or two of each sample.
- Small shovel or trowel (for digging samples).
- Small plastic containers/cups for mixing samples
- **Water** (in a cup or spray bottle) – to moisten dry soil for color observation.
- White paper or tray – to spread soil on for examining color.
- **Soil color reference chart** (relating color to % organic matter) – *use provided NRCS guide [INSERT LINK TO PDF].* If there is no chart, you will compare which sample is darker.
- **Gloves** (optional for handling soil).
- Paper towel or rag (for cleanup).

Instructions: (Work with your group to test two soil samples)

1. **Collect Soil Samples:** Go to your first site and collect multiple small sub-samples of soil (down to about 6 inches deep). Remove large debris (sticks, rocks). Combine them in a Ziploc or bucket – this mixed sample is your "Sample 1." Do the same for a second site to get "Sample 2." Label them. *(Tip: Try to choose two contrasting sites – for example, one under dense grass or compost (high SOM) and one from an area with sparse plants or older, depleted soil (lower SOM).)*

2. **Prepare for Color Test:** If the soil is dry, add a little water and mix until it's just moist (like the consistency of a wrung-out sponge). A moist soil sample shows its color more clearly. **Caution:** add water slowly to avoid mud – you just want the soil damp, not soupy.

3. **Expose a Fresh Soil Face:** Take a clump of the moist soil and break it to look at the fresh, inner soil (or smear a bit on white paper). Observe the **color** of the soil. Is it dark brown, black, reddish, light brown, gray? A darker soil often indicates higher organic matter (more carbon).

4. **Use Color Chart:** If you have a soil organic matter color chart (from NRCS or class handout), match the soil's color to the chart to estimate its **% Organic Matter**. For example, very dark brown/black might correspond to >10% SOM, while light-colored soil might be <2%. If no chart, just rank which sample appears darker.

5. **Record Observations:** On your data sheet, note the color and estimated %SOM for each sample. Also note any other observations (texture, smell, does it form a crumbly "ball" when moist, etc.).

6. **Compare Samples:** Discuss with your group: Which sample likely has more organic carbon in it? What might have caused one soil to have more organic matter (think of plant inputs, decay, land management)?

7. **Clean Up:** Dispose of or return soil as instructed (or save for Activity B2 if directed). Wash your hands after handling soil.

Think about it: Soil organic matter is essentially **stored carbon** in the ground. A higher SOM means more carbon is built up and held in the soil, which generally leads to richer soil that retains water and nutrients. This is one way carbon is **"maintained"** in ecosystems, rather than released to the air.

Activity B2: Soil Respiration – Does Your Soil Breathe Out CO_2?

*Resource: Follow the NRCS Soil Respiration test guide [**Soil Respiration**] and see the demonstration videos for this activity [YouTube: **Overview** **and** **Test**. 10–15 min setup; read the next day].*

Objective: Observe soil **respiration**, which is the release of carbon dioxide (CO_2) by microbes in the soil as they consume organic matter. You will set up a simple experiment to capture CO_2 from soil and then use a chemical reaction to indicate how much was released. This shows the "consume" part of the carbon cycle in soils (microbes eating carbon and releasing it as CO_2).

Materials (per group or demo setup):

- 2 *wide-mouth jars* or clear containers with tight-fitting lids (e.g. Mason jars). Each should be large enough to hold a soil sample and a small cup inside.
- Soil for testing: use the same two samples from B1 (or any **"active" soil** high in organic matter for contrast with a lower OM soil). About 1 cup of each.
- 2 small **plastic cups** or containers that fit inside the jars (to hold the CO_2 indicator). e.g. a film canister, condiment cup, or a shallow bottle cap.
- **Baking soda** (sodium bicarbonate) – about 2 tablespoons per jar (acts as a CO_2 **absorber**).
- **Vinegar** (acetic acid) – in a dropper bottle or small cup (will be used to react with the baking soda later).
- Plastic wrap or parafilm (optional, to help seal the jar if lid is not airtight).
- Labels or tape/marker (to label jars "Soil A" vs "Soil B").
- **Safety goggles** (recommended when handling chemicals like vinegar and for the fizzing step).
- **Gloves** (optional; soil and vinegar are generally safe, but use if desired).

Setup – "Day 1": Capturing CO_2 in a Jar

1. **Label Jars:** Mark one jar for Sample 1 and the other for Sample 2 (use the same soils from B1 or as provided by teacher). Also prepare a control jar with no soil if instructed (to compare background CO_2).
2. **Add Soil:** Place about 1 cup of **moist** (not soaking wet) soil into each jar. The soil should be at field moisture – damp enough to support microbes. If soil is very dry, sprinkle some water and mix before putting it in the jar (don't create mud). Spread the soil out on the bottom of the jar. *(Avoid getting soil on the jar rim to ensure a good seal.)*
3. **Add CO_2 Indicator (Baking Soda):** In each jar, place a small open cup or cap filled with ~2 tablespoons of baking soda. **Do not spill the baking soda onto the soil.** The baking soda should remain separate (it will absorb CO_2 from the air in the jar). If your small container has a shallow opening, you can use tape or a bit of clay to secure it so it doesn't tip.
4. **Seal the Jars:** Gently set the small baking soda cup inside the jar on top of the soil surface or propped to the side. Immediately close the jar lid tightly so it's air-tight. You want any CO_2

released by the soil microbes to be trapped in the jar and absorbed by the baking soda. Use plastic wrap or parafilm around the rim if needed to ensure no gas leaks.

5. **Incubate:** Keep the sealed jars at room temperature, out of direct sunlight (to avoid overheating). Let them sit **overnight (12–24 hours)**. During this time, the soil microbes in the jar will "respire" – consuming organic matter and releasing CO_2. The CO_2 gas will react with the baking soda, forming carbonate. (If time is short, even a few hours can show some effect, but overnight yields more CO_2.)

Observation – "Day 2": Releasing and Detecting the CO_2

6. **Preparation:** Put on safety goggles. Ensure you have your vinegar and maybe do this step on a tray or over a sink in case of overflow.
7. **Open and Add Vinegar:** After the incubation period, **carefully open** each jar. Avoid breathing directly into the jar (your breath has CO_2 too). Quickly pour or squirt a small amount of vinegar into the baking soda cup inside the jar (just enough to cover the baking soda). **Observe the reaction:** The vinegar will react with the baking soda and any carbonates formed from absorbed CO_2, causing **fizzing/bubbling**.
8. **Compare Fizz:** Do the same for each jar (and control, if you had one). Compare how vigorously each jar fizzes. A **strong fizz** indicates a lot of CO_2 was absorbed (meaning the soil produced a lot of CO_2). A weak fizz means less CO_2 was present (lower respiration). The control (no soil) should have little to no fizz, showing baseline.
9. **Record Results:** On your data sheet, describe the fizzing intensity for each jar (e.g. "Jar 1 fizzed over and produced foam, Jar 2 had only a few bubbles"). Note any other observations (any smell? condensation in jar? etc.).
10. **Interpret:** Discuss with your group: which soil had more microbial activity (and thus higher respiration)? Why do you think that soil released more CO_2? Consider differences in organic matter or microbial content between your samples.
11. **Dispose Safely:** After observing, dispose of the vinegar + baking soda solution (down the sink is fine) and soil as directed by your teacher. Rinse out jars. **Wash your hands** after handling soil and vinegar.

Safety Notes: Vinegar is a mild acid – avoid contact with eyes (wear goggles) and rinse skin if spilled. Open the jars slowly in case of slight pressure buildup. The reaction can cause foaming – add vinegar gradually and do not inhale the initial burst of CO_2.

Think about it: Soil **"breathes"** CO_2 because tiny organisms (bacteria, fungi, and soil fauna) are constantly eating organic material and respiring, just like we do. This is the **consumption** side of soil carbon: microbes turn some of that stored soil carbon back into CO_2. Healthy, active soil will release some CO_2, but that's part of a balanced cycle – as long as new carbon (from plant litter or compost) keeps entering the soil (Build & Maintain), we can maintain soil health and carbon levels. Too much consumption without rebuilding leads to carbon-depleted soils.

Activity B3: Let's Make a Compost Cake – Building Soil the Circular Way

*Resource: This activity is inspired by "Let's Make a Compost Cake" from the Soil Story curriculum (Kiss the Ground) – see pages 67–68 [**Soil-Story-Curriculum**] for reference.*

Objective: Work together to simulate a **compost pile** by layering organic "ingredients" like a layer cake. You will learn what components are needed for composting and how composting transforms waste into rich soil. This activity demonstrates **"building"** carbon in soils (and closing the loop of waste back into the soil).

Grouping & Time: This activity can be done as small groups (each group makes a mini compost in a container) **or** as a whole-class demonstration. It takes about **25–30 minutes** to build the compost cake. If done as a demo, you can involve volunteers for each layer. If done in groups, each team will need a set of materials. *(Teacher will decide grouping.)*

Materials: *(The following is for one compost cake setup – adjust amounts if multiple groups.)*

- **"Brown" materials (dry carbon-rich ingredients):** e.g. dry leaves, straw, shredded newspaper or cardboard. Aim for at least a few cups of browns.
- **"Green" materials (fresh nitrogen-rich ingredients):** e.g. fresh grass clippings, green leaves, fruit/vegetable scraps (non-meat), coffee grounds, or aged manure. A few cups of greens.
- **Soil or finished compost:** a few scoops of garden soil or mature compost. This acts as our **"microbe frosting"** – full of decomposers to start the process.
- **Container or space for the compost cake:** e.g. a bucket, bin, or even a circle of chicken wire/rope on the ground (~1–2 ft wide for a mini pile). A transparent container (like a large clear plastic tub) is great if available, so you can see layers from the side.
- **Water** (spray bottle or watering can) – to moisten layers as you build.
- **Shovel or trowel:** for adding/mixing materials.
- **Thermometer** (optional, for larger piles) – to measure temperature rise as compost "cooks."
- **Gloves:** recommended when handling compost materials, especially manure or food scraps.
- Tarp or newspaper (to cover floor/table for easy cleanup).

Instructions: (Work as a team to build your compost cake layer by layer)

1. **Sort Your Ingredients:** Divide your materials into three categories – **Browns (dry, carbon-rich)**, **Greens (wet, nitrogen-rich)**, and **Soil/Compost (microbe source)**. Make sure everyone in your group knows which items are "browns" and which are "greens." (For example: dried leaves = brown, straw = brown, shredded paper = brown; grass clippings = green, veggie scraps = green, coffee grounds = green; garden soil = soil inoculant).

2. **Prepare the "Pan":** Designate your compost area or container. If using an open area or bin, mark out roughly a circle or square base. If using a small container, ensure it's on your tarp/newspaper to catch any mess.

3. **Layer 1 – Browns Base:** Start your compost cake with a layer of **brown materials** about 2–3 inches thick. Spread the browns evenly as the first "layer" on the bottom. This layer provides carbon and also helps create airflow (if chunky). *(In a real compost pile, good airflow and structure often come from dry stalks or twigs at the base.)*

4. **Layer 2 – Greens:** Add a layer of **green materials** on top of the browns, about 2–3 inches thick. Spread it out. Greens will provide nitrogen and moisture to heat up the compost.

5. **Layer 3 – Soil "Frosting":** Sprinkle a thin layer of soil or finished compost on top of the greens (about 1 inch or enough to cover). This is like the "frosting" in our cake – it introduces decomposer microbes (bacteria, fungi) and soil organisms into the pile, and a bit of soil helps filter smells and insulate heat.

6. **Moisten the Layers:** Before adding the next round of layers, use a spray bottle or sprinkle water to dampen the stack. **Water each layer lightly** so that it's about as moist as a sponge. Don't drench it – too much water can make it anaerobic. The moisture helps microbes move and feed.

7. **Repeat Layers:** Continue building the compost cake with another round of **browns** → **greens** → **soil**. Aim to repeat these layers in order at least twice (or more if you have plenty of material). For a small demonstration cake, 2–3 repeats is fine. Remember to sprinkle a bit of water each time you add a new brown or green layer so everything is slightly moist.

    - As you build, mention what each layer is doing: *"We add browns (carbon) for energy, greens (nitrogen) for growth of microbes, soil for microbes and to kickstart decomposition."*

8. **Top it Off:** End with a final layer of soil on the very top as a final frosting. This caps the pile. Now your "cake" is complete! It might be one to two feet high if you had enough material. Pat it gently to make sure it's stable (but don't compact it too much; air needs to flow).

9. **Optional – Temperature Check:** If you have a thermometer, insert it into the center of the pile. Over the next days, a well-built compost pile can heat up (50–70°C or 120–160°F!). In a small classroom-sized pile, the temperature change might be modest, but see if it rises by the next day. (Make sure to check in on it if you're leaving it set up.)

10. **Observe & Discuss:** Immediately after building, notice the appearance and smell – it should look like layered yard trimmings and food bits, and smell earthy or like a fresh garden (nothing rotten if done right). **Predict** what will happen over the next couple of weeks: how will these materials change? (They'll break down into dark compost as microbes consume them.) Discuss why we needed to layer different ingredients rather than just one type of material.

11. **Clean Up:** Wash your hands thoroughly (compost ingredients can have lots of microbes). If this was a demo, help return any unused materials or tidy the area. If you made mini compost bins to keep, make sure they have airflow and won't leak – or transfer the mini piles to an outdoor compost after observing them.

Safety Notes: Wear gloves when handling compost ingredients, especially manure or fresh food waste, to avoid germs. Avoid touching your face or mouth during the activity. Keep a clean workspace; fallen bits of food or yard waste should be cleaned to prevent slips. After the activity, **wash hands** well with soap. If anyone has mold allergies, be cautious when handling decaying materials (though our ingredients are fresh at start).

Think about it: We just built a mini compost system. Over time, **decomposer organisms** (from the soil layer and naturally in the materials) will break down the greens and browns. The pile will get hot (a sign of microbial feasting!), then gradually cool as it turns into dark, crumbly **compost**. This compost is **rich in carbon** and nutrients – a perfect soil amendment. By composting, we're **transforming waste into a resource**. Instead of sending food scraps and leaves to a landfill (linear waste stream), we're cycling those nutrients and carbon back to the soil (circular system). This helps build soil organic matter (carbon in soil), which improves soil health and helps draw CO_2 out of the air (via plant growth). **Composting is a win-win: it reduces waste and builds healthier soil.**