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The Use of the Microcomposter to Study the Dynamics of a Mini-Ecosystem

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ABSTRACT Compost bins are beginning to make their way into home gardens and classrooms, allowing students to actively participate in greening their environment. However, do they really understand the process of composting? According to the *National Science Education Standards* (National Research Council [NRC] 1996, 20), "Learning science is something students do, not something that is done to them." Through the use of a microcomposter, students can study the composting process in their classroom and see the rich diversity of organisms present in the compost they create. This compost and the organisms in it can be considered a mini-ecosystem. Students can observe and test factors that affect the decomposition of organic matter and the recycling of these elements into the ecosystem. This article describes activities that teachers can do with students to assist them in understanding the composting process and exploring the biodiversity that can be found in leaf litter and compost.

KEYWORDS compost tea, composting, microcomposter, Tullgren funnel

Media coverage of environmental issues such as global warming, climate change, and resource depletion is making students increasingly aware of the importance of composting and its positive effects on the environment. These effects include reducing waste sent to landfills, reducing greenhouse gases, reusing organic materials, and recycling natural nutrients. Composting can also improve the soil without adding chemicals, produce rich humus for plants, and help people save money on fertilizers (Composting 101 Online 2003). The use of pesticides and insecticides in agriculture leads to the loss of biodiversity in the soil, whereas using compost can increase the microbial populations in soils, thus increasing biodiversity.

Compost bins are beginning to make their way into home gardens and classrooms, allowing students to actively participate in greening their environment. However, do students really understand the process of composting? According to the *National Science Education Standards* (National Research Council [NRC] 1996, 20), "Learning science is something students do, not something that is done to them. In learning science, students describe objects and events, ask questions, acquire knowledge, construct explanations of natural phenomena, test those explanations in many different ways, and communicate their ideas to others." Through the use of tools such as a microcomposter, students study the composting process in their classroom and see the rich diversity of organisms

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present in the compost they prepare. This compost and these organisms can be considered a mini-ecosystem. Students can observe and test factors that affect the decomposition of organic matter and the recycling of these elements into the ecosystem.

The elements (mulched dried leaves and vegetable waste) are layered like lasagna as this is the recommended method for beginning a compost pile (University of Illinois Board of Trustees 2009). The thin layers help prevent anaerobic pockets, which can cause noxious odors to develop and can allow microbes access to both green material (high in nitrogen) and brown material (high in carbon).[1] The last layer, composed of brown material, absorbs any odors before they leave the compost system (Florida's Online Composting Center n.d.).

Compost tea (liquid derived from solid compost to which water has been added) is a way to provide nutrients to plants and add important microbes to the soil and to plant roots. These microbes assist plants by outcompeting anaerobic and other pathogenic organisms and occupying infection sites on plants' root and leaf surfaces. Compost tea may also have properties that provide plants with resistance to many diseases. (All Things Organic 1995–2006). By harvesting the compost tea from the microcomposter and using a microscope to view the micro-organisms, students are exposed to the diversity of organisms in this rich resource.

At a more macroscopic level, the use of the Tullgren funnel allows students to observe and make an estimate of the biodiversity of macro-organisms in leaf litter. A Tullgreen filter is a device used to extract macro-organisms through the heating and drying of a soil sample. When the lamp is lit, heat is released and the macro-organisms in the compost will move as far away from the heat source as possible and drop into the bottom of the bottle. In order to capture the macro-organisms in approximately one liter of compost, the lamp must be lit for several hours, until the soil sample has completely dried. A lamp with a 25 W bulb will furnish heat for four funnels. Analyzing one liter of leaf litter is a good way to start estimating the biodiversity of macro-organisms in an environment. For example, to estimate the number of macro-organisms in a 10-L container of leaf litter, students multiply the number found in their sample by 10. If they find one spider, two worms, and three coleoptera larvae in one liter of compost, they can extrapolate that there would be about 10 spiders, 20 worms, and 30 coleoptera larvae in their 10-L container. Students may also compare the biodiversity found in the leaf litter collected outdoors or from an outdoor composter with that found in their microcomposter.

In this lesson, students use a Tullgren funnel to observe and classify macro-organisms in leaf litter. They also assemble a microcomposter, create compost tea, and make observations about what occurs and the changes in biodiversity with the decomposition of the organic material. The activities described in this article permit teachers to focus and support inquiries while interacting with students, orchestrate discourse among students about scientific ideas, encourage all students to participate fully in science learning, and encourage and model the skills of scientific inquiry, as described in teaching standard B of the *National Science Education Standards* (NRC 1996).

LESSON OBJECTIVES

The objectives of this lesson are for students to do the following:

- observe and describe the diversity of living things within the local environment;
- recognize that many living things are difficult to see with the unaided eye and observe and describe some examples;
- be sensitive to and develop a sense of responsibility for the welfare of other humans, living things, and the environment;
- make observations that are relevant to a specific question;
- select and use tools and instruments for observation and data collection; and
- record and organize observations in a variety of ways.

We used the microcomposter to create a mini-ecosystem whose biodiversity sixth-grade students could study. It took about four weeks for students to complete the experiments and research compost organisms. In one 30-min class, students collected leaf litter and created their Tullgren funnel. Two 30-min classes were devoted to assembling the microcomposter. Students took and examined a sample of compost tea after they finished assembling their microcomposters and then once each following week for comparison. During the week, students made observations of what was happening in the microcomposter–for example,

FIGURE 1 **Microcomposters created by sixth-grade students.**

condensation on the interior of the lid, track marks in the condensation, or any visible plants or insects.

EXPERIMENT PREPARATION

In order to determine what students already knew about composting, the teacher invited students to share their experiences with composting by asking questions such as the following:

- What is composting?
- How many of you compost?
- What things can be composted?
- What kinds of organisms do you think one can find in compost?
- What is the role of these organisms in the composting process?

The teacher then had students conduct research on the above questions. This research can be done concurrently with the exploration of the biodiversity in the microcomposter. Figure 1 shows microcomposters created by sixth-grade students. Students and teachers may use Web sites that indicate the micro-organisms and macro-organisms that are found in compost and the interactions among them to assist in answering the questions. Several such Web sites may be found in Student and Teacher Resources.

SAFETY

Students who have allergies (mold spores and mildew) should avoid contact with the microcomposter and its contents. Gloves and a mask may be used to avoid allergens. Although the design of the microcomposter reduces odors, the container should be placed in a well-ventilated area.

MATERIALS

The following materials are required for the creation of the microcomposter or mini-ecosystem, the compost tea, and the Tullgren funnel.

Microcomposter

- 12-L (2.5-gallon) plastic pail with round holes cut out approximately one third of the distance from the top to the bottom (to provide ventilation for the composting process)
- Plastic lid in which a hole has been cut to accommodate a transparent piece of plastic for viewing contents (optional)
- Drainage grill (egg crate material) cut to fit the bottom of the container
- Net bag with an elastic opening (for lining the interior of the microcomposter)
- Cardboard insert (placed between the net lining and the interior of the microcomposter to absorb excess moisture)
- 25 worms (Red Wigglers)
- Mulched dried leaves (brown matter)
- Vegetable waste brought from home
- Compost
- Tap water that has been sitting at room temperature overnight
- Masking tape
- Marker
- Ruler

Figure 2 shows the materials used to build the microcomposter.

FIGURE 2 **Microcomposter materials.**

FIGURE 3 Materials for the Tullgren funnel.

Compost Tea

- Plastic tongs
- Eyedroppers
- 250-ml measuring cup or beaker
- Slides and cover slips
- Microscope

Tullgren Funnel

- Two 2-L plastic bottles
- Damp paper towel
- Lamp with an electric bulb of about 25 W

The materials for the Tullgren funnel are shown in Figure 3.

PROCEDURE

In groups of three, students assemble the microcomposter, make the compost tea, and observe the microorganisms and macro-organisms found in the miniecosystem in the microcomposter. The construction of the microcomposter takes approximately 1 hr.

Construction of the Microcomposter

1. Place the drainage grill at the bottom of the container.
2. Insert the carton, placing it against the interior sides of the container.
3. Place the netting bag in the container so that it covers the bottom and the side of the carton. Attach the elastic to the outer opening edge of the container.
4. Use a ruler to mark a length of masking tape every 3 cm, and attach the marked tape to the outside of the container.

FIGURE 4 Rotifer.

5. Cover the bottom of the container with the mulched dried leaves, pressing them down to a depth of 3 cm.
6. Add about 3 cm of compost to the layer of leaves.
7. Cover the compost with about 3 cm of vegetal matter (which students have collected in a plastic bag during the week).
8. Place 25 composting worms in the container.
9. Add another 6-cm layer of leaves.
10. Add another 3 cm of vegetal matter
11. Add a final 3-cm layer of leaves.
12. Compress the layers.
13. Add 250 ml of water to the container.

Preparation of the Compost Tea

1. Add 500 ml water to the microcomposter.
2. Wait 10–15 min.
3. Remove the cover and take out the net bag of compost and the carton insert.

FIGURE 5 Nematode.

4. Pour the water from the bottom of the microcomposter into a container.
5. Replace the carton insert, the net bag containing the compost, and the cover.
6. Place a drop of the liquid onto a microscope slide and cover it with a cover slip.
7. Put the slide under a microscope and observe.
8. Place the lens of a digital camera in line with the ocular lens of the microscope to take photos or videos of the micro-organisms in the sample. As soon as an image appears in the viewfinder, take the picture or video of the specimen. Figure 4 and Figure 5 are examples of microorganisms that were found in compost tea samples.
9. Repeat the process once a week to observe changes in the microscopic diversity.

Preparation of the Tullgren Funnel

Figure 6 depicts the set-up of materials for the Tullgren funnel. It is important to emphasize that the bulb should not touch the compost, leaves, or other inflammable material in the sample. In Figure 7, students are placing leaf litter into the Tullgren funnel.

1. Cut one 2-L plastic bottle at the top and a second at the bottom. The volume of the funnel is about 1 L, so it is possible to measure the number of organisms in 1 L of compost.
2. Line the second bottle (with the top cut off) with a damp paper towel.

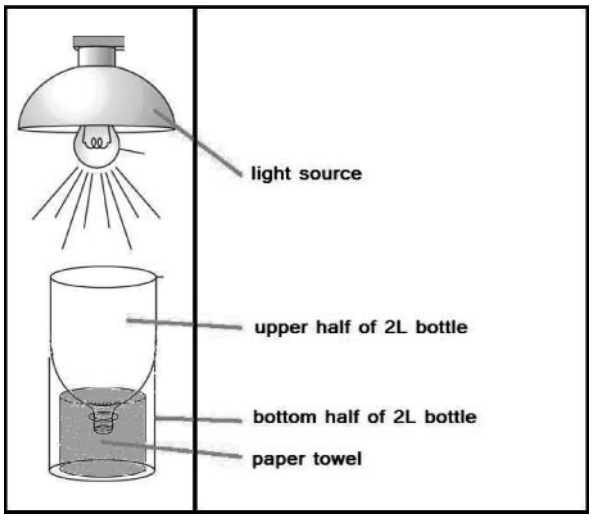

FIGURE 6 Tullgren funnel setup.

FIGURE 7 Addition of leaf litter into the Tullgren funnel.

3. Insert the neck of the bottle without a bottom into the second bottle.
4. Pour about 1 L of compost into the funnel.
5. Place the funnel near the lamp. Make sure the funnel does not touch the lamp.
6. Leave the lamp near the funnel for 24 hr.
7. Count the number of species and macro-organisms that drop into the bottom of the bottle.
8. Take a photo of each species using a digital camera with the macro option, placing a ruler beside the organism to indicate its size.

Inventory of Macro-organisms (To Be Done at the End of the Project)

Attention: Do this part in a well-ventilated area or outside.

1. Two groups of students should work together.
2. Empty the contents of each microcomposter onto a garbage bag that has been cut open and spread on the ground.

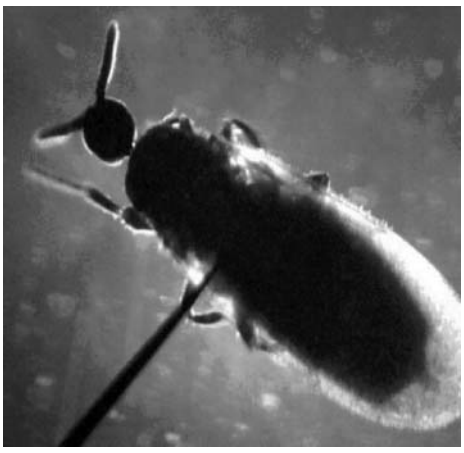

FIGURE 8 Fruit fly.

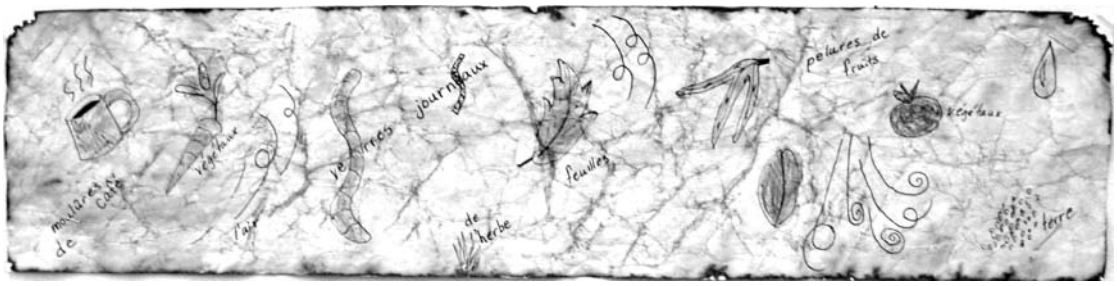

FIGURE 9 **Microcomposter art.**

3. Observe, identify, and count the total number of macro-organisms. Figure 8 shows a fruit fly, an organism that was found in some microcomposters.

STUDENT INQUIRY

Students noted their observations in a science log book. They were asked to keep in mind the following questions:

What organisms did you find in the microcomposter?
What is the role of these organisms in the composting process?

The teacher had students continue their preliminary research by choosing an organism that they discovered in the microcomposter and searching for information about its appearance, habitat, reproduction, role in the composting process, etc. Students were invited to present their findings to the class using software such as PowerPoint or Windows Photo Story (available at http://www.microsoft.com/windowsxp/using/digitalphotography/photostory/default.mspx). Students were also encouraged to present their project to parents and other students in the school.

INTERDISCIPLINARY CONNECTIONS

- The exterior of the microcomposter can be decorated to create an art connection. Figure 9 is an example of microcomposter art.
- Students can write a story about a day in the life of their organism.
- Students can create posters or presentations to create awareness about the importance of composting.
- The teacher can invite a specialist or scientist to speak about the process of composting.
- Because the microcomposter lid is transparent, the unit can be used as a mini-greenhouse where students can plant flowers or vegetables and then transfer these to a school or home garden.

CONCLUSION

Using this type of microcomposter allows students to explore the biodiversity of the mini-ecosystem. Once they have done the experiment once, the teacher can encourage students to create their own experiments, such as determining the effects on the biodiversity of changing the types of vegetables waste that is put into the microcomposter and determining which types of plants grow better in different compost mixtures. In the future, the authors hope to provide other examples of experiments that can be done with the microcomposter.

Student and Teacher Resources

For a compost food web diagram:

- Soil Foodweb International Australia. n.d. http://www.soilfoodeb.com.au/index.php?pageid=333.

On compost micro-organisms and macro-organisms:

- Cornell Composting, Science & Engineering: (a) Trautmann, N., and E. Olynciw. 1996. Compost microorganisms. http://compost.css.cornell.edu/microorg.html. (b) Trautmann, N. 1996. Invertebrates of the compost pile. http://compost.css.cornell.edu/invertebrates.html.
- Backyard Gardener: Schalau, J. 2001. Composting organisms. *Backyard Gardener*, Oct. 31. http://cals.arizona.edu/yavapai/anr/hort/byg/archive/compostorganisms.html.

NOTE

1. "Green material" is vegetable matter such as kitchen waste. "Brown material" includes leaves and paper.

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