Activity – Pop Bottle Composter

Decomposition is nature's recycling process in which earthworms, fungi, and other microorganisms help to release minerals and nutrients from decaying organic matter, enriching the soil. Humans can help this natural process by composting; reducing the amount of food waste that enters landfills and creating a carbon and nutrient rich product called humus that is useful in gardening, landscaping, and agriculture. Composting provides plants with a supply of nutrients; makes soil more porous allowing water, air, and plant roots to penetrate more readily; and improving water retention capability of the soil.

This hands-on activity provides students with a rich opportunity for scientific investigation and allows them to witness the interconnectedness of organisms. Through composting, students can go beyond reduce, reuse, recycle, allowing them to see the entire cycle; from "yucky" food waste, to something that is pleasant to handle and good for the soil.

Suggested Grade/Subject Levels

Applied Design, Skills, and Technologies (Foods 8, 10- 12, Culinary Arts 11)

Science 9, Environmental Science 11/12, Science for Citizens 11

Social Studies 10, Human Geography 11, Urban Studies 12

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The following are the curricular competency and content connections for the courses this activity could work for:

Subject Area	Curricular Competency	Content
Applied Design, Skills, and Technologies	• Engage in a period of research and empathetic observation in order to understand design opportunities • Identify potential users and relevant contextual factors • Critically analyze and prioritize competing factors, including social, ethical and sustainability considerations, to meet community needs for preferred futures • Use materials in ways that minimize waste • Evaluate personal, social, and environmental impacts and ethical considerations • Identify the personal, social, and environmental impacts, including unintended consequences of the choices they make about technology use • Identify how the land, natural resources, and cultural influence the development and use of tools and technologies	**Foods 8** • Social factors that affect food choices, including eating practices **Culinary Arts 11** • ethical, social, and environmental issues related to commercial waste management and recycling **Food Studies 10** • Simple and complex global food systems and how they affect food choices, including environmental, ethical, economical, and health impacts **Food Studies 11** • Issues involved with food security **Food Studies 12** • Food justice in the local and global community • Development of a food philosophy by an individual or group
Science	• Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest • Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments to collect reliable data • Experience and interpret the local environment • Seek and analyze patterns, trends and connections in data, including describing relationships between variables, performing calculations, and identifying inconsistencies • Evaluate their methods and experimental conditions, including identifying sources of error or uncertainty, confounding variables and possible alternative explanations and conclusions • Contribute to finding solutions to problems at a local and/or global level through inquiry	**Grade 9** • Sustainability of systems • First Peoples knowledge of interconnectedness and sustainably **Environmental Science 11** • Sustainability in Local Ecosystems **Science for Citizens 11** • Global science (agriculture practices and processes: environmental impacts and impacts of personal choices) **Environmental Science 12** • Land Use and Sustainability (land management and personal choices)
Social Studies	• Use Social Studies inquiry processes and skills to ask questions; gather, interpret, and analyze ideas; and communicate findings and decisions • Assess how prevailing conditions and the actions of individuals or groups influence events, decisions or developments (cause and consequence)	**Social Studies 10** • Human-environmental interaction **Human geography 11** • Global agricultural practices • Increased urbanization and influences on societies and environments **Urban Studies 12** • Urban planning and urban design • Contemporary issues in Urban Studies

Teacher Background

Soil is one of British Columbia's most important resources. It supports the growth of fiber and food; acts as a filter for air and water; affects global climate through gas exchange and storage; contains a wide range of organisms (fungi, bacteria, insects and worms); and supports natural ecosystems and wildlife habitats. The uppermost layer, called the topsoil, can be anywhere from 5 to 20 cm in depth and it's where plants typically obtain most of their vital nutrients. Soil itself goes far beyond just dirt with the average soil sample containing 45% minerals (sand, silt, and clay), 25% water, 25% air and 5% organic matter (living organisms, microorganisms, animal and plant residues, and humus). Plant growth and health depends on soil having the correct balance of each of these components.

Nature has long been working to ensure this correct balance is maintained. When vegetation (leaves, stems, fruits and all other plant material) falls to the ground, it decays and becomes part of the soil. Earthworms, fungi, and other microorganisms in the soil play central roles in this biological recycling process and with their help plants decompose, releasing minerals and nutrients that enrich the soil. However, wind and water erosion, degradation, contamination, and overuse are all threatening the very topsoil that farmers depend on to produce our food.

Humans can help with this natural process by combining dead plant material from the garden and food waste with soil and microorganisms in a compost pile or container. Composting not only provides a way to reduce the amount of food waste that ends up in landfills, but also converts it into a soil amendment product that is useful for gardening, landscaping, and on a much larger scale, agriculture. Once the composting process is complete, a carbon and nutrient rich product called humus is produced that can be added to garden beds to help other plants grow and thrive. Ultimately, the goals of composting are to provide plants with a supply of nutrients in a stable form; to make soil more porous, allowing water, air, and plant roots to penetrate more readily; and to improve water retention capability of the soil.

Compost is the product of plant decay that takes place through the action of earthworms, bacteria, fungi and other soil microorganisms. Earthworms eat and digest organic material found in plants and return approximately 60% of it back to the soil as they deposit their excrement (called worm castings). Bacteria and fungi also play important roles in the decay of organic matter. Single-celled organisms (protozoa), tiny worms (nematodes) and tiny insects called mites join in the process of decay and compost production as they feed on bacteria and fungi. Then larger predatory nematodes and other invertebrates (sow bugs, millipedes, beetles) feed on the protozoa, mites and nematodes. Together these organisms form a complex food chain that operates efficiently to recycle plant material back into the soil. The entire process involves altering the organic (carbon containing) materials found in plants, breaking them down into their simplest parts. The final products of composting are fiber-rich, carbon-containing material called humus and inorganic compounds that contain nitrogen, phosphorus and potassium (and other elements). These compounds are nutrients that promote the healthy growth of plants.

Among all microorganisms, aerobic bacteria are the most important initiators of decomposition and temperature increases within the compost pile. Psychrophilic bacteria work at the lowest temperature range and have an optimal temperature lower than 5^{o}C. Mesophilic bacteria do best at temperatures between 10^{o}C and 45^{o}C. Thermophilic bacteria are heat-loving and thrive above 50^{o}C.

Healthy composting is an aerobic process, which means the microorganisms need to consume oxygen as they eat their way through the organic matter. This is why turning and mixing a compost pile is so important and can speed up the decomposition. Microorganisms also require water and they respire (similar to humans) producing carbon dioxide and heat. This is why temperatures within compost piles can rise as high as 28 ^{o}C to 66 ^{o}C.

The initial temperature of the compost pile usually is related to the ambient air temperature. If the initial pile temperature is less than 21 ºC, psychrophilic bacteria begin decomposition. Their activity produces a small amount of heat and causes an increase in pile temperature, which in turn changes the environment for dominance by mesophilic bacteria. The mesophilic bacteria decompose more rapidly and further increase the pile temperature to create an environment where the thermophiles can thrive. As the decay process nears completion, the thermophilic bacteria in the pile decline in number and the temperature once again decreases. Compost is ready to be used when it is dark in color, crumbly and has an "earthy" smell. At this point it can be mixed into planter beds and gardens to help improve the soil for growing plants and producing food.

There is a direct relation between temperature and rate of oxygen consumption. The higher the temperature, the greater the oxygen uptake and the faster the rate of decomposition. Pile temperatures between 32 ºC and 60ºC indicate rapid composting. Temperature increases may be noticeable within a few hours of forming a pile.

Under natural conditions, the decomposition process can extend over a period of months or even years, depending on climatic conditions. However the natural process can be accelerated by controlling certain factors:

- Surface area and particle size (microbial activity is limited by surface area)
- Aeration (replaces oxygen deficient air in the center of the compost pile with fresh air)
- Porosity (spaces between particles containing either air or moisture)
- Moisture content (plays an essential role in the metabolism of microorganisms)
- Temperature
- pH of materials (optimal pH for microorganisms involved in composting lies between 6.5 and 7.5)

In this particular activity students will be creating composters on a much smaller scale than would be typically used in a garden or by a farmer. Because these units are so much smaller than outdoor bins, they need to be carefully designed to provide proper conditions for aerobic, heat-producing composting to occur.

Small amounts of compost material have a higher capacity for losing heat, which is why an insulation material must be used in order to generate the temperatures needed for decay. In addition, you may find that you do not end up with a product that looks as "finished" as the compost from larger piles. However, you should find that the volume shrinks by 1/2 to 2/3 and that the original materials are no longer recognizable.

If you are worried about potential odors, you can ventilate your bioreactor using rubber tubing out of the top that leads out the window, or you can store them in a fume hood. If your composters develop a foul odor, it may not be getting enough air (which means the anaerobic bacteria have taken over). Loosen the pile, break up any clumps, unblock the vents or add some wood chips to help the pile "breathe".

If the pile does not decrease in size or generate heat, composting may need a boost. You can add "old composting material" to help populate the composter with the correct microorganisms. If the pile is dry, add water and mix thoroughly. If the pile is wet and muddy, spread it in the sun and add dry material.

Materials

- Worksheet – Classroom Garbage Audit
- Worksheet – Pop Bottle Composter

Have 15 sets of the following:

- two 2-Liter pop bottles
- one small container (ex. plastic cup), about 5 cm high that fits in the bottom of the pop bottle
- one Styrofoam plate
- drill or nail for making holes
- duct tape or clear packing tape
- utility knife or sharp scissors
- insulating material (ex. Foam rubber or Styrofoam peanuts)
- fine-meshed screen or fabric large enough to cover top of pop bottle and air holes in the bottom half
- thermometer that will fit into the top of the pop bottle and be long enough to reach down into the center of the compost
- food scraps such as vegetable and fruit scraps, pulverized egg shells, coffee grounds, tea bags.
- bulking agents such as wood shavings or 1-2cm pieces of paper egg cartons, cardboard, or wood

Procedure

1. Conduct a class garbage audit
    a. This can occur in a single day or over the course of a week.
    b. Collect all of the garbage from your classroom and weigh it.
    c. With the students wearing rubber gloves, have them separate the garbage into compostable organic waste, recyclable materials, and landfill.
    d. Weigh the amounts of each and calculate the percentage of each. Have the students record their results on the worksheet provided.
    e. In the space provided, have students determine how much would be collected over the course of a school year (approx. 200 days). Multiply this by the number of classes in the school to determine the amount accumulated by the school in a year.
    f. Use these numbers to initiate a class discussion about the importance of recycling and composting.
2. Building a pop bottle composter
    a. Have students follow the procedure outlined in the handout *Building a Pop Bottle Composter*. Remind students to use caution with sharp scissor or utility knives, as well as any other laboratory rules you have established.
    b. Alternatively, you could provide students with the general design and then allow them to improvise and design their own composters using a variety of “upcycled” materials.
    c. Some options for bulking agents and microbial food are listed in the table below. Avoid meat, dairy products, bread and baked goods, and oily foods because they create foul odors and attract flies and rodents.

Bulking Agents	Food for the Microbes
Wood shavings	Lettuce scraps
Small wood chips	Carrot peelings
Newspaper strips	Apple cores
Pieces of paper egg cartons	Egg shells
Chopped straw	Banana peels
	Weeds
	Grass clippings

3. Once students have constructed and filled their composters, have them create a table for recording their observations. Students should chart the daily progress of their composters by taking temperature readings using a thermometer inserted in the center of the compost materials.
4. After the data collection period (up to 2 months) have students compare their results with those of other groups in the class. Have them analyze different variables (structural design, building materials, type of compostable material, moisture level, number of air holes, types of insulation etc.) to determine the optimal design.
5. Finished compost can be added to your school garden or raised planter beds.

Extension suggestions

- Conduct Nitrogen, Phosphorus, Potassium and pH tests on your compost samples.
- Have students create a food web that includes organisms in the soil (bacteria, fungi, plants, protozoa, nematodes, mites, larger predatory nematodes, sow bugs, millipedes, beetles, etc.)
- Compost can be used for gardening projects or for plant growth experiments ranging from nutrient analysis of compost-enriched soils to use of composts to suppress plant diseases.
- Have students investigate other types of composters that they could build on school grounds (garbage can bioreactors, worm bins, and outdoor composting bins)
- Have students investigate how composting happens on a larger scale (industrial composting facilities, agricultural composting)
- Have students research the various bacteria that are active at each temperature as well as how those temperatures affect other organisms in the compost (ex. Red wrigglers prefer to live between 15-25^{o}C so they don't like when compost starts to heat up)
- Have students visit a composting facility such as Net Zero Waste http://www.netzerowasteabbotsford.com/#home

Credit

The Classroom Garbage Audit has been adapted from a lesson in *Get Growing! Activities for Food and Garden Learning*, written by Stacy Friedman and Mary Gale Smith, and a publication of the Intergenerational Landed Learning on the Farm for the Environment Project at UBC

The Pop Bottle Composter has been adapted from a lesson in *Cornell Composting*, written by Tom Richard, Nancy Trautman, Marianne Krasny, Sue Fredenburg and Chris Stuart. http://compost.css.cornell.edu/

Classroom Garbage Audit

Name: ________________________________ Date: ________________

	Compostable Organic Waste	Recyclable Materials	Landfill or Garbage Dump
Examples			
Weight			
Percentage of Total Waste			
What amount would accumulate in a school year? (multiply total for one day by 200; or multiply total for one week by 40)			

Follow up Questions:

1. How much garbage could be eliminated if the school introduced a composting and recycling program? (multiply the one year totals by the number of classes in the school)

   ____

2. It is estimated that each backyard composter diverts approximately 250Kg of organic waste from landfills annually:
   a. If there are 5,000 households in your community, how much is saved from landfill? ____
   b. If there are 50,000? ____
   c. If there are 500,000? ____

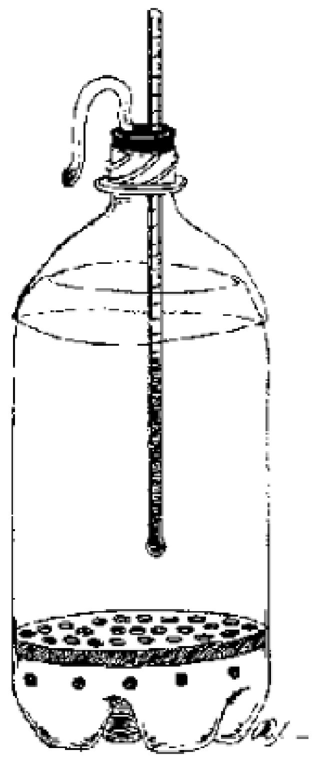
Building a Pop Bottle Composter

Purpose

To build a pop bottle composter that can be used a tool for composting research.

Materials

- two 2-Liter pop bottles
- one small container (ex. Plastic cup), about 5 cm high that fits in the bottom of the pop bottle
- one Styrofoam plate
- drill or nail for making holes
- duct tape or clear packing tape
- utility knife or sharp scissors
- insulating material (ex. Foam rubber or Styrofoam peanuts)
- fine-meshed screen or fabric large enough to cover top of pop bottle and air holes in the bottom half
- thermometer that will fit into the top of the pop bottle and be long enough to reach down into the center of the compost
- food scraps such as vegetable and fruit scraps, pulverized egg shells, coffee grounds, and tea bags. Avoid meat, dairy products, bread and baked goods, and oily foods because they create foul odors and attract flies and rodents
- bulking agents such as wood shavings or 1-2cm pieces of paper egg cartons, cardboard, or wood



Procedure

1. Using a utility knife or sharp-pointed scissors, cut the top off one of the pop bottles just below the shoulder, and the other one just above the shoulder. You now have a top that fits snugly over the bottom of the other.
2. Place a small container upside down in the bottom of the pop bottle. This will form the stand to support the Styrofoam tray with the compost.
3. To make the Styrofoam tray, trace a circle the diameter of the pop bottle on a Styrofoam plate and cut it out, forming a tray that fits snugly inside the bottle. Use a nail to punch holes through the Styrofoam for aeration.
4. Assemble the bottom of your composter by placing the stand into the bottle, then resting the Styrofoam try on top of it.

5. Make a mark on your bottle to indicate where the Styrofoam sits. Above this point is where the compost will be, and below it is where you want to make air holes.
6. Make air holes in the side of the pop bottle in the area below the mark that you made. You can either do this with a drill, or by carefully heating a nail and using it to melt holes through the plastic. Avoid making holes in the very bottom of the bottle because leachate (liquid) will be produced in the process.
7. Reassemble the composter pieces, making sure that you have provided sufficient air holes to allow air to enter the bottle and flow up through the stand and the Styrofoam circle.
8. Choose a bulking agent (see the table for possibilities) and cut or chop into roughly 1-2 cm pieces. Soak in water until thoroughly moist and then drain off excess water.

Bulking Agents	Food for the Microbes
Wood shavings	Lettuce scraps
Small wood chips	Carrot peelings
Newspaper strips	Apple cores
Pieces of paper egg cartons	Egg shells
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9. Mix roughly equal amounts of bulking agent (to provide air flow) and food scraps (provide food for the microbes) and then fill your pop bottle composter with the mixture. Remember that you want air to be able to move easily through the compost, so keep the mixture light and fluffy and do not pack it down.
10. Put the top pop bottle piece back on and seal it in place with tape.
11. Cover the top hole with a piece of screen or nylon, using a rubber band to hold it in place.
12. If you want to eliminate the possibility of flies becoming a problem, you can cover all the air holes with a piece of nylon stocking or other fine mesh fabric.
13. Insulate the pop bottle composter, making sure not to block ventilation holes.
14. Now you are ready to watch the compost at work! You can chart the daily process of your compost by taking temperature readings, inserting a thermometer down into the compost through the top of the pop bottle. Using temperature charts you can compare variables such as the types of compostable materials, moisture levels, amounts of air flow, and insulation systems.
15. Put your name on your composter and then place in the fume hood or other location indicated by your teacher.