

DESCRIPTION

Students will discover a third method of composting called bokashi composting, which utilizes beneficial microorganisms to ferment and decompose organic matter in an anaerobic environment. Students will make a fresh batch of bokashi, then use finished bokashi to compost food waste from their school cafeteria, which will be buried in the garden soil or compost pile two weeks later during Lesson 4.

TIME: 60 minutes

SUBJECTS: Language Arts, Science



LEARNING OBJECTIVES

After this lesson students will be able to:

- Understand and compare the similarities and differences between three types of composting systems and how bokashi complements the other two systems.
- Understand the importance of microorganisms and how they help us reduce waste, recycle nutrients, and nourish the garden soil and plants.
- Make and use bokashi and explain how the process works and why composting is important.

ACADEMIC STANDARDS*

CCSS, Language Arts: 3.RF.3, 3.W.1, 3.W.2, 3.W.10, 3.SL.1, 3.SL.4 **NGSS:** 3-LS4-3, LS4.C, Influence of Science, Engineering and Technology on Society and the Natural World, Patterns, Systems and System Models **Lesson Extensions:** 3.W.1, 3.SL.4, Analyzing and Interpreting Data

*A detailed list of the Academic Standards can be found in the Unit Overview document.

LESSON OUTLINE

- I. Introduction (20 minutes)
 1. Compost Review
 2. What Is Bokashi Composting?
 3. Making Bokashi with Beneficial Microorganisms
 4. Group Activities Overview
- II. Group Activities (30 minutes)
 1. Making Bokashi (15 minutes)
 2. Composting With Bokashi (15 minutes)
- III. Closing (10 minutes)

KEY TERMS AND CONCEPTS

Anaerobic - Refers to the absence of air (oxygen) in the system

Beneficial Microorganisms - Naturally-occurring plant and soil microorganisms that can be cultivated and applied to improve plant health and the recycling of soil nutrients

Bokashi - A Japanese term meaning 'fermented organic matter'; a material typically made with beneficial microorganisms, molasses, water, and wheat mill run or bran; a method of composting that uses beneficial microorganisms to ferment and accelerate the breakdown of organic matter

EM® - Effective Microorganisms™; a specific group of naturally-occurring microorganisms including lactic acid bacteria, yeast, and phototrophic/photosynthetic bacteria (which utilize solar energy to metabolize organic and inorganic substances); a technology pioneered by Dr. Teruo Higa, a scientist from Japan

Fermentation - The breakdown of materials into simpler components by bacteria, yeasts, or other microorganisms without the use of oxygen

Microorganism - Any organism too small to be seen by the unaided eye, such as bacteria, protozoa, and some fungi and algae

Mindful - Conscious or aware of something; to focus attention on the present moment

LESSON MATERIALS

Community Supplies:

- Hanging scale (to weigh wheat mill run and food waste, optional)
- 4 plastic dish tubs (for mixing bokashi)
- Measuring cup set
- Measuring spoon set



Food waste and Bokashi Compost Bucket, ready for the lesson.

Lesson Supplies:

- Decomposers Sign
- Garden Agreements Sign
- Compost Map Answer Cards: L.A.W., Anaerobic; Decomposers (F.B.I.), Beneficial Microorganisms; Wheatmill Run; Molasses; Water; Fruit & Vegetable Scraps; Meat, Bones, and Processed Foods; Garlic & Onion; Citrus
- Tarp (about 10 feet x 12 feet);
- Beneficial Microorganisms:
 - EM-1® (4 Tbs. per school) and Molasses (4 Tbs. per school) **OR** on-site cultivated Indigenous Microorganisms (IMO#2) and Lactic Acid Bacteria
- Wheat mill run (10 pounds per school)
- Bokashi Storage Bucket (one 5-gallon bucket with lid per school)
- Bokashi Compost Bucket (two 5-gallon buckets, one with drainage holes nestled inside the other, with airtight lid, 1 set per school)
- Finished bokashi (5 pounds per school; from last year's lessons, if available)
- Long plastic gloves, washable and reusable (2 pairs)
- Student Workbook and Class Data Workbook

Teaching Team to Provide:

- Container with tight fitting lid to fit up to 10 cups of water (e.g., 1-gallon jug)
- Container for collecting liquid from Bokashi Compost Bucket (e.g., large plastic food container)

School to Provide:

- 5-gallon bucket with lid for collecting food waste from school cafeteria (see Advance Preparation)
- Compost/Garden/Science Journals (1 per student if not using the Student Workbook)

ACCOMPANYING DOCUMENTS

- Resource Sheet: How To Cultivate Beneficial Microorganisms
- Resource Sheet: How To Bokashi
- Guided Notes
- Class Data Sheet: Daily Bokashi Log

ADVANCE PREPARATION

- Discuss lesson preparation and presentation plans with your teaching team.
- Discuss with your teaching team what form of beneficial microorganisms will be used: EM-1® and molasses or Indigenous Microorganisms (IMO#2) and Lactic Acid Bacteria (LAB). See recipe on page 5.
- Make copies of the Guided Notes, one per student if not using the Student Workbook.
- Make copies of the Daily Bokashi Log Class Data Sheet, one per class if not using the Class Data Workbook
- Gather one 5-gallon bucket full of pre- and/or post-consumer food waste from the school cafeteria (any and all types of food waste may be included except for milk and other liquids) and place a lid over the bucket. Collection of food waste may need to be done the day before the lesson if the lesson takes place in the morning before lunch. All classes will use the same bucket of food waste. Note: If the Bokashi Storage Bucket will be used for this purpose, thoroughly wash and dry the Bokashi Storage Bucket before use.
- Lay out the tarp outside and anchor the corners and edges with heavy objects.
- Divide the wheat mill run according to how many classes will be participating in the activity (see Group Activities: Making Bokashi for details).
- Have students ready to take notes in their journals if not using Student Workbooks.

INTRODUCTION

20 MINUTES

“Aloha! Today is our third ĀINA In Schools lesson on composting and we will explore our third composting method.” During the discussion, write key terms on the board and have students take notes in their journals or Student Workbooks. **Use the Compost Map Answer Cards during the discussion.**

“What are the two other main ingredients needed for aerobic composting and vermicomposting that make up the L.A.W.?” Desired answer: Air and water.

“The third type of composting system we will explore does not need air and can break down *all* types of food waste!”

COMPOST REVIEW

“In our first two lessons, we experienced two different composting methods. What are they?”

- Aerobic composting (compost pile)
- Vermicomposting (worm bin)



“What kinds of organic matter can be added to the aerobic compost pile?” Desired answers: Green waste (nitrogen), brown waste (carbon), some food waste (fruit and vegetable waste), and life (the soil F.B.I.: fungi, bacteria, and invertebrates). “What does the L.A.W. stand for?” Desired answer: Life, Air, and Water. “Who does the F.B.I. work for?” Desired answer: the L.A.W. “Correct! Because they are the Life of the L.A.W.”



“What should not be added to the aerobic compost pile?” Desired answers: Meats, dairy products, fish, processed foods, plastic, glass, and materials that might leach chemicals into the compost.

“What kinds of organic matter can be added to the worm bin?” Desired answers: Shredded paper, fruits and vegetables, composting worms, the soil F.B.I.

“What should not be added to the vermiculture?” Desired answers: Anything spicy, salty, or vinegary, dairy products, processed/junk foods, fat, fish, meat, and papaya seeds (which cause the worms to become sterile and will cause the colony to die out).

WHAT IS BOKASHI COMPOSTING?

“The third type of composting is called BOKASHI composting. BOKASHI is a Japanese term meaning ‘fermented organic matter.’ **Workbook Question #1:**

Have students write in BOKASHI on their Guided Notes. BOKASHI composting uses BENEFICIAL MICROORGANISMS to ferment any and all types of food waste in an anaerobic environment. It is recommended to cultivate the naturally-occurring beneficial microorganisms of your specific place such as Indigenous Microorganisms (IMO) and Lactic Acid Bacteria (LAB). You can also use EM®, to FERMENT (break down) any and all types of food waste in an ANAEROBIC environment, where air is absent.” **Workbook Question #2:** Have students write in FERMENT and ANAEROBIC in their Guided Notes.



Write beneficial microorganisms on the board. “What are MICROORGANISMS?” Desired answer: Any organism too small to be seen by the unaided eye.

“Fungi and bacteria are examples of microorganisms that we have already discussed.”



Decomposers Sign

Show the jar containing the beneficial microorganisms (EM-1® bottle or IMO#2 and LAB) and explain that it contains billions of naturally occurring, beneficial microorganisms, including different types of bacteria and yeast.

“Why are microorganisms important?” Desired answer: They help us reduce waste and grow

INTRODUCTION

CONTINUED

healthy gardens because they decompose (break down) organic matter such as food waste, recycling nutrients and making them available for plants. Show students the Decomposers Sign and remind them that even though they are tiny, microorganisms play a huge role in decomposition!

“Let’s be MINDFUL, or aware, of the living microorganisms we will handle today as we make bokashi and compost our food waste. They deserve our respect and care!” **Workbook Question #3:** Have students write in MINDFUL on their Guided Notes.

COMPOSTING WITH BOKASHI

“There are three steps in the process of composting with bokashi.” **Workbook Question #4:** Write the three headings on the board and have students fill them in.

- 1. Make the bokashi:** Mix the beneficial microorganisms, wheat mill run (the medium), and water (necessary for life!). If using EM-1® (Effective Microorganisms™): mix EM-1®, wheat mill run, molasses (a food source), and water. If using IMO#2 and LAB cultivated on-site, replace the EM-1® and molasses with equal parts IMO#2 and LAB. Store the mix in an air-tight container (anaerobic conditions) for 2 weeks, allowing the microorganisms to multiply. After 2 weeks the bokashi may be used directly (step 2), or it may be dried for storage.



- 2. Ferment the food waste:** Inoculate (mix) food waste with the finished bokashi, press down on the mix to remove air so that the waste ferments (decomposes in an anaerobic environment), let sit for 2 weeks, and drain the liquid daily.
- 3. Bury the fermented food waste:** Bury the mix in the garden soil or layer it under wood chips in an aerobic compost pile, where beneficial microorganisms will finish the composting process, transforming the food waste into beautiful compost for use by our garden plants within about two weeks!

“What kinds of food waste can we put in our bokashi bin?” Desired answer: All! “Why is this important?” Desired answer: Because we can now reduce even more of our waste and turn it into compost for our gardens!



Do Not Add: “Certain items that should not be added to our bokashi composting system include, moldy/rotten foods and paper products.”

“With bokashi composting, the Beneficial Microorganisms begin the work of decomposition in an anaerobic environment (called fermentation), and the soil F.B.I. (fungi, bacteria, and invertebrates) complete the process in an aerobic environment in the garden soil or compost pile!”

GROUP ACTIVITIES OVERVIEW

“Today we are going to make our own bokashi and start the fermentation and decomposition process by mixing some finished bokashi with food waste from the school cafeteria. In our next lesson we will bury the fermented food waste in the garden soil or compost pile to complete the process.” Show the finished bokashi and pass it around for students to feel and smell.

Garden Agreements

Have students take a deep breath, then repeat and discuss the Garden Agreements as listed on the Garden Agreements Sign:

- I will be SAFE
- I will be KIND
- I will have an OPEN MIND
- I will use my TIME WELL



Divide the class into four groups before going outside. Each group will be in charge of a bokashi making station.

GROUP ACTIVITIES

30 MINUTES

MAKING BOKASHI (15 minutes)

This activity will take place outdoors on the tarp. The amount of bokashi that each class makes will depend on the number of participating classes, according to the chart below. The chart shows the amount of each ingredient that each class should use. For example, if there are two participating classes, each class should use 5 lbs. of wheat mill run, 5 cups of water, 2 Tbs. of EM-1® and 2 Tbs. of molasses.

Remind students: “Please be MINDFUL while handling the ingredients and making the bokashi by being aware of your thoughts and actions. Even though the microorganisms are too small for us to see, we are handling living creatures that deserve our respect and care!”

Have student volunteers help with the following:

1. Use the hanging scale to weigh and divide the class’ portion of the wheat mill run equally into the four mixing bins.
2. Fill the container (e.g., 1-gallon jug) with the appropriate amount of water.
3. Add the appropriate amount of Beneficial Microorganisms to the water in the container. Place the lid on the container and mix gently and thoroughly by turning over several times.

4. Use the measuring cups to divide and place an equal amount of the liquid mixture into each group’s mixing bin, on top of the wheat mill run (have students make a crater for the liquid to be poured into).
5. Have students gently and carefully mix the bokashi well with their hands until there are no dry spots, being sure to keep all materials inside their mixing bin.
6. After mixing, have students perform the “snowball test” by squeezing the mixture into a ball. If the ball holds its shape and no extra liquid comes out, it is the correct moisture.
7. Have all groups combine their well-mixed bokashi together in the Bokashi Storage Bucket.
8. When all classes are finished, seal the Bokashi Storage Bucket with the lid and leave it covered for two weeks until Lesson 4.

“Now we have billions of beneficial microorganisms such as bacteria and yeast growing on the wheat mill run. The Bokashi Storage Bucket should remain closed for two weeks in order to grow our population of Beneficial Microorganisms, after which time we can use the bokashi to compost food waste or dry it for storage.”

*This recipe gives the option of using beneficial microorganisms in the form Lactic-Acid Bacteria (LAB) & Indigenous Microorganisms (IMO#2) cultivated on site OR EM-1®. To cultivate LAB and IMO#2 for use in bokashi, refer to the KHF Resource Sheet: How to Cultivate Beneficial Microorganisms.			If using EM-1®:		If using on-site cultivated Beneficial Microorganisms: IMO#2 and LAB	
Number of Classes	Wheat Mill Run (divide before lessons)	Water	EM-1®	Molasses	IMO#2	LAB
1	2.5 lbs.	2.5 cups	1 Tbs.	1 Tbs.	1 Tbs.	1 Tbs.
2	5 lbs.	5 cups	2 Tbs.	2 Tbs.	2 Tbs.	2 Tbs.
3	Two classes make 2.5 lbs.; one class makes 5 lbs.	2.5, 2.5, 5 cups	1, 1, 2 Tbs.	1, 1, 2 Tbs.	1, 1, 2 Tbs.	1, 1, 2 Tbs.
4	10 lbs.	10 cups	4 Tbs.	4 Tbs.	4 Tbs.	4 Tbs.

GROUP ACTIVITIES

CONTINUED

COMPOSTING WITH BOKASHI (15 minutes)

“Now we will mix the food waste from your school cafeteria with the finished bokashi that was made by students during last school year’s compost lessons.” All classes will work to fill the same Bokashi Compost Bucket, so be sure that enough food waste and finished bokashi are left for the remaining classes to process.

“To our Bokashi Compost Bucket we need to carefully add small pieces of food waste while sprinkling and mixing in the bokashi at the same time. Every surface of the food waste needs to be coated with the bokashi to make sure the system works properly. We will also press down gently on the mixture to remove air so that an anaerobic environment is created for Beneficial Microorganisms.” Note: Use more bokashi when composting meat and dairy.

Select two student volunteers who will handle the food waste and have them wear the long plastic gloves. Once the process begins, have one student break the food waste into golf ball-sized (1 to 2 inch) pieces while the other student gently mixes the food waste with the bokashi inside the Bokashi Compost Bucket as the food ingredients are added. They should also gently press down on the mixture to remove air pockets. Have other student volunteers rotate into this duty.

Have the remaining students form a line and take turns adding the finished bokashi to the bucket. Bokashi is safe to handle without gloves. It is very important that the students take their time and use enough bokashi so that the food pieces are completely coated.

After all classes have processed the food waste according to the above instructions, the Bokashi Compost Bucket should be full. Have the final group of volunteers add an extra layer of bokashi (about 1 inch thick) to the top of the food waste/bokashi mix, then press down on the contents to remove any remaining air pockets. Place the lid on the bucket. The classes will share the responsibility of caring for their school’s Bokashi Compost Bucket according to the instructions in the Follow Up Bokashi Care section.

All students must wash their hands thoroughly with soap and water.



One student volunteer (right) breaks food waste into golf ball-sized pieces while the other volunteer (left) mixes the pieces with bokashi inside the Bokashi Compost Bucket.



Food waste thoroughly mixed and coated with bokashi inside the Bokashi Compost Bucket.

CLOSING

10 MINUTES

Gather all the students in the garden/compost area. Have students refer to their Guided Notes and ask them to share about their experience.

Discuss with students:

- What are **MICROORGANISMS** and why are they important?
- Describe the steps for making and using **BOKASHI**.
- Describe one or more similarities or differences between the three types of composting systems.

Explain to students how to care for their Bokashi Compost Bucket as listed in the Follow Up Bokashi Care section (daily and weekly duties).

“Use your eyes and nose to determine whether your bokashi composting system is healthy and working properly. A pleasant smell, like pickles, and growth of white mold are indications of a healthy bokashi composting system. If the contents of the Bokashi Compost Bucket smell very bad and have a lot of black mold growing on them, the system is unhealthy and the contents should be thrown away; it is likely that not enough bokashi was used when creating the fermented food waste (try again and use more next time). If we have prepared the contents properly and continue to care for them as described, we can complete the bokashi composting process in two weeks as we add the fermented materials to our garden soil or compost pile.” **Workbook Question #5:** If time permits have students draw and label the main ingredients in the two bucket bokashi system.

FOLLOW UP BOKASHI CARE

Follow Up Bokashi Care is the responsibility of the classroom teacher and students.

- Work with the other participating classes to plan for a schedule of care for the Bokashi Compost Bucket (e.g., Each class is in charge of care duties for one week at a time, and may assign a number of **Bokashi Monitors** to carry out the duties as described in the following points at right).

- The **Bokashi Monitors** will carry out the following tasks with regard to the Bokashi Compost Bucket (containing the mixture of finished bokashi and food waste) and complete the Daily Bokashi Log:
 - **Every School Day:** Lift the top bucket out of the bottom bucket, and drain any liquids that may be found in the bottom bucket into a container (e.g., large yogurt container). Fill the container with water to dilute the drained liquid. Apply the diluted liquid to the soil around trees on campus (do not apply to edible plant parts).
 - **Two Times Per Week** (e.g., Mondays and Thursdays): Open lid and smell, the mix should smell like pickles. If the mix has a very bad smell it should be discarded in the trash. White mold is fine; black mold is not.
 - **In Two Weeks:** During Lesson 4 we will bury our fermented bokashi compost in the garden or layer it under wood chips in our aerobic compost pile!
- Thoroughly wash the bucket where the food waste was stored prior to the lesson.
- Students must wash their hands thoroughly with soap and water after working with the bokashi composting system.

Daily Bokashi Log



Drain and dilute liquids from the Bokashi Compost Bucket and apply them to the soil around trees on campus.



FOLLOW UP ACTIVITIES

Follow Up Activities are the responsibility of the classroom teacher.

- Have students complete the Guided Notes. Review together as a class.

- Have students keep a journal about the composting experience including notes, opinions, drawings, poems, stories, etc.
- Continue to have students care for the aerobic compost pile(s) and worm bin(s) as described in the Follow Up sections of Lessons 1 and 2.

LESSON EXTENSIONS

Zero Waste Lunch

(Analyzing and Interpreting Data)

1. Recycle Hawai'i encourages schools to participate in "Zero Waste Cafeteria Day" on November 15 as part of America Recycles Day.
2. Have your school participate in this initiative by having your students facilitate the collection of all school lunch food waste for the day, weighing it, and mixing it with your finished bokashi inside the Bokashi Compost Bucket for a "zero waste lunch" solution!
3. Data may be analyzed to determine how much food waste is produced by the school. Have students calculate the average amount of food waste produced per person.
4. Approximately 10 pounds of bokashi and 2 Bokashi Compost Buckets are needed to process the school lunch food waste for one day at a school of about 400 students (though the amount of food waste will vary).
5. After two weeks of fermentation, bury the fermented food waste in the garden soil or layer it under wood chips in a compost pile to give your gardens a healthy boost of nutrition! Encourage all classes to reflect on the importance of reducing waste and recycling nutrients through composting.

Zoo Doo

(3.W.1, 3.SL.4)

1. Did you know that the Honolulu Zoo uses EM® (Effective Microorganisms™) to compost all of the manure from their herbivorous animals?
2. Have students watch the short news clip about the zoo's manure composting system here: <http://www.emhawaii.com/index.php/nothing-goes-to-waste-at-the-honolulu-zoo.html>
3. Take your students on a field trip to the zoo to experience this large scale composting system first hand!
4. Have students create and share pictures, poems, stories, essays, and/or presentations about the zoo's efforts to reduce waste through composting!

EM® Teachers Manual

Visit the following website to download a free PDF copy of the EM® Teachers Manual, "Transforming Waste to Wonderful: Recycling at School Using Effective Microorganisms™": <http://www.emhawaii.com/index.php/em-teachers-manual.html>.

