WASTE NOT

Mai hoʻomāunai i ka ʻai o huli mai auaneʻi o Hāloa e nānā.
Do not be wasteful of food lest Hāloa turn around and stare [at you]
(*Mary Kawena Pukui, ʻŌlelo Noʻeau No. 2052*)

How can we use technology to speed up the decomposition of wastes?

HAWAIʻI DOE STANDARD BENCHMARKS

Science 1: The Scientific Process: SCIENTIFIC INVESTIGATION

- **SC.6.1.1** Formulate a testable hypothesis that can be answered through a controlled experiment.

Science 2: The Scientific Process: NATURE OF SCIENCE

- **SC.6.2.1** Explain how technology has an impact on society and science.

Science 3: Life and Environmental Sciences: ORGANISMS AND THE ENVIRONMENT

- **SC.6.3.1** Describe how matter and energy are transferred within and among living systems and their physical environment.

NĀ HONUA MAULI OLA

- **NHMO 8-8** Identify and utilize appropriate forms of technology for improving the quality of life in the community.

KEY CONCEPTS

- In the decomposition process, matter is broken down, nutrients are returned to the physical environment, and heat is released.
- When microorganisms are combined effectively they can accelerate the decomposition process in a healthy, organic way.

ACTIVITY AT A GLANCE

Students conduct an experiment using waste they collect from a class *pūpū* (snack) party. They record their observations on a data sheet and share their results with classmates.

ASSESSMENT

Students:

- Write a one-page lab report describing their hypothesis, methodology, results and conclusions.
- Diagram how matter and energy are transferred in the decomposition process.
- Explain how Effective Microorganisms (**EM**) might improve the quality of life in the school community.

TIME

3 class periods (over a 3-week period)

SKILLS

observing, classifying, measuring, collecting and interpreting data, inferring, making and testing a hypothesis

MATERIALS

Provided:

- ✓ Learning Logs 4 - 7
- ✓ EM (Effective Microorganisms) Bokashi Recipe
- ✓ EM Technology "From Waste to Wonderful" DVD

Needed:

- ✓ hand soap
- ✓ old newspaper
- ✓ masking tape and markers (for labels)
- ✓ 20 small (sandwich size) clear plastic containers with tight lids
- ✓ measuring cups and spoons
- ✓ 5 sandwich bags of EM mixture (See sources at the end of this lesson.)
- ✓ pitcher of water
- ✓ 1 bottle molasses for EM mix
- ✓ 4 lbs. wheat bran
- ✓ 5 sandwich bags of soil
- ✓ 5 sandwich bags of sand
- ✓ different types of snack foods

VOCABULARY

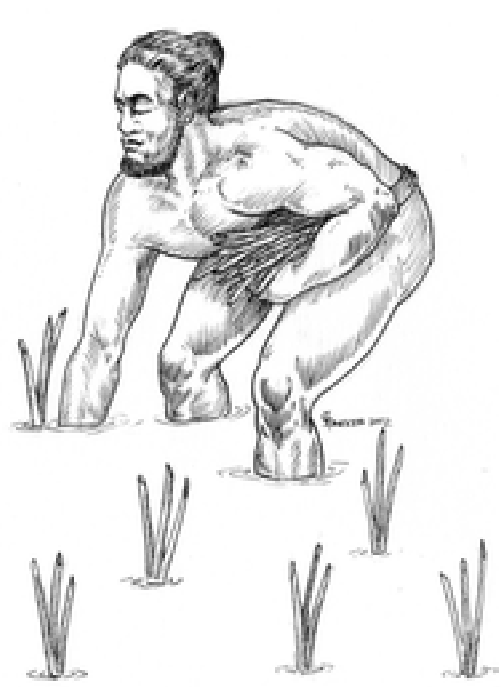
Bokashi – a Japanese term for fermented organic matter

decomposition – the breakdown or decay of organic matter

energy – the capacity for work; power

fermentation – a process guided by beneficial microorganisms associated with pickling

microorganism – an organism that can only be seen using a microscope



nutrients – any matter that, taken into a living organism, serves to sustain it, promote growth, replace loss, and provide energy

photosynthesis – a process by which plants produce carbohydrates using sunlight energy to combine carbon dioxide and water in the presence of chlorophyll

putrefaction – decomposition of organic matter that creates an unpleasant odor; the process of rotting

solid waste – garbage, rubbish, trash and refuse; items that are no longer useful or items no one wants

variable – something that is likely to change

vermicaste or vermicast – worm waste, ejected in the form of castings

worm castings – a complete organic fertilizer that is produced naturally by earthworms

ADVANCE PREPARATION

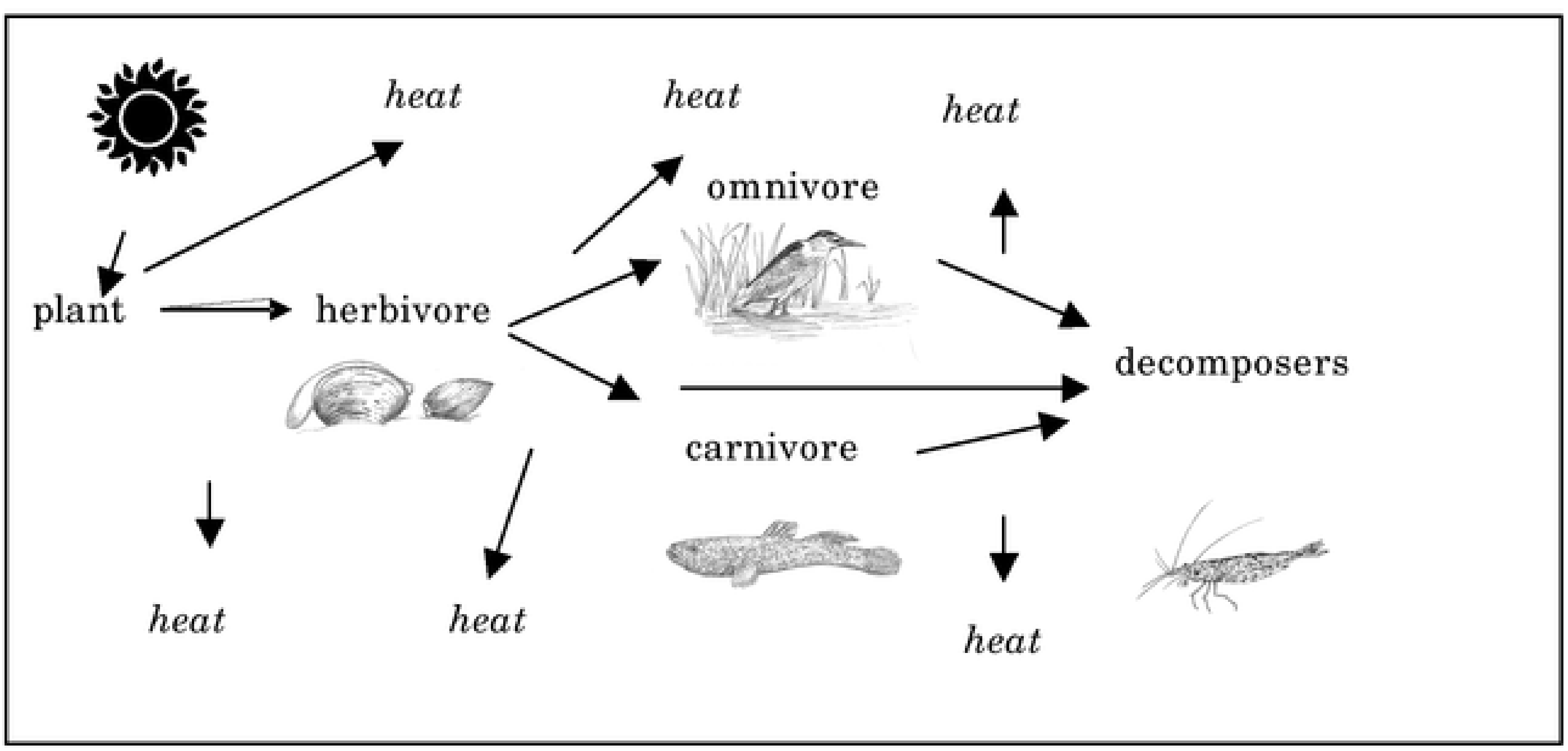
- ☐ Make a copy of Learning Logs 4, 5, 6 and 7 for each student.
- ☐ Ask students to bring healthy snacks for a class *pūpū* (snacks) party (especially snacks with peels or shells, e.g., bananas, oranges, peanuts).
    - ☐ Prepare the EM Bokashi mixture unless you opt to have students help prepare it. **NOTE: The Bokashi mixture will need two weeks to ferment before students can use it in their decomposition experiments.** See the EM Bokashi Recipe provided after the Resources section in this lesson.

Teacher Background Information

To understand the natural decomposition process, students will need to explore how matter and energy are transferred within and among living systems and their physical environment. Energy can be a difficult concept to understand since it is not an object that can be seen or touched. Although energy isn't visible, **it can** be detected. Jumping, shooting a basketball, eating, and laughing all require energy. Nonliving things such as a radio clock, toaster oven, and mechanical toys all require energy to operate. Work is involved whenever anything moves, and energy is needed to do work. Therefore, energy is defined as the ability to do work.

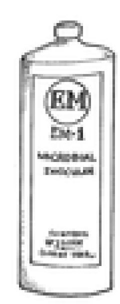
The most basic need of any organism is energy. Through photosynthesis plants or producers convert solar energy into food (chemical energy). The plants are eaten by herbivores, which are in turn, consumed by omnivores or carnivores. At each step in the food chain, energy is lost as heat. This energy loss is due to the cellular respiration, reproduction, movement and other survival needs of every living thing. A plant uses some of the energy it receives to grow and function. The herbivore uses its energy to grow, but also to look for food, escape from predators, and reproduce. A carnivore uses large amounts of energy to obtain food in addition to its regular life processes (e.g., breathing, digesting food, moving). The energy these organisms use eventually leaves their bodies in the form of heat. The amount of energy transferred from one organism to the next in the food chain is generally about 10 percent. For example, herbivores must consume an enormous amount of food to obtain the chemical energy necessary to meet their survival needs.

Heat Loss in Food Chain



Decomposition
When plants or animals die, their remains decay through the action of decomposers. Large decomposers help to break up the organic matter into smaller pieces, which are then fed on by microorganisms, including different types of fungi and bacteria. This process is called decomposition. The action of the microorganisms releases nutrients into the environment. These nutrients are taken up by the plants, and the cycle begins all over again.

Effective Microorganisms



Microorganisms are too small to be seen by the naked eye. These tiny organisms, which can include bacteria, protozoa, and fungi, aid in the decomposition process. Twenty-five years ago, Dr. Teruo Higa, a scientist from Japan, found that by combining beneficial microorganisms, which include lactic acid bacteria (commonly found in yogurt and cheeses), yeast (found in bread and beer), and phototrophic bacteria ("cousins" of blue-green algae), he could accelerate the decomposition process in a healthy, safe, and organic manner. This innovation helped reduce the vast amounts of waste ending up in landfills in Japan.

EM Bokashi
Bokashi is a Japanese term meaning fermented organic matter. EM Bokashi is fermented organic matter made with EM. The organic matter used to make EM Bokashi is typically rice bran or wheat bran. EM Bokashi is commonly used to accelerate the decomposition process of food waste. The general idea is to combine organic matter with a sugar source and inoculate it with beneficial Effective Microorganisms. The organic matter acts as the "EM House" and the sugar is food for the microorganisms.

Designing an Experiment

<u>Controlling Variables</u>

In this lesson, students will be conducting experiments to find out if EM Bokashi affects the rate of decomposition. They will combine the EM Bokashi with natural food wastes to see how quickly the wastes break down. When setting up their experiments, they will be manipulating one or more variable (EM, sand, soil) to see how this affects another variable (decomposing food items). The terminology can be confusing since there are two kinds of variables – one that they will manipulate, which could be called the treatment, and one that will be measured (the amount of decomposition). It is important to control as many variables as possible so that they can be sure that changes they observe are due to the EM, sand or soil, and not other factors. For example, to determine how effective the EM Bokashi is in accelerating the decomposition process, students need to control variables, such as the type of natural food waste, the amount of waste, and physical factors such as light, oxygen, and temperature. If they have identical set-ups and the only variable is the EM Bokashi, they should be able to conclude that differences in the decomposition rates are due to the EM Bokashi. Similarly if they have identical set-ups and the only difference is the presence of sand or soil (which contains microorganisms) they should be able to conclude that the differences in decomposition rates between these containers and the control are due to these materials. They can then compare the decomposition rates of all materials.

Experiment Set-up You may want to conduct this lesson as a teacher-led inquiry and guide the experimental set up as follows: Use the same type and amount of food waste in each of four (4) containers. Then add:

Container 1: add 1 cup EM
Container 2: add 1 cup soil
Container 3: add 1 cup sand
Container 4: add nothing (control)

Seal all containers and store in the same cool, dark environment for three (3) weeks. Alternatively, have student teams design their own experiments using materials on hand and design their own observation sheets (see Learning Log 6).

Teaching Suggestions

Part 1

1. **Conduct a class discussion about food chains, using an example of an orange as breakfast food for students.**
   - Have students imagine that they had an orange smoothie for breakfast. If they were to illustrate the life cycle of the orange, what would that look like?
   - Ask a student volunteer to illustrate it on the board, using a simple visual diagram. Make adjustments to the diagram if necessary.
   - Use the diagram to trace the path of matter and energy from the sun to the producer to the human and finally to the decomposers who break down our wastes, releasing nutrients back to the orange tree.

2. **Review how matter and energy are transferred within and among living systems and their physical environment.** (Refer also to the diagram in the Teacher Background Information above.)

Part 2: The *Pūpū* Party

3. **Divide the class into 5 research teams and assemble groups at tables for the *pūpū* party.** (You may want to assemble the teams so that students with different skills can work together.)
   - Invite students to share the *pūpū* (snacks) that students have brought to class.
   - Give each group some old newspapers and ask them to hang onto all of the wastes, including food waste and paper and plastic products.

4. **Ask each group to sort the food waste.**
   - After they finish their snacks, have each group sort all of the waste into two piles – food wastes and other waste.
   - Discuss what happens to the wastes when they are thrown away.
     <u>Discussion Questions</u>
     - Can you predict what would happen to the different kinds of waste if it were left alone for three weeks? If it were buried in the soil?
     - Which type of waste would decompose first? Why?
     - Which of these materials could be recycled? Can food be recycled? How could the recycled food materials be utilized?
     - How do natural materials break down in nature?

5. **Distribute Learning Log 4 and show the EM Technology "From Waste to Wonderful" DVD.**
   - Have each student fill out the **Learning Log 4** as they watch the film.
   - Review their responses and discuss the role of microorganisms in the decomposition process.
   - Ask students to create their own diagrams, with captions, to explain how matter and energy are transferred during decomposition.

6. **Distribute Learning Log 5 and work with students to design their experiments.**
   - Challenge each team to develop a hypothesis that they could use to test the effectiveness of the EM Bokashi.
   - Suggest other tests that students could conduct such as adding soil or sand to additional containers of food to see if this affects decomposition.
   - Present characteristics of testable hypotheses to answer questions about the effectiveness of EM Bokashi in speeding up decomposition.

     Characteristics of a testable hypothesis:
     - It is clearly stated.
     - The hypothesized relationship between the variable (in this case, EM Bokashi) and the predicted result is based on what we know, observe, or research.
     - It can be tested with the materials and conditions available.

7. **Discuss the need to control variables to make useful comparisons.**
   - Show students the materials available for their experiments.
   - Ask them what would happen in they had two containers of food and added EM Bokashi to both of them. How would they know if the EM had been effective if they had nothing to compare it to?
   - Discuss the need to have a control in their experiment (that would not have EM added to it).

- Define "variables" and ask students to come up with ideas of what they would need to control if they want to be sure any effects they find are due just to EM. (See Teacher Background Information.)

8. **Have each group collect materials for their experiment.**
   - Show them the materials available for their experiments.
   - Each team should receive four small clear plastic containers with lids (for their wastes), a bag of the EM Bokashi mixture that was prepared ahead of time (See Advance Preparation), a bag of sand, a small bag of soil, a measuring cup, permanent marker, and container labels or masking tape.
   - Also distribute **Learning Log 6** to students and have everyone record their team's observations for day 1.

9. **Review the following guidelines for the experiment and safety procedures:**
   - Wash hands thoroughly after handling waste.
   - Place the same amount and types of wastes into each small plastic container.
   - Completely cover the wastes with the sand, or soil, or EM Bokashi.
   - Label each container with what has been added.
   - Label the date and team name on each container.
   - Store containers in a cool, dark environment.

10. **Twenty-one-day follow-up: Record observations on Learning Log 6.**
    - After 21 days, ask students to record their observations of their experiment on **Learning Log 6**.
    - Have each group retrieve their containers and take them outside to open them and record their observations. (Anticipate some unpleasant smells so plan for outdoors.)
    - Be sure students open the container with the EM Bokashi first so they can make observations without being overwhelmed by smells from the control container.
    - When they are finished with the containers, collect the EM Bokashi wastes for later use as fertilizer.

11. **Have each group present the students' findings to their classmates and conduct a class discussion.**
    - Ask students to refer to the chart in Student Reading 1 from Lesson 1 for various decomposition rates of products without EM.

      <u>Discussion Questions</u>
      - Why did the materials in the containers smell differently? (fermentation in the EM container vs. putrefaction in the control)
      - Were your hypotheses validated?
      - What can you conclude from your experiment?
      - How effective is EM for speeding up the decomposition process?

- Did you find that the wastes combined with EM Bokashi decomposed more rapidly than the wastes that did not have the EM Bokashi mixture?
- If not, what other factors might account for their results?
- If conducted this experiment again, what methods might you change? Why?
- How could we use the EM Bokashi and wastes to fertilize plants at school? (Refer to the DVD).

12. Distribute Learning Log 7 to students.

- Review the criteria for students' lab reports and set a due date for completion.

ADAPTATIONS / EXTENSIONS

Challenge students to research composting with worms and set up compost bins for this purpose at school. For more information on worm composting, including materials to use and avoid in a classroom worm bin, see: http://www.css.cornell.edu/compost/worms/basics.html

RESOURCES

City and County of Honolulu. Recycling and Waste Disposal. Retrieved on March 10, 2007 from www.opala.org.

EM Technology Network. © 2002-05 EM Technology Network, Inc., Tucson, Arizona. *Waste to Wonderful* Teacher's Manual. Retrieved on March 10, 2007 from http://www.emtechnologynetwork.org/~en/_web/library/teachersmanual/teachersmanual.html Free download; a great resource for teachers wanting to introduce this system to schools.

EM Technology Network. © 2002-05 EM Technology Network, Inc., Tucson, Arizona. *Waste to Wonderful* video. Retrieved on March 10, 2007 http://www.emtechnologynetwork.org/~en/_web/library/coverimagese2/P1010802w800.html: A USA-produced video gives the bigger picture and details of the process, including how to use the system in schools. The video comes highly recommended.

Higashi, Y. and H. Nago. *Applications of EM at the Zoological Gardens*. (Honolulu Zoo). © 2001-04 EM Hawaii, Inc. Retrieved on March 10, 2007 from http://www.emhawaii.com/eminfo/empapers/emzoogardens.html

Pukui, Mary Kawena. 1983. *ʻŌlelo Noʻeau. Hawaiian Proverbs & Poetical Sayings.* Bernice P. Bishop Museum Spec. Pub. 71, Bishop Museum Press, Honolulu, HI.

U.S. Environmental Protection Agency. Municipal Solid Wastes – Basic Facts. Retrieved on March 14, 2006 from http://www.epa.gov/garbage/facts.htm

University of Wisconsin-Stevens Point. © 2006. University of Wisconsin - Stevens Point. *Heat Loss in Food Chains.* Retrieved on March 10, 2007 from http://www.uwsp.edu/cnr/wcee/keep/images/online/foodchain.gif

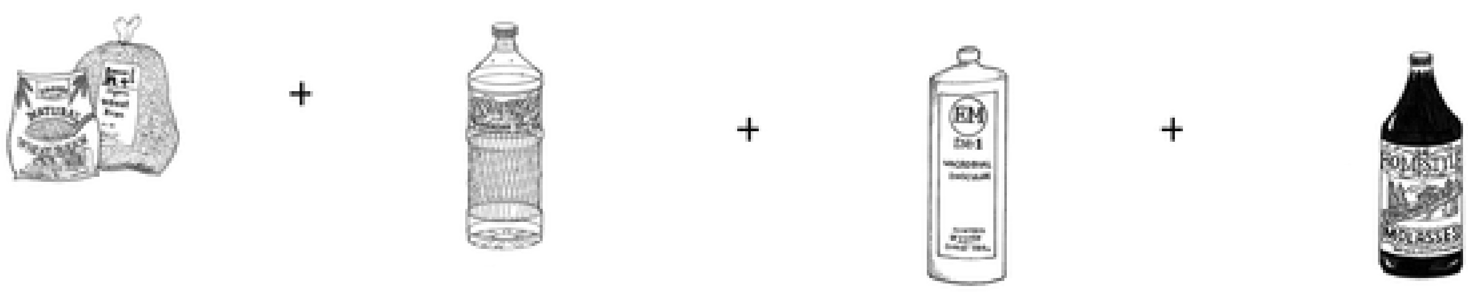
Authorized EM Resellers

ISLAND OF O`AHU **Fukuda Seed Store** 1287 Kalani Street, #106 Honolulu, HI 96817 Phone: 808-841-6719 Fax: 808-842-0295	 **Waimānalo Feed Supply** 41-1560 Kalanianaole Hwy Waimanalo, HI 96795 Phone: 808-259-5344 Fax: 808-259-8034
United Agri Products (UAP) 96-1345 Waihona Street Pearl City, HI 96782 Phone: 808-454-0041 Fax: 808-454-0046	**Environmental Waste Management System (EWMS), Inc.** P.O. Box 25577 Honolulu, HI 96825 Phone / fax: (808) 396-2378 e-mail: ewms@hawaii.rr.com
BioSolutions-Hawaii, LLC. P.O. Box 235672 Honolulu, HI 96823 Phone: (808) 258-5403 fax: (808) 838-7711 www.biosolutionshawaii.com	**EM Hawaii, LLC.** Gentry Pacific Center, Suite 217A 560 North Nimitz Highway, #65 Honolulu, HI 96817 Phone/Fax: (808) 548-0396
ISLAND OF HAWAIʻI **TIM Lloyd - TNT Products** P.O. Box 1384 Hilo, HI 96721 Phone: 808-937-9874	 **United Agri Products (UAP)** 900 Leilani Street Hilo, HI 96720 Phone: 808-935-7191 Fax: 808-934-8436
Island Herbs Organic Estate Consultations & Makers of EM Bokashi P.O. Box 2649 Kamuela, HI 96743 Ph: 808-989-1836	
ISLAND OF MAUI **United Agri Products (UAP)** 201 Papa Place Kahului, HI 96732 Phone: 808-871-2622 Fax: 808-877-4532	**ISLAND OF KAUAʻI** **United Agri Products (UAP)** Lihue Industrial Park 3042 Peleke Street Lihue, HI 96766 Phone: 808-245-3472 Fax: 808-245-2838

Waste Not — EM Bokashi Recipe

Ingredients

Recipe for 1 pound of EM Bokashi	Recipe for 4 pounds of EM Bokashi	Recipe for 50 pounds of EM Bokashi
• 1 pound of wheat bran or rice bran • 1 cup of clean, or tap water •1½ teaspoon EM •1½ teaspoon of molasses	• 4 pounds of wheat bran or rice bran • 1 to 1½ quarts, distilled or tap water • 2 tablespoons EM • 2 tablespoons of molasses	• 50 pounds of wheat bran or rice bran • 1 to 1½ gallons distilled or tap water • ½ cup EM • ½ cup molasses



1. Combine molasses and water.

2. Add EM and mix thoroughly.

3. Pour the solution slowly into the wheat bran.

4. Mix the liquid into the wheat bran with your hands. Make sure the ingredients are thoroughly mixed. Once the wheat bran mixture reaches a 35% - 40% moisture content level, STOP! (How is this determined? Grab a handful of the mixture and squeeze it into a ball. No liquid should drip through your fingers. When you open your hand the EM Bokashi ball should keep its shape but crumble slowly to the touch. If excess water drips through your fingers, it indicates too much liquid has been added. To correct this, simply add more wheat bran and mix thoroughly to achieve the desired moisture level.)

5. After the wheat bran has been mixed, let it dry. Then place the dried mixture inside a plastic bag or other airtight container. Remove as much air as possible before sealing.

6. Allow mixture to ferment for about two weeks or longer. Store mixture at room temperature out of direct sunlight.

7. In two weeks, check the mixture. Fermentation is successful if the EM mixture has a sweet fermented smell (similar to a pickle).

8. The moist EM Bokashi can be applied directly to a garden or flower box. It acts like a fertilizer. OR it can be added to kitchen waste to help with the decomposition process.

9. If you would like to store EM Bokashi for future use, allow it to sit in an airtight container in low humidity. The mixture should be evenly distributed in the container to a thickness of 1-3 inches.

10. Any questions concerning the EM Bokashi recipe and EM product contact the following distributor: Jo-Anne A. Kaneshiro, Fukuda Seed Store, Inc., phone: 841-6719.

