Energy from Biomass Lab

SUMMARY

In this lab activity, students build a calorimeter to test how much energy is contained in various biomass materials. Students also complete a *Student Lab Journal* to compare temperature change, mass change, calories, and British thermal units.

BACKGROUND

Biomass materials contain stored energy. Burning these materials is a way of measuring their energy content. In this experiment, students measure the amount of energy released from a known mass of biomass material by measuring the change in temperature of a known volume of water. A homemade calorimeter is used to measure the change in temperature of water caused by the absorption of the heat released by burning various biomass materials. Students calculate the change in temperature of the water, change in mass of the biomass material, and calories and British thermal units produced.

Common units of heat measurement are British Thermal Units (Btu) and calories (cal). A Btu is the standard unit of energy used to measure the heat content and energy value of fuels. A calorie is the amount of heat required to raise the temperature of 1 gram (1 milliliter) of water 1 degree Celsius.

1 Btu = 252 cal

The idea for this activity was adapted from *Energy in Common Biomass Materials*, Michigan Biomass Curriculum Project, Michigan Association of Conservation Districts, 2005 and *Peanut Power,* Energy Quest: California Energy Commission, 2006.

activity 13

SUBJECTS

Mathematics, Science

KEY QUESTIONS

1. How is energy measured?
2. How much energy is contained in various biomass materials?

OBJECTIVES

By the end of the activity, students will be able to do the following:

1. Explain how energy is released from biomass materials and how this energy is transferred (SC.912.P.10.1).
2. Compare amounts of energy released from various biomass materials (MA.912.A.2.7).
3. Analyze data by calculating calories and British thermal units produced by various forms of biomass (MA.912.A.1.5; MA.912.A.2.7).

MATERIALS

For each lab station:

- Raw peanuts
- Wood chips or splints
- Dried grass or corn stalks
- Tin can
- Pie plate
- Needles/safety pins
- Erlenmeyer flask
- Crucible
- Square pieces of screen to place on top of the crucible
- Clay
- Thermometer
- Triple beam balance
- Kitchen matches or wand lighter
- Pot holders
- Copies of *Instructions* and *Student Lab Journal* (one copy per student)

TIME ESTIMATE

50 minutes to 1 hour

TEACHER

Teacher Instructions

Assessment Suggestions

OBJECTIVE 1:
Review answers to *Student Lab Journal Summary,* Question 1. Example answers are provided in the *Teacher Key*.

OBJECTIVE 2:
Review answers to *Student Lab Journal Summary,* Questions 2 and 3. Example answers are provided in the *Teacher Key*.

OBJECTIVE 3:
Review *Student Lab Journal Data Tables*, particularly Calories, Calories/gram, and Btu/gram. You can check student calculations using formulas on *Instructions* sheet.

Preparation

1. It is highly recommended that students complete *Activity 3: Biomass Basics Web-quest* prior to doing this activity. *Activity 3* provides students with important knowledge and information about biomass and bioenergy that better enables them to understand this activity.
2. More background information on woody biomass and conversion technologies is available in *Activity 5: Case Study Jigsaw*. Additional information on wood to energy conversion processes is available in the *Resources* section of this activity and in fact sheets found in the *Supplemental Reading* section of this curriculum: *Systems That Convert Wood into Energy; Technological Processes: Bio-chemical; and Technological Processes: Thermochemical.*
3. Review the complete lab setup and procedure instructions found on the *Instructions* sheet.
4. Gather the required lab materials and supplies listed at the beginning of the activity. You will need to prepare tin cans for experiment—poke holes in bottom and sides of cans and cut a viewing square approximately 2 cm x 2 cm in dimension.
   Note: *The wood chips or splints and dried grasses can be difficult to light and require use of a lighter rather than matches. In addition, these materials burn better if placed on a screen over a crucible. It is recommended that you practice lighting these materials before conducting the experiment in class. Peanuts or other types of nuts are relatively easy to light, so you may decide to have students burn various types of nuts and compare the amounts of energy in each.*
5. Make copies of the *Instructions* and *Student Lab Journal.*

Procedure

1. Divide your class into groups (four or five students to a group is recommended) and distribute copies of the *Instructions* and *Student Lab Journal.*
2. To introduce this lab activity, ask students to define energy. Talk about the different types of energy. Ask students if they think a peanut or a piece of wood contains energy. Explain that all organic materials have stored energy stored and that burning materials is one way to release this energy.
3. Explain and define the common units of energy: calorie and Btu.

Teacher Instructions

TEACHER

4. Explain instructions for assembling the calorimeter and tell groups to begin the experiment. To assemble the calorimeter:
   - Place the tin can upside down on top of the pie plate.
   - Place Erlenmeyer flask with water in it on top of tin can.
   - To burn the peanuts, mount the peanuts on a needle/safety pin and insert the needle/safety pin into the piece of clay. Insert this into the tin can through one of the holes and carefully light the peanut using a kitchen match.
   - To burn wood chips or wood pellets, place a piece of screen on top of a small crucible dish and place a small amount of each material onto the screen. This will allow air to move around the material and make it easier to light. Please tell students that these materials can be difficult to light.
5. When students have repeated the procedure for all biomass fuel samples, instruct them to clean up stations and put away lab materials.
6. Have students complete and turn in the *Student Lab Journal* for assessment. To complete the journal, students will need to reference the formulas and unit conversions at the end of the *Instructions*.

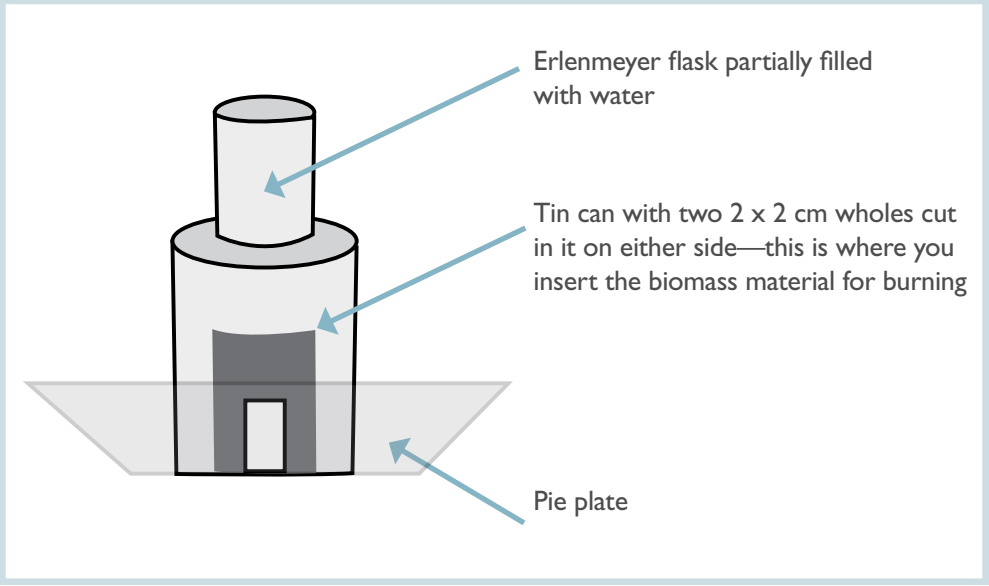

FIGURE 1. Calorimeter assembly.

Resources

- *National Renewable Energy Laboratory: Biomass Basics: http://www.nrel.gov/learning/re_biomass.html*
- *University of Wisconsin KEEP Energy Education Program: What is energy?: http://www.uwsp.edu/cnr/WCEE/keep/mod1/Whatis/energymeasures.htm*

Extensions

For additional comparison of energy in biomass materials, ask students to graph the changes in temperature and mass for each biomass material. Students can graph the lines on one piece of graph paper using colored pencils.

LAB

ENERGY FROM BIOMASS LAB

Instructions

In this lab activity, you will assemble a calorimeter to measure the amount of heat released from a given mass of biomass material. You will measure the change in temperature of a known volume of water. This change is caused by the absorption of heat released from the burning of a known mass of fuel. By analyzing both the change in temperature and the mass of the fuel, you can estimate the amount of energy stored in various biomass materials.

Common units of heat measurement are British Thermal Units (Btu) and calories (cal). A Btu is the standard unit of energy used to measure the heat content and energy value of fuels. A calorie is the amount of heat required to raise the temperature of 1 gram (1 milliliter) of water 1 degree Celsius.

1 Btu = 252 cal

1. Follow your teacher's instructions for assembling the calorimeter. On your *Student Lab Journal*, draw a diagram and label the parts of the calorimeter.
2. As you conduct the experiment, carefully record your own personal observations. Use the *Data Table* to record all measurements.
3. Weigh each biomass fuel sample and record the mass in grams (g).
4. Draw a diagram of each biomass fuel sample.
5. Use the beaker to measure 100 millimeters (ml) of water and pour it into the Erlenmeyer flask.
6. Measure and record the initial temperature of the water in degrees Celsius (°C).
7. Mount the peanut on a needle and place the needle in a piece of clay. If you are also experimenting with wood chips, wood splint pieces, wood pellets, or dried grass, place a piece of screen on top of the crucible dish and then place the material on this screen.
8. Place the biomass fuel sample on the pie plate and carefully light the sample. *(The wood chips and pellets may take some time to light.)*
9. Once the biomass fuel sample is lit, carefully place the tin can over the burning sample and place the flask of water with thermometer in it on top of the can.
10. Continuously stir the water with the thermometer as the biomass fuel sample burns.
11. Watch the temperature rise, and record the maximum temperature. (*The temperature may continue to rise even after the fuel sample is no longer burning.*)
12. Allow the calorimeter to cool for 2 to 3 minutes before disassembling. Use pot holders to disassemble the calorimeter.
13. Weigh the final mass of the biomass sample after burning and record this mass in the *Data Table*.
14. Repeat the procedure for each biomass fuel sample. It is important to change the water in the flask each time.
15. Clean up your station and store lab materials according to your teacher's instructions.
16. Follow the instructions below to analyze the results of your experiment and record all data calculations in your *Data Table*.
    - Calculate calories for each biomass material:

      Calories = Volume of water (ml) X Temperature Change (°C)

    - Convert the amount of calories to British thermal unit (Btu):

      1 Btu = 252 calories (convert calories to Btu by dividing by 252)

    - Calculate the amount of calories produced per gram of each biomass fuel sample:

      $$\text{Calories/gram} = \frac{\text{(Volume of water} \times \text{Temperature change)}}{\text{Mass change (g)}}$$

    - Calculate the amount of Btu produced per gram of biomass:

      $$\text{Btu/gram} = \frac{\text{Btu}}{\text{Mass change}}$$

17. Finally, based on what you discovered about energy from biomass materials, answer the *Summary Questions*.

Student Lab Journal

LAB

NAME _____ DATE _____ PERIOD _____

Data Table

Biomass Fuel Type	Initial Temp. (°C)	Maxi-mum Temp.	Temp. Change (°C)	Initial Mass (g)	Final Mass (g)	Mass Change (g)	Calories	Btu	Calories /gram	Btu/ gram

Diagram of Calorimeter

Diagram of Biomass Fuel Samples

Fuel Sample 1: _____	Fuel Sample 2: _____	Fuel Sample 3: _____

Observations

Summary Questions

1. Explain how energy was released and transferred from biomass materials during this experiment.

2. How did the amount of energy released differ among the biomass fuel samples? Can you think of reasons for this difference?

3. Which biomass fuel sample do you think is the most efficient? Why?

4. What are the potential advantages and disadvantages of extracting energy from biomass materials through combustion?