PHYSICAL SCIENCE FAX!

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Land versus Water

Specific Heat Activity

Introduction

While at the beach on a hot summer day, have you ever observed the temperature difference between the dry sand and the body of water? You nearly burn the bottom of your feet trying to get to the water! Why is there such a huge temperature difference between land and water? Use this activity to get your students thinking about the concept of specific heat and why various substances have different specific heat values.

Concepts

- Heat energy
- Specific heat
- Temperature

Background

The *temperature* of a substance is a measure of the average kinetic energy of the particles that make up the substance. As the temperature of a material increases, the molecules that make up that substance will move more vigorously. As the temperature of a material decreases, its molecules will slow down. It is also known that all matter does not necessarily heat up or cool off at the same rate. This is due to the specific heat of the substance.

Specific heat is defined as the heat needed to raise the temperature of one gram of a substance by one degree Celsius. The SI units for specific heat are given in J/g °C. Specific heat values are also commonly given in cal/g °C, where 1 calorie = 4.184 joules. In general, the greater the specific heat of a substance, the less the temperature will increase when a specific amount of heat energy is absorbed. But why do different substances have different specific heat values? The main reason for this is the atom. All matter is made up of atoms, and atoms have different masses. Imagine you fill two separate containers with 100 g of two different substances. You may have two containers with the same overall mass, but each container may possess a different number of atoms because they are filled with different substances. If heat is added to each container, the one possessing fewer atoms should show a more drastic increase in temperature. This is because it is much easier to set a fewer number of atoms into motion than a larger number of atoms.

Materials

Balance, 0.1-g precision
Lamp, infrared with reflector
Paper towel, white
Petri dishes, 2
Ruler, metric
Soil, potting
Support stand and clamp
Thermometers, 2
Timer
Water, deionized, room temperature

Safety Precautions

Handle the heat lamp with care, it may get very hot and may cause burns. Do not leave the lamp unattended. Wear safety goggles and heat-resistant gloves. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all normal laboratory safety guidelines.

Procedure

1. Fill a Petri dish just below the brim with deionized water. The water should be at room temperature. Measure and record the combined mass of the Petri dish and water.

2. Place an empty Petri dish on a balance and add dry soil until the combined mass (dish and soil) is equal to that of the Petri dish filled with water. Record the mass of the soil and Petri dish. *Note:* The Petri dish used for the soil should be identical to the one used for the water.
3. Using a support stand, set up a heat lamp as shown in Figure 1.
4. Place the two Petri dishes under the heat lamp on a white paper towel.
5. Place a thermometer under the surface of each substance in the Petri dishes (see Figure 1). *Note:* The bulb of the thermometer must be just under the surface of the substance. The exposed end of the thermometer may need to be propped up to prevent it from tipping out of the Petri dish.
6. Adjust the heat lamp so it is about 5 cm above the Petri dishes. Make sure the Petri dishes receive equal amounts of light.

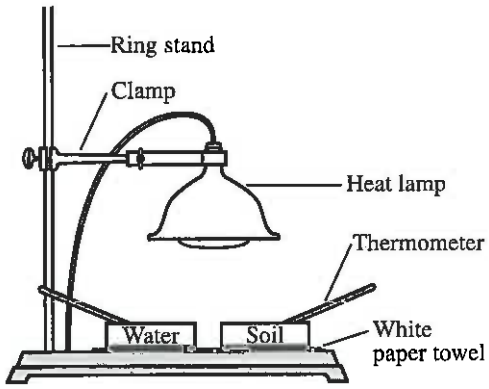


Figure 1.

7. Measure and record the initial temperature for each substance.
8. Turn on the heat lamp. Measure and record the temperature of each substance every minute for a total of 15 minutes.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
- MS-PS1 Matter and Its Interactions
  - PS1.A: Structure and Properties of Matter
- MS-PS3 Energy
  - PS3.A: Definitions of Energy
  - PS3.B: Conservation of Energy and Energy Transfer

Disciplinary Core Ideas: High School
- HS-PS1 Matter and Its Interactions
  - PS1.A: Structure and Properties of Matter
- HS-PS3 Energy
  - PS3.A: Definitions of Energy
  - PS3.B: Conservation of Energy and Energy Transfer
  - PS3.D: Energy in Chemical Processes

Science and Engineering Practices
- Developing and using models
- Analyzing and interpereting data

Crosscutting Concepts
- Cause and effect
- Scale, proportion and quantity
- Stability and change

Tips

- When the activity is completed, have students analyze their data and determine which substance has the larger specific heat. Remember, the greater the specific heat, the less the temperature will rise.
- Make sure that the bulb of each thermometer is placed just beneath the surface of each material. If the thermometers are too deep, the results may be compromised.
- Use this as an inquiry activity before the students learn about specific heat.
- Have students work with a partner. One student may record the data for the water, while the other student records the data for the soil.
- Take this activity a step further by using wet soil. Try different types of soil or sand.
- This activity may be used to discuss radiation and absorption of heat. It may also be used to discuss weather patterns and climate.
- For further concept development on this topic, try Flinn Scientific's *Specific Heat and Climate Laboratory Kit* (Catalog No. FB1883), *Heat Transfer Kit* (Catalog No. AP4536) or *Heat and Temperature* (Catalog No. AP7017).

Sample Data

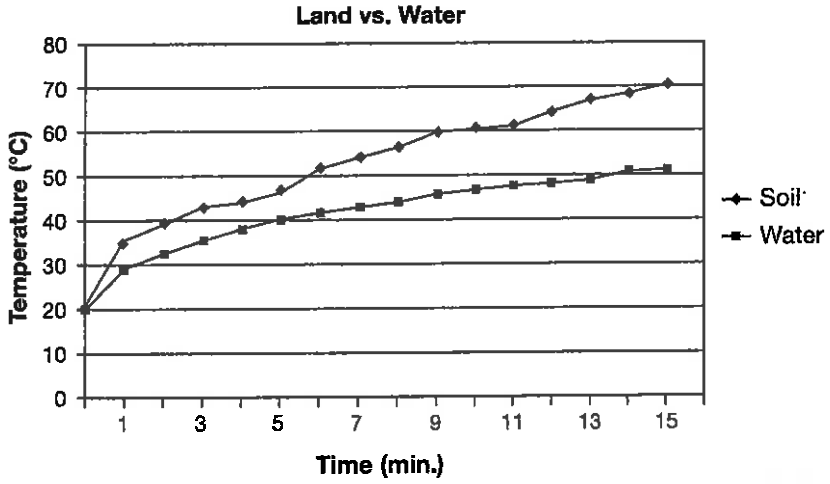
Mass of Water and Cup 99.2 g

Mass of Soil and Cup 99.2 g

Sample Data Table

Time (min.)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Water Temperature (°C)	20.9	29.2	32.6	35.5	38.2	40.4	41.7	43.1	44.5	46.0	47.1	48.0	48.1	48.9	50.6	50.9
Soil Temperature (°C)	20.4	35.4	39.1	42.8	44.3	46.6	51.8	54.1	56.6	59.5	60.1	61.2	64.5	66.8	68.6	70.2

Sample Land versus Water Graph



Place an empty Petri dish on a balance and add dry soil until the combined mass (dish and soil) is equal to that of the Petri dish filled with water. Record the mass of the soil and Petri dish. *Note:* The Petri dish used for the soil should be identical to the one used for the water.

Using a support stand, set up a heat lamp as shown in Figure 1.

Place the two Petri dishes under the heat lamp on a white paper towel.

Place a thermometer under the surface of each substance in the Petri dishes (see Figure 1). *Note:* The bulb of the thermometer must be just under the surface of the substance. The exposed end of the thermometer may need to be propped up to prevent it from tipping out of the Petri dish.

Adjust the heat lamp so it is about 5 cm above the Petri dishes. Make sure the Petri dishes receive equal amounts of light.

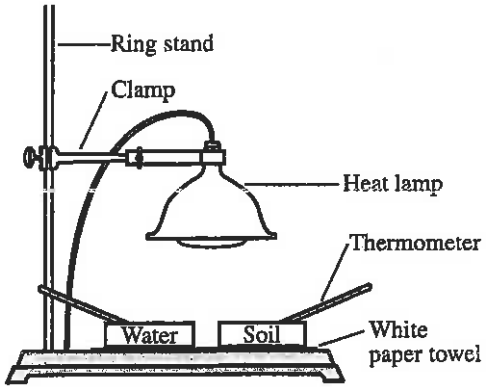


Figure 1.

Measure and record the initial temperature for each substance.

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