

Comparing heat absorption in different soil types

Hypothesis

Sand will absorb heat at a different rate than potting soil.

A dark surface will absorb heat at a different rate than a light surface.

Primary Learning Outcomes

At the end of this lesson, students will be able to:

- Collect and graph temperatures of soil samples
- Calculate average heat absorption
- Be familiar with the importance of heat absorption in different soil types

Assessed GPS

Characteristics of Science:

Habits of Mind:

SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.

- a. Follow correct procedures for use of scientific apparatus.
- b. Demonstrate appropriate techniques in all laboratory situations.

SCSh3. Students will identify and investigate problems scientifically.

- a. Suggest reasonable hypotheses for identified problems.
- c. Collect, organize and record appropriate data.
- d. Graphically compare and analyze data points and/or summary statistics.
- e. Develop reasonable conclusions based on data collected.
- f. Evaluate whether conclusions are reasonable by reviewing the process and checking against other available information.

SCSh4. Students use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.

- a. Develop and use systematic procedures for recording and organizing information.

SCSh5. Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.

- c. Recognize the relationship between accuracy and precision.
- e. Solve scientific problems by substituting quantitative values, using dimensional analysis and/or simple algebraic formulas where appropriate.

Content:

SC6. Students will understand the effects motion of atoms and molecules in chemical and physical processes.

- b. Collect data and calculate the amount of heat given off or taken in by chemical or physical processes.

SPS7. Students will relate transformations and flow of energy within a system.

- c. Determine the heat capacity of a substance using mass, specific heat, and temperature.

Duration

90 minutes

Materials and Equipment

Each workstation will consist of the following:

- 6 250ml beakers
- Sand for two 250 ml beakers
- Potting soil for two 250 ml beakers
- One sheet each of light- and dark-colored cardboard
- 4 mercury thermometers
- 1 or 2 incandescent lamps
- 1 or more rulers
- color pencils of two different colors
- graph paper

Procedures and Background

Step 1: Introduction, 25 minutes

Previous set-up: Set up one 250ml beaker with a sheet of light-colored cardboard paper underneath it and another 250ml beaker with a dark-colored cardboard paper underneath it. Put one or two ice cubes in each beaker. Pose the following question to the students: In which beaker will the ice cubes melt first? Write the inquiry question on the board. Elicit student predictions. The ice in the beaker with the dark cardboard should melt first due to the higher light/heat absorption by dark surfaces. Shine a lamp about 6-10" from the two beakers. Observe the effects. After ice has been observed to melt in the dark-colored cardboard beaker, explain that different soil types also have different rates of light/heat absorption. Explain that temperature readings will be recorded in a sample of sand/sandy soil and a sample of potting soil. Explain that a line graph will be constructed by each student and submitted along with the student worksheets. This graph will have time as the x-axis and temperature as the y-axis. A different color will be used for each soil type (for example, red for sand, blue for soil, etc.).

Step 2: Activity, 45 minutes

Previous set-up: Each workstation will have a total of four 250ml beakers. Two beakers will contain sand or sandy soil, and two beakers will contain dark potting soil. Fill to about a third of the beaker volume. Take one each of the sand and soil beakers and place them 6-10" under an incandescent lamp (or each under its own lamp). These are the experimental beakers. The other two beakers of sand and potting soil will serve as controls and are placed out of the light range of the lamp(s). Mercury thermometers are placed in each of the four beakers.

Explain the need for controls. Variables are soil type and light/no light. Ambient environment, including beakers, are not studied and thus are controlled, i.e., they must not have differences amongst each sample. If there is an appreciable difference in temperature between the sand and soil samples not receiving light, then something in the experimental setup is causing the variation in the sample temperatures. Thus, experimental sample readings are not as reliable.

Have students break up into pairs. Direct the students to construct the correct experimental set up. Ask students: Which will absorb heat more quickly, the sand or the potting soil? Have students write their predictions in Student Worksheet 1.

Instruct the students to shine the lamps on the two experimental beakers. Once the lamps are on, temperatures should be read from the thermometers and tabulated in Student Worksheet Table 1. Readings should be taken in 5 minute intervals for a total of six readings and a total elapsed time of 30 minutes.

Have students graph the tabulated values on the supplied graph paper as previously instructed.

Step 3: Review and Discussion, 20 minutes

Construct a grid such that one axis will be the student group names and the other axis is the time interval (5, 10, 15 minutes, etc.) Have a student from each group come to the board and fill in their observed temperatures. Have students calculate the class average for each time interval and have a volunteer record elicited answers on the board.

Lead a discussion about whether results supported hypotheses (predictions) and why or why not. Explain that sand and sandy soils absorb heat more quickly but also lose it more quickly. Conversely, darker soils absorb but also release heat more slowly. Discuss the implications; i.e., how the earliest agriculture was made possible in Mesopotamia, the Nile Valley, etc. in the presence of dark soils. Ask students what other factors made agriculture possible.

Assessment

Completed student worksheets along with graph paper with completed graphs will be collected and graded.

Student understanding of activity components may be assessed by unit examination.

Student affect and work ethic may be assessed by affect/ethic rubric.

Extensions

1. Students can also measure cooling-off times in similar intervals and elapsed times. This could confirm a hypothesis that, if a soil type has a short heating time then it would have a short cooling time. And so on with a soil type with a long heating time.
2. Have students identify locally grown crops and the soil types most favorable to their cultivation. Does the soil type indicate the level of plant heat tolerance or even heat preference?
3. An electronic temperature probe may be used in conjunction with mercury thermometers. Data quality can be compared between the two types of temperature readings. Concepts of accuracy, precision and significant figures can thus be incorporated into the activity.

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Student Procedure Handout

Materials and Equipment

6 250ml beakers
Sand for two 250 ml beakers
Potting soil for two 250 ml beakers
One sheet each of light- and dark-colored cardboard
4 mercury thermometers
1 or 2 incandescent lamps
1 or more rulers
color pencils of two different colors
graph paper

Procedure

1. Set up and label beakers **sand1** and **soil1** under the lamp. Lamp should be about 6-10" from beakers. Set up and label beakers **sand2** and **soil2** away from the lamp. Insert mercury thermometers into all beakers.
2. Use digital (stop) watch to take temperature readings every 5 minutes for 30 minutes. Record data in Table 1.
3. Graph your data on the supplied graph paper. Both temperature readings are to be graphed on the same graph. Use time (minutes) as the x-axis and temperature ($^{\circ}\text{C}$) as the y-axis. Use one color pencil to show the sandy soil temperatures. Use another color pencil to show the potting soil temperatures.

Name _____

Date _____

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Student Worksheet

Please answer the following questions before starting experiment.

There are two pairs of samples, **sand1 & soil1** and **sand2 & soil2**.

Which pair are the experimental samples?

Which pair are the control samples?

Why do we have both experimental and control samples?

Which sample will absorb heat more quickly? State your hypothesis here:

Please answer the following questions after completing the experiment.

Which type of soil absorbs the most heat?

Do your results support your hypothesis?

What are some desert plant adaptations to a sandy terrain?

Don't forget to complete and submit your graph along with this worksheet.