Activity 2 Urban Development and Air Quality

Goals

In this activity you will:

- Investigate how urban heat islands can affect local temperatures.
- Develop an understanding for factors that cause the urban-heat-island effect.
- Investigate ways to minimize the urban-heat-island effect.

Think about It

"The temperature today in Atlanta reached a sweltering 90°F. Nearby Athens reported in with a reading of 86°F."

Think of a time when you may have been in the heart of a city or out in the open countryside.

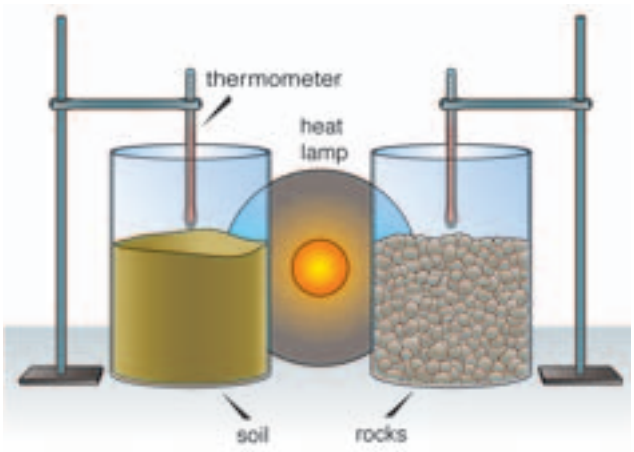
- What are the differences in the weather and/or air quality between the two places?

What do you think? Record your ideas about this question in your *EarthComm* notebook. Be prepared to discuss your responses to these questions with your small group and the class.

Investigate

Part A: Modeling the Urban-Heat-Island Effect

1. Using two identical containers, fill one 2/3 full with damp soil and the other 2/3 full of rocks. The soil should not be completely dry, but it should also not be water-saturated to the point of being soupy.
2. Suspend a thermometer about three centimeters above the soil and another thermometer about three centimeters above the rocks. Make sure the thermometers are at the same height above both containers.
3. Place a light source, shining directly on the materials filling each container, an equal distance from both containers. Be careful not to shine the light directly on the thermometers, or to place the light too far away from the setup. Make sure each setup is identical except for the contents of the containers.



4. Read the temperature on each thermometer at 5-min intervals for a total of 25 min.
   a) Copy the chart shown below into your notebook.
   b) Record your data in the chart.

Light ON	Temperature	
Time (min)	Soil	Rocks
5		
10		
15		
20		
25		

5. Turn off the light and continue to read the temperatures at 5-min intervals for a total of 15 min.
   a) Copy the chart shown below into your notebook.
   b) Record your data in the chart.

Light OFF	Temperature	
Time (min)	Soil	Rocks
5		
10		
15		

6. Plot the data you collected in steps 4 and 5 on one graph showing temperature versus time with the light on and off.

Do not touch the hot lamp. Report any broken thermometers to your teacher.
Clean up any spills immediately.

7. Write a paragraph comparing the temperature data for the soil and rock samples.

   a) How long does the temperature difference between the two containers last after the lamp is turned off?

8. How might slightly higher temperatures affect weather patterns, plants, animals, and human residents of a community?

Part B: Changing the Urban-Heat-Island Effect

1. Repeat the investigation from Part A, but this time modify your setup. Use one or more of the following examples, or design your own variations to simulate conditions found in your own community.

   Possible modifications:
   - Use lighter-colored or darker-colored rocks.
   - Try materials other than rocks to represent other building materials, such as brick, concrete, pieces of wood, or pieces of man-made materials such as fiberglass or plastics.
   - Use containers made of different materials, such as wood, aluminum, or ceramic.
   - If you live in or near a desert or beach, fill one container with sand.
   - If you live near a large lake or ocean, fill one container with water.
   - Devise a model in which you include solid materials and a man-made lake in your containers.
   - Partially or completely cover the tops of the containers with a reflective coating (such as aluminum foil).
   - Partially or completely cover the tops of the containers with grass, leaves, or other plant material.

2. Analyze your data.

   a) How did your data change between Part A and Part B?

   b) What possible sources of error may exist in your models, and how would they affect your data?

3. Supplement your data by collecting temperature data from real cities. If you do not live in a city, pick a city near your community to study. You can find temperature records for many places in the United States from the following sources:
   - Local newspaper (go to the library for back issues).
   - Local TV meteorologist.
   - Local weather service.
   - GLOBE data base.
   - National Climatic Data Center. (Consult the AGI *EarthComm* web site for suggestions.)

Keep flammable materials away from the hot lamp.

Reflecting on the Activity and the Challenge

Changing one Earth system can have a dramatic effect on other Earth systems. In this investigation you modeled how the composition of the Earth's surface (part of the geosphere) can affect the atmosphere above it. Understanding how characteristics of the Earth's surface affect its ability to absorb and release heat helps urban planners recognize how development projects may affect Earth systems. You will need to consider how human activities can influence Earth systems as you prepare to advise the town council on development plans for your community.

Geo Words

urban: relating to a city.

urban-heat-island effect: the fact that many cities have higher average temperature than the surrounding countryside.

solar radiation: energy from the sun available to be absorbed by all of the Earth systems.

Digging Deeper

URBAN-HEAT-ISLAND EFFECT

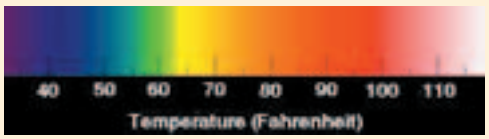
The **urban-heat-island effect** refers to the fact that many cities have higher average temperatures than the surrounding countryside, especially in the summer. Several factors cause this, the most obvious being that buildings, roads, and parking lots absorb more solar radiation than soil and vegetation do. Also, some of the **solar radiation** that falls on vegetation is used by the plants for life processes, rather than raising the temperature of the vegetation. This extra urban heating during the day keeps the city from cooling off as quickly as the country at night.

Figure 1 The numerous buildings and vast paved areas of Chicago absorb large quantities of solar radiation, causing temperatures in the city to be much higher than those of surrounding areas.

Another reason urban areas tend to be warmer is that rain in the city runs quickly off buildings and over paved areas into underground drainage networks rather than soaking into the ground as it does in undeveloped areas. As a result, after a rainstorm there is less surface and ground water remaining for **evaporation** in the city than there is in the country. Because water must absorb heat in order to evaporate, evaporation cools the air. Therefore, having less water available for evaporation in urban settings means that an important cooling process is less effective.

Heat is also generated in developed areas by car emissions, industrial operations, and heating and air-conditioning systems. Pollutants produced by cars and industry also act like a blanket to hold heat in the atmosphere over a city. The decrease in temperature as you move away from the center of a city is shown in the thermal data image *Figure 3*.

Figure 2 How would the temperature in this area differ from the temperature in Chicago? Why?



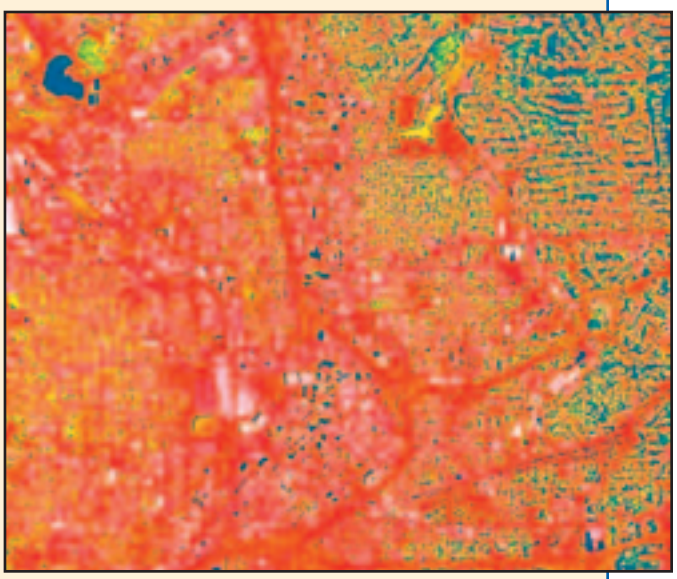


Figure 3 This thermal data image of Atlanta, GA. was taken during the day by a Landsat satellite.

Geo Words

evaporation: the change of state of matter from a liquid (water) to a gas. Addition of heat is required for this change.

Geo Words

condensation: the change of state of matter from a gas (water vapor) to a liquid. Heat is released.

Urban-heat-island effects cause people to use more energy for air conditioning in the summer. Using this extra energy increases the cost of electric bills and causes more pollution. Urban heat islands exist in winter as well as in summer, but then they act to moderate cold winter temperatures. Clear winter nights are almost always colder in areas outside the city, except when strong winds are blowing. Winds tend to even out temperature differences from place to place, by bringing cooler air into warm areas and vice versa.

Urban heat islands also can change local weather patterns by causing more rainstorms, and especially more thunderstorms. The hotter air over the city contributes to strong upward air currents that trigger thunderstorms. In addition, pollutants are actually small particles that can act as **condensation** nuclei that aid in the formation of raindrops.

The extra heat also increases ozone pollution. Ozone pollution is caused when emissions from cars react with warm summer sunshine. (Do not confuse ozone pollution in the lower atmosphere with the ozone hole in the upper atmosphere; they are two separate problems.) Ozone formation increases as the temperature increases. Ozone pollution is dangerous for people with asthma or other breathing problems, as well as the very young and very old. These people must stay inside on days that are predicted to exceed federal ozone standards.

Across the country, as many urban areas continue to grow, urban heat islands are getting bigger. Even in small communities, human development can measurably affect local temperatures. There are, however, ways to help lessen heat-island effects.

Areas of vegetation, especially large trees, can help to reduce the urban-heat-island effect. Vegetation does not absorb as much solar radiation as roads and buildings do. Trees shade roads and buildings from the sun, reducing the amount of solar radiation absorbed. In addition, large volumes of water evaporate or are transpired from vegetation on most days, and this produces a cooling effect. Vegetation absorbs and/or traps pollutants, slowing their introduction into both the atmosphere and the hydrosphere. Plants provide additional benefits such as providing oxygen, slowing runoff (which can help reduce flooding), and filtering runoff (which can help reduce water contamination).

Careful selection of building materials can also reduce the urban-heat-island effect. Some materials absorb less solar radiation than others. For example, wood absorbs less solar radiation than brick. New materials that absorb less heat are constantly being developed. Also, lighter-colored materials absorb less radiation than darker materials. Covering structures with reflective materials reduces the amount of solar radiation that the structures absorb.

Check Your Understanding

1. What factors cause the urban-heat-island effect?
2. What kinds of building materials do you think contribute most to urban-heat-island effect?
3. During which time(s) of the day would you expect urban ozone pollution to be greatest? Why?
4. Describe how vegetation can be used to reduce the urban-heat-island effect.

Understanding and Applying What You Have Learned

1. How would the addition of a new shopping mall effect a community with an urban-heat-island problem?
2. How would the average temperature of a community be affected if an airport were built on an area formerly used as farmland?
3. What are some ways of lessening the urban-heat-island effect of city skyscrapers?
4. Many cities in the United States cite rush-hour commuting as a major cause of severe ozone pollution. What kinds of programs could city planners design and/or promote to help reduce this kind of pollution?
5. A developer in a large town wants to build a large office complex to house businesses. Although the town leaders support this plan because it will create jobs in their community, they are concerned that large developments may affect the local environment. What characteristics can the leaders suggest for this development in order to minimize heat-island effects?

Preparing for the Chapter Challenge

In your Chapter Challenge you will need to make recommendations on how to guide future growth in and around your community. Write a paragraph explaining what can be done to direct future growth in such a way as to avoid or minimize the urban-heat-island effect, as well as ozone pollution, in your community.

Inquiring Further

1. **Urban-heat-island effect in your community**

   Design an experiment to study the urban-heat-island effect in your community or in a city near your community. Pick a question that has occurred to you during this activity, such as *"Would reflective roof covers really help?"* or *"I wonder if there's been increased precipitation in my community because of an urban-island-heat effect?"*

   Make a plan for how you would go about answering the question. To be valid, your study should cover a span of at least five years.

2. **A model community**

   Make a model community (to scale) that has been designed to address and minimize the problems associated with urban-heat-island effects. Explain at least five features of the model.

Have your teacher approve your design before proceeding.