

Introduction

Airborne particulates are among the unhealthiest components of air pollution to humans. Very small particulates can lodge deep inside lung tissue where they can stay throughout the life of a person. The sources of particulates can be natural as well as anthropogenic. Airborne dust, pollen, soil, or particles from the smoke and exhaust of automobiles, factories, and power plants all contribute to the total amount of particulates in the air.

Every member of the class will measure the particulate concentration inside and outside his or her home, and then contribute individual data to the efforts of the entire class to uncover trends in the distribution patterns of particulates in the community.

Procedure

1. Read the background information on this sheet regarding particulate pollutants and bioaerosols, as well as, air quality standard information.
2. Prepare particulate collectors by smearing a circle of petroleum jelly in a one-inch diameter circle in the center of both the top and bottom of a petri dish.
3. Take the particulate collector home, install one half indoors and one half outdoors, about 5 feet above the ground or floor, and measure particulates during the time period prescribed in class (at least 24 hours).
4. Bring the particulate collector to school the following class.
5. Sketch a picture of the exposed particulate collector as seen through a dissecting microscope using both a black and a white background.
6. Try to identify particular particulate contaminants by placing a sample on a glass slide with cover slip and examine under various powers as dictated by the size of the particles. Refer to the sample images on this sheet and sketch at least two of your particulate pollutants from each source.

Background Information

Quick Facts (from <http://www.epa.gov/air/particlepollution/fastfacts.html>)

- Particles that are less than 2.5 micrometers in diameter are known as "fine" particles; those larger than 2.5 micrometers, but less than 10 micrometers, are known as "coarse" particles.
- Fine particles are easily inhaled deep into the lungs where they may accumulate, react, be cleared or absorbed.
- Scientific studies have linked particle pollution, especially fine particles, with a series of significant health problems, including:
 - increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing, for example;
 - decreased lung function;
 - aggravated asthma;
 - development of chronic bronchitis;
 - irregular heartbeat;
 - nonfatal heart attacks; and
 - premature death in people with heart or lung disease.
- Particle pollution can cause coughing, wheezing, and decreased lung function even in otherwise healthy children and adults.
- Studies estimate that thousands of elderly people die prematurely each year from exposure to fine particles.
- The average adult breathes 3,000 gallons of air per day.
- According to the American Academy of Pediatrics, children and infants are among the most susceptible to many air pollutants. Children have increased exposure compared with adults because of higher minute ventilation and higher levels of physical activity.
- Fine particles can remain suspended in the air and travel long distances. For example, a puff of exhaust from a diesel truck in Los Angeles can end up over the Grand Canyon.
- Some of the pollutants which form haze have also been linked to serious health problems and environmental damage.
- Particle pollution settles on soil and water and harms the environment by changing the nutrient and chemical balance.
- Particle pollution, unlike ozone, can occur year-round.
- People can reduce their exposure to air pollution by checking their daily air quality forecast and adjusting strenuous outdoor activities when an unhealthy AQI is forecast.

Particulate Matter Air Pollution What is Particulate Matter?

Particulate matter -- particulates or PM for short -- refers to the many types and sizes of particles suspended in the air we breathe each day. Particulates include products of combustion, such as soot or ashes, wind blown dust, and minute droplets of liquids known as aerosols. PM can range in size from visible pieces of sand and dirt to microscopic particles so small that 500,000 of them could fit on the period at the end of this sentence.

Why should you be concerned about PM?

Particulate matter not only impairs visibility, it also poses a serious health threat to citizens. Our respiratory systems are equipped to filter out larger particles. However, the lungs are vulnerable to particles less than 10 microns in diameter (PM10), which can slip past the respiratory system's natural defenses. Very tiny particles (PM2.5) can penetrate deeply into the lungs and do the most harm.

The particulates we breathe enter the lungs and pass through progressively smaller airways until they reach the alveoli, tiny air sacs where oxygen enters the blood stream. Particulates that get trapped in these most sensitive tissues interfere with oxygen uptake. Toxic and cancer-causing compounds can "hitchhike" into the lung on these particulates and be directly absorbed into the lungs.

What are the health effects of PM air pollution?

PM air pollution can cause coughing, wheezing, and overall decreased lung function in otherwise healthy children and adults. Particulate pollution can trigger asthma attacks and respiratory illness in the more sensitive subgroups of the population, such as the elderly and those with heart and lung disease. Children are more susceptible to particulates because they have smaller lungs and less mature immune systems. In the past 10 years, more than two dozen health studies have linked high concentrations of particulate air pollution with an increase in emergency room visits, hospital admissions, and even premature death.

What causes PM air pollution?

PM is introduced to the air through both natural and human causes. The primary sources of PM in California, excluding agricultural dust, are motor vehicles; diesel trucks and buses; residential wood stoves and fireplaces; industrial emissions; agricultural, slash and yard waste burning; and even exhaust from lawn mowers and boats. PM concentrations tend to be especially high in areas with greater population density, nearby industries or agriculture, or where local topography or weather conditions contribute to air stagnation.

Here are a couple of quick facts about sources of particulate matter:

- During wintertime air inversions, wood stoves and fireplaces release more hazardous particles.
- Diesel trucks and buses are major producers of particulate matter and should be replaced with natural gas-, methanol-, or electric-powered vehicles.
- As our population increases, our vehicle miles traveled increases at a much higher rate, which means more cars on the road and more air pollution from motor vehicle exhaust.
- Industrial emissions are a major source of air pollution. The best control technologies should be encouraged to protect human health and the environment.

What is being done to control PM air pollution?

Our nation's Clean Air Act of 1970, in combination with important amendments adopted in 1977 and 1990, requires that the United States Environmental Protection Agency (EPA) identify and set standards for air pollutants. These National Ambient Air Quality Standards (NAAQS) must be strict enough to protect the health of even the most sensitive members of the population. PM10 is currently one of six "criteria" pollutants identified by the EPA. Here in California, the Department of Ecology and local air pollution control agencies cooperate with the EPA to implement laws designed to reduce PM levels.

National Ambient Air Quality Standards (NAAQS)

The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

National Ambient Air Quality Standards for Particulates (<http://www.epa.gov/air/criteria.html>)

| Pollutant | Primary/Secondary | Averaging Time | Level | Form |
|-------------------|-------------------|----------------|-----------------------|--|
| PM _{2.5} | both | Annual | 15 µg/m ³ | annual mean, averaged over 3 yrs |
| PM _{2.5} | both | 24-hour | 35 µg/m ³ | 98th percentile, averaged over 3 yrs |
| PM ₁₀ | both | Annual | 50 µg/m ³ | annual mean, averaged over 3 yrs |
| PM ₁₀ | both | 24-hour | 150 µg/m ³ | not to be exceeded more than once per year on average over 3 yrs |

A New PM standard

Though our air quality has improved since adoption of these laws, our visibility has worsened. There is also mounting evidence that the PM₁₀ standards may not be strict enough to protect lung health. A 1996 analysis by the Natural Resources Defense Council (NRDC) estimates that PM levels far below current air pollution limits contribute to over 1,000 premature deaths each year in Washington state. Experts suggest that changing the PM standard to contain limits on fine particles (those 2.5 microns or less in diameter) would better protect lung health. A PM_{2.5} standard might mean tougher restrictions on diesel trucks and buses, wood stove and fireplace usage, outdoor burning, and industrial sources. It will also mean that citizens will breathe easier and spend less on health care to treat PM-induced illnesses.

Criteria Air Pollutants (from <http://www.ces.ncsu.edu/depts/fcs/housing/pubs/fcs3605.html>)

| Pollutants | Sources | Health Effects | Standard |
|-------------------------|---|--|--|
| Particulate Matter (PM) | Wood burning, motor vehicles, industry, outdoor burning, windblown dust, construction, mining, unpaved, roads, diesel | Eye and nose irritation, airway irritation, cough, decreased lung function, increased respiratory illness, premature mortality | PM ₁₀ 150 µg/m ³ (24 hour average) PM ₁₀ 50 µg/m ³ (annual average) |

What are bioaerosols?

A healthy indoor environment is important to you and your family. This includes keeping the air free of biological contaminants, which can cause health problems. Scientists call these airborne contaminants bioaerosols.

Bioaerosols are extremely small living organisms or fragments of living things suspended in the air. Dust mites, molds, fungi, spores, pollen, bacteria, viruses, amoebas, fragments of plant materials, and human and pet dander (skin which has been shed) are some examples. They cannot be seen without a magnifying glass or microscope.

Can bioaerosols cause health problems?

They can cause severe health problems. Some, like viruses and bacteria, cause infections (like a cold or pneumonia). Others cause allergies. Both allergic responses and infections may be serious or even fatal. An allergic reaction occurs when a substance provokes formation of antibodies in a susceptible person. We call substances which will cause an allergic reaction in some people antigens or allergens. Bioaerosols may cause allergic reactions on the skin or in the respiratory tract. Rashes, hay fever, asthma (tightness in the chest, difficulty in breathing), and runny noses are common allergic reactions. A few people develop a severe allergic reaction in the lung, which can destroy lung tissue. This is called hypersensitivity pneumonitis. It is not an infection, but repeated episodes can lead to infections of the lung, such as bacterial pneumonia. Hypersensitivity pneumonitis can be triggered by exposure to very small amounts of the allergen, once a person is sensitive to it. Symptoms can range from tightness in the chest, cough, and difficulty in breathing, to low-grade fever, muscle aches, and headaches.

What are sources of bioaerosols in the home?

Molds, mildews, bacteria, and dust mites like the same conditions that we do--warmth and moderate to high humidity. They need little more than a constant moisture supply for survival. You may find bacteria, molds, and mildews in air conditioning equipment, humidifier reservoirs, dehumidifier drip pans, shower heads, toilets, and ice machines. Water damaged carpets, ceiling panels, walls, and paneling are prime sites for new growth if they are allowed to stay damp. When molds, mildew, dust mites, and bacteria are disrupted or release their spores into the air, this results in bioaerosol formation. Molds and mildews develop from spores, which are in the air all around you. As soon as spores settle in an area with the right conditions for growth, they establish colonies, which are often visible to the naked eye. These colonies are a source of more spores, can cause unsightly stains, and may release low levels of toxic chemicals called mycotoxins into the air.

Humidifiers are such a common source of bioaerosols that cause health problems that doctors now use the term humidifier fever. Protozoa, amoebas, and strains of bacteria have been found in humidifiers, and these are readily released into the air with the moisture produced by humidifiers. These have been linked to allergic responses in sensitive people. Mold and mildew may be found in the ductwork of your heating or cooling systems. If there are leaks in the ductwork, or places where moisture and outside air get into the system, mold and mildew can grow. Sometimes they are found in the coils of an air conditioner or in the connection between the unit and the ductwork. Moisture problems are worse where ductwork insulation is on the inside as opposed to the outside of the duct. The insulation's porous surface collects dust and moisture. Mold and mildew may also grow on dirty furnace and air conditioning filters. Plumbing leaks and dampness in attics, basements, and crawl spaces can increase humidity inside your home and promote the growth of agents that will be released as bioaerosols. Bathrooms without outside-vented exhaust fans, combustion appliances like kerosene space heaters, drying laundry indoors, and venting clothes dryers to attics or crawl spaces can also increase the humidity levels in your home. Dust mites and their waste products are the most common allergens in indoor air. Dust mites eat human and pet skin (dander) as it is shed. It has been estimated that we shed about seven million cells per minute! Dust mites live in rugs and carpets, sheets, mattresses and pillows, and upholstered furniture. Ten to 15 percent of people are allergic to dust mites.

Post-Lab Questions

1. What is the difference between a "fine" vs. "course" particulate pollutant?
2. List three health effects caused by "fine" particulates?
3. Name five examples of particulate pollutants.
4. How are the alveoli of the lungs affected by (PM₁₀) and (PM_{2.5}) particulates?
5. What are the major anthropogenic causes of particulate pollution?
6. Which agencies regulate particulate pollution? What are the current daily standards? Annually?
7. What are some of the benefits and negative aspects to tighter particulate pollution controls?
8. What are bioaerosols?
9. What are some of the symptoms associated with bioaerosol hypersensitivity?
10. What are mycotoxins?
11. Describe some of the conditions and locations in which bioaerosol pollutants thrive?
12. Describe the locations and abiotic conditions where your samples were collected.
13. Which particulate pollutants were most abundant in your indoor sample? Outdoor?
14. Which pollutants surprised you in terms their high or low levels?
15. What kind of specific measures could you take to specifically reduce indoor particulate pollutants?
16. What were the likely sources of the particulates identified in your samples?
17. Estimate from your samples the percent proportion of bioaerosols to non-bioaerosols.
18. Design a procedure so you could get a quantifiable value for the mass of your two particulate samples.
19. How do you think seasonal climatic variations might influence your experimental results?
20. Explain any sources of error or provide any areas in which the experiment could be improved.