Monitoring Air Quality

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

- Describe and discuss several air pollutants and methods for detecting them.
- Describe the chemical reactions behind how several monitoring systems function.

Introduction
Degrading air quality due to motor vehicles convinced the California legislature to enact the first air pollution laws in the U.S. in 1947. The results of this law were to establish air pollution control districts and in 1960, to require of air pollution control devices on cars. In 1970, the U.S. government passed the Clean Air Act establishing the national ambient air quality standards (NAAQSs). The act set standards for maximum allowable concentrations of particular pollutant for a particular distance from a source in a particular time period. This act was helpful but not perfect, and it resulted in some silly solutions such as simply building a taller smoke stack. Of course, building a taller smoke stack is not a solution and amendments to the Clean Air Act have addressed some of these problems by dealing with annual emissions of particular pollutants. The good news is that there has been a major reduction in many pollutants; however, population increases and increases in the number of cars has prevented a significant reduction in some pollutants such as carbon and nitrogen oxide.

Hypothesis: Write a hypothesis that addresses the following question: “How healthy do you think the air is outside our school campus?”

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Materials:

<u>Lichen</u>

Graph Paper	Clip Board/Pencil	Measuring Tape/Ruler	Lichen key

<u>Ozone</u>

Filter Paper (10 cm or larger)	Hole Punch	Medium Paintbrush	Plastic Bags
Distilled Water	Potassium Iodide	Cornstarch	Ornament Hangers or String

<u>Particulates</u>

Plastic Wrap	Cellophane Tap/Glue	Blue Index cards	Microscope slides and cover slips
Particulate Matter Key	Vaseline	String	Hole Punch

<u>**Procedure Part One**: **Lichens**</u>
Lichen, which consists of a symbiotic relationship between a fungus and an alga, is sensitive to atmospheric pollution including nitrogen and sulfur emissions that lead to acid rain, as well as toxic lead and mercury emissions. This sensitivity makes lichen a valuable biological indicator of air quality. It can be difficult to identify lichen species, even for seasoned naturalists. We’ll generalize lichen into three categories for this activity. Generally speaking, the more lichen you see (in color and quantity) the cleaner the air.

- **Crustose** lichens form a “crust” onto their substrate of trees, rocks or soil. The crust is attached so firmly that it cannot be removed without causing damage.
- **Foliose** lichens are leafy (think: foliage) that attach loosely, and the lobes of the leaf are often parallel to the surface of the substrate.
- **Fruticose** lichens are the three dimensional, often growing perpendicular to their substrate. They can look like little bushes growing off the side of a tree or rock.

crustose

foliose

fruticose

1. Identify a tree close to your classroom.

2. Map the lichens from the chest-high mark to the base of the tree identifying the type (crustose, foliose, fruticose) of lichen and indicating the size of the lichen patch. Use the lichen key to help. RECORD your drawings and data.

   Sketch Tree & Identify Lichen:

3. Using the modified Hawksworth & Rose Index (below) determine the relative air quality: ___________________

Hawksworth and Rose Index

1. no lichens present (very poor, high sulfur dioxide concentrations)
3. crustose lichens only (poor, high sulfur dioxide concs)
6. leafy and crustose lichens (moderate to good air, medium sulfur dioxide concs)
9. foliose, leafy and crustose lichens present (good air, low sulfur dioxide concs)
10. foliose lichen *Usnea articulata* (string of sausages) (very clean air, virtually no SO_2 concs)

<u>Procedure Part Two: Tropospheric Ozone</u>

In this lab, you will use chemically reactive paper to measure the concentration of ground-level (tropospheric) ozone. The ozone test paper used in this lab was first developed by Christian Friedrich Schoenbein (1799-1868), as a result it is called Schoenbein paper. To prepare the Schoenbein paper, filter paper will be coated with a mixture of potassium iodide, starch and water. To use the Schoenbein paper, you will hang it, in air, out of direct sunlight, for eight hours which will allow a chemical reaction to take place. If there is ozone in the air, Schoenbein paper takes advantage of its high reactivity. Ozone in the air will oxidize the potassium iodide on the Schoenbein paper to produce iodine. The iodine reacts with the starch to produce a purple color. The shade of purple on exposed Schoenbein paper correlates with the concentration of ozone present in the air at the test site. The two chemical reactions follow:

$$2KI + 0_3 + H_2O \rightarrow 2KOH + O_2 + I_2$$

$$I_2 + \text{starch} \rightarrow \text{Blue or Purple color}$$

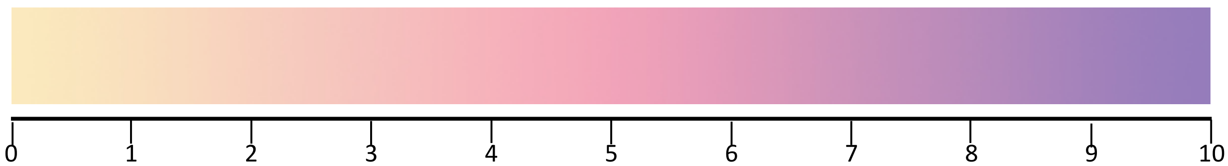
1. Wet an ozone indicator paper with distilled water.

2. Using string, hang ozone detector strip at your tree location site close to the school and allow to hang for **24 hours.**

3. After 24 hours, remove ozone strip and check for change in coloring. Rewet the strip first with distilled water. Indicator turns blue in presences of ozone. A darker color indicates higher ozone level. Use the Schoenbein charts below to record tropospheric ozone concentrations.

4. Record the Schoenbein number: _____________

Schoenbein Color Scale



Schoenbein Number	
0-3	Little or no change
4-6	Lavender Hue
7-10	Blue or Purple

5. Find the average relative humidity for the previous day:

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6. Use the Relative Humidity Schoenbein Number chart to determine the amount of Ozone in ppb, using the relative humidity (in %) and Schoenbein number:

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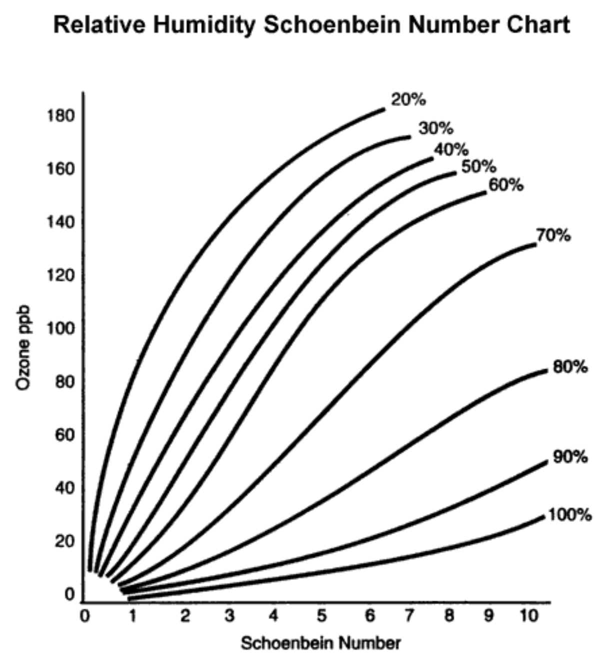


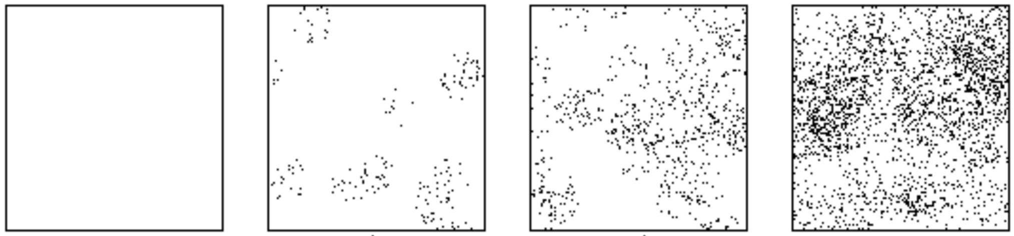
Procedure Part Three: Particulate Matter

Particulate matter, or PM, is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. Particles can be suspended in the air for long periods of time. Some particles are large or dark enough to be seen as soot or smoke. Others are so small that individually they can only be detected with an electron microscope. Some particles are directly emitted into the air. They come from a variety of sources such as cars, trucks, buses, factories, construction sites, tilled fields, unpaved roads, stone crushing, and burning of wood.

1. Prepare a particulate collector by taping a glass slide on a white index card. Spread a thin layer of petroleum jelly over the slide (this will trap particulates). Holes may be punched and string added to hang slide.

2. Place card at your tree location site close to the school and map the location of your collector.

3. After **24 hours**, remove your card and record its appearance (circle which of the following best represents your slide):



None Light Medium Heavy

Conclusion: Based on data gathered, accept or reject your hypothesis. Give supporting evidence.

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Post-Lab Questions:

1. Determine the ozone concentration for the following:

Schoenbein Number	Relative Humidity	Ozone Concentration
2	23%	
2	48%	
2	81%	
	28%	100 ppb
	40%	100 ppb
	72%	100 ppb

2. Go to airnow.gov. Find the air quality measurements for ozone and particulate matter. Compare your data with that of the data found at airnow.gov (governmental data).

3. Go to http://www.epa.gov/sunsafety and determine the UV Index at the test site (zip code: 27519). Explain how the UV Index is related to the concentration of ozone present in air.

4. The highest rating the EPA will allow for ozone in a community is 80 ppb. Any community with over 80 ppb average, over three years, is in noncompliance with the Clean Air Act. Compare your number to this standard. Did the triangle meet the standard on this day? Using what you know about the formation of ozone, decide if you believe the measurement you made was an accurate measurement of the air quality of Wake County, and why.