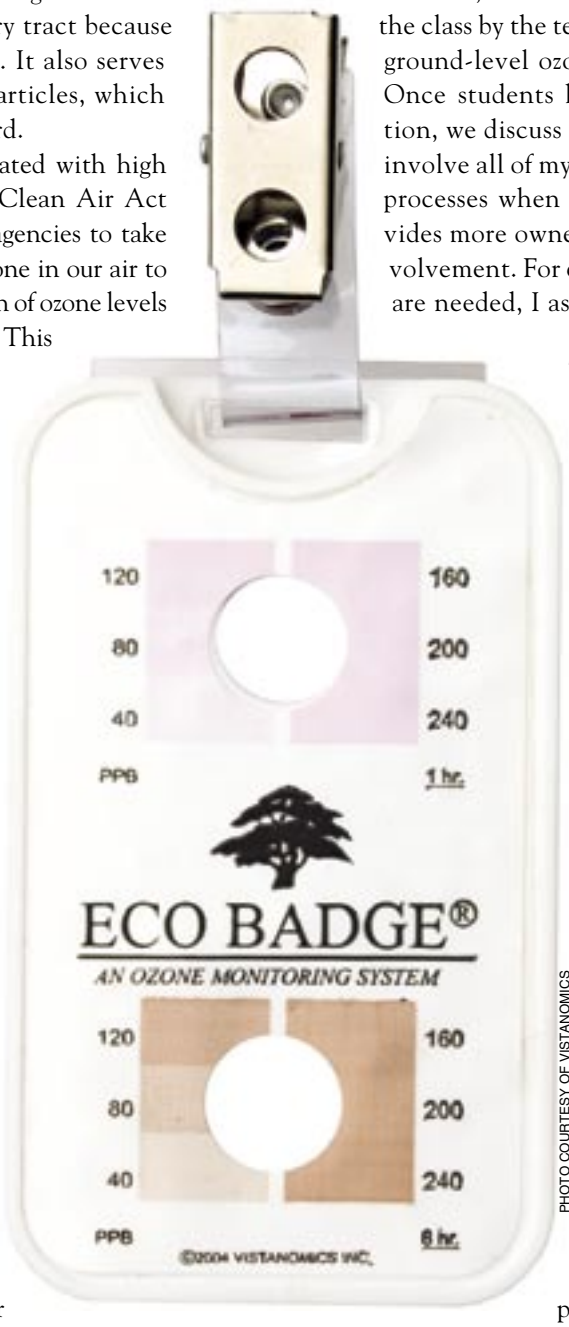
Ozone notebook

Ground-level ozone is created when nitrogen and hydrocarbons produced by cars, industry, power plants, and other sources react with sunlight. Ground-level ozone irritates our respiratory tract because it causes the destruction of tissue. It also serves as a carrier for smog-producing particles, which presents another respiratory hazard.

To combat the problems associated with high levels of ground-level ozone, the Clean Air Act of 1970 called on all government agencies to take measures to reduce ground-level ozone in our air to 120 parts per billion (ppb). Detection of ozone levels is accomplished in a number of ways. This activity uses the Eco Badge.

The Eco Badge comes in a kit that has 150 test cards (strips) and five Eco Badges, plus background information on ozone and its effects. There are two levels, middle school and high school. The current price is $145.00 for the kit and $40 for the replacement parts. The strips are kept in a silvered envelope to avoid exposure to anything that might affect them. The badge has a space to hold a paper strip. When the strip is exposed to ozone in varying amounts, it produces different colors. Once the color develops over a designated time frame, it can be compared to colors directly on the badge to determine the number of parts per billion (ppb) of ozone present. The paper strip is intended to be exposed for either one hour or eight hours. Two circular dots appear on the strip, a lighter one for the one-hour measurement and a darker one for the eight-hour measurement. Separate color bands are replicates of the circular bands that appear on the outside of the opening and the color tells the ppb of ozone present. The kit contains a sheet with the band colors spread out, which can be used to more accurately determine the ozone ppb level.



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Brainstorming

Students can read the background information that comes in the kit, or the information can be presented to the class by the teacher. Students can also research ground-level ozone and ozone detection online. Once students have acquired enough information, we discuss how they might proceed. I try to involve all of my students in the decision-making processes when performing experiments. It provides more ownership and a greater degree of involvement. For example, when weekend readings are needed, I ask a few students to volunteer.

The details

During the two-week period, we took our ozone measurements in 45-minute segments rather than one-hour readings as recommended by the kits. The location selected for measuring ozone was determined by trial testing. A sheet was set up to collect data on the following: date, morning temperature and rating (ppb), noon temperature and rating (ppb), and after-school temperature and rating (ppb).

Students found that measurements recorded at any point along the front of the building consisted of the same values. This was because buses move along the front of the building within a short time frame. Because the buses run on a regular schedule, it was important to have all the materials prepared in advance. Usually this can be accomplished by someone who lives near the school or by the teacher. The location can be near the entrance to the school or some

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other site selected by students, with teacher and administrative approval.

Collection times need to be set and consistently followed. We took measurements three times a day: morning readings from 7:15 to 8:00 a.m., noon readings from 12:30 to 1:15 p.m., and after-school readings from 2:30 to 3:15 p.m. These times were selected based on bus and lunch schedules. Two students recorded the measurements on a data sheet (a simple table) and also on a large poster board in the classroom. Students can alternate taking the measurements. Temperatures were taken with a thermometer at the time of each reading. Data taken from December 4–17 are shown in Figure 1 and were taken from the front of the school. The data in Figure 1 show some interesting trends:

FIGURE 1 **Morning, noon, and afternoon ozone readings (December 4–17)**

	Morning		Noon		Afternoon	
Date	Temp (C)	Ozone (ppb)	Temp (C)	Ozone (ppb)	Temp (C)	Ozone (ppb)
12/4	6	100	16	100	20	50
12/5	17	59	18	250**	20	150
12/6	10	10	17	50	17.5	50
12/7	11	10*	17	100	17.5	125
12/8	3.5	10	15	100	17.5	50
12/9	7	50	18	50	18	25
12/10	10	10*	18	50*	18	5
12/11	3	50	6	100	3	50
12/12	1	10	8	50	13	100
12/13	8	10*	17	50*	13	100*
12/14	10	10*	18	10*	15	100
12/15	12	10	17	100	14.5	100
12/16	11	10	17	100	14.5	100
12/17	9	10	17	50	15	50

*rain **full car lot

- Ground-level ozone occurs more often during warm weather. These chemical reactions must be temperature dependent.
- There are three time periods when the Clean Air Act standards are exceeded at 120 ppb. Because the data were taken around the school, the available time frame for students to take readings was 45 minutes. If the strips had stayed out for a full hour, as the kit directed, the data extrapolated would add eight additional days when the ozone content exceeded the Clean Air standards.
- There are many factors that influence data collection that have to be taken into account when data are examined: wind speed, intensity of sunlight, warmth, humidity, and time of year, among others. These can be used for discussion purposes in conjunction with the material presented in the kit.

If the data for rainy days are extracted, the data illustrate both temperature and moisture effects (Figure 2). Figure 2 shows that on rainy days the rating is less than 50 ppb, regardless of the temperature. The humidity must be a factor in ozone assessment.

FIGURE 2 **Ozone ratings on rainy days**

M = morning, N = noon, A = afternoon

Date	Time of day	Temperature (C)	Ozone (ppb)
12/7	M	11	10
12/10	M	10	10
12/10	N	18	50
12/13	M	8	10
12/13	N	17	50
12/13	A	17	50
12/14	M	10	10
12/14	N	15	50
12/14	A	17	50

FIGURE 3 **Ozone ratings on weekends**

M = morning, N = noon, A = afternoon

Date	Time of day	Temperature (C)	Ozone (ppb)
12/4	M	6	10
12/4	N	18	100
12/4	A	20	50
12/5	M	17	50
12/5	N	16	67
12/5	A	17.5	50
12/11	M	3	50
12/11	N	6	100
12/11	A	5	50
12/12	M	1	10
12/12	N	8	50
12/12	A	13	10

FIGURE 4 **Morning, noon, and afternoon ozone readings (May 19–June 1)**

	Morning		Noon		Afternoon	
Date	Temp (C)	Ozone (ppb)	Temp (C)	Ozone (ppb)	Temp (C)	Ozone (ppb)
5/19	20	150	22	50	22	150
5/20	20	10	22	10	21	10
5/21	17	10	20	20	22	10
5/22	16	wind	18	wind	21	125
5/23	17	10	20	50	22	200
5/24	17	100	26	50	28	150
5/25	18	100	22	10	22	125
5/26	17	100	22	10	27	100
5/27	17	10	19	25	20	50
5/28	17	10	14	10	13	50
5/29	14	10	19	10	22	50
5/30	13	50	19	100	20	175
5/31	14	100	23	150	26	175
6/1	16	50	27	10	29	175

Students can easily extrapolate data from the information in the data sheet. Figure 3 shows that, regardless of the morning temperature, the ozone rating is 50 ppb or less. At noon, the ratings are never greater than 100 ppb. All afternoon values are low. At times of the day when no vehicles are present (M and N), ozone is never greater than 50 ppb.

Figure 4 reflects the data taken during the period of May 19 to June 1. On the days that it rained, the wind blew, or the temperatures were relatively low, there were no significant ratings. However, every day except the two days it rained in the afternoon, the data amounts were significant. The three days of the Memorial Day weekend do not show significance because there were no buses or cars near the school. On May 31, the noon reading was at 150 ppb. This unusual occurrence happened because many parents came and picked up their children.

Conclusion

This activity allows students to evaluate their school's environment and air quality. My students wanted to report their findings to our principal. I made the arrangements, and students presented their data to the principal. The principal took the information under advisement and suggested a reliability study. Because this experiment was conducted near the end of the school year, we did not follow up with a reliability study, but I encouraged students to address this issue with their future teachers.

Acknowledgment

The Eastern Panhandle Soil Conservation Service in Martinsburg, West Virginia, provided the funds to purchase the materials that were used in this experiment. This organization provided funds to do many projects at our school, such as acid rain and stream studies.

Resources

Maryland Department of the Environment—*www.mde.state.md.us/arma/programs/aqplan/ozone/facts.html*

Ground-level ozone (smog) information—*www.epa.gov/region1/airquality/index.html*

Vistanomics—www.ecobadge.com