

2007

Trouble Breathing?

STORM Project

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Middle Level Science

Trouble Breathing?

Objective:

Students will make connections from everyday situations to air quality. Students will know the 7 criteria pollutants established by the EPA and monitored by each state.

National Science Education Standard:

As a result of activities in grades 5-8, students will learn that natural environments may contain substances that are harmful to human beings. Maintaining environmental health involves establishing or monitoring quality standards related to use of soil, water, and air.

Essential Questions:

1. What are the Criteria Pollutants?
2. When and Why were they identified?
3. Have any Criteria pollutants changed over time? If so, why?
4. What are the NAAQS values and how are they used?
5. How do our actions impact air quality?

Teacher Notes(Background Information):

This activity will take approximately one week to complete.

An air pollutant can be defined as a substance that is poisonous to humans, animals, or vegetation, has an objectionable odor or irritates our senses, obscures visibility or damages property.

The Clean Air Act establishes maximum allowable standards of 7 pollutants. They are called the criteria pollutants. These limits are for ambient air, which is outdoor air where we breathe (not directly above a smokestack, for example). These seven criteria pollutants are lead, ozone, carbon monoxide, NO_x (nitric oxides), SO_x (sulfur oxides), PM_{2.5} and PM₁₀ (the last two are particulate matter, the first being smallest-up to 2.5 microns, and the last is PM₁₀, which includes the PM_{2.5} and goes up to particles 10 microns in size). To give perspective, a human hair is about 60-70 microns wide.

The 7 criteria pollutants promulgated by the EPA and currently being monitored by each state are considered harmful to public health and the environment. Information on the 7 criteria pollutants are listed in the National Ambient Air Quality standards (NAAQS) located at <http://epa.gov/air/criteria.html>

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](#) (40 CFR part 50) 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.

The EPA Office of Air Quality Planning and Standards (OAQPS) has set National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" pollutants. They are listed below. Units of measure for the standards are parts per million (ppm) by volume, milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air ($\mu\text{g}/\text{m}^3$).

National Ambient Air Quality Standards

Pollutant	Primary Standards		Secondary Standards	
	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour ⁽¹⁾	None	
	35 ppm (40 mg/m^3)	1-hour ⁽¹⁾		
Lead	0.15 $\mu\text{g}/\text{m}^3$ ⁽²⁾	Rolling 3-Month Average	Same as Primary	
	1.5 $\mu\text{g}/\text{m}^3$	Quarterly Average	Same as Primary	
Nitrogen Dioxide	0.053 ppm (100 $\mu\text{g}/\text{m}^3$)	Annual (Arithmetic Mean)	Same as Primary	
Particulate Matter (PM ₁₀)	150 $\mu\text{g}/\text{m}^3$	24-hour ⁽³⁾	Same as Primary	
Particulate Matter (PM _{2.5})	15.0 $\mu\text{g}/\text{m}^3$	Annual ⁽⁴⁾ (Arithmetic Mean)	Same as Primary	
	35 $\mu\text{g}/\text{m}^3$	24-hour ⁽⁵⁾	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour ⁽⁶⁾	Same as Primary	
	0.08 ppm (1997 std)	8-hour ⁽⁷⁾	Same as Primary	
	0.12 ppm	1-hour ⁽⁸⁾ (Applies only in limited areas)	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Mean)	0.5 ppm (1300 $\mu\text{g}/\text{m}^3$)	3-hour ⁽¹⁾
	0.14 ppm	24-hour ⁽¹⁾		

- (1) Not to be exceeded more than once per year.
- (2) Final rule signed October 15, 2008.
- (3) Not to be exceeded more than once per year on average over 3 years.
- (4) To attain this standard, the 3-year average of the weighted annual mean PM_{2.5} concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m³.
- (5) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m³ (effective December 17, 2006).
- (6) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm. (effective May 27, 2008)
- (7) (a) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.
- (8) (a) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is ≤ 1 .
(b) As of June 15, 2005 EPA revoked the [1-hour ozone standard](#) in all areas except the 8-hour ozone nonattainment [Early Action Compact \(EAC\) Areas](#).

Engage:

Materials- Water, clear cup, 4 colors of food coloring, bleach

Begin with a clear plastic cup or beaker of water. Tell them that the water represents the quality of the air. Using a whiteboard, chalkboard or overhead projector, ask students to brainstorm a list of activities they have done in the past 24 hours. Then process the list with the students, noting ones that have negatively impacted the air quality by adding pollutants to the air (a good way is to circle or put dots next to these activities-if possible you could color code by type of pollutant). Since this is an introductory activity, explain to the student's that they will be learning about each of these pollutants that are identified over the next week.

- Any activities that require gasoline (car or bus to school or work for example) would release Carbon Monoxide, Nitric Oxides, Sulfur Dioxide, Particulate Matter, and VOC's (volatile organic compounds). For each of these activities listed, add one of blue food coloring.
- Any activities that require electricity probably contributed to the air quality in that most power plants rely on burning fossil fuels (the exception would be if your area is served by a nuclear power plant). For each of these activities listed, and one drop of yellow food coloring.

- Many activities release Volatile Organic Chemicals (VOC's) into the air. While these are not one of the 7 criteria pollutants that are the focus of this lesson, they do negatively impact the air quality. Chemicals used in shampoos, hair sprays, fingernail polish, deodorants, dry cleaning, paints and many others release VOC's. For each of these activities listed, add a drop of red food coloring.
- Any burning (like wood stoves, campfires, leaves) release both particulate matter and carbon monoxide. If it is age appropriate, smoking releases a host of harmful air pollutants, the worst of which may be high levels of small particulate matter (PM_{2.5}). For each of these activities, add a drop of green food coloring.

Ask the students: After looking at the water, would they be comfortable breathing in air that was similarly polluted? What thinks could they change to personally reduce the amount of pollution put into the air?

Explain that over the next week we will investigate both the causes and effects of many air pollutants, as well as actions we can take to reduce them.

At the end of the week (please see Elaborate), take a dropper bottle of chlorine bleach, and the original cup of “polluted” water. Use the ideas students generated throughout the week to generate a list of activities that will reduce air pollution. For each idea, add 1 drop of bleach to the polluted water and it will gradually clear.

Explore:

Materials:

Copies of student plays, ID necklaces for full class performance, reference materials, various web sites, situation cards, poster board, art materials

The Play—**Barely Breathing**—Criteria Air Pollutants

The cast of characters and some suggestions for props and costumes:

- 1) Adam Mosefear—reporter—props, microphone and notebook



- 2) Lenny the Lead—Wears a wanted sign
- 3) Ozone---heels, glamorous clothing
- 4) Carbon Monoxide—costume—sneakers, hat, trench coat, sunglasses
- 5) Nitrogen dioxides(aka NO_x--- picture of a fummy tailpipe)
- 6) Sulfur dioxide(SO_x for short---yellow t-shirt)
- 7) PM10 and
- 8) his little brother PM2.5

Tips for putting on the play

- Have students read through the play in groups of 8 (or 4 with double roles if more convenient)
- After the read through, take 8 student volunteers to perform the play as students add basic information to the “Big 7 fact sheet” handout.
- After the play, go over the fact sheet on an overhead projector to make sure students got the essential information from the play.

Setting: TV Reporter Adam is at center stage. In turn, each indoor air pollutant comes over to be interviewed, while the other pollutants continue to lay in the background.

Adam: Hi, I'm Adam Mosphere(Mose-Fear). I'm here at (insert teacher's name) home to cover a late breaking story. Eight of the world's worst air pollutants are here to have their side of the story heard. In today's special report, we'll ask them tough questions to give you the scoop on where these pollutants come from and the ways they can hurt living things.

Adam: Our first interview is with sulfuric and nitric oxides, also known as SO_x and NO_x, welcome to the show.

SO_x: Happy to be here.

NO_x: How you doin'?

Adam: So SO_x, tell me about yourself, how did you two meet?

SO_x: Well, I was just hanging with my buddies deep in the earth in a coal bed, it was a nice quiet life. That is until some guy excavated us, piled us into rail cars, and shipped us cross country to be burned to power an electrical generator. That changed my life forever, before you know it, I'd hooked on with some oxygen and was floating around the atmosphere, that's where I met NO_{xy} over here.

Adam: So that brings us to you NO_x, what's your story?

NO_x: Same old, same old, you know what I mean? Shot out of a tailpipe on the interstate, then I meet SO_x over here and we were just chillin' in the atmosphere when BAM, we both met water molecules and it was like an instant reaction! Just a little water was all it took and now we're both acids. People always wondered why we hung out, being different elements and all, but now we're both acids (weepy), I love you Man! (To SO_x)

SO_x: C'mon NO_{xy}, why do you always have to get gushy! He's right though, all of a sudden, it's not SO_x and NO_x anymore, we're the Acid Rain Brothers! You should see what we can do to buildings, let alone wildlife, and just let us get a crack at your lakes, rivers and streams and we'll show you some serious damage.

SO_x and NO_x together: "We'll NO_x your SO_x off!"

Adam: Thanks for the offer, but I think I'll pass. Next up is another pair, can we all please welcome the Particulate matter brothers PM₁₀ and his little brother PM_{2.5}. C'mon out guys. Guys, where are you.

PM₁₀: I'm right here! I'm about 1/7th the width of a human hair, and I'm the big brother. You're going to need to put a zoom lens on that camera of yours.

Adam: Okay folks, give us a second to focus in, alright, there you guys are, welcome to the show.

PM 2.5: Thanks, happy to be here.

Adam: So what's your guy's story?

PM10: Not much to tell really. Soot, ash, aerosols, whatever, the only qualification to be in our club is that you have to be really small!

PM 2.5: You said it big guy! He's the best big brother a guy could have. You know we started out as the same leaf.

PM10 Yeah little buddy, those burn barrels use very little oxygen, which means more of you and me! And some people think we're too small to do any damage, but let me tell you, we are small but powerful.

Adam: What do you mean?

PM10: We really give fits to those with respiratory disease, coughing fits that is. We also can wreak havoc with the elderly or those with heart disease!

PM 2.5 Only people are getting wise to us, and tuning up their engines, composting instead of burning and upgrading or eliminating wood stoves to where a poor PM doesn't stand (sniffle) a chance.

PM10: take it easy there little guy.

Adam: Thanks guys, next up is Olivia Ozone.

Ozone: Hello Dahling. I hope you are impressed that I'd consent to this interview. I'm not used to sharing a stage with lowly precursor molecules.

NOx: Why I oughta.....what a snob.

SOx: Let it go man.

Ozone: See what I mean, so unrefined! (scoffs)

Adam: So when you say precursor molecules, what are we talking about exactly.

Ozone: Well Dahling, I won't show up just anywhere. But if the conditions are right, with NOx, Heat, Sunlight, and VOC's, then it's time to party!

Adam: VOC's...they aren't on our panel of guests.

Ozone: That's because they aren't a criteria pollutant, but trust me, those volatile organic compounds can do some damage, but when they all show up, count me in. But this program is about harmful chemicals, so why on earth would you ever ask me? Ozone just like me shields the earth from excess UV rays, I'm a hero.

Adam: But isn't it true that that's in the upper atmosphere. Down here isn't your impact a little different?

Ozone: Well, if you're talking about smog, then I guess you have a point. But is it my fault that those with respiratory conditions like asthma can't go out when I'm around?

Adam: Now I'll introduce the folks at home to our next pollutant, Carbon Monoxide. Hey, where did he go? Oh, there you are! You think you're pretty sneaky don't you CO?

Carbon Monoxide: Yeah, sneaking up on people is what I do best. I get into air when cars and trucks burn fuel inefficiently---but you can't see or smell me.

Adam: Then how can we tell when you're around?

Carbon Monoxide: You'll find out when you breathe me in! I can give you a bad headache and make you feel really tired(gives an evil laugh). Just be sure you don't go to the store and buy a detector, so then you will never know when I am around.

Adam(yawns) Oh, I see what you mean. Thanks for talking with us Monoxide(yawns again, bigger this time) CO returns to a seated position.

Our next interview is with Lenny the Lead— tries to hide his face

Lenny: Of course I'd be last. It figures. Everyone's forgetting about me, they take me outta gasoline, and all of a sudden I'm a nobody. I remember when I ruled this town. I used to be a somebody.

Adam: Which just goes to show that if we have the collective will, we can reduce the impact of these pollutants.

Lenny: Well sure, but let me tell you about myself. I....

Adam: I'm sorry Lenny, but it looks like that's all the time we have. Join us next week as we investigate "Clean Coal", nature's perfect fuel or a wolf in sheep's clothing, you decide, next time on EnviroNews.

Explore 2:

(Teachers note: If a computer lab is not available, the lesson in Explore 1 could stand alone. For the poster activity in Explain, teachers could provide each group printed material on their assigned criteria pollutant. The websites listed at the end of this document would be an excellent source.)

In groups of 2-3 students select a "Situation Card". Students then use reference materials and web sites to find the connection between their situation and the production of outdoor air pollutants. Groups of students research to learn about a connection and present this in writing to the teacher who approves them or guides them to other concepts. Students are given criteria to continue their research using the references materials and web sites listed at the end of this document. These criteria are:

- a. a connection between situation and air pollution
- b. what pollutants are produced
- c. the source(s) of the pollutants
- d. health risks

- e. possible solution(s) to the situation

Students will turn in a written response to all the criteria for the teacher to evaluate using the rubric listed under Evaluate. The Teacher then will give feedback on the criteria report, looking for completeness and correctness of responses. See the air pollution connections in the table shown in the resources at the end of this document. Students will conduct an activity (they should work to come up with their own if possible) that specifically relates to their situation. (If they are unable to come up with an idea for an activity, many are listed in the support materials at the end of the document.) They are required to explain their activity and document their findings.

Explain

Students will create a poster to present to their peers. The criteria are:

- a. situation phrase
- b. pollutants produced
- c. source
- d. health risks
- e. explain their activity (could be in diagram or picture form)
- f. results of activity (what they found out)
- g. possible solutions to the situation

While making the presentation, other students will return to the student worksheet “The Big 7 Fact Sheet”. The teacher will make sure each group includes the key information. Additionally, the teacher may need to add to the presentations to make sure the information is correct and complete on the student fact sheet.

Elaborate:

Using the colored water (the simulated polluted air) from the beginning demonstration, add a dropper of chlorine bleach for each solution students pose to combat air pollution. The water will become more clear with each drop of chlorine solution. Stress to students their solutions can make a difference in the quality of air they breathe.

Evaluate 1: (Formative assessment)

Students will be given a list of terms related to air quality. They then will be instructed to draw a concept map connecting the terms as logically as possible (If a computer lab with Inspiration is available it is an excellent tool for these activities). Students should try to use every word given, and should be encouraged to add any others they feel are important. Each one should be enclosed (circle or other) and the lines that connect the terms should have arrows and words to clarify the relationship when possible.

Air	Carbon Monoxide	Particulate Matter	Small	Large
NOx	Ozone	EPA	SOx	PM10
States	Amount	Health Concerns	enforce	PM2.5
Standards	Asthma	regulate	NAAQS	Lead

Evaluate 2 (teacher evaluation rubrics):

Rubric for Written Response to Situation

Connection between situation and air pollution	correct ___/2	complete ___/2
Pollutants produced	correct ___/2	complete ___/2
Sources of pollutants	correct ___/2	complete ___/2
Health risks	correct ___/2	complete ___/2
Possible solutions	correct ___/2	complete ___/2

TOTAL POINTS ___/20

Rubric for Poster

<u>Content</u>	
Situation phrase on poster	___/2
Pollutants produced	___/3
Sources of pollutants	___/2
Health risks	___/3
Explains activity	___/10
Shows results of activity	___/10
Possible solutions	___/5
Sub total	___/35
<u>Aesthetics</u>	
Neat	___/3
Colorful	___/3
Pictures or diagrams included	___/4
Sub total	___/10
<u>Presentation</u>	
Everyone included	___/3
Easily heard	___/2
Easily understood	___/2
Evidence of advance prep	___/3
Sub total	___/10
GRAND TOTAL	___/55

Situation Cards (Explore 2)

Living close to an animal feeding operation



Leaving your computer on



Using lights to read



Burning
leaves or
trash



Choosing
fuel for your
family
vehicle



Needing an
inhaler
outdoors.



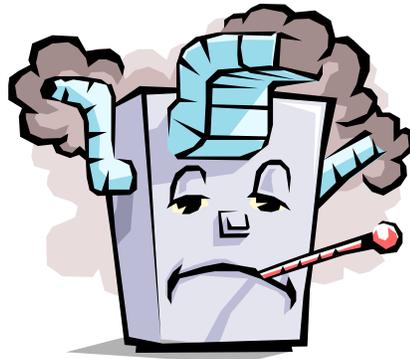
Not
maintaining
your vehicle



Using SPF
Lotion



Not main-
taining your
furnace



Riding your
bike on a gravel
street or road



Not recycling
waste



Using
polystyrene
cups



Resources to Guide Student Learning with Situation Cards (Explore 2)

Situation	Air pollution Connections & Resources
Leaving your computer on all day and night	Electricity from a coal-fired electrical plant gives off SO _x , NO _x , and Lead (Pb). <ul style="list-style-type: none"> • http://www.need.org/needpdf/EfficiencyI.pdf
Burning leaves/trash	Particulates are produced. <ul style="list-style-type: none"> • http://www.epa.gov/ebtpages/air.html • http://www.iowadnr.com/air/citizen/burn/burn.html • http://www.airdefenders.org/identify/index.htm
Using SPF lotion	The depletion of the ozone allows in more UV rays. <ul style="list-style-type: none"> • http://www.epa.gov/sunwise/
Using lights to read	Electricity from a coal-fired electrical plant gives off SO _x , NO _x , and Lead (Pb). <ul style="list-style-type: none"> • http://www.need.org/needpdf/infobook_activities/IntInfo/LightI.pdf • http://www.need.org/needpdf/EfficiencyI.pdf
Needing an inhaler outdoors	There is an increase in health issues due to air pollution. <ul style="list-style-type: none"> • http://kidshealth.org/parent/medical/allergies/ozone_asthma.html
Not recycling waste	Recycling uses less energy so less pollution. <ul style="list-style-type: none"> • http://www.need.org/needpdf/EfficiencyI.pdf
Not maintaining your furnace	Improperly maintained furnace promotes incomplete combustion and the production of CO. <ul style="list-style-type: none"> • http://www.powerhousetv.com/stellent2/groups/public/documents/pub/phtv_se_he_ma_000606.hcsp
Living near a animal feeding operation	Besides the odors given off, particulates are produced. <ul style="list-style-type: none"> • http://www.pca.state.mn.us/hot/legislature/factsheets/feedodor.pdf
Riding your bike on a gravel road	Fugitive dust (both PM2.5 and PM10 particulates) is stirred up. <ul style="list-style-type: none"> • http://www.forester.net/ecm_0203_arrest.html
Using polystyrene cups	The production of polystyrene also produces CFC's. <ul style="list-style-type: none"> • http://www.earthresource.org/campaigns/capp/capp-styrofoam.html
Not maintaining your family vehicle	Vehicles' exhaust gives off SO _x , NO _x , and CO. These primary pollutants lead to the production of ground-level ozone (O ₃). Poorly maintained cars give off more pollutants. <ul style="list-style-type: none"> • http://www.need.org/needpdf/WhatCar2003.pdf
Choosing fuel for your family vehicle	Ethanol gives off less CO ₂ due to more complete combustion. <ul style="list-style-type: none"> • http://www.need.org/needpdf/EfficiencyI.pdf

Situation	Possible Student Activities(suggest to groups if needed)
Leaving your computer on day & night	Using electrical meter to track energy use http://www1.eere.energy.gov/kids/roofus/electric_meter.html
Burning leaves/trash	Composting your leaves instead of burning them http://www.ciwmb.ca.gov/Schools/Curriculum/Worms/98Activities.pdf
Using SPF lotion	Experimenting with UV beads http://solar-center.stanford.edu/webcast/wc03.html
Using lights to read	Doing a home energy audit http://www.rebuild.gov/sectors/quiz/quiz.html
Needing an inhaler outdoors	Having a guest speaker like a health professional on asthma and respiratory diseases aggravated by air pollution Students participate in online activity “Lung Attack”: http://www.airinfnow.org/html/activities.html http://www.nutramed.com/asthma/airborne.htm
Not recycling waste	Completing an environmental home survey http://www.swa.org/pdf/activity_sheets/misc_activities.pdf
Not maintaining your furnace	Doing an online home energy audit http://hes.lbl.gov/
Living near a animal feeding operation	Experimenting with a “sense of smell” kit which can be purchased from various science vendors at a fairly reasonable price
Riding your bike on a gravel road	Investigating particulates http://www.nef1.org/ftf/aq.html http://www.nps.gov/lacl/kids/air.htm
Using polystyrene cups	Creating a petition calling for reduced or nonuse of polystyrene products and getting people to sign it
Not maintaining your family vehicle	Capturing tail pipe particulates http://www.hcdoes.org/airquality/Outreach/Teacher%201%20-%20Sock%20It%20To%20Them.htm
Choosing fuel for your family vehicle	Checking for fuel efficiency http://www.naturalfamilyonline.com/1-nl/47-fuel-efficiency.htm Considering solar cars http://www.bu.edu/lernet/GK12/tommy/Solar_car.htm

Student Sheet

Date _____ Period _____ Name _____

The Big 7 Fact Sheet

Pollutant	Source	Health Risks
Carbon Monoxide (CO)		
Lead (Pb)		
Nitrogen Dioxide (NO _x)		
Particulate Matter (PM _{2.5} & 10)		
Ozone (O ₃)		
Sulfur Oxides (SO _x)		