GRADE 9 SCIENCE

UNIT C:
Environmental Chemistry

THE CHEMICALS WE BREATHE

A UNIT ON **AIR QUALITY**

Edmonton Space & Science Foundation

TELUS WORLD of SCIENCE Edmonton

Dear Teacher,

Thank you for your interest in the TELUS World of Science – Edmonton Professional Development Program on Air Quality for Science Teachers. We've worked hard to create a high-quality set of resources to help you bring the science of air quality into your classroom through hands-on activities, inquiry-based lessons, and real science tools. This unit guide has been designed to seamlessly integrate with the Alberta science curriculum and expose your students to this important subject matter through experimentation and exploration. Using the PocketLab Air sensor your students will explore air pollution in their own communities and connections to their daily lives.

We all have a stake in the quality of the air we breathe. Your participation in this project facilitates our goal of educating over 400,000 people on the gases and factors that impact air quality, the way in which air quality affects health and the environment, and where to find reliable sources of air quality information.

This guide includes all of the information, instructions, materials list, and resources necessary for you to confidently lead air quality lessons with your students. The unit is broken up into several lessons designed to be completed over a series of days or weeks. Follow the guide exactly, or adjust to suit your style and student needs.

All materials found within this booklet can also be accessed online at www.twose.ca. Here you will be able to access student worksheets, background information and full lesson plans.

We've partnered with The King's University Centre for Visualization in Science to provide you with additional resources, available at http://sensors.kcvs.ca/. Here you will find information on operating the PocketLab Air sensor, analyzing its data, and navigating Alberta's Air Quality Health Index online mapping tool.

We hope you enjoy these resources and will share your experience with us. To offer feedback, share your story, or if you require further information or clarification please contact us using the information below.

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This project was funded through a creative sentencing order of the Provincial Court of Alberta with the goal of bringing awareness about air quality issues to Albertans.

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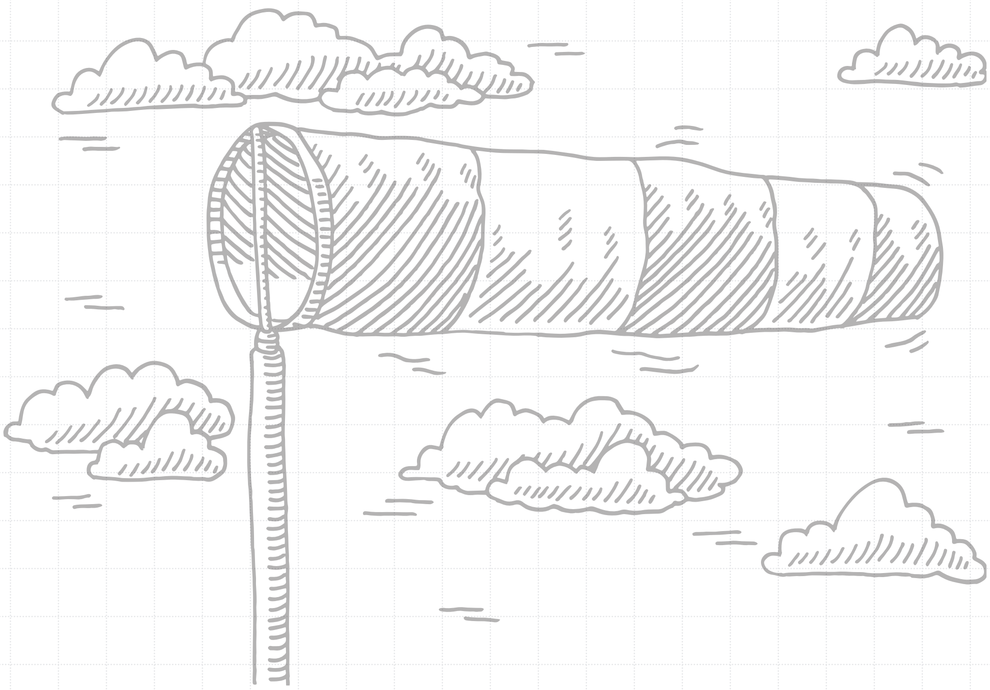


INTRODUCTION

The Chemicals We Breathe

In this unit, students will examine the chemistry of the air that is around us. They will explore the chemicals that make up our atmosphere and identify pollutants that affect both the environment and human health. Students will use experimentation to explore the chemistry of acid precipitation and its linkage to air quality. Using the PocketLab Air sensor, students will collect information on the levels of common pollutants in their local area and compare their data to the Alberta Air Quality Health Index (AQHI) data, which is available to the public.

Curriculum Connections

Grade 9 Science, Unit C: Environmental Chemistry

1. Investigate and describe, in general terms, the role of different substances in the environment that support or harm humans and other living things
    - describe and illustrate processes by which chemicals are introduced to the environment or their concentrations are changed (e.g., dilution in streams, biomagnification through food chains)
    - describe the uptake of materials by living things through ingestion or absorption, and investigate and describe evidence that some materials are difficult for organisms to break down or eliminate (e.g., DDT, mercury)
    - identify questions that may need to be addressed in deciding what substances—in what amounts—can be safely released into the environment (e.g., identify questions and considerations that may be important in determining how much phosphate can be released into river water without significant harm to living things)
2. Identify processes for measuring the quantity of different substances in the environment and for monitoring air and water quality
    - identify chemical factors in an environment that might affect the health and distribution of living things in that environment (e.g., available oxygen, pH, dissolved nutrients in soil)
    - apply and interpret measures of chemical concentration in parts per million, billion or trillion
    - identify acids, bases and neutral substances, based on measures of their pH (e.g., use indicator solutions or pH meters to measure the pH of water samples)
    - describe effects of acids and bases on living things (e.g., acid rain in lakes, antacids for upset stomachs, pH in shampoos and conditioners)
3. Analyze and evaluate mechanisms affecting the distribution of potentially harmful substances within an environment
    - describe mechanisms for the transfer of materials through air, water and soil; and identify factors that may accelerate or hinder distribution (e.g., wind speed, soil porosity)
    - comprehend information on the biological impacts of hazardous chemicals on local and global environments, by:
    - interpreting evidence for environmental changes in the vicinity of a substance release
    - Identifying and evaluating information along with gathering evidence related to an issue in which environmental chemistry plays a major role (e.g., evaluate evidence that the use of insecticides to control mosquitoes has an effect/has no effect on bird populations)

Enduring Understandings

All matter is made up of chemical elements. Some chemicals can be harmful to our health and the health of the environment.

Chemicals released from human activity can cause air pollution. They come from multiple sources and can impact the environment and human health.

The Alberta Air Quality Health Index (AQHI) provides information and data for us to learn about the air quality of our area.

Air pollution can be hard to regulate and monitor; setting pollution limits is important, if difficult.

Oxides of carbon, nitrogen and sulfur are soluble in water. Dissolving these substances in water in the atmosphere produces acid precipitation.

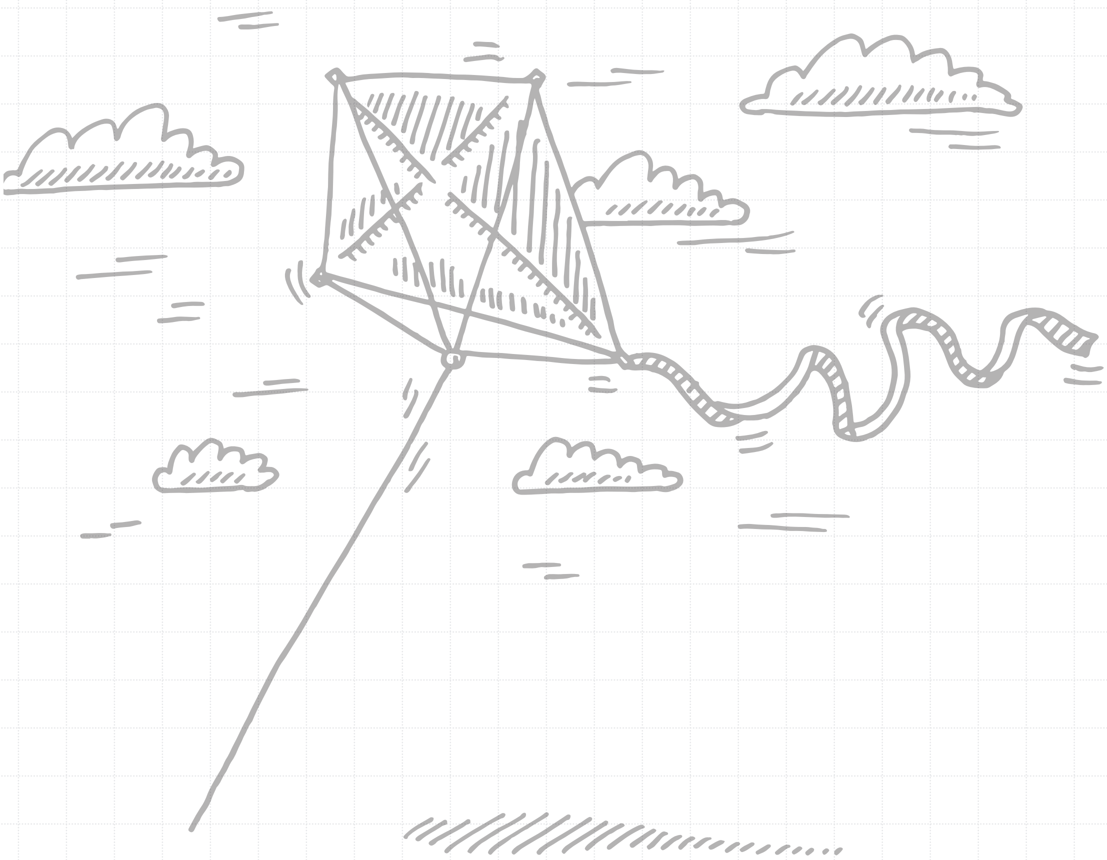
Acid precipitation has major impacts on the environment including plants and aquatic systems.

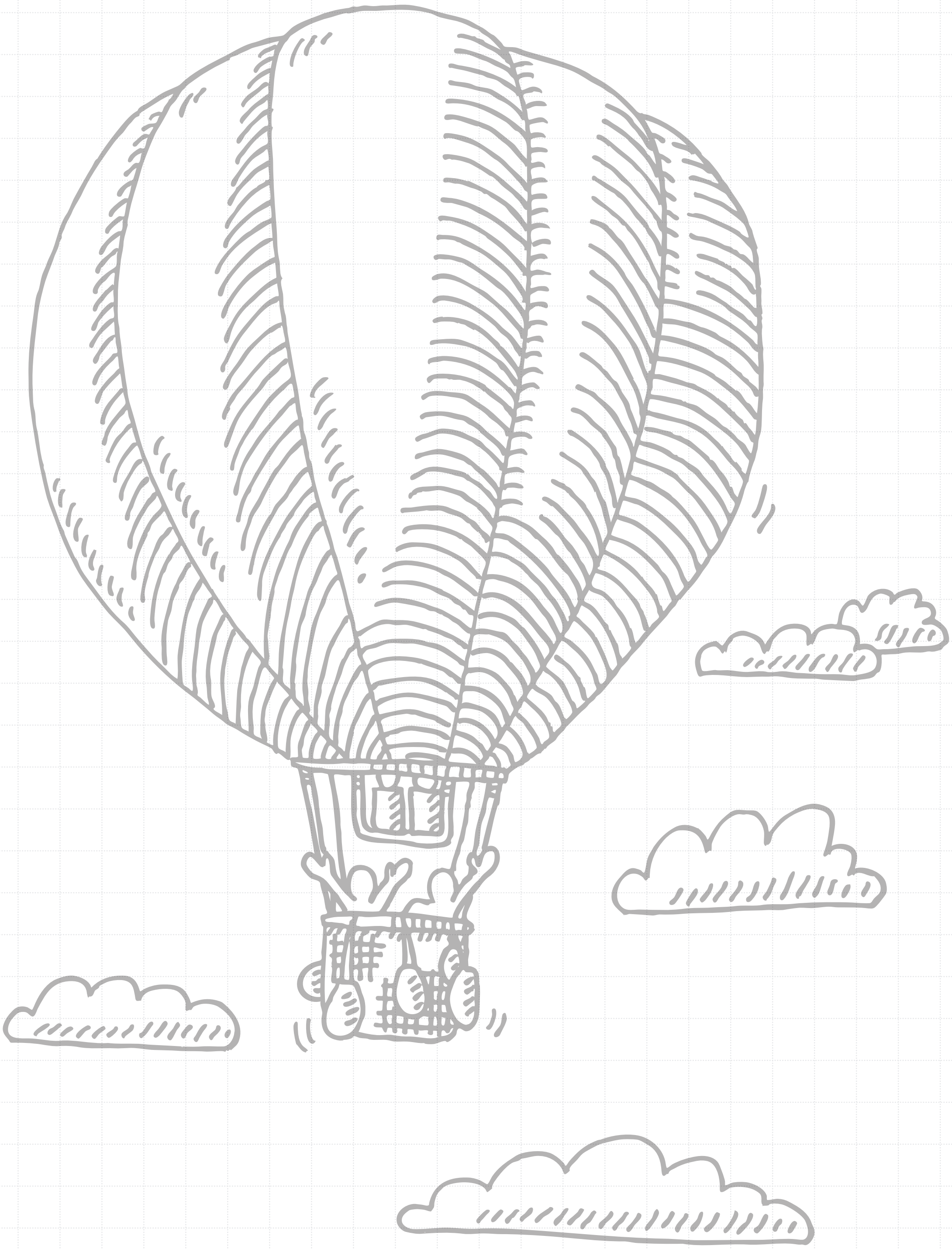
Air quality data is rigorously collected by airshed organizations across the province, and this data is available online.

The precision of air quality instruments should be considered and applied appropriately depending on the desired outcome of the study.

Prior Knowledge

Students should have a basic understanding of the periodic table of elements and chemical naming rules. They should also be able to recall the components of Earth's atmosphere.





LESSON 1:

WHAT ARE CHEMICALS?

LESSON 1:
WHAT ARE CHEMICALS?

In this lesson, students learn that everything, from the air we breathe to the food we eat, is made up of chemicals. They explore the natural components of our atmosphere and research specific chemicals that are released into the atmosphere as pollutants. At the end of the lesson, students learn how to access Air Quality Health Index (AQHI) information for Alberta in preparation for a research project in the next lesson.

Learning Goals:

- Students will compare and contrast the following terms: chemical, element, substance, matter.
- Students will list the names of the chemicals that make up our atmosphere and state the relative proportion of each chemical.
- Students will explain the difference between point source, non-point source, and natural source air pollutants and give an example of each.
- Students will collectively research several common air pollutants and will inform their classmates' own learning by sharing their findings in a jigsaw activity.
- Students will identify and interpret the current AQHI value for their community.
- Students will generate a list of considerations that may be important in determining how much of a specific pollutant can safely be released into the atmosphere.

Resources & Materials

- *Airborne Chemicals* worksheet
- Access to a computer for research
- *Air Pollutant* posters

Time Required

140 minutes

Preparation

- Collect all materials
- Arrange for student access to laptops or computers for research
- Set up Air Pollutant posters around the room
- Print *Airborne Chemicals* worksheet
- Review teacher's background information, if necessary

Instructions

1. Introduce the lesson
   a. Discuss the terms chemical, element, substance and matter
   b. Discuss periodic table and chemical naming
2. Discuss atmospheric components
   a. What chemicals make up our air?
   b. What are pollutants?
3. Airborne Chemicals worksheet/jigsaw activity
   a. Explain jigsaw activity and have students research their assigned pollutants
   b. Have students share their findings within their groups
4. Gallery walk
   a. Explain the activity and have students brainstorm consideration for setting air pollution limits.

Assessment

Pre-assessment

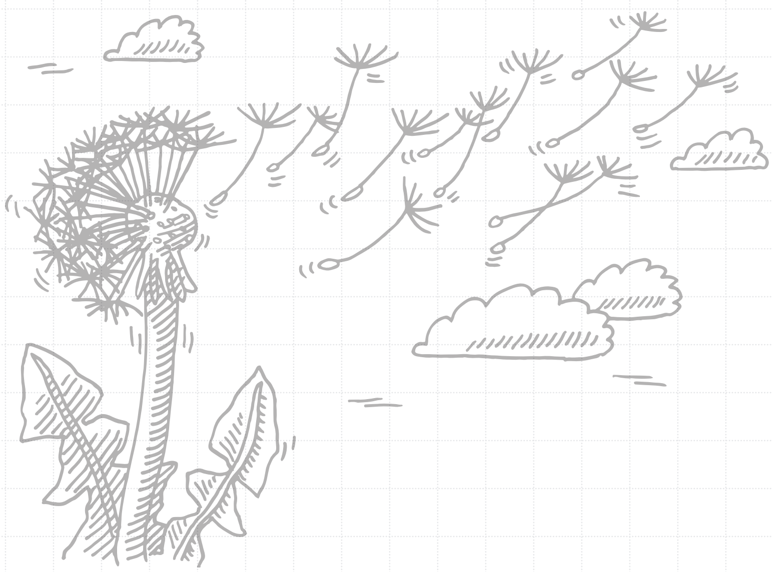
- Determine students' current understanding of the terms chemical, element, substance, and matter. Can they provide a definition for each?
- Can the students list the gases that make up earth's atmosphere?

Formative Assessment

- Students are responsible for informing the learning of their classmates during a jigsaw research activity and should complete the worksheet completely and accurately.
- Students should clearly communicate their findings to their classmates and share research notes for the benefit of the whole group.
- Students should apply what they learned in the jigsaw activity to identify considerations for air pollution regulation. They should actively participate in the gallery walk.

Summative Assessment

- The Airborne Chemicals worksheet may be taken for marks to incentivise active participation and ensure all students learn about all six pollutants.
- Post it notes from the gallery walk may be used as an assessment of participation.



AIRBORNE CHEMICALS

Group A

Pollutant	Chemical Formula	Source(s)	Point Source, Non-Point Source, Natural Source?	Environmental Impact	Health Concerns
Carbon Monoxide					
Nitrogen Dioxide					
Ozone					

KEY

Group A

Pollutant	Chemical Formula	Source(s)	Point Source, Non-Point Source, Natural Source?	Environmental Impact	Health Concerns
Carbon monoxide	CO	Vehicle emissions Gas appliances Charcoal grills Smoking	**answers here will depend on the sources the students have listed. Point sources are things like factories or power plants (stationary and traceable), while non-point sources are often mobile and pollutants cannot be traced back to the source*	Can react with other pollutants to form ground level ozone	Lethal for all humans and animals at high concentrations Headache, dizziness, coma at low concentrations
Nitrogen dioxide	NO_2	Vehicle emissions Coal fired power plants Furnaces Space heaters *these typically release NO which reacts with ozone to become NO_2		Contributes to acid precipitation	May contribute to cardiovascular and respiratory disease Aggravates existing conditions such as COPD or asthma
Ozone	O_3	Found naturally in the stratosphere Ground-level ozone is a secondary pollutant is created through chemical reactions between nitrogen oxides and volatile organic compounds (VOCs) that come from vehicle exhaust, and chemical solvents		Contributes to smog which can cause plants to grow more slowly and become vulnerable to disease, pests, drought and cold.	Can contribute to cardiovascular and respiratory disease. Can cause coughing, airway irritation, and increased vulnerability to respiratory infections. Aggravates existing conditions such as COPD or asthma.

Group B

Pollutant	Chemical Formula	Source(s)	Point Source, Non-Point Source, Natural Source?	Environmental Impact	Health Concerns
Particulate Matter	PM_{10} & $PM_{2.5}$	PM_{10} comes from wind-blown soil, dust, and particles from industrial activities. $PM_{2.5}$ comes from gases released into the air by combustion processes (vehicle emissions, forest fires)	**answers here will depend on the sources the students have listed. Point sources are things like factories or power plants (stationary and traceable), while non-point sources are often mobile and pollutants cannot be traced back to the source*	Reduced visibility. Covers plants making processes like photosynthesis and cellular respiration more difficult.	PM_{10} can be inhaled, while $PM_{2.5}$ can become trapped in delicate lung tissue. Can contribute to cardiovascular and respiratory disease. Can cause coughing, airway irritation, and increased vulnerability to respiratory infections. Aggravates existing conditions such as COPD or asthma. Can lead to lung cancer.
Hydrogen Sulfide	H_2S	Natural gas processing plants Petroleum refineries Animal feedlots		Toxic to aquatic life, birds and animals.	Lethal after just a couple of breaths and high concentrations. Lower concentrations may irritate the eyes, nose and throat.
Sulfur Dioxide	SO_2	Combustion of fossil fuels containing sulfur Natural gas processing plants Oils sands facilities Coal-fired power plants		Contributes to acid precipitation Combines with other atmospheric gases to produce fine particulate matters $PM_{2.5}$	Lethal at high concentrations. Lower concentrations can cause eye and respiratory irritation Can contribute to cardiovascular and respiratory disease Increased vulnerability to respiratory infections and chronic bronchitis

AIR POLLUTANT POSTERS

CARBON MONOXIDE

Environmental Considerations/Questions	Health Considerations/Questions
Think: How does this pollutant impact the environment? How would these impacts affect regulatory considerations?	**Think:** How does this pollutant impact human health? How would these impacts affect regulatory considerations?

NITROGEN DIOXIDE

Environmental Considerations/Questions	Health Considerations/Questions
Think: How does this pollutant impact the environment? How would these impacts affect regulatory considerations?	**Think:** How does this pollutant impact human health? How would these impacts affect regulatory considerations?

OZONE

Environmental Considerations/Questions	Health Considerations/Questions
Think: How does this pollutant impact the environment? How would these impacts affect regulatory considerations?	**Think:** How does this pollutant impact human health? How would these impacts affect regulatory considerations?

PARTICULATE MATTER

Environmental Considerations/Questions	Health Considerations/Questions
Think: How does this pollutant impact the environment? How would these impacts affect regulatory considerations?	**Think:** How does this pollutant impact human health? How would these impacts affect regulatory considerations?

HYDROGEN SULFIDE

Environmental Considerations/Questions	Health Considerations/Questions
Think: How does this pollutant impact the environment? How would these impacts affect regulatory considerations?	**Think:** How does this pollutant impact human health? How would these impacts affect regulatory considerations?

SULFUR DIOXIDE

Environmental Considerations/Questions	Health Considerations/Questions
Think: How does this pollutant impact the environment? How would these impacts affect regulatory considerations?	**Think:** How does this pollutant impact human health? How would these impacts affect regulatory considerations?

Teaching Notes

**Words in italics generally represent teacher's script*

Introduction – 10 minutes

What are chemicals? Are chemicals harmful? Where have you used chemicals? How have you used the word chemical in the past? Use it in a sentence.

The truth is, everything is made up of chemicals. All matter is made up of the elements we find on the periodic table. A chemical is an element, or combination of elements. For example, oxygen in the air we breathe is a chemical (O_2). Similarly, water which is made up of 2 hydrogen atoms and 1 oxygen atom is a chemical, in this case, a combination of elements. So we could argue that anything is a chemical. The air we breathe, the sugars in our food, and the water we drink can all be considered chemicals.

Discuss the periodic table and chemical naming. This will be important for the activity that follows.

So chemicals are all around us. We need chemicals to survive, as do all living organisms. Of course, some chemicals or too much of a certain chemical can be harmful. Today we are going to explore the chemicals that are present in our air, and how the amount of these chemicals can significantly impact the quality of our air.

Body – 120 minutes

What are the chemicals that make up our atmosphere?

Prompt students to recall what they learned in previous grades.

Our atmosphere is made up of 78% nitrogen gas, 21% oxygen gas, 0.9% argon and many other trace gases. Nitrogen gas (N_2) is made up of two nitrogen atoms – it is a chemical. Oxygen gas (O_2) is made up of two oxygen atoms – it is a chemical. Argon gas (Ar) is a noble gas (this means it is inert or non-reactive). It is made up of a single argon atom – it is a chemical. These three chemicals make up 99.9% of our atmosphere. The remaining 1% is made up of many trace gases, meaning they are present in very small amounts.

Our focus today will be on the trace gases present in the atmosphere. Carbon dioxide (CO_2) and water vapour (H_2O) are two of these trace gases. Human activity releases additional gases and other pollutants into the air. What is a pollutant?

Have students discuss as a group what they think makes a substance a pollutant.

It is important for students to recognize that a majority of our atmosphere is composed of nitrogen and oxygen. Trace gases such as carbon dioxide, water vapour and air pollutants make up only a very small portion of the atmosphere, however, they can have significant environmental and health effects.

When we consider pollutants that are released into the environment it is important for us to know where they came from, or their source. There are three types of sources where pollutants can originate from. Point source, non-point source/mobile source, and natural source.

A point source is a specific location where pollution originates. For example, a factory stack that is releasing toxic chemicals into the air; pollutants can be traced back to this specific location. A non-point source has no specific location and pollutants are diffused. An example of non-point source air pollution is a gas burning vehicle because the vehicle is mobile and pollutants cannot be traced back to a specific car. Natural sources of emissions include trees, vegetation, gas seeps and wetlands which primarily release carbon dioxide and methane.

Note: some pollutants react with other substance in the air to form new pollutants. Nitrogen oxides and sulfur dioxide can react with substances in the air to increase the level of particulate matter in the atmosphere. Primary pollutants are those emitted directly from a source, while secondary pollutants result from chemical reactions involving primary pollutants.

Carbon monoxide, nitrogen dioxide, ozone, particulate matter, hydrogen sulfide and sulfur dioxide are chemicals that are released into the atmosphere by human activity, usually due to the burning of fossil fuels. Let's see if we can learn more about these substances: what they are made of, where they come from and how they impact the environment and our health.

The main activity in this lesson has students working through a jig-saw style research project. Break the students into groups of 4 and instruct one half of the group to research the Group A pollutants and the other half to research Group B (as listed on the Airborne Chemicals worksheet). Each group must complete all sections for their assigned pollutants as they will be responsible for teaching the other half of the group about the pollutants they researched. The research that the students do will directly impact their classmates, so it is important that they do a good job. You might consider using the worksheet as an evaluation, grading the students on the completion of all sections as an incentive for them to do a good job.

Within your group of 4, two of you are responsible for researching and completing the worksheet for the group A pollutants. The other two group members are responsible for researching and completing the worksheet for group B pollutants. At the end of class, you will meet back in your group of 4 to exchange information. It is your job to teach the other half of your group, so make sure you do a good job of researching your chemicals and be prepared to share what you discover.

For the research aspect of this lesson, you may wish to give the students a list of approved resources or use this activity as an opportunity to discuss credible sources and using appropriate information. Try to guide the students towards using sources that are both credible and appropriate for their level of understanding.

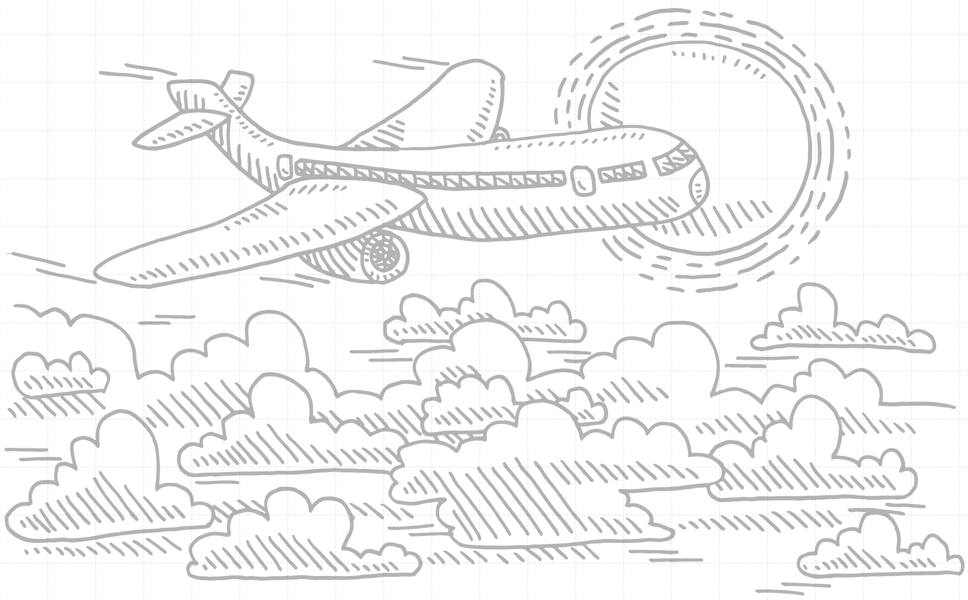
Have students conduct their research using internet sources and complete the worksheet. Be sure to leave time for sharing information before the end of class.

After the students have shared what they learned with their group, gather the class for the next discussions.

Note: The activity may be divided in half and completed across multiple blocks. Here would be a good natural endpoint for the first half of the lesson.

Now that we know more about how these chemicals enter the atmosphere, and how they impact our health and the environment, let's consider ways that we can protect ourselves from these potentially harmful impacts.

In Alberta, we have something called the Air Quality Health Index. It is a system that relates air quality to health concerns and helps to protect us from the harmful effects of air pollution. There are monitoring stations all across Alberta that measure how many chemicals are in the air. Scientists use this information to determine what the air quality health index is for the day.



We can find out what the AQHI is for our location at any time by going online (http://airquality.alberta.ca/map/). This map shows us what the air quality is like and even predicts what it will be in the days coming, similar to a weather forecast.

Locate your area on the map and discuss the current AQHI and the forecast for the next few days. Discuss what the AQHI values indicate. For example, what does an AQHI of 1 mean, and how does this compare to an AQHI value of 10? (See Teacher's Background Information).

You may wish to discuss the AQHI Mapping Tool and its capabilities in detail in this lesson (see Teacher's Background Information) or have the students explore the tool in a self-guided fashion in the next lesson in which they are given basic instructions on how to access information using the tool.

There are many types of pollutants that make their way into the atmosphere. The AQHI considers the following pollutants: carbon monoxide, nitrogen dioxide, ozone, particulate matter and sulfur dioxide.

In Alberta, we also have a system that regulates the amount of pollution that can be emitted into the atmosphere by industrial operations, such as power plants. The government sets limits for how much of each specific pollutant can be released. Companies must adhere to these regulations.

The second activity of this lesson is a gallery walk. You will need to hang Air Pollutant posters around the room and give each student a stack of sticky notes. Their job for this activity is to apply what they know about common air pollutants to generate a list of considerations that are important in regulating air pollution. Encourage students to reflect on their research, specifically the health and environmental impacts of each pollutant. How would these impacts affect regulatory measures?

Gallery walk: ***Using what you have researched and learned about carbon monoxide, nitrogen dioxide, ozone, particulate matter, hydrogen sulfide and sulfur dioxide you are going to generate a list of questions and considerations that may be important for decision-makers to address when they are setting pollution limits for each substance. Around the room, you will find posters, one for each substance. Your job is to come up with a question or consideration based on your research that would inform regulatory limits for each substance. Think about the health and environmental impacts of each chemical.***

Jot down your idea on a sticky note and leave it attached to the poster. You should leave at least one note on each poster. Try not to repeat ideas – read the notes that have already been left and try to add something new. You may add onto a previous idea or use it as inspiration.

Have the students complete the gallery walk activity. They should be thinking critically about the implications of releasing each substance into the environment. For example, carbon monoxide is toxic to all living things; this health concern is a major consideration in determining how much CO can be released because of its potentially lethal effects.

Conclusion – 10 minutes

It can be very difficult regulating air pollutants. The processes that release these chemicals, such as driving our cars or generating electricity, are necessary for our communities, even though they release chemicals that could harm us and the environment. Governments and other decision-makers have a lot to consider when setting limits on the amount of pollution that can be emitted.

In the next lesson, we are going to look at some of the consequences of releasing these chemicals into the atmosphere and how they can impact the chemical make-up of the environment.

Depending on your students level it may be important to review the periodic table of elements during this introductory lesson. This review will provide background and context for the discussion that follows, specifically with regard to understanding the definition of chemicals, naming chemicals and compounds, and identifying components of the atmosphere.

Depending on time, you may wish to divide this lesson into sections; part one is the jigsaw research experiment while part two is the gallery walk activity.

LESSON 2:

INTRODUCTION TO ACID PRECIPITATION

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Students will understand that burning fossil fuels results in the release of oxides (SO_x NO_x, CO_2) which contributes to acid precipitation. Students will explore this relationship by conducting an experiment in which they will observe the changing pH by dissolving CO_2 in water. Students will also begin an investigation in which they will be collecting air quality data in their local community.

Learning Goals:

- Students will list the reactants and products for the combustion of methane and recognize that oxides (SO_x NO_x, CO_2) are always produced in combustion reactions.
- Students will label substances with a pH <7 as acidic and substances with a pH >7 as basic.
- Students will describe how the presence of carbon dioxide, nitrogen dioxide, and sulfur dioxide lead to the production of acid precipitation using words and/or chemical equations.
- Students will accurately and consistently collect air quality data over the course of three days, and ensure all data is effectively recorded.

Resources and Materials

- PocketLab Air Sensor
- Observation Sheet
- Cups or beakers
- Straws
- pH paper
- Distilled water

Time Required

80 minutes, plus data collection over 3 days

Preparation

- Collect all required materials
- Print observations sheets, one per group of three
- Fill beakers or cups with approximately 100mL of distilled water (one per group)
- Prepare a list of testing sites around the school (parking lot, entrance, field, etc.)
- Create data collection schedule for all groups.

Instructions

1. Introduce the lesson
   a. Discuss combustion reactions, resulting in the production of carbon dioxide.
   b. Discuss environmental impacts of increased levels of carbon dioxide in the atmosphere

2. Review pH
   a. What makes something an acid or a base?
   b. How do we measure pH?
3. Dissolved carbon dioxide experiment
   a. Explain experiment
   b. Have students perform experiment recoding all results on the Observation Sheet
   c. Discuss results
4. Introduce and explain PocketLab Air sensor
   a. How to use the sensor
   b. How to record data
5. Explain data collection process
   a. Assign each group a site and time to collect data
   b. Instruct students to record all data on the Observation Sheet.

Assessment

Pre-assessment

- Determine students' current understanding of pH, acidity and alkalinity. What makes a substance acidic? What makes a substance basic?

Formative Assessment

- Students should complete the experiment accurately and record all observations on the worksheet.
- Students should work collectively within their group to complete the data collection aspect of the activity, clearly communicating and sharing responsibility.
- Students should use the PocketLab Air sensor correctly.

Summative Assessment

- The observation sheet may be collected for marks/proof of participation in both activities in this lesson.

OBSERVATION SHEET

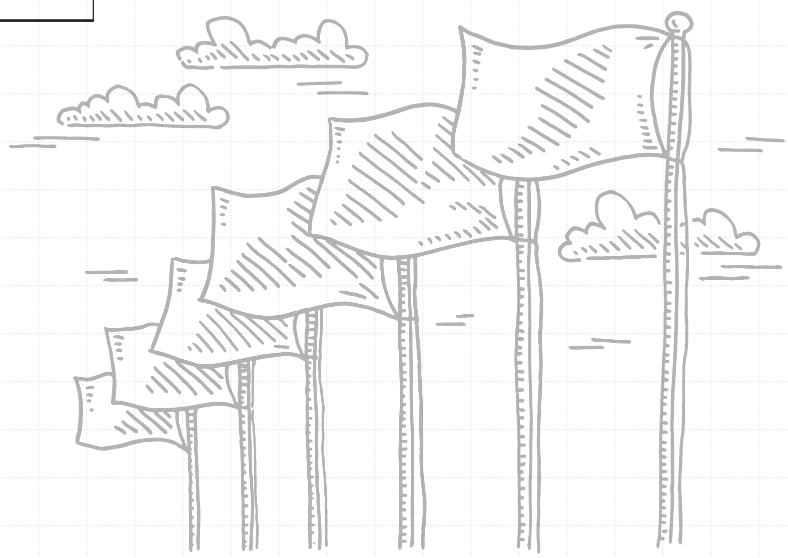
Part 1

Time (minute)	pH	Time (minute)	pH
Initial		7	
1		8	
2		9	
3		10	
4		11	
5		12	
6		Final	

What do you predict will happen to the pH of the water as you exhale through the straw into the water?

Did you observe a change in pH?

How can you explain this change?



Part 2

Site: ____________ Time: ____________ Names: ____________

Pollutant	Date	Amount	Temperature °C	Pressure	Humidity	Light	Air Quality Index Measured
Carbon Dioxide							
Ozone							
Particulate Matter							
Carbon Dioxide							
Ozone							
Particulate Matter							
Carbon Dioxide							
Ozone							
Particulate Matter							

Teaching Notes

**Words in italics generally represent teacher's script*

Introduction – 10 minutes

We now know that human activity is one of the biggest contributors of airborne pollutants like carbon monoxide, nitrogen dioxide, ozone, fine particulate matter, hydrogen sulfide and sulfur dioxide. We also learned that these pollutants can impact our health in numerous ways. Today we are going to focus on the environmental impacts of these airborne pollutants.

One chemical we only looked at briefly is carbon dioxide. Who can guess what the chemical formula of carbon dioxide is?

Carbon dioxide occurs naturally in our atmosphere, but levels of CO_2 ***have dramatically increased since the Industrial Revolution. This makes sense if we consider the chemical equation for burning the fuel methane.***

$CH_4 + 2\ O_2 \text{ -> } CO_2 + 2\ H_2O + \text{energy}$

One molecule of methane reacts with 2 molecules of oxygen (remember, we need oxygen to burn fuel) to produce one molecule of carbon dioxide, two molecules of water and energy. Burning any hydrocarbon fuel source will result in a similar reaction – oxides (oxygen containing compounds) are always produced. As humans began burning more and more fossil fuels (hydrocarbons), the levels of carbon dioxide steadily increased.

Of course, carbon dioxide is necessary for survival on our planet. What do we need it for? (plants need CO_2 ***for respiration, carbon dioxide helps trap heat from the sun in the atmosphere)***

However, increased concentration of CO_2 ***in the atmosphere has caused problems. Does anyone know what phenomena increased levels of carbon dioxide contributes to?***

Ask student's to reflect on the previous lesson and the impact of increased CO_2 on climate change.

Carbon dioxide and other airborne pollutants like nitrogen dioxide and sulfur dioxide can greatly affect environmental chemistry, specifically pH.

Body – 60 minutes, plus 3 days of data collection

Before we complete our experiment today, we need to discuss pH. Who remembers learning about pH in previous units or grades? Can you explain what pH measures?

pH stands for power of hydrogen; it is a scale that measures the relative acidity or basicity (alkalinity) of a substance. Remember acids are chemicals that produce acidic substances and have a pH value of less than 7. Bases are chemicals that produce basic (or alkaline) substances that have a pH value of more than 7. What would we call a substance with a pH of exactly 7? (neutral).

We can determine whether a substance is an acid or a base by using a chemical indicator. Indicators are chemicals that change colour depending on the pH of a substance. Today we will be using pH paper to measure pH.

Experimental set up: Each group of three gets one plastic cup with tap water, pH paper, observation sheet and three straws.

Briefly explain how to use the pH test papers and divide the students into groups of three. To test the pH of the water students should dip a single pH paper into the water for 3 seconds and then immediately compare it to the coloured pH scale.

Let's begin by recording the pH of our school's tap water. Working with your group use your indicator to determine what the pH of your tap water sample is. Record this measurement as the initial pH. Be sure to record your findings on Part 1 of your observation sheet.

Allow all groups to record their data.

Carbon dioxide gas is soluble in water – it can be dissolved in water. Let's determine if there will be a change in pH when carbon dioxide is dissolved in water. Remember, our lungs inhale oxygen and exhale carbon dioxide so for the next portion of the experiment we need our breath. What do you think will happen to the pH of the water as we blow through the straw into the water? Record your predictions on your observation sheet.

Have one person in your team blow through the straw into the water for one minute. After on minute test the pH again and record your findings. Repeat this process for twelve minutes.

The students may change responsibilities throughout, each having a turn to blow through the straw.

What happened to the pH of your water as the carbon dioxide from your breath was dissolved in the water?

Discuss the results.

What happened to the pH of the water? What does this mean?

During the experiment the groups should have seen the pH go down, meaning the water became more acidic. These results may vary depending on the initial pH of the water. If the water is slightly basic (pH of 8) then the students may observe a drop to a pH of 7 (neutral). pH 7 is not acidic, but it is lower than pH 8, so the water is becoming more acidic. You may wish to use distilled water for this experiment as it will have a neutral pH (7 or slightly lower). The students should then be able to observe the water become slightly acidic.

Discuss what the results mean in terms of environmental impacts, knowing both carbon dioxide and water exist in the atmosphere.

It is important to note CO_2 will always dissolve in the presence of water; blowing through a straw simply speeds up the process. As soon as distilled water is exposed to the atmosphere, carbon dioxide will begin dissolving, and the water will become more acidic. This is true of carbon dioxide and water present in the environment as well.

When oxides of carbon, nitrogen and sulfide are released into the atmosphere by burning fossil fuels, they become dissolved in water in the atmosphere and create acid precipitation.

Note: other forms of precipitation such as sleet, snow, and mist can also be abnormally acidic as the result of these processes.

You may wish to discuss the scientific method during this activity, particularly as it pertains to data collection procedures and consistency. Students must ensure that they complete the pH activity with accuracy, and consistently collect air quality data over a three day period. The data collected here will be used in the next activity.

Discuss the chemical equations for the creation of carbonic, sulfuric, nitric acid.

$CO_2 + H_2O \rightarrow H_2CO_3$

$H_2CO_3 \rightarrow H+ + HCO_{3-}$

CO2 dissolves in water to form carbonic acid (H2CO$_3$). Carbonic acid then dissociates to produce a hydrogen ion (H+) and hydrogen carbonate ion (HCO$_{3-}$). Note: ions are molecules with a net electrical charge, positive or negative, that results from the loss or gain of an electron.

$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

$HNO_3 \rightarrow H+ + NO_{3-}$

NO_2 dissolves in water to form nitric acid (HNO_3) and nitrogen monoxide (NO). Nitric acid then dissociates to produce a hydrogen ion (H+) and a nitrate ion (NO_3^-).

$SO_2 \rightarrow SO_3 + H_2O \rightarrow H_2SO_4$

$H_2SO_4 \rightarrow H+ + SO_4^{\ 2-}$

In the presence of oxygen in the atmosphere, sulfur dioxide (SO_2) is converted to sulfur trioxide (SO_3) which is easily dissolved in water to produce sulfuric acid (H_2SO_4). Sulfuric acid then dissociates to form hydrogen ions (H+) and sulfate ions ($SO_4^{\ 2-}$).

Based on these formulas we can see that acids are substances with the ability to deliver H+ ions to a solution. This dissociation lowers the pH of a solution. So another definition for an acid is a substance that dissociates to produce H+ ions!

How might acid precipitation affect the environment?

Ecosystems are highly sensitive to changing pH. Different organisms and vegetation have varying tolerances for changing acidity, but impacts to one population can greatly impact an entire ecosystem (think about food chains).

Discuss how increased CO_2 is related to climate change and ocean acidification (see Teacher's Background Information).

Now we are going to examine the air quality around our school using hand held-air sensors. These sensors can measure carbon dioxide, ozone, particulate matter and atmospheric conditions.

Briefly explain the PocketLab Air sensors, how they work and how data is displayed (see PocketLab User Manual).

In your teams of three, you will be responsible for collecting air quality data from specific sites around the school over the course of three days. All data should be recorded on your observation sheet!

Assign each group a site and times to take their measurements. Explain that they need to measure and record quantities of carbon dioxide, ozone, particulate matter and atmospheric conditions (temperature, pressure, humidity and light). Be sure students record data thoroughly using the Observation Sheet as it will be used in the next lesson. Each group should collect 3 days' worth of data. This can be facilitated by having groups assigned a specific time of day to take their measurements. For example, group 1 will record data from site 1 at 10:30AM for three days. Group 2 will record data from site 2 at 11:30AM for three days.

The data collection aspect of this experiment may be adjusted to suit your needs. For example, you may wish to lengthen the data collection period from three days to several weeks and challenge the students to identify trends in their data.

Pay careful attention to the units you are recording. What do they mean (ppm, ppb, etc.)?

Conclusion – 10 minutes

You may have noticed that concentrations of each substance were measured in ppm/ppb. What does this mean?

Briefly discuss ppm/ppb in relation to concentration.

In the next lesson, we will be using the data you collected and comparing it to the values available from the Alberta Air Quality Health Index.

LESSON 3:

DATA COMPARISON

LESSON 3:
DATA COMPARISON

In this lesson, students will explore mechanisms by which airborne pollutants are dispersed including wind, turbulence, temperature and topography. They will also analyze the air quality data that was collected in the previous activity and compare it to the data publicly available for all of Alberta online. Students will become familiar with Alberta's air quality data system and will navigate the site to answer a series of research questions.

Learning Goals:

- Students will list the mechanisms by which air pollutants are dispersed and explain how these mechanisms impact the concentration of airborne pollutants in an area.
- Students will search for and record data available on Alberta's Air Quality Health Index (AQHI) online mapping tool.
- Students will compare AQHI data with the air quality data they collected in the previous activity and interpret the similarities and differences across the two data sets.

Students will assess both systems of data collection and determine which method is most appropriate for hypothetical research situations.

Resources and Materials

- Data Comparison worksheet
- Access to laptop/computer for research

Time Required

80 minutes

Preparation

- Print *Data Comparison* worksheet (one per student, or group)
- Arrange access to laptops or computer lab for research
- Review teacher's background information, if necessary

Instructions

1. Introduce the lesson
   a. What did student's notice during data collection (from previous lesson)?
   b. Do they expect the data they collected to be the same as the data available from the AQHI online mapping tool?
2. Discuss factors that affect air pollution dispersion
   a. Temperature, topology, turbulence, wind
3. Introduce the data comparison activity and worksheet
   a. Support students as they complete the worksheet

Assessment

Pre-assessment

- Ensure all students have successfully completed the data collection activity presented in the last lesson.

Formative Assessment

- Students are working collaboratively to complete the worksheet, are thinking critically, asking questions and discussing the hypothetical scenarios in their groups.

Summative Assessment

- Students complete the Data Comparison worksheet and submit it for grading at the end of the allotted time, or use the worksheet to inform a wrap up class or small group discussion.

DATA COMPARISON WORKSHEET

AQHI Mapping Tool Instructions

Particulate Matter and Ozone Comparison

1. Launch the AQHI Online Mapping Tool: http://airquality.alberta.ca/map/
2. Navigate to your area on the map by dragging the map and scrolling to zoom in or out.
3. Click on the Stations tab in the left-hand panel. Locate the monitoring station that is closest to your community on the map. Hover over the station marker (small green, grey or red dots) and record the name of the station.
4. Click the Query & Download tab. Adjust the start and end date to match the start and end date of your data collection period. Adjust the time to match your data collection time.
5. Click on the By Station button. Use the Station drop-down menu to select the station located closest to your community. Use the Parameter drop-down menu to select Fine Particulate Matter and Ozone.
6. Click on the Tabular Data button.

Air Quality Index Comparison

1. Launch the AQHI Online Mapping Tool: http://airquality.alberta.ca/map/
2. Navigate to your area on the map by dragging the map and scrolling to zoom in or out.
3. Click the Query & Download tab. Adjust the start and end date to match the start and end date of your data collection period. Adjust the time to match your data collection time.
4. Click on the By Community button.
5. Use the By Community drop-down menu to select the station located closest to your community.
6. Click the Tabular Data button.

Data Interpretation Notes

- Some stations across the province will not always have this information available. If that is the case, navigate to the next closest station.
- When making comparisons in the questions that follow be sure to use the correct time. For example, if you recorded air quality data at 8:00AM be sure you use data from the AQHI Online Mapping Tool that was also recorded at 8:00AM.

QUESTIONS

Use your observation sheet and AQHI Data to answer the following questions, and attach all data recordings before handing in the assignment.

1. What was the average level of each pollutant that you recorded for your study site across the three days? *Answer these questions using the data you collected with the PocketLab.*

   a. Particulate matter

   b. Ozone

2. What was the average level of each pollutant measured by the nearest Alberta monitoring station for the same three days? *Answer this question using data obtained from Alberta's AQHI online mapping tool: http://airquality.alberta.ca/map/.*

   a. Particulate matter

   b. Ozone

3. Record the difference in the average measurements for:

   a. Particulate matter

   b. Ozone

4. What was the air quality index (AQI) that you recorded for each day? *Answer these questions using the data you collected with the PocketLab.*

   a. Day 1

   b. Day 2

   c. Day 3

5. What was the AQHI that was reported for each day? *Answer these questions using data obtained from Alberta's AQHI online mapping tool: http://airquality.alberta.ca/map/.*

   a. Day 1

   b. Day 2

   c. Day 3

6. Describe the similarities and differences between your PocketLab data and the online AQHI data you observe.

7. What environmental factors might cause the pollutant levels for your site to be different from what has been reported online?

8. Besides environmental factors, what else could account for the differences in the data?

Read the Disclaimer at the bottom of the control panel on the Query & Download tab of the AQHI Online Mapping Tool. Use this information to answer the following questions:

9. If we wanted to conduct an air quality study in our community using the same PocketLab Air sensor, what would we have to consider based on your answers to the questions above?

10. Suppose your school wanted to create a plan for improving air quality in the areas surrounding the school buildings (parking lot, playground, etc.). Would you recommend that the school collect their own air quality data or use the data that is available online? Defend your answer.

11. Suppose your municipal government wanted to determine the level of particulate matter in the region's atmosphere before and after a new pulp and paper mill was built. What tool(s) would you recommend they use?

Key

1. **What was the average level of each pollutant for your study site across the three days?**
    a. **Particulate matter**
    b. **Ozone**

Dependent on individual data collection. Students should record their measurements using correct units.

2. **What was the average level of each pollutant as measured by the nearest monitoring station across the same three days?**
    c. **Particulate matter**
    d. **Ozone**

Dependent on individual data retrieval. Students should record their measurements using correct units.

3. **Record the difference in the average measurements for (remember your units!):**
    e. **Particulate matter**
    f. **Ozone**

Dependent on individual data collection. Students should record their measurements using correct units.

4. **What was the air quality index (AQI) that you recorded for each day?**
    g. **Day 1**
    h. **Day 2**
    i. **Day 3**

Dependent on individual data collection. Students should record their measurements using correct units.

5. **What was the AQHI that was reported for each day?**
    j. **Day 1**
    k. **Day 2**
    l. **Day 3**

Dependent on individual data retrieval. Students should record their measurements using correct units.

6. **Describe the similarities and differences you observe.**

Dependent on individual data collection and comparison.

7. **Why might the pollutant levels for your site be different from what has been reported online?**

Pollutant levels could be different for a number of reasons. The data we collected was for a specific site, while the data online was collected across a larger region. The wind, temperature, and turbulence conditions at our site versus the larger region could impact pollution levels. The topography of the area could also affect the data.

8. **Besides environmental factors (wind, temperature, turbulence and topography), what could account for the differences in the data?**

Students might discuss differences in collection methods. The technology they used is very basic compared to the instruments and rigorous process used by the air quality monitoring agencies across the province.

9. **If we wanted to conduct an air quality study in our community using the same PocketLab Air sensor, what would we have to consider based on your answers to the questions above?**

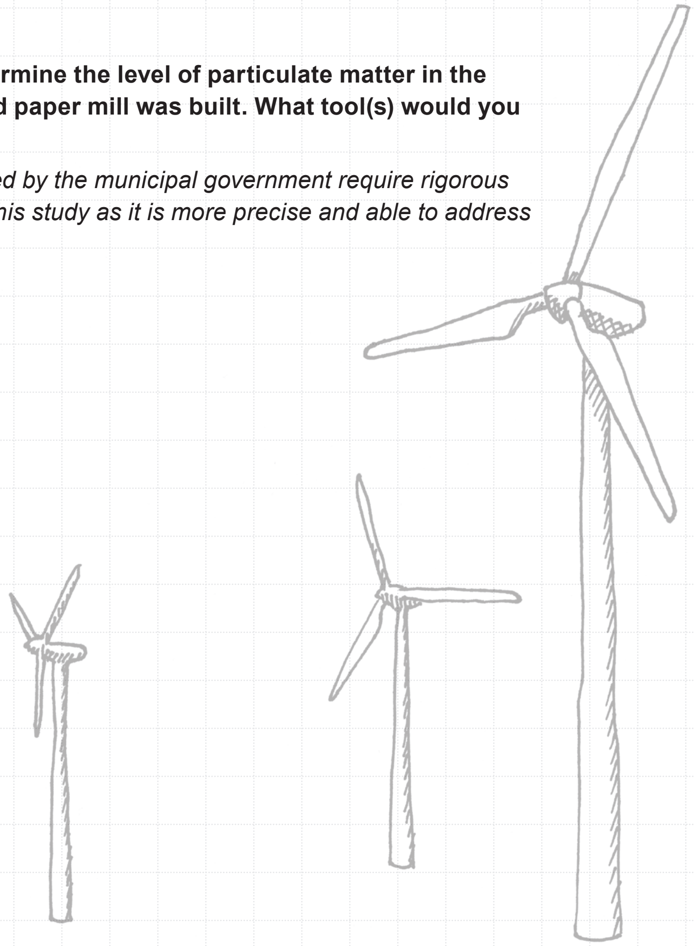
Students should account for any differences between the two data sets that they observed. They might discuss the nature of the air quality sensor they have been using, compared to the more advanced instruments used in air quality monitoring across the province. For example, students may discuss that an air quality study using the PocketLab should only be for educational or awareness purposes. The PocketLab is not as advanced as the instruments used at monitoring stations in terms of capacity and calibration, so the chance of error is higher, *therefore the results from this type of study would not be standardized and would not be used to inform public policy, for example.*

10. Suppose your school wanted to create a plan for improving air quality in the areas surrounding the school buildings (parking lot, playground, etc.). Would you recommend that the school collect their own air quality data or use the data that is available online? Defend your answer.

Students should identify that in an informal/educational scenario such as this the data that is collected using the hand-held air pollution sensor is adequate. Using this sensor would also allow for the data that is used to create the air quality improvement plan would be specific to the area in question rather than the larger region that is monitored by the airsheds in the area.

11. Suppose your municipal government wanted to determine the level of particulate matter in the region's atmosphere before and after a new pulp and paper mill was built. What tool(s) would you recommend they use?

Students should recognize that environmental studies solicited by the municipal government require rigorous data. They should recommend the airshed data be used for this study as it is more precise and able to address a larger region (the municipality) than hand-held sensors.



Teaching Notes

*Words in **italics** generally represent teacher’s script.

Introduction – 5 minutes

This activity is largely self-guided with the students using the Data Comparison worksheet to navigate the AQHI online mapping tool, answer the questions and compare data sets. Each student or group will need access to a computer for this lesson. You may choose to have the students work within their original data collection groups or individually. The worksheet may be used as an assessment tool (see teacher’s key).

Today we are going to be looking closely at the air quality data you have collected over the past few days and compare our data to that which has been collected and uploaded to Alberta’s air quality data warehouse.

Do you expect our data to be close to the data available from the province? Why or why not?

There are many factors that can affect how pollutants are transported and dispersed throughout the atmosphere. Before we can analyze our data, we need to understand how the distribution of these potentially harmful substances is affected by wind, temperature, turbulence and topographical features.

Body - 60 minutes

After air pollutants enter the atmosphere, they are immediately affected by the conditions in the area. Wind speed plays a huge part in how quickly or slowly pollutants are dispersed from an area. High wind speeds disperse pollutants more rapidly than slower wind speed. If it is a very calm day, little to no wind, pollutants can build up. If we collected air quality data near the school parking lot in the morning on a calm day, what would you expect to find? What about on a windy day?

Temperature can also impact air quality. In the lower portion of Earth's atmosphere temperature normally decreases with height (the higher up in the atmosphere, the lower the temperature). However, sometimes a temperature inversion occurs and temperature actually increases with height (the higher up in the atmosphere, the higher the temperature). When a temperature inversion happens, atmospheric mixing decreases which means dispersion also decreases because there is less moving air. Temperature inversions are common in Alberta in the winter time and can last several days. What would you expect to happen to the air quality index in our area if we were in a temperature inversion?

If atmospheric mixing decreases, as in a temperature inversion, we can expect that dispersion rates would slow and pollutants would begin to concentrate in that area.

Turbulence is another factor that can impact pollutant levels. What do you think turbulence is?

Turbulence is the random movement of air in the atmosphere. If turbulence is high, what would you expect to happen to dispersion rate?

In times of high turbulence, pollutants disperse more quickly.

Finally, topographical features like mountains and valleys can affect pollutant levels. These features greatly affect wind speed and direction. How do you think mountains impact wind speed?

Air can become trapped in valleys because usually there is not much wind or atmospheric mixing, meaning pollutants can become concentrated in valleys.

Today our focus will be on analyzing our data, and comparing what we have collected to the rigorously collected data available on the Alberta Government website. Airsheds around the province continuously collect data on air quality and upload this data, making it publicly available online. Your task is to find the appropriate data for our area across the time in which you collected air pollutant information using our sensor, download it and compare the findings. Are they similar? Are they different? Why might they be different?

You will be working through this activity with your data collection team and complete the following worksheet. It will guide you through how to gather the correct information from the site and questions to consider when doing your comparison.

Each team will need access to a laptop or computer and a worksheet. Circulate among the teams and provide support as needed.

Note: AQHI does not consider carbon dioxide. Students will only be comparing particulate matter and ozone.

Conclusion – 15 minutes

To conclude the activity, you may choose to go over the answers to the worksheet as a class. Alternatively, you can use the worksheet as an assessment and discuss the answers at a later date.

TAKE THE NEXT STEP

We encourage you and your students to continue engaging with air quality issues in Alberta even after you complete these lessons. The following list offers suggestions for your class to get involved in improving air quality in your community and continuing engaging with this important conversation.

- Contact your local Airshed to learn how you can be a champion for clean air.
    - The Alberta Airsheds Council offers student friendly resources and information on how to get involved, as well as links to all of the Airshed organizations around the province:
    - https://www.albertaairshedscouncil.ca/
- Host an air quality event at your school. This is a great opportunity for your students to share their final projects, and educate their peers on the importance of air quality.
- Submit your student's work to the TELUS World of Science – Edmonton Blog.
    - Share your class's final project, or tell us about the air quality event you hosted at your school. We'll share it with our readers through our science blog.
    - To submit a blog post please send the following information to sim@twose.ca
        - School Name and community
        - Grade
        - Teacher's Name
        - Photos of final projects, events, or lesson plan activities (please ensure student faces are not included in the photo)
        - Caption for each photo
        - Description of the project, activity or event.
        - Tell us about your experience with the lesson plan. Did you complete all, or some of the activities? Did you adapt or change the lesson plan in any way?
        - Did you or your students engage with air quality beyond the scope of the lesson plan? Tell us how so.
        - Optional: student reflections on the project, activity or event.
    - To see sample posts, check out the blog at www.twose.ca/learn

AIR QUALITY IN ALBERTA – TEACHER'S BACKGROUND INFORMATION

AIR QUALITY: WHAT IS IT AND HOW IS IT MEASURED?

Our Atmosphere

Earth's atmosphere is unique in that it is the only one that we know of that supports life. Made up of 78% nitrogen gas, 21% oxygen gas, 1% argon and many other trace gases, this mixture of gases regulates the planet's temperature, protects us from UV radiation and facilitates natural cycles such as cellular respiration and photosynthesis (King's Centre for Visualization in Science, n.d.).

Our atmosphere is divided into four layers: the troposphere, the stratosphere, the mesosphere and the thermosphere. Most of the atmospheric gases are found in the troposphere which extends 15 km above the earth's surface. The atmosphere is very thin. If we think of the Earth as the size of a globe, our atmosphere would be as thin as the layer of paint surrounding the globe (King's Centre for Visualization in Science, n.d.).

Air Quality

Air quality is a measure of how clean our air is, determined by the rate at which pollutants are emitted into the atmosphere and how effectively the atmosphere can disperse those contaminants. It is affected by wind, temperature, turbulence and local topography (Alberta Capital Airshed, n.d.).

High winds disperse pollutants more rapidly, while slower wind speeds can cause pollutant dispersal rates to slow and contaminants to build up, especially where pollutant sources are concentrated. Normally, temperature in the lower atmosphere decreases with height. However, sometimes a temperature inversion occurs and temperature actually increases with height. During an inversion atmospheric mixing decreases causing pollution dispersion to also decrease. Temperature inversions are common in Alberta in the wintertime and can last up to several days. Turbulence is the random movement of air in the atmosphere; this movement allows contaminants to disperse more readily. Finally, topographical features such as mountains and valleys significantly impact wind speed and direction, impacting pollutant dispersion (Alberta Environment and Parks, n.d.).

Pollutants

There are numerous pollutants that impact our air quality and are monitored on a continuous or intermittent basis in Alberta.

Carbon monoxide (CO) is a colorless, odorless gas formed during incomplete fossil fuel combustion when there is not enough oxygen present to produce carbon dioxide (King's Centre for Visualization in Science, n.d.). Sources of CO include vehicle emissions, gas appliances, blocked fireplaces, charcoal grills and smoking (Alberta Capital Airshed, n.d.). CO is toxic to all humans and animals. Patients who suffer from CO poisoning show a range of clinical presentations including: headache, dizziness, coma, and even death (Shochat, 2017).

Nitrogen oxides (NO_X) are most commonly found in the form nitrogen oxide (NO) and nitrogen dioxide (NO2). They are produced during high temperature combustion of fossil fuels, such as in motor vehicles, power plants, furnaces, and space heaters. Typically these sources release NO, which is quickly changed to NO_2 when NO reacts with ozone (O_3) in the atmosphere. NO_2 is a reddish-brown gas with a sharp sweet-smelling odour that has been linked to respiratory disease and contributes to acid rain (Alberta Capital Airshed, n.d.).

Ozone (O_3) is found naturally in the atmosphere and is a component of smog. Stratospheric ozone is formed by reactions involving oxygen and light from the sun. It is an important component of our atmosphere as it protects us from too much UV radiation. Ground-level ozone, on the other hand, is produced by human activity and can be harmful to our health (King's Centre for Visualization in Science, n.d.). At normal concentrations, O_3 is an odorless colourless gas, but at concentrations over 1 part per million (ppm) it has a metallic or "clean" smelling odour. Tropospheric O_3 is a secondary pollutant created through chemical reactions between nitrogen oxides and volatile organic compounds (VOCs). These reactions contribute to the production of photochemical smog; a visible brown haze commonly noticed in highly populated areas (Energy Education, 2015). The largest sources of tropospheric O_3 are vehicle exhaust and chemical solvents (a substance that dissolves a solute to produce a solution) as they produce the nitrogen oxides and VOCs that lead to the production of O_3. Lightning and some vegetation species also emit ozone (Alberta Capital Airshed, n.d.).

Sulfur dioxide (SO_2) is a colourless gas with a strong odour (similar to matches) that comes from both natural and man-made sources, primarily the processing and combustion of fossil fuels containing sulfur. SO_2 reacts in the atmosphere to form sulfuric acid, contributing to acid precipitation. It can also combine with other atmospheric gases to produce fine particulate matter (Alberta Captial Airshed, n.d.). In Alberta over half of atmospheric SO_2 comes from natural gas processing plants. Oil sands facilities and coal-fired power plants are also major sources (Alberta Environment and Parks, n.d.).

Hydrogen sulfide (H_2S) is a colourless gas with a rotten egg odour and is commonly produced by natural gas processing plants, petroleum refineries, and animal feedlots. H_2S in natural gas makes the gas "sour," making it hard to store and ship due to the damage it causes to equipment and piping (Alberta Capital Airshed, n.d.). H_2S occurs naturally in the body and the environment but in high concentrations becomes harmful, with a similar toxicity to CO (Wikipedia, 2018). Our body uses small amounts of H_2S as a signaling molecule, but a few breaths of air containing high concentrations of this substance can cause death (Prostak, 2013).

Particulate matter (PM_{10}, $PM_{2.5}$) consists of a mixture of particles ranging from 10 micrometers (μm) in diameter (PM10) that can be inhaled, to less than 2.5 μm in diameter ($PM_{2.5}$) that can become trapped in the airways and lung tissue and may also reduce visibility. PM10 particles include wind blown soil, dust, particles from industrial activities. $PM_{2.5}$, also know as fine particulate matter, comes from gases released into the atmosphere by combustion processes, such as forest fires (Alberta Capital Airshed, n.d.).

Total hydrocarbons (THC, CH_4, NMHC) are a family of chemicals that contain carbon and hydrogen. CH_4, or methane, in a non-reactive hydrocarbon and the hydrocarbon that is most commonly found in our atmosphere. Other non-methane hydrocarbons can react with nitrogen oxides in sunlight to form ozone. Sources of hydrocarbons include vegetation, vehicle emissions, gasoline storage tanks, petroleum and chemical industries, dry cleaning, fireplaces, and aircraft traffic (Alberta Capital Airshed, n.d.). Hydrocarbons can also be emitted by the evaporation of solvents, leaking valves, and pumps and compressors at industrial facilities. Vehicles are the major source of hydrocarbons in urban locations (Alberta Environment and Parks, n.d.).

Methane (CH_4) is a colourless, odourless gas. It is the main component of natural gas and is used as fuel (Alberta Capital Airshed, n.d.). The main impact of methane on a global scale is as a greenhouse gas. Methane is produced naturally by wetlands and oceans, but it is also produced during the production, transportation and use of fossil fuels. Livestock farming is also a source of methane (What's Your Impact, n.d.).

Lead (Pb) is a metal that can be found in our air as a constituent of particulate matter. Using lead as an additive in fuels for decades has resulted in its continued presence in our atmosphere. Leaded fuel products have been phased out of use, but lead continues to be present in the atmosphere (King's Centre for Visualization in Science, n.d.).

Ammonia (NH_3) is a colourless gas with a strong odor found in household cleaners. It is produced by both natural and human sources. In Alberta, the fertilizer industry is the main industrial source of NH_3, followed by commercial feedlots as NH_3 is produced during the decay of plant and animal waste (Alberta Environment and Parks, n.d.).

Polycyclic Aromatic Hydrocarbons (PAHs) are a class of chemicals that are formed during incomplete combustion of gasoline, diesel, oil, coal, wood, garbage, or other organic substances. Tobacco smoke and charbroiled meats are other sources of PAHs. These substances usually occur as mixtures rather than single compounds. People can be exposed to these chemicals through breathing, eating or drinking, or even touching substances that contain PAHs (Alberta Environment and Parks, n.d.).

Volatile Organic Compounds (VOCs) include a large group of chemicals containing carbon and hydrogen atoms that can react quickly to form other chemicals in the atmosphere. They can react with oxides of nitrogen in the presence of sunlight to form ozone and photochemical smog, and they can be toxic to humans, animals or vegetation. VOCs come from vegetation, vehicle emissions, gasoline dispensing and storage tanks, petroleum and chemical industries, dry cleaning, fireplaces, natural gas combustion and aircraft emissions. Natural sources (forests, swamps, etc.) are estimated to contribute almost 6 times more VOCs than human sources. VOCs can be released indoors by furniture, paint, adhesives, draperies, carpeting, spray cans, cleaning compounds and other household products. Indoor concentrations are usually higher than outdoor concentrations (Alberta Environment and Parks, n.d.).

Sources

The pollutants listed above come from both human activity and natural sources. There are three main types of emission sources:

1. Point Sources – factories, industry, electrical power plants, etc.
2. Non-Point/Mobile Sources – cars, trucks, lawnmowers, airplanes, etc.
3. Natural Sources – trees, vegetation, gas seeps, wetlands, etc.

The Government of Alberta regulates emissions from point sources through approvals under the Environmental Protection and Enhancement Act. Approvals cover all phases of an industrial operation and may require operators to minimize pollution, install control measures, or a combination of both. A facility is allowed a maximum amount of pollution based on models and impact assessments.

Non-point source emissions (such as from vehicles) are not easily regulated. Typically these emissions are managed during the manufacturing phase (i.e. production of the vehicle) and through public awareness efforts, such as no idle education (Fort Air Partnership, n.d.).

It is important to know that certain pollutants can react with other substances in the environment to form different pollutants. Nitrogen oxides, for example, are involved in complex reactions that increase the level of atmospheric particulate matter. Primary pollutants are those that are emitted directly from a source. Secondary pollutants are those that result from reactions involving primary pollutants (King's Centre for Visualization in Science, n.d.).

Ambient Air Quality Objectives (Alberta)

Alberta's Ambient Air Quality Objectives are meant to provide protection of the environment and human health in a way that is technically and economically feasible, as well as socially and politically accepted. The objectives are used to:

- Assess compliance near major industrial air emission sources
- Establish approval conditions for regulated industrial facilities
- Evaluate proposals for constructing facilities
- Guide special ambient air quality surveys
- Inform Albertans on air quality through an air quality index
- Report on the state of Alberta's atmospheric environment

The objectives are based on scientific, social, technical and economic factors that consider: monitoring, natural levels and fluctuations, sensitive environmental receptors (i.e. an organism's sensitivity to the pollutant throughout its lifecycle), substance behaviour in the atmosphere, substance behaviour in the environment (i.e. bioaccumulation), and technological availability.

The Air Quality Objectives and Guidelines Summary can be found online here:
http://aep.alberta.ca/air/legislation-and-policy/ambient-air-quality-objectives/documents/AAQO-Summary-Jun29-2017.pdf

(Alberta Environment and Parks, 2018)

Environmental Impacts

Human activity can compromise the atmosphere and its protective properties through the release of pollutants. For example, the temperature on Earth is regulated predominantly due to the effects of greenhouse gases (GHGs) in our atmosphere such as carbon dioxide, methane and water vapour. These gases help to "trap" warm air in the atmosphere by absorbing the infrared radiation that the earth emits back into space. Without GHGs the average temperature on Earth would be -18°C. However, we have significantly increased the rate at which GHGs enter the atmosphere since the industrial revolution (King's Centre for Visualization in Science, n.d.). The burning of fossil fuels in motor vehicles, industrial activity, and power production release carbon dioxide into the atmosphere. In addition landfills, natural gas and oil use, agriculture, and coal mining produce methane. Both of these substances are GHGs, and the accumulation of these gases in the atmosphere contributes to climate change (Fort Air Partnership, n.d.), resulting in increased global temperatures, increased frequency of extreme weather events, and rising sea levels.

High levels of air contaminants can result in smog, which is primarily made up of ground-level ozone and particulate matter. Smog causes plants to grow more slowly and become vulnerable to disease, pests, drought and cold (Fort Air Partnership, n.d.). Ground-level ozone is effectively toxic to plants, interfering with photosynthesis (King's Centre for Visualization in Science, n.d.).

Air pollution can also result in acid deposition (the transfer of acidic substances in the air onto surfaces). Sulfur dioxide and nitrogen oxides are the primary components of acid precipitation (Fort Air Partnership, n.d.). Acid precipitation forms when these pollutants dissolve in water droplets, making them acidic, or when the oxidation products of $SO2$ and $NO2$ are found in particulate matter. Natural precipitation has a pH of approximately 5.6 due to the presence of dissolved $CO2$. Acid precipitation, on the other hand, results from the presence of other acids, such as sulfuric acid or nitric acid, or acid-forming substances such as sulfate and nitrate ions. These substances cause the pH of acid precipitation to be much lower. Because the pH scale is logarithmic, a drop in pH by one point represents a ten-fold increase in acidity (King's Centre for Visualization in Science, n.d.).

Monitoring Methods

There are three methods for monitoring air quality in Alberta: continuous, intermittent and passive. Continuous monitoring provides nearly instantaneous measurements of pollutant concentrations. Air is drawn into a commercial analyzer that has been calibrated to produce an output that is proportional to the ambient pollutant concentration. Data is stored in one-hour time blocks. Intermittent monitoring involves collecting 24-hour average pollutant concentration, once every 6th day. This method involves collecting pollutants using reactive tubes, absorbents or filters. The samples provide a more detailed look at air quality but need to be analyzed in a lab to determine air pollutant levels, meaning data may not be available for several months. Finally, passive monitoring involves passive samplers collecting air pollutants without the need for electricity, data loggers, or pumps (unlike continuous and intermittent monitoring). Pollutants transfer from the air to a reactive surface and lab analysis is needed to determine concentration. This method is used for long-term trends and can be used in a network over large spaces to understand the spatial variance in pollution levels (Alberta Environment and Parks, n.d.).

Nitrogen oxides are measured continuously using the principle of chemiluminescence. The air sample is split into two pathways. The first pathway is to measure NO; it goes directly into the analysis chamber and is mixed with O_3 in a reaction that produces light. The amount of light that is detected is proportional to the NO concentration and is the measurement of NO in the sample air. In the second pathway, a catalytic converter is used to change all of the NO in the sample into NO2. A catalytic converter is a device that catalyzes redox reactions, in this case a molecule of oxygen is added to NO to produce NO_2 in and oxidation reaction. The sample then goes into the analysis chamber. The amount of light detected is the sum of NO and NO_2. The difference in the readings between the two pathways is calculated and is the concentration of NO_2 (Alberta Environment and Parks, n.d.).

Carbon monoxide (CO) is continuously monitored by either non-dispersive infrared photometry or gas filter correlation. Non-dispersive infrared photometry is a process based on the absorption of infrared light by CO. Gas filter correlation is operated on the same principle, but is more specific to CO because it eliminates water vapour, CO_2 and other interferences allowing for more precise results (Alberta Environment and Parks, n.d.).

Ozone (O_3) is monitored continuously using ultra-violet (UV) light. The air sample is exposed to UV light which is absorbed by O_3. The amount of UV light that is absorbed is proportional to the amount of O_3 in the sample. The more UV light that is absorbed, the greater the amount of O_3 that is present (Alberta Environment and Parks, n.d.).

Sulfur dioxide (SO_2) is continuously monitored by pulsed fluorescence. Air is drawn through a sample chamber where it is irradiated with pulses of UV light. Any SO_2 in the sample is excited to a higher energy level. When it returns to its ground state, light or fluorescence is released. The amount of fluorescence measured is proportional to the concentration of the pollutant (Alberta Environment and Parks, n.d.). Hydrogen sulfide (H_2S) is monitored with the same method. Initially all of the SO_2 is scrubbed out of the sample so that it does not interfere with the measured H_2S concentration (Alberta Environment and Parks, n.d.).

Particulate matter is monitored using Beta attenuation or Tapered Element Oscillating Microbalance (TEOM). For both methods, particle sizes (PM_{10}, $PM_{2.5}$) are aerodynamically separated before analysis. Beta attenuation involves particle matter being deposited onto filter tape and emitted beta rays (high energy, high speed electrons emitted by radioactive substances) being attenuated, or slowed, as they pass through the sample. Readings from this process are then converted into mass concentrations. TEOM has the air sample pass through a filter that is attached to a tapered element in the mass transducer. The element naturally vibrates its frequency. As particles are deposited onto the filter the oscillating frequency changes in proportion to the amount of mass deposited. Particulate matter is also monitored on an intermittent basis using a dichotomous sampler. The sample aerodynamically separates the two size fractions (PM_{10}, $PM_{2.5}$). The particles are collected by drawing a known volume of air through two filters for a 24-hour period. The total particulate concentration in the two size ranges may then be calculated for the 24- hour period (Alberta Environment and Parks, n.d.).

Hydrocarbons are monitored continuously by a hydrogen flame ionizer detector. Hydro-carbon bonds are broken when burned creating ions that conduct electricity. An electrical current can then be measured by an electrometer (an instrument that measures electrical charge) to give a signal proportional to the number of ions (Alberta Environment and Parks, n.d.).

Polycyclic Aromatic Hydrocarbons (PAHs) are analyzed in total suspended particulate samples every 6th day. The samples undergo laboratory analysis using gas chromatography/mass spectrometry. Gas chromatography (GC) is a process that allows you to separate and identify gases based on the compounds boiling point and relative molecular weight. Mass spectrometry, which analyzes masses within a sample, is paired with GC for more precision. The specific PAHs that are monitored are benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, indeno(1,2,3-c,d)pyrene, benzo(k)fluoranthene and benzo(g,h,i)perylene (Alberta Environment and Parks, n.d.).

VOCs are monitored continuously by gas chromatography or intermittently using a stainless steel electropolished (SUMMA) canister. For the canister sampling method, air samples are drawn into the canister at a constant rate for a 24-hour time period. These air samples are then analyzed by gas chromatography systems using a cryogenic preconcentration technique, which improves GC results, to quantify concentrations of over 150 hydrocarbon species (Alberta Environment and Parks, n.d.).

Monitoring Air Quality in Alberta

Alberta is a signatory to the National Air Quality Management System which is a comprehensive collaborative approach to reduce air pollution in Canada. The System calls for consistency across Canada but also allows flexibility for provinces to achieve optimal air quality outcomes (Government of Alberta, 2017).

Ambient air monitoring in Alberta happens in two ways: community monitoring and perimeter (or fenceline) monitoring. Community monitoring uses permanent monitoring stations to measure the level of air pollution where people live and to track trends over time. Perimeter monitoring involves discrete sampling of substances at various locations along an industrial property boundary to measure the level of pollution leaving a facility. Ambient air monitoring allows the province to assess the impact of releases on the environment, ensure pollution control technologies are operating effectively, and provide data to track trends in environmental performance and effects (Government of Alberta, 2017).

Air quality for industrial facilities is primarily monitored through the environmental assessment, approval and enforcement process. Facility operators are mandated to report ambient air monitoring data and pollution emissions. The nature of these reports is determined through the project approval process (Government of Alberta, 2018).

Air quality in Alberta is collectively monitored by the provincial government, airsheds (see below), the federal government and industry. The data is collected at a network of stations across the country, most of which is sent to airsheds or Alberta Environment and Parks. It is archived online in the Alberta Environment and Park airdata Warehouse. The stations monitor average concentrations of pollutants as well as meteorological factors (Fort Air Partnership, n.d.).

The National Air Pollution Surveillance (NAPS) Network also plays a role in monitoring air quality. The NAPS Network is a joint federal and provincial program that monitors and assesses ambient air quality in urban centers across Canada. Airsheds provide data for this program which allows comparisons across 55 Canadian cities (Fort Air Partnership, n.d.).

Airsheds

Airsheds are not-for-profit, multi-stakeholder organizations that monitor, collect and share information on air quality to the public. There are nine airsheds in Alberta, each with its own geographical zone, that provide data to the airdata warehouse. Because air quality issues are local, these airsheds provide an opportunity for local stakeholders to design local solutions to their concerns when province-wide approaches may not be appropriate. Each airshed is responsible for monitoring and reporting on air quality in the region, and play an important role in developing management plans to deal with air quality concerns. The nine airsheds in Alberta are:

- Alberta Capital Airshed (ACA)
- Calgary Region Airshed Zone (CRAZ)
- Fort Air Partnership (FAP)
- Lakeland Industry and Community Association (LICA)
- Parkland Airshed Management Zone (PAMZ)
- Palliser Airshed Society (PAS)
- Peace Airshed Zone Association (PAZA)
- West Central Airshed Society (WCAS)
- Wood Buffalo Environmental Association (WBEA)

(Alberta Environment and Parks, n.d.)

Indoor Air Quality

The quality of the air in our homes, places of work and recreation facilities is also important to consider as Albertans, and Canadians in general, spend 90% of their time indoors. Indoor air quality is greatly affected by the ambient outdoor air quality, but is also impacted by climate, household products and furnishings, temperature, and building regulations. Climate and weather combined with building structures can result in the growth of mold in households. This mold can then be released into the air and make its way into our respiratory system. Household products and furnishings on the other hand, can release pollutants into the air in our homes, often as volatile organic compounds, and airborne particles and gases (Government of Alberta, 2009).

The factors that impact air quality in our homes include: the type of building, the weather, the quality of the outdoor air, nearby industry, products of combustion during cooking, furnishings, toiletries, cleaning products, and waste. In addition, because we keep our doors and windows closed for most of the year, the toxins and pollutants that are released remain in a relatively closed system (Government of Alberta, 2009).

In offices, shopping centres and schools furnishings again, are the major source of pollutants, but printers, computers, carpets, and painted walls can also generate VOCs. The air quality of commercial centres can also suffer from asbestos found in insulation and the contamination of heating, ventilation and air conditioning systems (Government of Alberta, 2009).

Finally, indoor industrial environments pose significant health effects as the result of poor air quality. Industrial facilities are of special concern because of the proximity of pollutants. These facilities often produce polycyclic aromatic hydrocarbons, pesticides, mercury, lead particles, and sulfur compounds (Government of Alberta, 2009).

Because indoor air quality is affected by numerous factors it is hard to manage and regulate. In Alberta industrial settings are regulated by occupational exposure limits but there is no mechanism in place to manage air quality in our homes. The Alberta Indoor Air Quality Toolkit offers recommendations for appropriate temperature, humidity level, and contaminant concentrations for commercial buildings, but exposure limits for households are only recommended and not enforceable (Government of Alberta, 2009).

AIR QUALITY AND HEALTH

Nitrogen dioxide, ground-level ozone and particulate matter are the pollutants of greatest importance when it comes to health as these contaminants have been found to contribute to cardiovascular and respiratory disease. Depending on a person's state of health and the concentration of pollutants, air pollution can irritate lungs and airways, make it harder to breathe, and worsen chronic illnesses. Children, people participating in outdoor sports or other strenuous activities, people with lung disease, and seniors are high-risk populations who may experience the effects of air pollution more severely (Government of Alberta, 2017).

Particulate matter contains particles that are as small as 2.5 micrometers (μm). For reference, a human hair is about 60 μm in diameter. These small particles are able to pass through our body's protective membranes and can become deeply embedded in our lung tissue, which can lead to respiratory diseases and lung cancer. Continual exposure to fine particulate matter (such as in large cities) can be linked to serious health effects and mortality (King's Centre for Visualization in Science, n.d.).

When inhaled, nitrogen dioxide inflames the lining of the respiratory tract, increasing the likelihood of respiratory disease. NO2 can also aggravate existing conditions, such as asthma (King's Centre for Visualization in Science, n.d.).

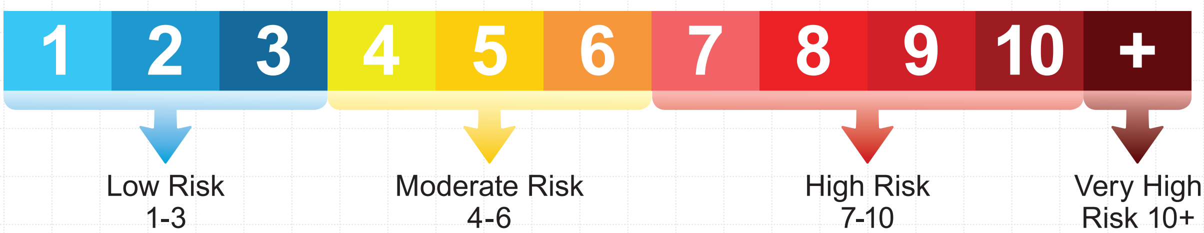
Stratospheric ozone is formed naturally through reactions involving the oxygen and light from the sun. Ozone in the stratosphere is important as it protects the earth from too much UV radiation from the sun. Ground-level ozone, on the other hand, comes from human activity and leads to the production of smog. When O_3 enters our lungs, it can cause coughing, irritation to the airways and increased vulnerability to respiratory infections. Ozone can also aggravate existing conditions (King's Centre for Visualization in Science, n.d.).

Sulfur dioxide can also lead to serious health effects. At high levels, SO_2 is fatal, but at lower levels it can cause eye and respiratory irritation and increases the likelihood of cardiovascular and respiratory disease. Exposure to this substance has also been linked to increased vulnerability to respiratory infections and chronic bronchitis (King's Centre for Visualization in Science, n.d.).

Carbon monoxide is another gas that can cause harmful health effects. CO reduces the amount of oxygen that is able to circulate in our blood because it easily binds to hemoglobin (a protein that carries oxygen). This means there is less hemoglobin available to carry oxygen. Decreased oxygen in the blood can lead to headaches, fatigue, difficulty concentrating or nausea. Exposure to high levels of CO can cause more serious effects and even death (King's Centre for Visualization in Science, n.d.).

Lead found in particulate matter can make its way into the blood stream, and eventually build up in bones. Very young children and pregnant women are especially sensitive to the effects of lead. Exposure can result in learning deficits, behavioral problems, and delayed growth. The substance can cross the placental barrier and affect fetuses. Lead can also impact adults, causing hypertension, decreased kidney function and reproductive problems (King's Centre for Visualization in Science, n.d.).

Albertans can refer to the Air Quality Health Index (AQHI) to protect themselves from the harmful effects of air pollution. The AQHI relates air quality to health, using a scale from 1 to 10. The pollutants measured to calculate the AQHI are carbon monoxide, nitrogen dioxide, ozone, fine particulate matter and sulfur dioxide. (Fort Air Partnership, n.d.)



(Government of Alberta, 2018)

The AQHI also identifies health messages for the general population and at-risk groups.

Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population	General Population
Low Risk	1 – 3	**Enjoy** your usual outdoor activities.	**Ideal** air quality for outdoor activities.
Moderate Risk	4 – 6	**Consider** reducing or rescheduling strenuous activities outdoors if you are experiencing symptoms.	**No need to modify** your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High Risk	7 – 10	**Reduce or reschedule** strenuous activities outdoors. Children and the elderly should also take it easy.	**Consider** reducing or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High Risk	Above 10	**Avoid** strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	**Reduce or reschedule** strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

(Government of Alberta, 2018)

The Canadian national Air Quality Health Index (AQHI) represents a mixture of common air pollutants which are known to be harmful to human health. Three pollutants were chosen as indicators of the overall mixture of outdoor air including: ground-level ozone, fine particulate matter, and nitrogen dioxide.

In Alberta the national AQHI was modified to account for additional pollutants and rapidly changing air quality. Hourly pollutant concentrations are compared against Alberta's Ambient Air Quality Objectives and if the following thresholds are exceeded the AQHI value is adjusted to the High or Very High risk value:

- 80 micrograms per cubic metre for fine particulate matter
- 172 parts per billion for sulfur dioxide
- 159 parts per billion for nitrogen dioxide
- 82 parts per billion for ozone
- 13 parts per million for carbon monoxide
- 1 part per million for hydrogen sulfide and total reduced sulfur

Alberta also has a special messaging protocol for odour or visibility events when concentrations of specific pollutants are higher than specified odour or visibility thresholds. When these thresholds are triggered the AQHI value is rated as Low or Moderate risk:

- 25 micrograms per cubic metre for fine particulate matter (based on visibility)
- 100 parts per billion for sulfur dioxide (based on odour)
- 10 parts per billion for hydrogen sulfide or total reduced sulfur (based on odour) (Government of Alberta, 2018).

MANAGEMENT & REPORTING

Management

The air quality data that is collected across the province is used by stakeholders (airsheds, industry, governments, researchers) for numerous purposes including:

- Assessing whether additional industrial activity in an area should be approved
- Establishing operating conditions for approved industrial facilities
- Providing information that helps decision makers develop air quality management policies
- Ensuring pollutant concentrations remain below levels that are considered safe for human exposure
- Assessing how pollutant concentrations compare with government air quality standards
- Supporting policy monitoring programs
- Assessing impacts of local emissions sources on air quality
- Evaluating long-term trends
- Informing the public
- Supporting research efforts
- Validating the accuracy of predictive air modeling computer programs

Overall, the data is primarily used by Alberta Environment and Parks to ensure industrial activities are designed and operated in a way that meets the Alberta Ambient Air Quality Objectives, and to support policy decisions (Fort Air Partnership, n.d.).

Air quality management in Alberta includes a number of elements including the National Air Quality Management System which is a national collaborative approach for reducing air pollution in Canada. Alberta also takes a provincial approach to air quality management with industrial approvals, ambient air monitoring, management frameworks, and regional planning (Alberta Environment and Parks, 2018).

Reporting

Airsheds, industry, Alberta Environment and Parks and the NAPS Network analyze and report on air quality data. Airsheds are primarily responsible for reporting air quality data to the public, often producing annual reports and educational materials. Industry is required to submit monthly and annual compliance reports to the Province. Data collected by industry may also be used to inform public consultation processes. Alberta Environment and Parks uses air quality data to produce numerous reports including the State of the Environment report. Finally, the NAPS network publishes reports that compare air quality with the National Air Quality Objectives under the Canadian Environmental Protection Act and uses the data to evaluate pollution control strategies and identify trends (Fort Air Partnership, n.d.).

DATA SOURCES

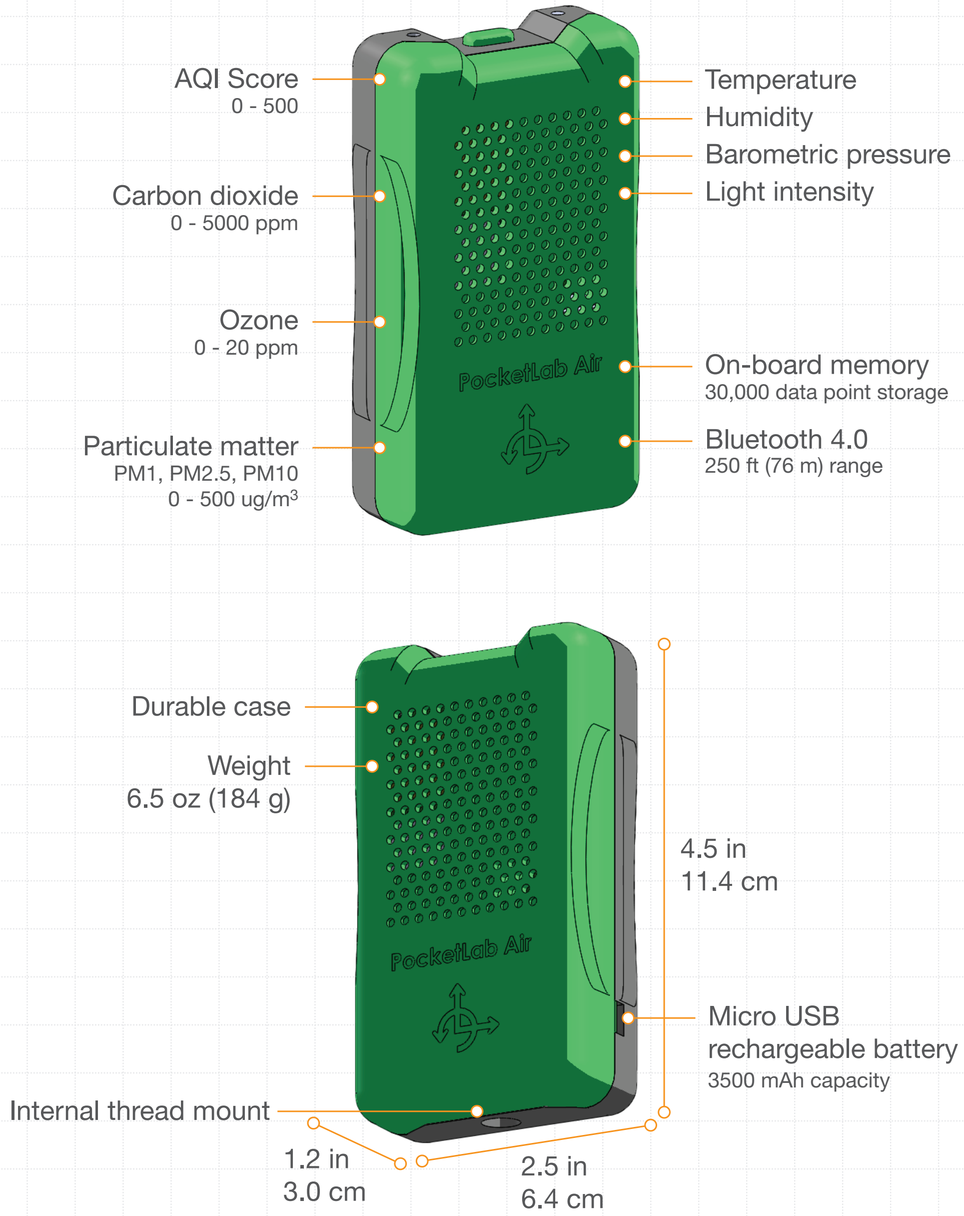
Alberta Environment and Parks Data Warehouse: airdata

Formerly known as the Clean Air Strategic Alliance (CASA) Data Warehouse, Alberta's ambient air quality data warehouse, airdata, was operational in September of 1997. airdata was created in responses to CASA's 1995 strategic plan that recommended a central repository for ambient air and ecological data. The data warehouse would also be responsible for the dissemination of information to a wide range of stakeholders. It is publicly available and contains both archived historical data extended back to 1986 and near real-time, current air quality data (Alberta Environment and Parks, n.d.). http://www.airdata.alberta.ca/Default.aspx

Air Quality Health Index (AQHI) Map

Real time air quality data can also be accessed by the public at any time using Alberta's AQHI online mapping tool. The map displays AQHI values for the province, and can be used to search for levels of specific pollutants. Data is stored for the previous 365 days. It is important to note that the data has been uploaded from monitoring stations in real time and therefore has not been checked or cleaned of errors. Data accessed through this site is purely for informational/education purposes (Government of Alberta, n.d.). http://airquality.alberta.ca/map/

POCKETLAB AIR
GETTING STARTED GUIDE



PocketLab Button		
Short button press	Fast red and green flash	Start Bluetooth advertising
Long button hold	Solid red	Power off PocketLab

LED Flashing Codes	
Alternating fast red and green flash	PocketLab Air is advertising and ready to connect via Bluetooth
3 blue flashes	PocketLab Air initiated Bluetooth connection to the app
1 violet flash every 5 seconds	PocketLab Air is connected to the app
Alternating slow red and green flash	PocketLab has disconnected from the app is powered on
3 red flashes every 5 seconds	PocketLab battery is low
3 red flashes every 10 seconds	PocketLab battery is changed when connected to micro USB
Orange flashes	PocketLab is downloading stored memory data to the app

App Button Functionality	
	Settings, help, and battery meter
	Select sensor graph views
	Memory Data Logging set up
	Select sensor data rate
	Select the graph units
	Select camera mode (iOS only)
	View more options

App Requirements	
iOS	iPhone 4s, and newer iPads all except the iPad 1 and iPad 2 iPod Touch 5th gen and newer
Android	Android OS 5.0 and newer Most phones and tablets made since 2013
Windows 10	Native Bluetooth 4.0 support required. Most PCs made since 2013. Updated Chrome browser.
Mac OS	Macbook, Macbook Pro, Macbook Air with OSX 10.11 or later. Updated Chrome browser.
Chromebook	Bluetooth 4.0 support required. Most Chromebooks made since 2013.

App Installation and Setup

1. The PocketLab App is supported on the latest operating system and app versions. Please make sure your OS version and PocketLab App are up to date.
2. Before connecting, go to your device settings and turn Bluetooth ON.
3. For iPhones, iPads, and Android phones, download the PocketLab App from the Apple App Store or Google Play Store.
4. For MacOS, Chromebooks, and Windows 10 devices there is no need to download anything. Make sure you are using the latest version of a Google Chrome web browser and go to thepocketlab.com/app to connect to the PocketLab Web App.

Battery Charging

1. To charge the battery, connect a micro USB cable to the connector on the PocketLab. Plug the USB cable into a USB charger or computer port.
2. The LED will blink red every 10 seconds while charging and stop blinking when fully changed.

Connecting to PocketLab from an iPhone, iPad, or Android Phone

1. Launch the PocketLab app.
2. Press the top button on the PocketLab sensor. The LED will flash alternating red and green.
3. If the PocketLab sensor is in close range to your device, the sensor will connect automatically, and the LED will flash blue. If the sensor does not connect, tap on the serial number on the connection screen.
4. When connected to the app, the LED will flash violet every 5 seconds.

Connecting to PocketLab from a MacOS, Chromebook, and Windows 10 Device

1. Open a Chrome browser and go to thepocketlab.com/app.
2. Click “Connect to PocketLab.”
3. A connection window will appear listing available PocketLabs to connect with.
3. Press the top button on the PocketLab sensor. The LED will flash alternating red and green.
4. The name of the PocketLab will appear in the connection window. Click on the name of the PocketLab and then click “Pair.”
5. When connected to the app, the LED will flash violet every 5 seconds.

Display and Record Sensor Data

1. To record data, press the Record button on the graph screen. The current data will clear and the app will record new sensor data.
2. To stop the data recording, press the Stop button.
3. When the data recording has stopped, you can scroll through the graph, zoom in and out, and select graph points to view the data values.
4. Press the Share button to save or export the recorded sensor data.
5. When you are done reviewing or saving your data, press the Clear button to start streaming real-time sensor data gain.

Disconnect the Sensor

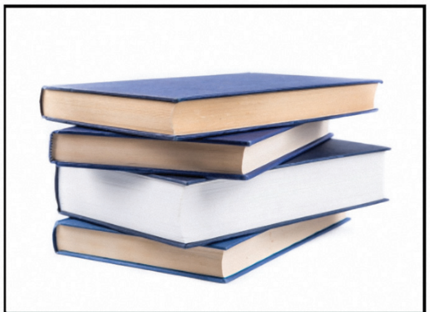
1. To disconnect, press and hold the top button on the PocketLab sensor for 5 seconds. The LED indicator will flash red then stop.
2. Exit the PocketLab App.

AQHI MAPPING TOOL USER MANUAL
AIR QUALITY MATTERS

TELUS World of Science – Edmonton worked in partnership with The King's Centre for Visualization in Science from The King's University to develop resources you can access to supplement the workshop and tools presented in these lesson plans. The electronic resources shown below can be found at http://sensors.kcvs.ca/.

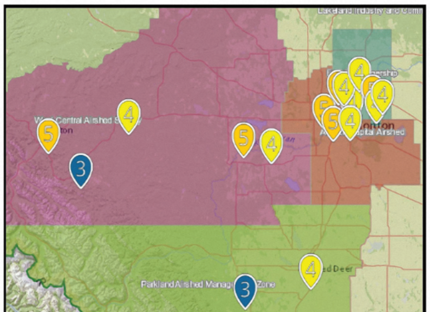
The PocketLab Air

How to use your PocketLab Air, including detailed instructions, updates, possible extensions, and more.



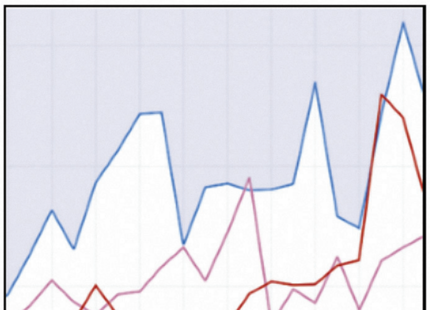
Lessons and Teacher Resources

Here you can find more resources on Air Quality including our lessons for Grade 4, 7, 9, and Science 30. As the Alberta curriculum is updated, keep an eye on http://sensors.kcvs.ca/ and www.twose.ca for current content.



Air Quality Health Index (AHQI)

A detailed guide to using the Alberta Air Quality Health Index (AQHI) interactive map.



Data and Analysis

Many of our lessons involve processing data, a skill that takes time to learn. These tools can help you and your students understand air quality data and how to record and display the data collected with the PocketLab Air.

KCVS.ca
King's Center for Visualization in Science

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