GRADE 4 SCIENCE

TOPIC A:
Waste and Our World

INVISIBLE WASTE

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 though 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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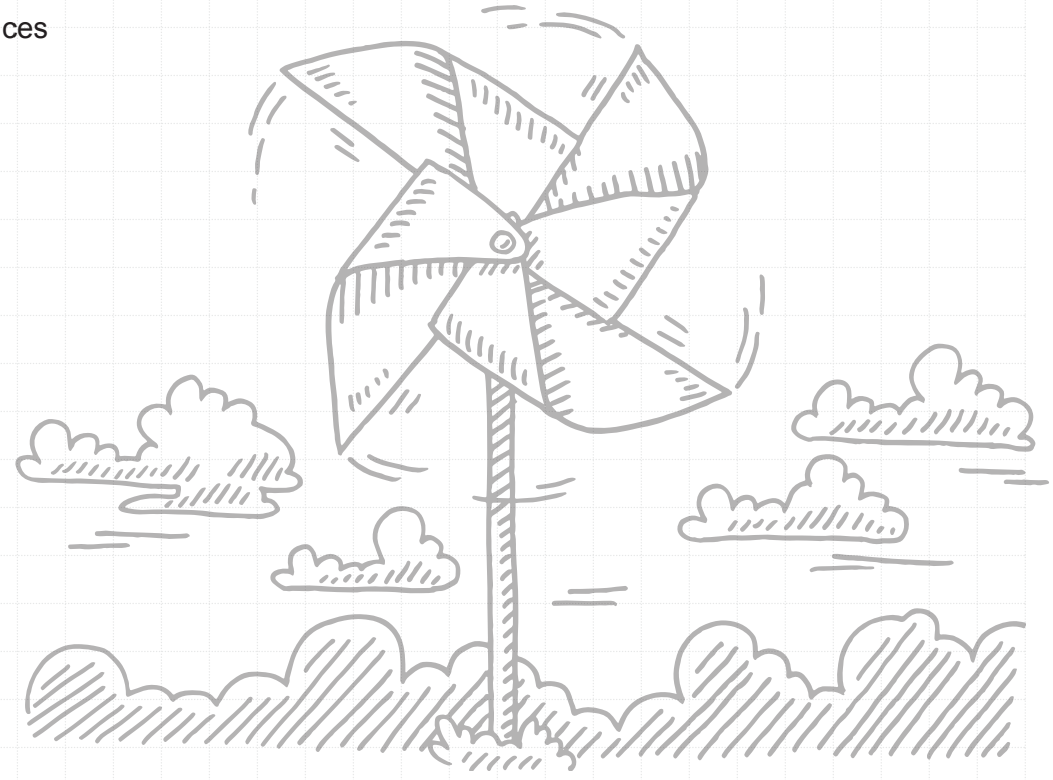


INTRODUCTION

Invisible Waste

In this series of lessons, students will learn that industrial processes and daily activities produce waste products that are released into the air as pollutants. They will learn the names of common pollutants and will be able to identify sources of air pollution. They will understand that some of these pollutants are toxic to both humans and the environment. Students will be measuring and recording air quality data and will learn about Alberta's Air Quality Health Index. They will come up with strategies for improving the air quality in their school or community, and implement a plan to do so.

Curriculum Connections

Grade 4 Science, Topic A: Waste and Our World

2. Identify and classify wastes that result from human activity.

4-5 Recognize that human activity can lead to the production of wastes, and identify alternatives for the responsible use and disposal of materials.

7. Identify kinds of wastes that may be toxic to people and to the environment.

11. Identify actions that individuals and groups can take to minimize the production of wastes, to recycle or reuse wastes and to ensure the safe handling and disposal of wastes.

12. Develop and implement a plan to reduce waste, and monitor what happens over a period of time.

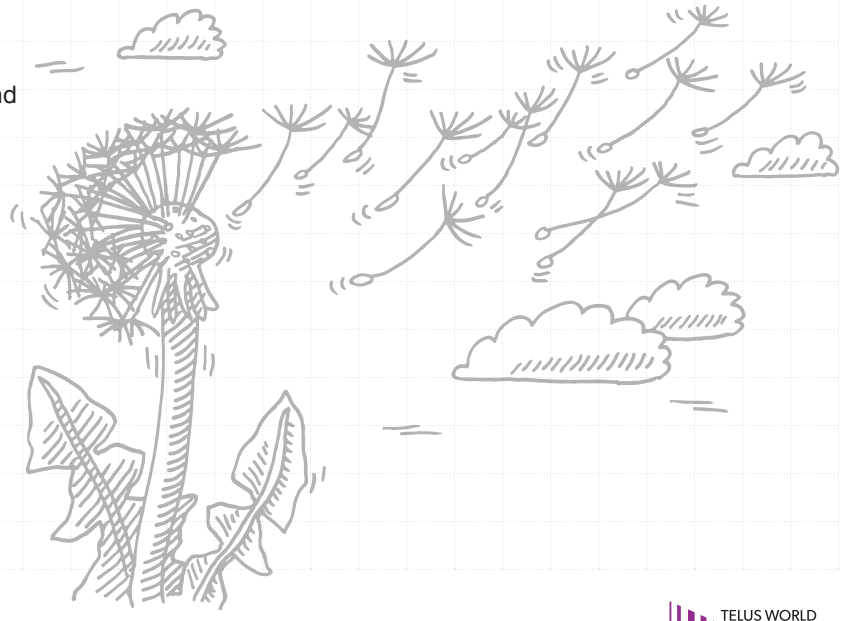
Enduring Understandings

- Waste comes from many sources, and we can't always see it with our eyes.
- Air pollution results from the waste products of energy production, industrial processes, daily activities such as driving a car, and even from nature.
- Some pollutants found in the air are toxic to humans and the environment.
- Air quality can impact our health. We can measure and monitor pollutant levels to help keep ourselves safe.
- We can all take steps to help keep our air clean and prevent it from becoming polluted.

Prior Knowledge

Students should be able to identify natural processes and human technology that produce waste. They should understand that materials are recycled through the environment over and over again.

Students should identify clean air as a necessity of life for humans, plants, and animals.



LESSON 1:

POST-IT THROW DOWN

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POST-IT THROW DOWN

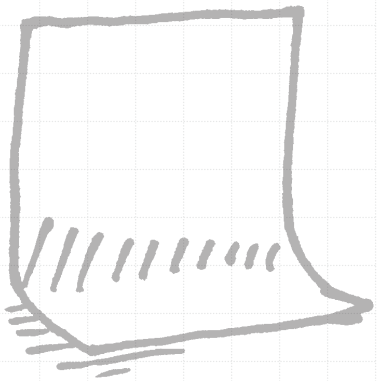
In this lesson, students will discover “invisible wastes” or air pollutants and learn where they come from as well as how our actions contribute to air pollution. In a group brainstorming activity, have students come up with a list of activities they participate in on a daily basis that could lead to invisible wastes entering the atmosphere.

Learning Goals:

- Students will list examples of everyday activities they participate in that require energy (i.e. electricity) and explain that this energy is produced in power plants through burning coal or harnessing energy from the sun, wind or hydro.
- Students will identify air pollutants as waste products resulting from energy production, such as coal burning power plants, and daily activities like driving a car, having a campfire and using a gas stove.
- Students will generate a list of air pollution sources and identify their own activities that may contribute to air pollution.

Resources and Materials

- Post-It Notes
- Markers
- Poster paper or whiteboard space
- Tape (optional)



Time Required

30 minutes

Preparation

- Arrange your room for a class discussion
- Gather all materials
- Review teacher’s background information, if necessary
- Prepare exit slips (optional)

Outline

1. Introduce the lesson
   - Review what students know about waste
   - Discuss the importance of air
   - Discuss air pollution as the result of waste products from energy production
2. Discuss the invisible nature of air pollution
   - Where does air pollution come from?
   - Discuss sources of pollution, citing energy production (coal-fired power plants) as a major source

3. Post-It Throw Down activity
    - Lead brainstorming activity, encouraging students to identify air pollution sources they participate in
4. Conclude the lesson
    - Briefly discuss the ideas that were generated during the activity
    - Conduct exit slip activity (optional)

Assessment

Pre-assessment

- Determine student's current understanding of waste. What can they recall from previous classes, units or grades? Where does waste come from? How can we categorize waste? What do they know about air?

Formative Assessment

- Students should actively participate in the post-it activity, thinking critically about where air pollutants might come from.
- Students are able to communicate their ideas during the post it activity and provide reasoning as to why their idea is a pollutant source.

Summative Assessment

- Each student submits at least one post-it note indicating a pollutant source.
- Students will generate a list of questions about air pollution they wish to further explore based on the content of this lesson. This assessment can be completed informally as a class discussion or formally by having each student submit their questions in writing.

Teaching Notes

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

Introduction - 5 Minutes

This lesson is based on the understanding that air pollution is a waste product of industrial processes and daily human activities, which may be difficult for the students to understand, as we typically refer to wastes as the trash and other physical material that we throw away. Throughout this and subsequent lessons, students will come to realize that pollutants are by-products of processes like burning coal for energy, or burning fossil fuels in our cars and are released into the environment as waste, even though we cannot see them. Come back to this idea throughout the introductory discussion and make connections to what the students have previously learned during the unit.

Even though we can't see it, air is all around us! We can feel air, it carries smells to our nose, and sometimes we can even taste it.

Have students use their senses to prove air is all around. Can they feel it (wave their hand through the air)? Can they taste it? Can they smell it? You might consider spraying perfume or air freshener in the room before students arrive and ask if they noticed it upon entering.

Why is air important to us? What would a world without air be like?

Encourage class discussion.

Sometimes waste can end up in our air. When harmful gases, dust or fumes are released into the air we call it air pollution. Many gases already exist in our atmosphere, but if we release extra or too much of one gas, it is considered air pollution as well. For example, carbon dioxide is an important gas in our atmosphere that helps regulate the temperature on our planet. However, when we add extra carbon dioxide to the atmosphere by burning fuel in our cars it can be harmful for the environment and for our health.

Refer to the Teacher's Background Information section for more detailed explanations of pollution that results from coal fired power plants and sources of common pollutants. It is important to emphasize that some of the pollutants students will learn about are found naturally in the environment. These substances become pollutants when they are in excess, or at elevated concentrations beyond the normal environmental baseline. When substances reach these levels and become harmful to humans or the environment they are considered pollutants.

Refer back to what students have learned about waste so far, if applicable. What types of waste have they learned about?

Sometimes waste can pollute our air, or make it dirty. What might happen if our air becomes dirty?

Today we are going to look at ways waste, or pollutants, can enter our air.

Body – 15 Minutes

Can we always "see" when our air is dirty or polluted?

Students may tell you about a time when they have seen smog, which is an indication of pollution. They may also talk about fog, which is a natural process of water condensing near the surface of the earth; it is not pollution.

Sometimes we can see when our air has been polluted; it might look like brown fog, or smog, hanging over our homes and schools. But most of the time we can't see dirty air because it is invisible, or clear.

Waste products from human activity can end up in our air as pollution. Any time we use electricity we are using energy that is produced in a power plant.

Did anyone use electricity this morning?

Any form of electrical usage is acceptable here.

Power plants that burn coal, natural gas or oil give us electricity for all of these activities but this technology also produces waste. In this case, air pollution.

You may wish to discuss clean energy sources here (wind, hydro, solar, etc.) as alternative energy sources that don't produce air pollutants and the pros and cons associated with these technologies.

Other activities that burn fuel like gas or oil such as cars, trucks, buses, boats and lawn mowers also create air pollution. Remember, usually we can't see this invisible waste because they are released as gases.

Remind students of the three states of matter if necessary.

How many of you drove to school with an adult or rode the bus this morning? How many of you rode your bike or walked to school?

Take a class poll by asking for a show of hands.

It looks like every one of you used energy from a power plant or burned fuel from a car today. That means we all participated in an activity that produced air pollution.

Now let's think of some things that might be polluting the air in and around our school. We are going to do a brainstorming activity.

Activity: Each student will receive a stack of post it notes and a marker. Their task is to think of things that might pollute the air in and around the school. Examples include cars, trucks, buses, nearby power plants, etc. They may write or draw their ideas on a post it note. Once the have completed the note they should bring the

note to the front of the class, briefly explain their idea and secure the post it to a poster board or whiteboard at the front of the room. You may wish to tape the notes as they will be used in a subsequent lesson. Students may submit multiple post it notes.

Optional: Take your students on a "field trip" around the school to look for sources of air pollution. Have them jot down their ideas on the walk then return to class to complete the activity as described above.

Hand out a stack of post it notes and markers to each student. Explain the activity and their task. Can the students think of other wastes that might enter the air that haven't been discussed (ex. smoking, dust and sand blown by the wind, etc.)?

Students' ability to brainstorm potential pollution sources will vary. Throughout the brainstorming activity remind students about the sources that were discussed, and ask them about their daily activities. Is it possible that these activities could have led to air pollution? How? At this point students may list uses of electrical energy as sources of air pollution, for example, using kitchen appliances. This example is acceptable, however, during the concluding discussion you should clarify that using kitchen appliances contributes to air pollution because the electricity that is required comes from a power plant (often coal-based in Alberta), and the burning such fossil fuels results in waste products released into the atmosphere. If electricity in your area comes from solar, wind or hydro, air pollutant emissions will be far less significant.

If students submit an incorrect answer during the brainstorming activity, discuss the idea with the class and encourage them to argue for or against as to why that idea could be a source of air pollution. For example, breathing out carbon dioxide during respiration does not constitute pollution because carbon dioxide occurs naturally in the atmosphere. However, carbon dioxide from the burning of fossil fuels releases excess amounts of the gas (far greater than normal atmospheric levels) which can be harmful for the environment.

Conclusion – 10 Minutes

Following the brainstorm activity, discuss the ideas with the class. Are there any themes that appeared (indoor vs. outdoor sources, for example), or similar ideas that can be grouped together? Move the post-it notes to create categories. Encourage students to identify categories. If new ideas come up, encourage the student's to draw or write them down. Add additional sources if necessary (refer to background information).

What is one new thing you learned today? What is one thing about air pollution that you want to learn more about?

You may choose to conduct an exit slip activity with these questions. The slips can then be used for subsequent lessons as review. For example: "I learned_____." "I want to know more about_____."

Conclude the lesson by briefly reviewing the key concepts:

1. Not all waste is visible. Air pollution is an invisible waste that comes from human activities.
2. We can't always see air pollution because it is often released as a gas.
3. We use energy every day and producing that energy often involves burning fossil fuels such as coal, oil or gas which emit air pollutants into the atmosphere.

Now we have a good idea of where air pollution might come from. Next lesson we are going to take a look at the different types of waste that can pollute our air. Be ready for an experiment!

LESSON 2:

IS CLEAR AIR CLEAN AIR?

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In the previous lesson students explored where invisible wastes, or air pollution, come from. In this activity, they will explore what air pollution is, and learn the names of some common pollutants through an experiment that replicates what happens to our air as we add more and more invisible waste.

Learning Goals:

- Students will list the names of common air pollutants including carbon monoxide, nitrogen dioxide, ozone, fine particulate matter, and sulfur dioxide.
- Students will identify natural sources and human activities that produce these pollutants and list health concerns for each.
- Students will explain that air pollutants are often hard to detect because they are released as gases, which we can't see. Some pollutants have an odour that can be detected, while others do not.

Resources and Materials

- Clear plastic cups (one per student)
- Straws or stir rods (one per student)
- Water
- Mixture ingredients (see teaching notes)
- Is Clear Air Clean Air worksheet (one per student)

Time Required

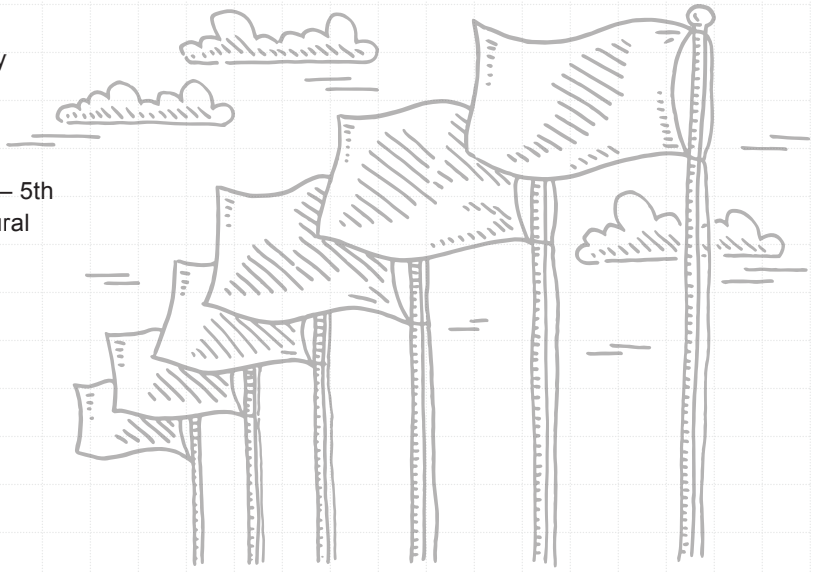
30 minutes

Preparation

- Select appropriate mixture ingredients
- Gather all materials
- Print Is Clear Air Clean Air worksheets
- Review teacher's background information, if necessary

Credit

This activity was adapted from the Air, Air Everywhere 3rd – 5th Grade Activity Guide by the Wisconsin Department of Natural Resources available at: http://eekwi.org/teacher/air.htm.



Outline

1. Introduce the lesson
   - Review what was discussed in lesson 1
2. Is Clear Air Clean Air experiment
   - Hand out one set of materials to each student
   - Hand out one worksheet to each student
   - Explain the procedure
   - Guide students through the experiment
3. Debrief
   - Lead a closing class discussion or have students complete the observation questions on their worksheet.

Assessment

Pre-assessment

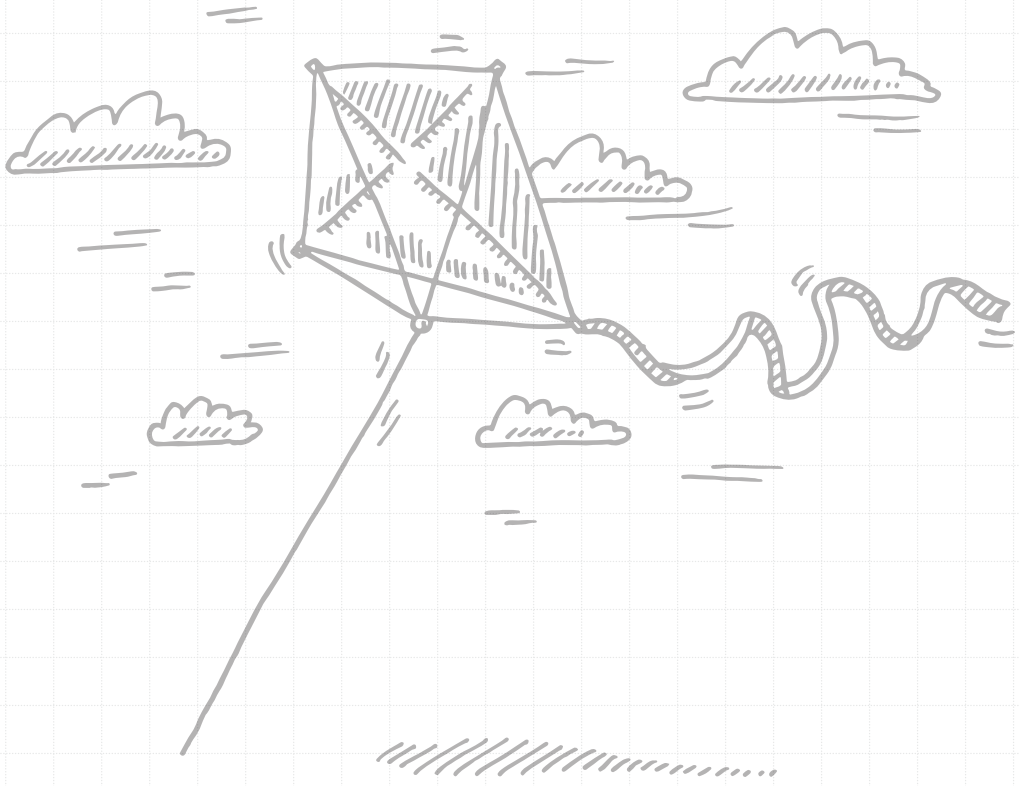
- Ask students to recall what was discussed in the previous lesson. Can they name potential pollutant sources?

Formative Assessment

- Students should actively participate in the experiment, follow instructions, and complete their worksheet independently.
- Students will make observations throughout the experiment and make connections between what is happening in the experiment and air pollution.

Summative Assessment

- Students complete the follow-up questions provided with their work sheet. This assessment can be completed informally as a class discussion or formally by having each student submit their questions in writing.



IS CLEAR AIR CLEAN AIR?

Record one checkmark for each activity in which you have participated. Record the correct mixture ingredient for each pollutant.

Pollutant	Activity	Natural Sources	Health Concerns	Student Checklist	Mixture Ingredient
Carbon Monoxide (CO)	Rode in a vehicle to school. Cooked on a gas stove	Some types of plants	Toxic to all humans and animals at high levels. Causes headaches and tiredness. Can cause death in high amounts.		
Nitrogen Dioxide (NO_2)	Rode in a vehicle to school Used electricity generated at a coal-fired power plant Use a furnace in your house	Lightning	Irritates the lungs and makes it hard to breathe. Can lead to lung disease. Worsens asthma symptoms.		
Ozone (O_3)	Rode in a vehicle to school on a hot day.	Found in the stratosphere naturally	Causes coughing, irritates the lungs, and worsens asthma symptoms.		
Fine Particulate Matter (PM)	Had a campfire Rode in a vehicle to school	Wildfires Blowing dust	Particles can become trapped in the lungs and airways. Worsens symptoms of asthma. Can lead to lung cancer.		
Sulfur Dioxide (SO_2)	Rode in a vehicle to school Use a furnace in your house Use a gas oven	Volcanic eruptions	Irritates the lungs and eyes. Can lead to respiratory infections and bronchitis		

IS CLEAR AIR CLEAN AIR?

Observation Questions

1. What does the water in your cup look like?

2. Can you tell which pollutants came from each activity?

3. If air pollution was this easy to see would you want to breathe the air? Why?

4. What might happen if you were to breathe air that has been polluted?

Teaching Notes

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

Introduction – 5 Minutes

In the last lesson, we came up with some ideas about where air pollution comes from. Today we are going to find out what air pollution is made of.

Have students recall what they discussed in the previous lesson and some of the ideas about where air pollution might come from around the school.

How can we tell if our air is polluted? Can we see it? Not always because air is invisible. Today our experiment will help us "see" what these wastes might look like if they weren't invisible.

Body – 15 Minutes

There are many different types of waste that can enter our air from the sources we identified last lesson. Today we are going to learn their names.

For our experiment, the water in your cup represents our air. Let's see what sort of pollutants we produced today and how they affect our air.

Explain experiment to students and pass out one Is Clear Air Clean Air worksheet to each student.

You may wish to engage students in a discussion regarding the scientific method, lab protocol, safety concerns, etc. in advance of this lesson as students will be performing their own experiment.

Procedure:

- Discuss each pollutant on the worksheet and complete the Mixture Ingredient section as a class (i.e. students should indicate Carbon Monoxide is chocolate syrup for the experiment)
- As you discuss the sources for each pollutant, ask the students if they participated in any of these activities today. If so, they should put a mark in the Student Checklist column.
- Discuss the potential health concerns associated with each pollutant.
- Give each student one clear cup filled halfway with water
- Give each student the pre-measured mixture ingredients
- Using the Student Checklist and Mixture Ingredient columns instruct students to add the appropriate ingredients for each activity they participated in (each pollutant they produced).
- When they have added all of the ingredients the students should stir their mixture well.
- Observe.

Refer to the Teacher's Background Information section for more information on each of the pollutants that will be discussed. You will also find supporting material to support the discussion regarding natural vs. human sources, and health concerns. Be sure to emphasize fine particulate matter during the activity as students will be exploring this pollutant in depth in the next activity.

Using your worksheet, add each pollutant, or ingredient, that you produced today. Make sure to stir your cup well.

When selecting different mixture ingredients it is important to ensure at least one ingredient is strongly scented. Part of this lesson involves students observing what happens when pollutants are added to their water, and making the link to air pollutants. Some air pollutants such as sulfur dioxide have a strong odour which can tell us about the quality of the air in that area.

What do you notice about your water?

Conclusion – 10 Minutes

Lead a wrap-up discussion with the students.

What happened to the water as you added each ingredient? What does your cup look like now? If air pollution was this easy to see would you want to breathe the air? Can you tell which pollutants came from each activity?

Did you notice any smells when we added the ingredients? Which ones?

Discuss how some air pollutants, such as sulfur dioxide can be detected through scent.

Now we know that just because we cannot see air pollution doesn't mean it is not there. Remember, every day we all participate in activities that create air pollution. Is there another way we can use our senses to identify air pollution?

Discuss how some pollutants, such as sulfur dioxide, have strong odours so we can identify when they are in the air.

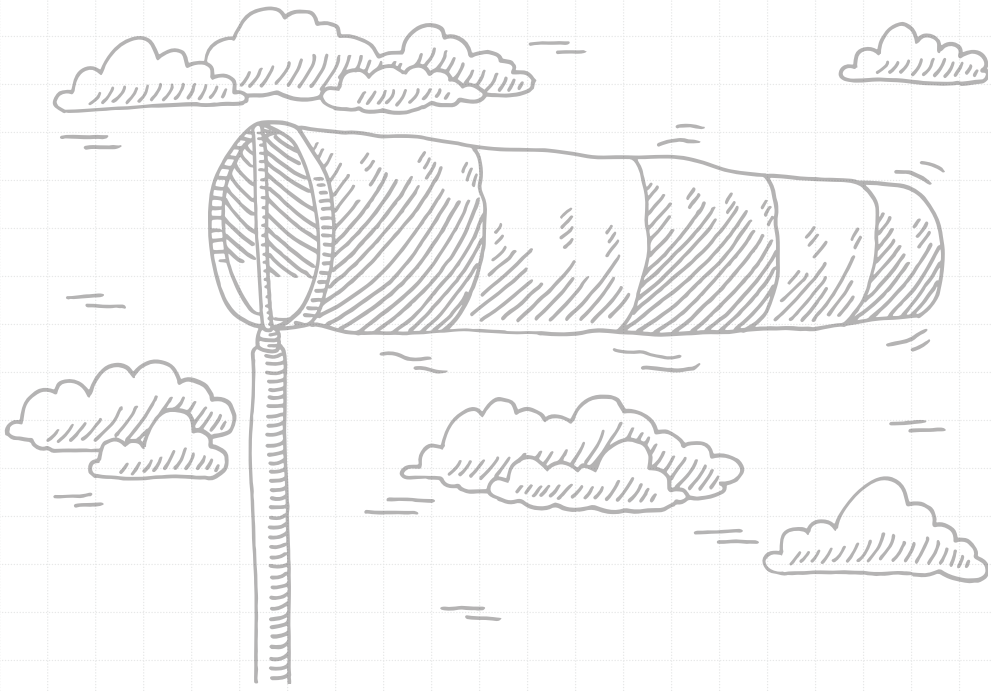
Do you think breathing polluted air is good for our health? What might happen to us if we breathe polluted air?

You may wish to have the students record their observations and answer the follow-up questions that have been provided as an assessment tool rather than discussing these items in class.

Next lesson we are going to learn more about how air pollution can be bad for our health and do an experiment to measure how clean or dirty our air is.

Sample Mixture Ingredients

Pollutant	Mixture Ingredient
Carbon Monoxide (CO)	Chocolate syrup
Nitrogen Dioxide (NO_2)	Drink mix powder
Ozone (O_3)	Vegetable oil
Fine Particulate Matter (PM)	Coffee grounds
Sulfur Dioxide (SO_2)	Mint extract (or some other strong smelling substance)



LESSON 3:

LET'S TEST!

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In this activity, students learn about how we can find information on the quality of the air in our area using the Alberta Air Quality Health Index online mapping tool. The students also learn how they can measure air pollutants for themselves using the PocketLab Air sensor. Students will measure the amount of fine particulate matter in several locations around their school and compare this information to that which is available online.

Learning Goals:

- Students will access information on air quality in Alberta, and explain how and why the Alberta Air Quality Health Index is used.
- Students will measure and record information on local air quality and use a handheld air quality sensor to measure levels of fine particulate matter around the school.
- Students will generate predictions about the state of the air quality at their school.
- Students will compare fine particulate matter levels in different locations around the school.

Resources and Materials

- PocketLab Air Sensor
- Let's Test Observation Sheet

Time Required

- 90 minutes, plus data collection over 5 days

Preparation

- Gather all materials
- Review teacher's background information, if necessary
- Review PocketLab Air user guide, if necessary
- Create data collection schedule

Outline

1. Introduce the lesson.
    - Ask student to discuss the air quality in their community
2. Discuss the Alberta AQHI scale
    - Show students the scale and graphics
    - Discuss what each level means
3. Discuss the Alberta AQHI online mapping tool
    - Show the students the map and discuss the types of information it can generate
4. Discuss fine particulate matter
    - Have students recall what they learned about this pollutant in the previous lesson

5. Generate predictions about levels of particulate matter at the school
   - Have students brainstorm where fine particulate matter levels might be higher around the school
   - Collect predictions and record them on the board
6. Explain the activity and PocketLab Air
   - Explain how to use the sensor to collect fine particulate matter data
   - Explain the activity (using the sensor to collect fine particulate matter data at locations around the school)
   - Divide students into groups and create a schedule for data collection
7. Debrief
   - Discuss the data that the students collected; look for themes and trends
   - Compare the data to the AQHI online mapping tool data for the same time frame (optional)

Assessment

Pre-assessment

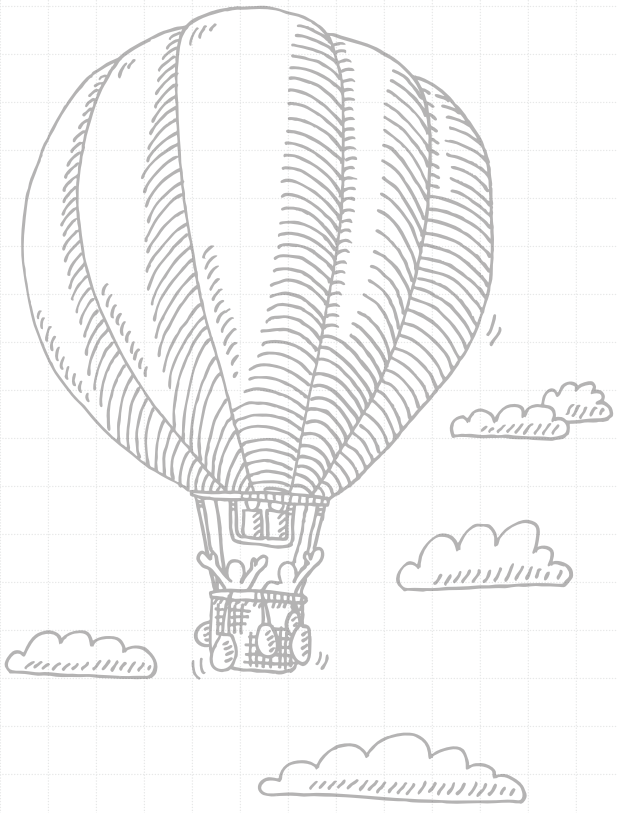
- Ask students to recall what was discussed in the previous lesson. How does the experiment they conducted relate to air pollution? Can we see air pollution? How do we know it is there?

Formative Assessment

- Students should actively participate in the experiment, follow instructions, and complete their worksheet independently.
- Students will make observations throughout the experiment and make connections between what is happening in the experiment and air pollution.

Summative Assessment

Students complete the follow up questions provided with their worksheet. This assessment can be completed informally as a class discussion or formally by having each student submit their questions in writing.



LET'S TEST - OBSERVATION SHEET

Date	Time	Particulate Matter	Other Observations (weather, activity in the area, smells, etc)

Teaching Notes

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

Introduction – 5 Minutes

Last time we learned the name of the waste products that become air pollution, where they come from, and how they can impact our health. Today we are going to test the air quality of our school.

Do you think we have clean air here in (town/city)? What might be polluting our air? Have you ever noticed poor air quality before?

Today you are going to be responsible for measuring the air quality in and around our school.

Body – 60 Minutes, plus data collection over 5 days

In Alberta, we have something called the Air Quality Health Index. It is a scale that tells us about the air quality in our area. If the air quality is poor, the AQHI tells us what we should do.

Show AQHI scale and chart: http://aep.alberta.ca/air/air-quality-health-index/about-AQHI.aspx

Discuss each level of the AQHI scale with the students. The scale is divided into low, moderate, high and very high risk. Discuss the health messages for each level and what determines the index on a daily basis.

There are monitoring stations all across Alberta that measure how much carbon monoxide, nitrogen dioxide, ozone, fine particulate matter and sulfur dioxide is 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 online.

Show students the AQHI mapping tool: http://airquality.alberta.ca/map/

Open the AQHI online mapping tool and show the students how to access information on the index for your area. You may also wish to show them how to find information about particular pollutants. Explain how air quality data is collected around the province to inform the AQHI.

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.

One of the pollutants that is important for the AQHI is fine particulate matter. We learned about fine particulate matter in our last experiment. Do you remember where fine particulate matter comes from?

Encourage students to recall what they learned in the last lesson.

Today you will be using the PocketLab Air sensor to measure fine particulate matter levels around our school. Let's make some predictions. Where do you think fine particulate matter levels will be the highest? Where will they be the lowest? Will levels be higher during some parts of the day, and if so when?

For this activity, students will be responsible for collecting data on fine particulate matter at various locations around the school. Before doing so, ask the class to make some predictions about the air quality and fine particulate matter levels at the school. In this way, they will be helping to design the research project. Guide them to use what they know about fine particulate matter to make their predictions. For example, they may recall that one source of fine particulate matter is vehicles so they may predict that fine particulate matter levels will be higher in the parking lot.

You may consider having the students write their predictions on sticky notes, or on the board, allowing them to directly contribute to the learning and get up out of their desks. Collect as many predictions as you wish and record them on the board at the front of the room. Students will be testing these predictions so you may wish to

record as many as there are groups (i.e. each group tests one prediction). It is also okay for one prediction to be tested by multiple groups.

Explain the PocketLab Air sensors to the students. Explain how the PocketLab measures fine particulate matter and how to read measurements using the associated app. Explain the units used to measure fine particulate matter.

Divide the students into groups and assign a location to each group. Locations could be in the classroom, hallway, school entrance, parking lot, or playground, but will vary depending on the list of predictions the class has generated. For example, they may predict PM will be higher outdoors than indoors; choose locations that will allow for this comparison. Divide the students into groups of no more than five, so each student is required to collect and record data for their group on at least one day.

Your responsibility is to measure the air quality in your location once a day at the same time for 5 consecutive days and record your findings on your Observation Sheet.

Students will be collecting data at their assigned locations for 5 consecutive days. You will need to create a class schedule as there is only one air sensor. Students must record their data on the worksheet and return it to you at the end of the 5 days.

Have students collect data over the course of the week. They should submit their observation sheet at the end of the week so you can compile the data in advance of the concluding discussion.

Conclusion – 25 Minutes

This part of the activity will take place after the 5 days of data collection. In advance of the conclusion discussion, it may be necessary for you to interpret the student's data. You may wish to display the data in a graph, or alternatively, you could lead a discussion and ask the students to participate in the data analysis. The purpose of the discussion is to observe any themes or trends in the data and assess whether the student's predictions were accurate.

Let's look at the data we collected over the past week and see if our predictions were correct.

Explain the compiled data to the students. Point out trends or outlier data and ask questions to get the students thinking about what the data means. Highlight whether or not their predictions are reflected in the data.

We can also compare the data that we collected to the Alberta AQHI data. Do you think the measurements will be similar? Why or why not?

Compare the data that was collected by the class to the fine particulate matter data from the Alberta AQHI mapping tool for the same date range in your area.

Discuss the differences between the students' data and the AQHI data available online. It is important for students to understand the difference between data collected using a hand-held monitoring device and the rigorous protocol used by Alberta Environment and Parks. Differences can also be explained by differences in the methods and equipment used to collect data. The data collected for the AQHI uses advanced equipment and rigorous testing, compared to the PocketLab Air which is useful for local readings but should only be used in an educational context. Data may be different due to dispersion factors in the local area (wind, geography, temperature, etc.) and may also be affected by the distance to pollutant sources. For example, if you are located close to a factory or mill, local air pollutant readings may be higher.

LESSON 4:

MAKING A DIFFERENCE

LESSON 4:
MAKING A DIFFERENCE

In this concluding activity, students will use their understanding of air pollution to create a plan to help improve the air quality at their school. Drawing on their findings from the previous data collection activity, students will recommend a plan to reduce the amount of fine particulate matter in the air and present their ideas in a poster to be shared with their class or school.

Learning Goals:

- Students will use data they have collected to create a strategy to improve air quality around the school.
- Students will communicate their idea in a poster and will be able to clearly share this information with their classmates.

Resources and Materials

- Poster Paper
- Pens, crayons, markers

Time Required

- 60 – 120 Minutes

Preparation

- Gather all materials for posters
- Gather notes from Post-It Throw Down and previous brainstorming activities

Outline

1. Introduce the lesson.
   - Review what has been covered in previous lessons, focusing on the fine particulate matter data that was collected by the students
2. Brainstorm
   - Lead students through a brainstorming activity to generate ideas on how to improve air quality at the school
3. Research
   - Guide students through research phase to learn more about their chosen air quality improvement strategy
4. Poster Development
   - Explain to students that they need to present their idea in a poster. Consider providing a template
5. Presentation
   - Have each group present the air quality improvement strategy to the class.

Assessment

Pre-assessment

- Quiz students on their understanding of the AQHI. What does an AQHI of 2 tell us? What does an AQHI of 10 tell us?
- Ask students to summarize the findings of the fine particulate matter data collection they previously conducted.

Formative Assessment

- Students are able to think critically about what they have learned and the data they collected to generate ideas on how to improve the air quality at the school.
- Students are working collaboratively to generate ideas, develop and plan, and create a communicative poster.

Summative Assessment

- Students submit their final poster including a summary of their idea and steps to implement the strategy.
- Students present their improvement plan and poster to the class.

Teaching Notes

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

Introduction – 5 Minutes

So far we have learned what air pollution is, where it comes from, how it affects our health, and how we can measure it. Now it is time for us to come up with some strategies to keep our air clean and safe.

Review what the students have learned in the previous lessons. Prompt them to name common air pollutants and their sources.

In your same data collection groups, you will be designing a plan for our school to keep the air healthy and clean for everyone.

Body – 60 to 120 Minutes

For this activity, students will be using everything they have learned over the previous lesson to develop a strategy for improving air quality at their school. As they are brainstorming strategies encourage them to think about pollutant sources, the predictions they made in the last lesson, and the results of their data. It may be useful to conduct a large group brainstorming activity if students are having trouble generating ideas. Consider the snowball method in which students write an idea on a piece of paper, crumple the paper into a ball and toss it to another person in the class. Students then add onto the idea that has been tossed to them. Repeat as needed.

Divide the students into their groups. Explain that their task is to work with their group to come up with ideas to help reduce the amount of fine particulate matter that enters the air in and around the school.

Step one: Brainstorming

Students should begin by brainstorming ideas (list, mind map, etc.). Encourage the students to reflect on the data they collected. For example, was there a specific location that had higher levels of fine particulate matter? What might have caused this? How can we help to improve the air quality in that location?

You may wish to repeat the post-it throw down activity to help the students generate ideas, or lead a similar group discussion. If they are having trouble generating ideas remind them of pollution sources, and reflect back to the first lesson when they learned about all of the activities they do on a daily basis that produces air pollution. Prompt the students to think about the data they collected and the predictions they tested.

Step two: Research

After the brainstorming session each group should decide which solution they like the best and how they could implement it in the school. Students may wish to research multiple ideas. For example, if students want to limit the amount of fine particulate matter around the school by lowering vehicle emissions they might research no idle efforts happening in other cities/jurisdictions.

Step three: Recording

After the research phase student groups should record their idea to help structure their action plan. You may choose to give students a template to follow to help organize their thoughts. For example, the poster must include a title, at least one image, an explanation of the idea, steps for individuals or other classes to take to implement the plan, etc. Encourage students to think about how they could display or explain their data.

Step four: Presentation

The final phase of this activity is to have each group present their idea and poster to the class. The students may present their idea to their classmates and/or display the posters in the hallways for other students to learn from.

Extension: Host an air quality event in which students are able to show off their posters to other classes or the school. The students should encourage their peers to participate in as many strategies as they can. The students can then monitor the air quality around the school for a period of time to determine if there are any changes. The event could incorporate other waste interventions the class learns about during the Waste in Our World unit to draw connections to product life cycles. For example, reducing consumption to reduce reliance on greenhouse-gas-emitting manufacturing.

Conclusion – 10 Minutes

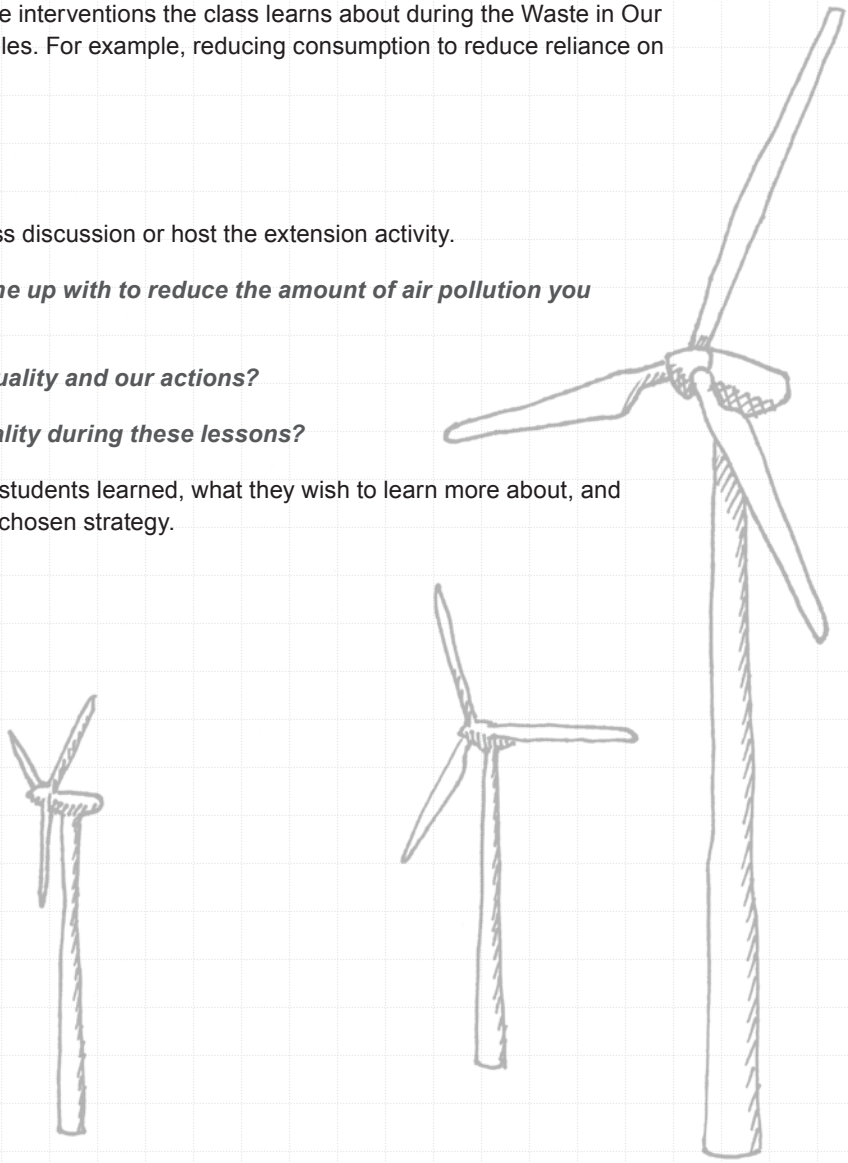
Summarize each group's strategy and lead a class discussion or host the extension activity.

Will you try any of the strategies we have come up with to reduce the amount of air pollution you produce?

Why is it important for us to think about air quality and our actions?

What was one thing you learned about air quality during these lessons?

To conclude this air quality unit discuss what the students learned, what they wish to learn more about, and whether or not they will take steps to act on their chosen strategy.



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.
    - Optional: student reflections on the project, activity or event.
  - To see sample posts, check out the blog at https://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 (NOX) are most commonly found in the form nitrogen oxide (NO) and nitrogen dioxide (NO_2). 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 SO_2 and NO_2 are found in particulate matter. Natural precipitation has a pH of approximately 5.6 due to the presence of dissolved CO_2. 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 NO_2. 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 an 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.).

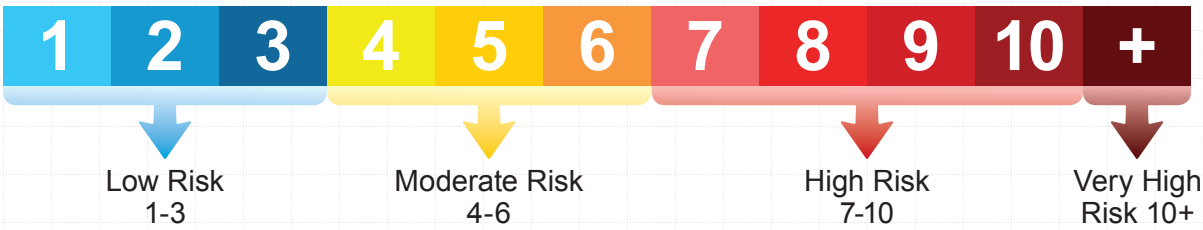
Stratospheric ozone is formed naturally through reactions involving the oxygen and light from the sun. Ozone in the stratosphere is important as it protects the earth from too much UV radiation from the sun. Ground-level ozone, on the other hand, comes from human activity and leads to the production 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

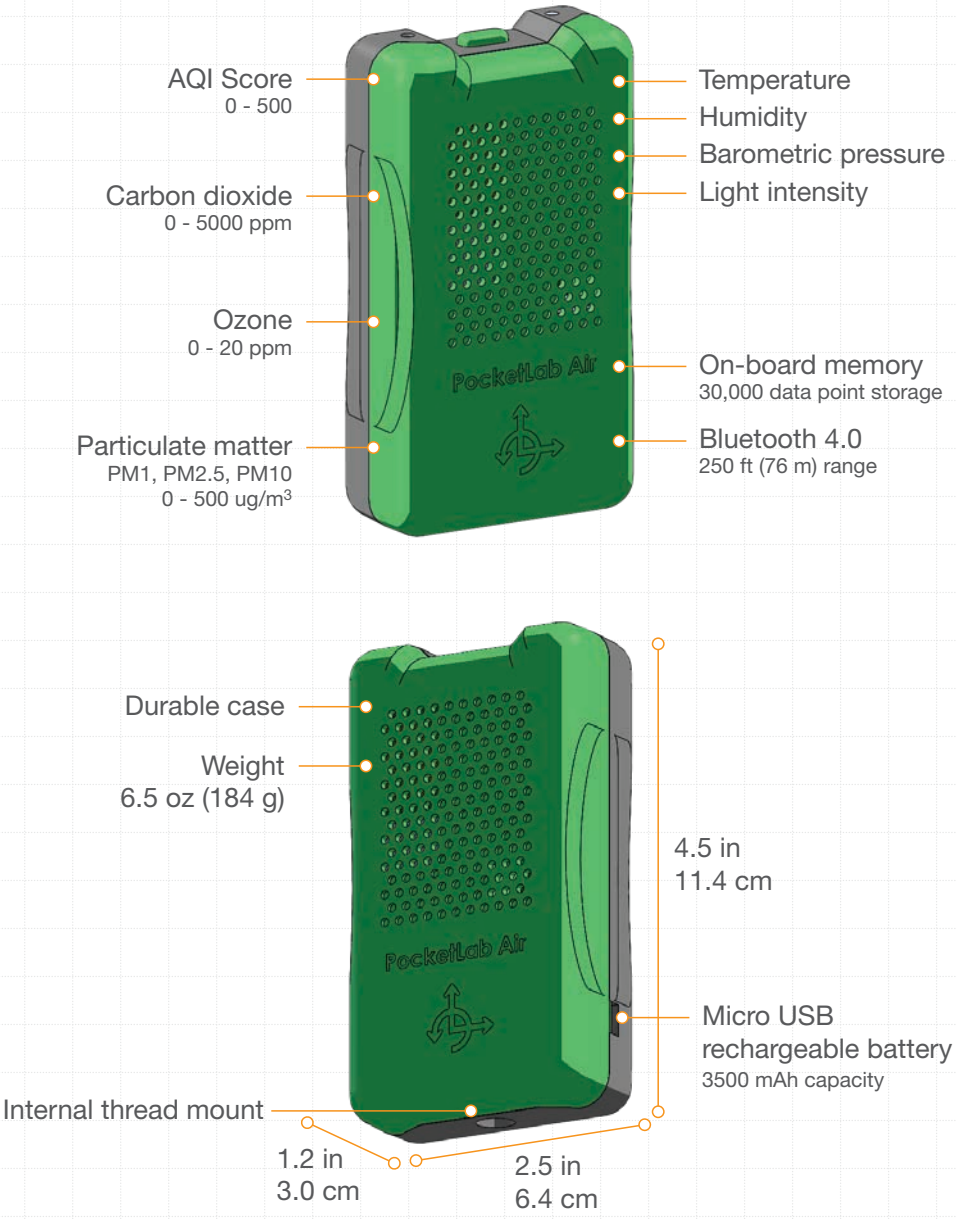
Alberta Environment and Parks Data Warehouse: airdata

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

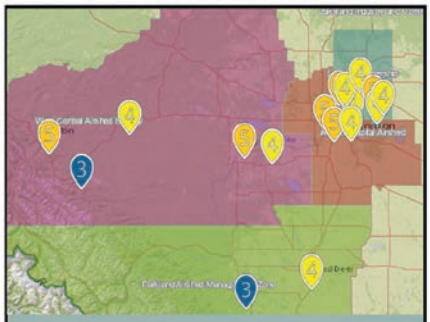
TELUS World of Science – Edmonton worked in partnership with The King's Centre for Visualization in Science from The King's University to develop resources you can access to supplement the workshop and tools presented in these lesson plans. The electronic resources shown below can be found at http://sensors.kcvs.ca/.

The PocketLab Air

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

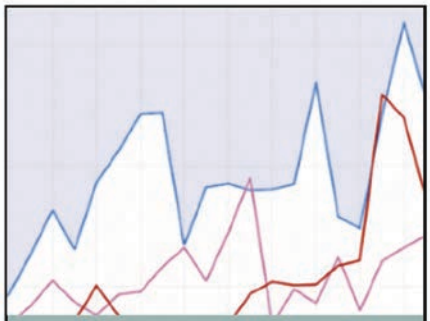
Lessons and Teacher Resources

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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