GRADE 7 SCIENCE

UNIT A:
Interactions and Ecosystems

THE AIR FACTOR

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.

TELUS World of Science – Edmonton, Science in Motion
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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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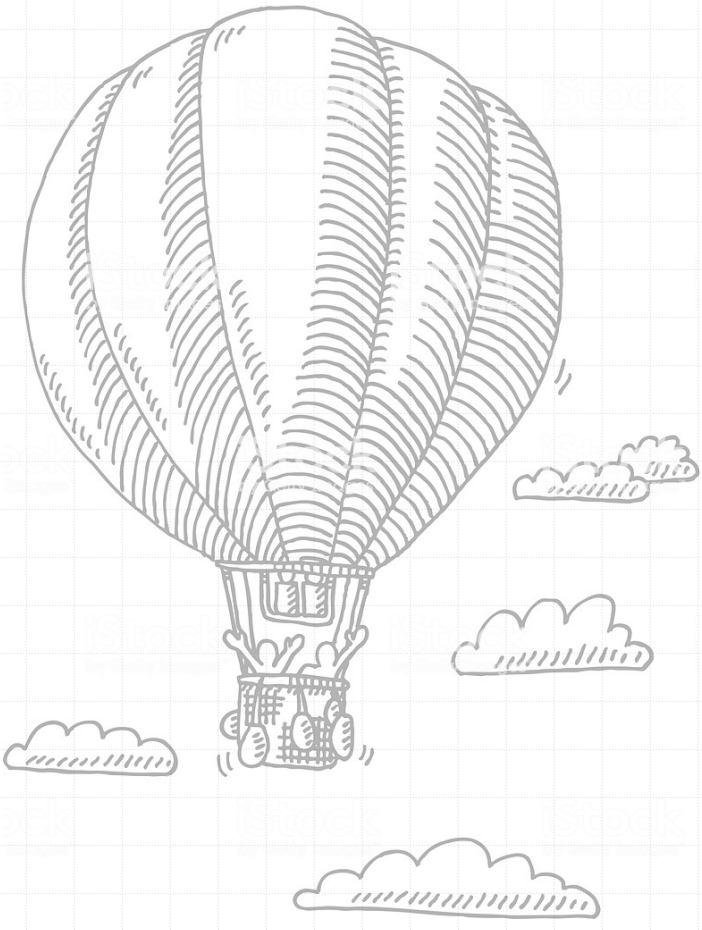


INTRODUCTION

The Air Factor

In this unit, students will explore interactions and ecosystems through the theme of air quality. Students will learn about our atmosphere and air pollutants that can be damaging to both the environment and our health. They will learn about the water cycle, and how this is a mechanism by which air pollutants can enter ecosystems. Students will understand how air quality is monitored in Alberta and where they can access this information. They will also be exposed to real air monitoring tools and conduct their own inquiry based investigation as "ecologists in training" whose role is to uncover the environmental impacts of a proposed new development in their community.

Curriculum Connections

Grade 7 Science, Unit A: Interactions and Ecosystems

1. Investigate and describe relationships between humans and their environments, and identify related issues and scientific questions
   - identify examples of human impacts on ecosystems, and investigate and analyze the link between these impacts and the human wants and needs that give rise to them (e.g., identify impacts of the use of plants and animals as sources of food, fibre and other materials; identify potential impacts of waste products on environments)
2. Trace and interpret the flow of energy and materials within an ecosystem
   - analyze an ecosystem to identify biotic and abiotic components, and describe interactions among these components
   - identify mechanisms by which pollutants enter and move through the environment, and can become concentrated in some organisms (e.g., acid rain, mercury, PCBs, DDT)
3. Monitor a local environment, and assess the impacts of environmental factors on the growth, health and reproduction of organisms in that environment
   - investigate a variety of habitats, and describe and interpret distribution patterns of living things found in those habitats (e.g., describe and compare two areas within the school grounds—a relatively undisturbed site and a site that has been affected by heavy use; describe and compare a wetland and a dryland area in a local parkland)
   - investigate and interpret evidence of interaction and change (e.g., population fluctuations, changes in weather, availability of food or introduction of new species into an ecosystem)
4. Describe the relationships among knowledge, decisions and actions in maintaining life-supporting environments
   - identify intended and unintended consequences of human activities within local and global environments (e.g., changes resulting from habitat loss, pest control or from introduction of new species; changes leading to species extinction)
   - describe and interpret examples of scientific investigations that serve to inform environmental decision making
   - illustrate, through examples, the limits of scientific and technological knowledge in making decisions about life-supporting environments (e.g., identify limits in scientific knowledge of the impact of changing land use on individual species; describe examples in which aboriginal knowledge—based on long-term observation—provides an alternative source of understanding)
   - analyze a local environmental issue or problem based on evidence from a variety of sources, and identify possible actions and consequences (e.g., analyze a local issue on the control of the beaver population in a nearby wetland, and identify possible consequences)

Enduring Understandings

Ecosystems are comprised of both biotic and abiotic components, one of which is air.

Our atmosphere makes our planet unique, and provides us with protection and the gases necessary for survival.

Human activity impacts the quality of our air through the release of gaseous and solid pollutants.

The water cycle is an essential ecosystem process that can become polluted by airborne contaminants (i.e. acid rain).

Air pollution can be measured and monitored over time, and be used to assess the air quality of a specified region.

There are many types of air pollutants that come from a variety of sources and have specific environmental and health effects.

Air quality is monitored continuously across Alberta and the data is easily accessible. The Air Quality Health Index is an important tool for learning about air quality and protecting us from the potential health impacts of poor air quality.

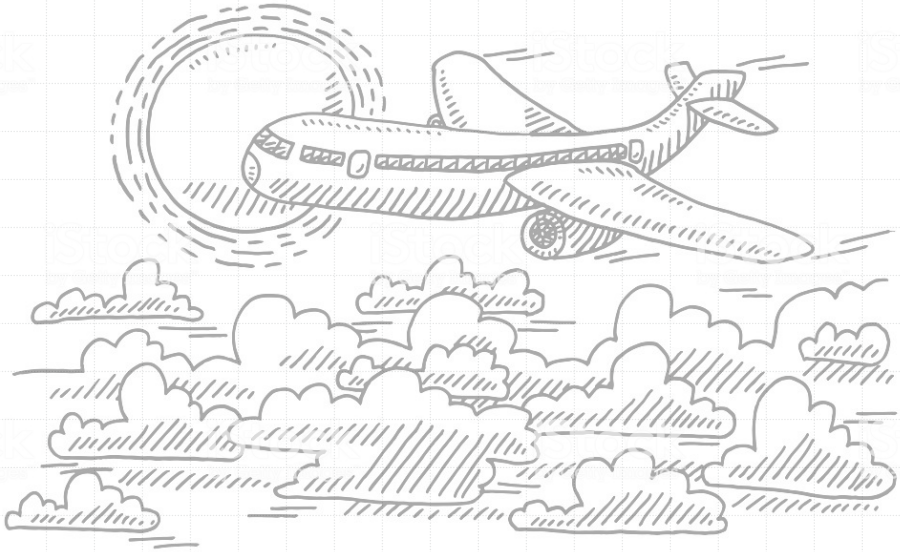
Human activity has the potential to drastically impact the environment. We can predict what these impacts will be by examining the current status of an ecosystem and making predictions about the environmental impact of the activity.

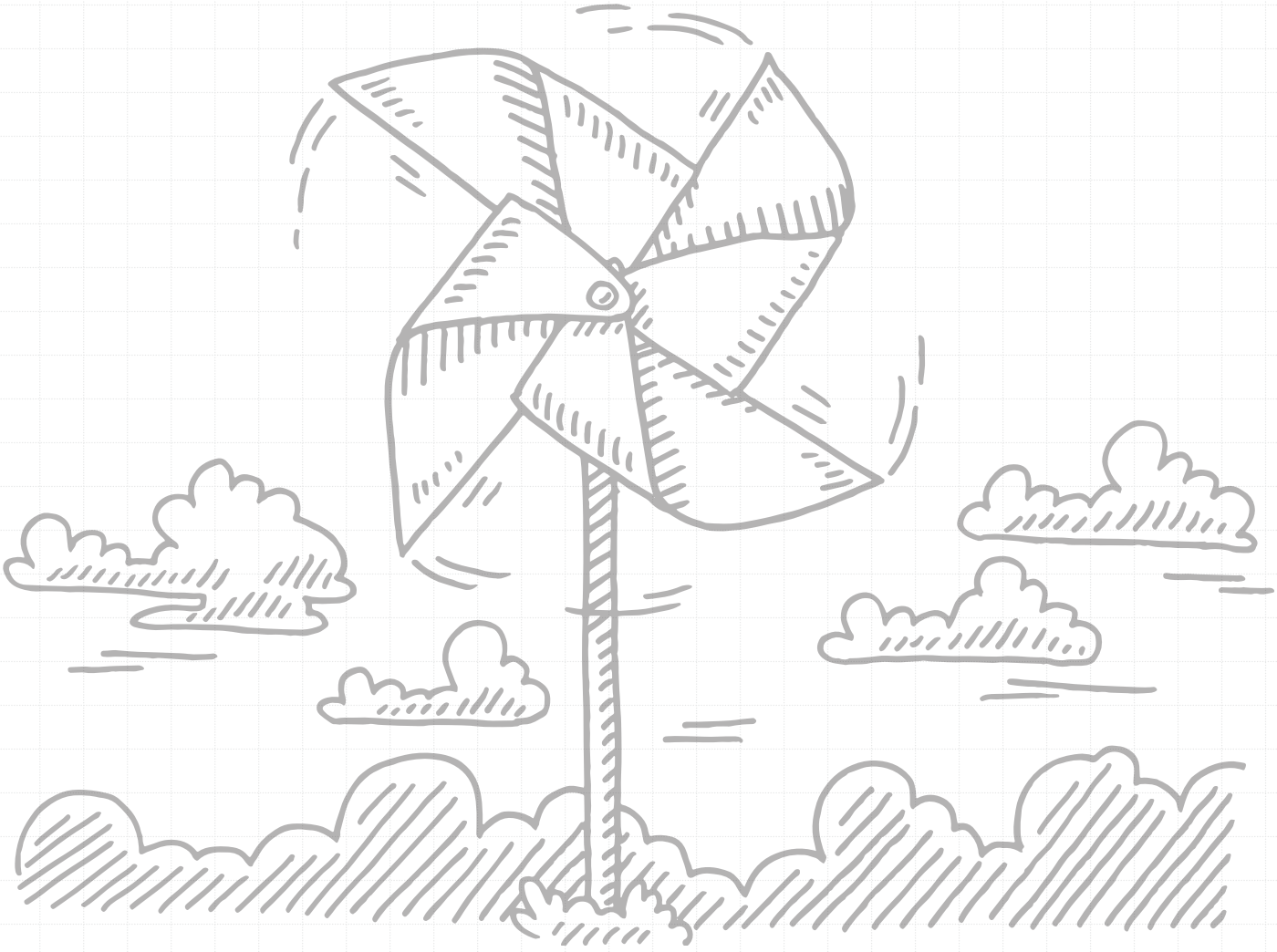
Environmental investigation and monitoring can serve to inform environmental decision making.

Prior Knowledge

Students should be able to recall the properties of air and the gases that make up Earth's atmosphere. They should identify air as an essential component for all life on Earth.

Students should have a general understanding of what an ecosystem is, although this will be covered in more detail in this lesson.





LESSON 1:

DEFINITION DETECTIVE

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DEFINITION DETECTIVE

In this introductory lesson, students will complete a definition activity in which they will discover the meaning of several key terms that will be used throughout the unit. Students will discover air as an abiotic component of all ecosystems with the potential to impact both environmental and human health and will begin to understand how air pollutants make their way into the atmosphere and ultimately ecosystems through processes like the water cycle.

Learning Goals:

- Students will identify the two categories of ecosystem components (biotic and abiotic) and will list examples of both.
- Students will name the gases that make up Earth's atmosphere, and identify the names and vertical zoning of atmospheric layers.
- Students will provide examples of how human activity can lead to air pollution and will be able to identify sources of airborne pollutants.
- Students will explain how the water cycle is a process by which atmospheric pollutants enter ecosystems, in this case, as acid precipitation.
- Students will complete the pre-lesson definition activity and share their findings during class discussion to follow.

Resources and Materials

- Definition Detective Graphic Organizer
- Access to research tools (library, internet, textbook)

Time Required

60 minutes

Preparation

- Print copies of the Definition Detective graphic organizer (one per student)
- Arrange access to research materials for the first 30 minutes of the lesson
- Review teacher's background information, in necessary.

Instructions

1. Introduce the lesson and Definition Detective activity

   a. Divide the students into groups of three or four to complete the activity (30 minutes)
2. Lead the follow up discussion, addressing each of the terms from the Definition Detective activity
3. Collect a list of questions the students would like to address for the rest of the air quality unit and record on the board

Assessment

Pre-assessment

- Determine student's current understanding of ecosystem interactions. What can they recall from previous classes, units or grades? What do they know about the atmosphere and air pollution?
- If this lesson is completed near the end of the unit, you may consider using the introductory definition activity as an assessment tool, asking the students to complete the graphic organizer without researching the terms. What terms can they recall?

Formative Assessment

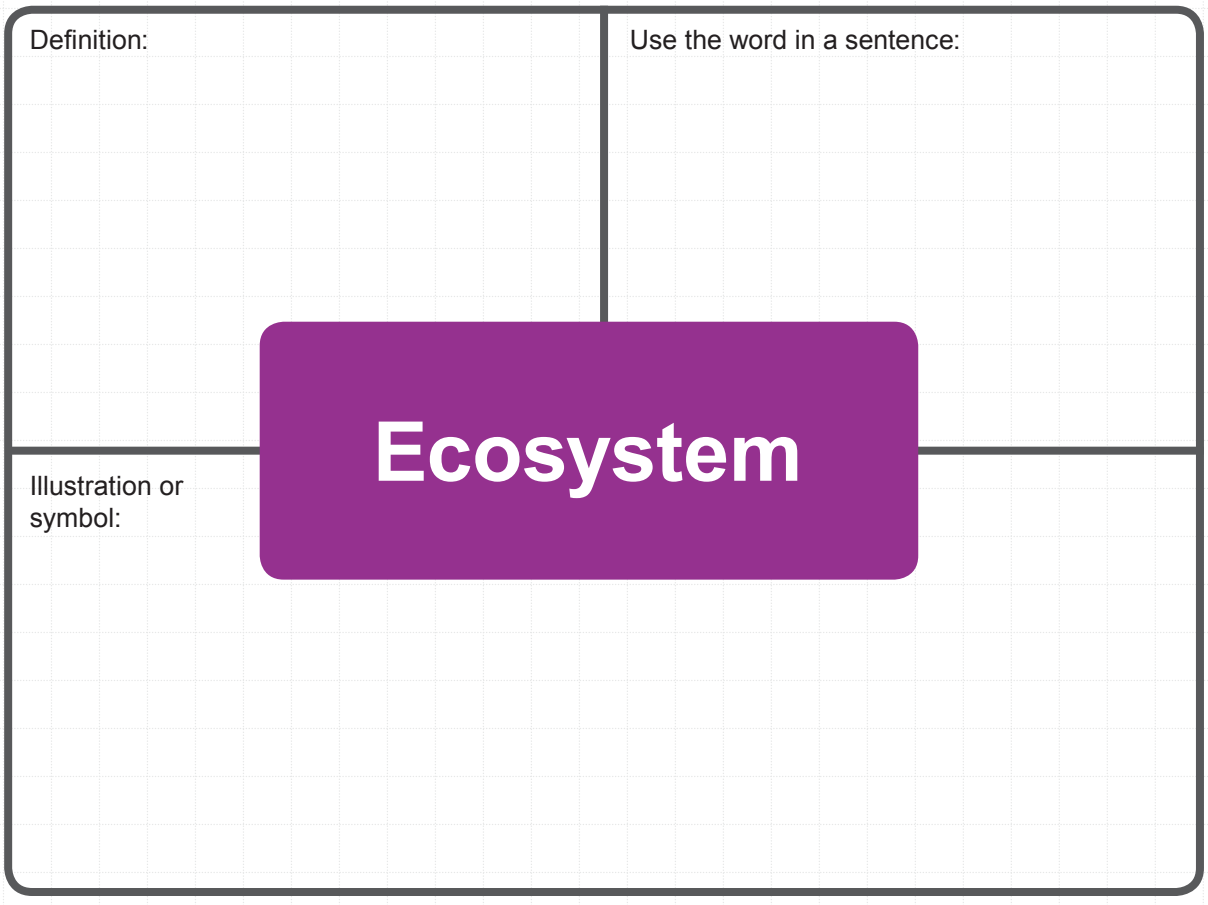
- Students should work collaboratively to complete the definition activity in the allotted time. They should choose their resources thoughtfully with the understanding that some sources are more credible than others.
- Students should actively engage in the class discussion, offering suggestions and participating in brainstorming ideas about pollutant sources, environmental impacts, and health concerns.

Summative Assessment

- Students will generate a list of questions about air quality or 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.

Definition Detective Graphic Organizer

Instructions: With your team, research and record definitions for the terms below. You may use your textbook, library resources, or the online resources for this activity.



Definition:

Use the word in a sentence:

Biotic

Illustration or symbol:

Definition:

Use the word in a sentence:

Abiotic

Illustration or symbol:

Definition:

Use the word in a sentence:

Atmosphere

Illustration or symbol:

Definition:

Use the word in a sentence:

Biosphere

Illustration or symbol:

Definition:

Use the word in a sentence:

Hydrosphere

Illustration or symbol:

Definition:

Use the word in a sentence:

Lithosphere

Illustration or symbol:

Definition:

Use the word in a sentence:

Troposphere

Illustration or symbol:

Definition:

Use the word in a sentence:

Stratosphere

Illustration or symbol:

Definition:

Use the word in a sentence:

Mesosphere

Illustration or symbol:

Definition:

Use the word in a sentence:

Thermosphere

Illustration or symbol:

Definition:

Use the word in a sentence:

Photosynthesis

Illustration or symbol:

Definition:

Use the word in a sentence:

Cellular Respiration

Illustration or symbol:

Definition:

Use the word in a sentence:

Pollution

Illustration or symbol:

Definition:

Use the word in a sentence:

Acid Rain

Illustration or symbol:

Definition:

Use the word in a sentence:

Pollutants

Illustration or symbol:

Definition:

Use the word in a sentence:

Water Cycle

Illustration or symbol:

Definition:

Use the word in a sentence:

Evaporation

Illustration or symbol:

Definition:

Use the word in a sentence:

Transpiration

Illustration or symbol:

Definition:

Use the word in a sentence:

Condensation

Illustration or symbol:

Definition:

Use the word in a sentence:

Precipitation

Illustration or symbol:

Key

Ecosystem - all the interacting parts of a biological community and its environment

Biotic - a term applied to living things in the environment such as humans, plants, birds, animals and insects

Abiotic – a term applied to non-living things in the environment; for example, air, water, and soil are abiotic

Atmosphere - the air surrounding the earth

Biosphere - the thin area around the Earth that can sustain life; made-up of the atmosphere, the hydrosphere, and the lithosphere.

Hydrosphere - all water found on the Earth including lakes, oceans, rivers, and ground water

Lithosphere – the hard outer layer of the Earth consisting of the crust and the upper level of the mantle

Troposphere - the lowest region of the atmosphere, extending from the earth's surface to a height of about 6-10 km; 85% of atmospheric gases are found in this layer

Stratosphere - the layer of the earth's atmosphere above the troposphere, extending to about 50 km above the earth's surface

Mesosphere - the region of the earth's atmosphere above the stratosphere and below the thermosphere, between about 50 and 80 km in altitude.

Thermosphere - the region of the atmosphere above the mesosphere and below the height at which the atmosphere ceases to have the properties of a continuous medium

Photosynthesis - the process by which plants make their own food using sunlight

Cellular Respiration – in the cells of living things, the process in which oxygen is used to get energy from food and is converted into carbon dioxide.

Pollution - a collective term for the different types of harmful materials that are released into the environment through human activities

Acid rain – rain that contains higher than normal levels of acid; caused by waste gases released into the atmosphere by industries and automobiles; damaging to the environment

Pollutants – substances that cause pollution

Water cycle - the continuous movement of water through the biosphere; the water cycle consists of evaporation, transpiration, condensation and precipitation

Evaporation - the process by which a liquid, such as water, changes into a gas or vapour

Transpiration - the process in which water that is taken in by a plant or an animal evaporates from the organism

Condensation - the process of changing from a gas or vapour to a liquid; clouds, fog, and dew are examples of condensation.

Precipitation - the water (in its liquid or solid state) that falls to Earth; rain, snow, sleet, hail, etc

Teaching Notes

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

Introduction - 30 minutes

Today we are going to start with a short definition activity. Working in small teams, you need to find a definition for all of the terms on the worksheet. Try to complete as much of the worksheet (definition, illustration, etc.) as possible. We'll be using them for the rest of the lesson.

Have the students divide into teams of 2 or 3 and let them know they will have 30 minutes to find as many definitions as they can. They may divide the work among group members however they like.

The definition activity at the beginning of the lesson is meant to get students engaged with several of the terms they will be introduced to in the Interactions and Ecosystems unit. This part of the lesson would serve well as an introduction to, or a review of, the unit. The Air Factor lessons could be easily adopted at any point during the unit as you wish.

During the definition activity encourage your students to use a variety of resources to complete their graphic organizers. You may wish to do this portion of the activity in a library or other room where the students can access laptops or computers to conduct their research. Students may use the graphic organizer in whatever way is useful to them. For example, some students may prefer a written definition while others may prefer to complete a drawing to represent the term.

Body – 25 minutes

After the students have completed the definition activity, the terms they have learned will be used throughout the remainder of the discussion. As you conduct the lesson discuss each term (bold text below) and allow students to add to their graphic organizers as required.

This activity is meant as an introduction to the subsequent activities. Students will be exposed to the basics of air quality here and will be asked to further explore the topic through the inquiry based activities that follow. Refer to the Teacher's Background Information section of this plan for more detailed explanations of the content.

We know that an ecosystem is all the interactions between living and non-living things in an environment. Ecosystems can be as small as a fallen rotting tree in a forest, or as large as the entire forest itself. The biotic components and abiotic components are always interacting. We also know that ecology is the study of these interactions. Today we are going to focus on the abiotic components of an environment. What could be considered an abiotic component?

Collect suggestions from students. They may include any non-living part of any environment.

Today's lesson will focus on one abiotic component that is present in every ecosystem on earth. Can you guess what it is?

Air!

It is easy for us to forget that air is an essential component in every environment because we can't see it and it is always there. Our atmosphere is what makes our planet unique. The mixture of gases that make up our air is what allows life to be sustained here. What are the gases that make up our atmosphere?

Have students recall the name of the gases that make up our air that are learned in grade 6.

Our atmosphere is 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 respiration and photosynthesis, which are two very important interactions between living and non-living things.

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.

Of course, the atmosphere is not the same everywhere on earth. Air is always moving, and these layers can interact. Sometimes air moves between layers, but often due to temperature differences it becomes trapped within a layer.

Additionally, the atmosphere also interacts with the hydrosphere, geosphere and biosphere. This means that pollutants in the water, for example, can enter the atmosphere.

As humans, we depend on the environment to meet our basic needs, such as food, clothing, water and shelter. But all of our wants are also supported by nature.

Discuss needs vs. wants briefly.

Unfortunately, human activity can also damage the environment. Can you think of some activities that might damage or pollute our air?

Have students briefly brainstorm ways air becomes polluted. Have students jot their ideas on sticky notes or write them on the board to discuss as a group.

Combustion of fossil fuels is a major source of pollution that comes from human activity. When fossil fuels like oil, gas or coal are burned, when we drive a car for example, carbon dioxide, sulfur dioxide and nitrogen dioxide are released as wastes. These substances naturally exist in the environment, but excess levels lead to pollution.

How might these pollutants impact an ecosystem, such as a forest?

Have students brainstorm the impacts of air pollution on both abiotic and biotic components of an ecosystem.

One important way air pollution impacts ecosystems happens when it enters the water cycle as acid precipitation. Water is continuously moving through an ecosystem in a cycle that involves four main processes. Evaporation, transpiration, condensation, and precipitation.

Briefly discuss the water cycle. During your discussion you may wish to review the concept of pH with your students, and discuss the impacts of changing pH on an ecosystem. Be sure to draw connections between pH, air pollutants, and acid precipitation.

Pollutants like sulfur dioxide, nitrogen dioxide and carbon dioxide in the air dissolve in water droplets in the atmosphere. When this happens, the water droplets become acidic. When acid rain falls on an ecosystem, it damages plant life and can even destroy entire lakes. Acid rain is a great example of an ecosystem interaction.

But air pollution isn't just a concern for plant and animal life; it also affects us and our health. Air quality is a measure of how clean our air is. Air quality scientists study how human activities change the composition of our atmosphere and try to understand how those changes impact both human and environmental health.

Briefly discuss health concerns associated with air pollution (see teacher's background information).

Conclusion – 5 minutes

Air quality is going to be the theme of our next few lessons. We have already learned that human activity can greatly impact an ecosystem and human health. Based on our discussion today, what do you hope to learn about air quality as we move forward?

Ask the students to generate a list of questions or areas of interest. Record the list and post it on the classroom to come back to throughout the remaining lessons.

Students should actively participate in the discussion throughout the lesson by brainstorming abiotic and biotic components of an ecosystem, air pollutant sources, environmental and health impacts of these pollutants, and questions they wish to have answered regarding air quality.

LESSON 2:

ECOLOGISTS IN TRAINING

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ECOLOGISTS IN TRAINING

This inquiry-based lesson asks students to consider the potential environmental impacts of a proposed pulp mill in their community. They learn about how air quality is measured and monitored in Alberta and how they can measure air quality locally using the PocketLab air sensor. As "ecologists in training" students are tasked with assessing the baseline condition of a local ecosystem, researching and identifying potential environmental impacts of the proposed mill development, monitoring and predicting changes to air quality in the area, and presenting their findings during a mock public engagement session.

Learning Goals:

- Students will list the pollutants that are monitored to inform Alberta's Air Quality Health Index (AQHI) and identify sources, environmental impacts and health concerns for each pollutant.
- Students will access and interpret up-to-date air quality information for their community through the Alberta AQHI online mapping tool.
- Students will prepare a baseline study and environmental impact assessment for a local ecosystem.
- Students communicate their research findings in an oral presentation using their choice of supporting media (poster, video, slideshow, etc.)
- Students will identify and conduct appropriate research methods for monitoring of a local ecosystem.
- Students will predict potential environmental impacts of new development.
- Students will apply their knowledge and skills to answer questions related to their project (i.e. make a recommendation regarding proposed development).

Resources and Materials

- Inquiry Package
  - o Ecologists in Training Inquiry Activity
  - o Field Journal Template
  - o Guiding Research Questions
  - o Project Proposal and Ecosystem Description
  - o Air Pollutants worksheet
- Access to research materials
- Presentation materials (posters, powerpoint, video equipment, etc.)

Time Required

4-6 hours over 2-3 weeks

Preparation

- Print Inquiry Packages (one per student)
- Prepare lesson for phase 3 (ecosystem studies review)

Instructions

1. Introduction
2. Phase 1
   a. Explain the Ecologists in Training activity, setting the stage for the inquiry activity
   b. Explain the inquiry package and question
   c. Introduce AQHI and mapping tool
   d. Explain Air Pollutants worksheet and have students complete research activity
3. Phase 2
   a. Discuss pollution dispersion mechanisms
   b. Explain PocketLab Air sensor to the students
   c. Discuss how students will use the sensor to complete their project
4. Phase 3
   a. Discuss ecosystem studies (baseline reports and environmental impact assessments)
   b. Have students work in their groups to begin inquiry activity
   c. Guide students through activity
5. Phase 4
   a. Host "town hall meeting" in which students share the results of their research and answer questions from their peers.

Assessment

Pre-Assessment

- Ask student to recall the material that was covered throughout the unit, paying special attention to environmental monitoring. What is a baseline study? What is an environmental impact assessment? What methods would an ecologist use to complete these studies?

Formative Assessment

- Students should work collaboratively throughout the project. Can students determine the necessary components of a baseline study? Can students determine the necessary components of an environmental impact assessment? Can students determine appropriate methods for measuring and monitoring air quality?
- Are students generating their own questions and interests to compliment the assignment? Can they formulate strategies to answer these questions?

Summative Assessment

- Students should complete a final report meeting all project requirements, submit all of their field journal notes, and present their findings.
- Have the students completed all aspects of the project? Were they able to communicate their research clearly?

Ecologists in Training – Inquiry Activity

Inquiry Question: How will the development of a new pulp mill affect a local ecosystem and the air quality of your community?

Members of your community received a notice in the mail stating that Pearly White Paper Products, a wood products company, has proposed the construction of a pulp mill in your community. Construction of this mill will provide hundreds of new jobs and economic opportunities for your community, but many are worried about how

this new development will impact the local environment.

You are an ecologist in training at a local environmental consultancy. Your team has been hired by the municipal government to assess the current condition of a local ecosystem and make predictions about how the new mill will impact the biotic and abiotic components of the environment. You have been asked to pay particular attention to air quality in the area and consider individuals who may be particularly sensitive to the airborne pollutants that are known to exist near pulp mills.

Your company will be hosting a public engagement session to explain your findings to the community. Not only will you be required to create a formal report, but you must also use your excellent communication skills to discuss your findings with the community and answer their questions.

It is important that you use your knowledge of ecosystems and interactions as your formulate your report and presentation. Consider all aspects of the ecosystem, living and non-living, and record your questions, research approach, and daily activities in your field journal.

You will be working in small teams of 3 to complete this project. You must ensure that all group members are contributing equally to the project. If you are absent and miss a team meeting, it is your responsibility to make up for that lost time. Don't let your team down!

Project Requirements

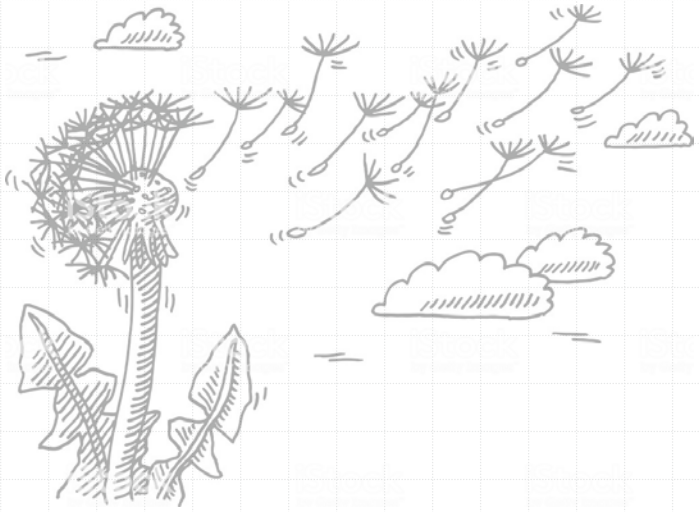
1. **Baseline Study** – you must determine the current condition of the ecosystem including the organisms present and the condition of the abiotic components of the area. Pay special attention to the baseline condition of the air quality in the area.
2. **Environmental Effect**s – use your research skills to determine how the pulp mill will, directly and indirectly, impact the environment. Consider land clearing, pollutants, and use of natural resources.
3. **Environmental Impact Assessment** – using your baseline study and predicted environmental effects prepare a report outlining how this development will affect the local ecosystem. Be sure to consider living and non-living components, and pay special attention to air quality.
4. **Presentation** – your team will deliver a presentation to the community during a public engagement session. You may choose how to present your findings (poster, PowerPoint, video), and be prepared to answer questions from your community.

Resources

Ecosystem and Project Description – this document will define the project being proposed by Pearly White Paper Products and the local ecosystem of concern.

Field Journal – use these pages to record your daily activities and observations. Document everything!

Guiding Research Questions – use these questions to help you get started. What other questions come to mind?



PROJECT PROPOSAL AND ECOSYSTEM DESCRIPTION – SAMPLE

Pearly White Paper Products – Project Proposal

Pearly White Paper Products is thrilled to propose the development of a new pulp mill right here in Edmonton, Alberta. This $650 million project will be located 10 kilometers west of the Science in Motion School. Our company specializes in the production of pulp products that are then used by paper manufacturers to produce printing paper, tissue and towel products. This process involves taking wood chip fibers and using both chemical and mechanical processes to transform them into pulp fibers. We sell and ship our pulp products all around the world!

The proposed west Edmonton Pulp Mill will bring 150 jobs to the area during the construction. Following construction, an additional 150 jobs will be created to operate the mill. Our high environmental standards, commitment to safety and dedication to our team members makes Pearly White Paper Products an excellent employer. This new venture will bring economic opportunities and stability to the communities of west Edmonton.

Ecosystem Description

The ecosystem you will be studying is located near the Science in Motion school in west Edmonton. It is a small ecosystem on the school property characterized by a mixture of open fields and non-native tree species. The proposed pulp mill will be located 10 km west of the ecosystem. Bordering this ecosystem is a forested landscape home to many native Albertan plants and animals.

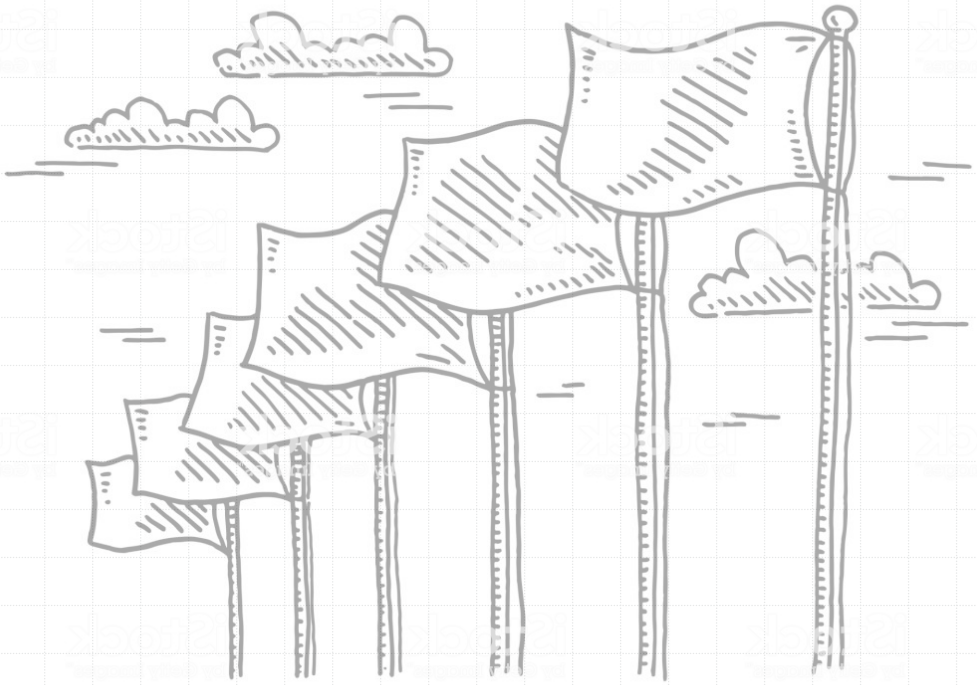
Teaching Notes

These descriptions should be adjusted based on your community, location, and environment. The activity is most successful when the scenario is as true to life as possible.

Guiding Research Questions

PULP & PAPER MILL RESEARCH				
PROJECT DESCRIPTION	PROJECT LOCATION & PROXIMITY	PROJECT PURPOSE & RESOURCE USE	PREDICTED POLLUTANTS	PLANS TO MINIMIZE POLLUTANTS
What is being proposed? Who is proposing it? What are the benefits of the project?	Where is the mill located? (map & written description) What ecosystems are in close proximity to the factory? What other communities are in proximity to the ecosystems? (e.g. towns, cities, roadways, gravel pits, dams, factories, processing plants, etc.)	What type of mill is it? What is the purpose of the mill? What natural resources will be needed to run the mill?	What types of air pollutants will the mill produce? Are there other pollutants that will be released into the environment?	What actions could be taken by the mill to minimize environmental pollutants?

ECOSYSTEM RESEARCH				
ECOSYSTEM DESCRIPTION	ECOSYSTEM LOCATION IN PROXIMITY TO PLANT	ECOSYSTEM STATUS	POSSIBLE ECOSYSTEM INTERACTIONS	LIKELY IMPACTS ON ECOSYSTEM
How would you describe the ecosystem? What are the abiotic components? What are the biotic components? What interactions are occurring between organisms? What interactions are occurring between organisms and the environment?	Include a map of the surrounding ecosystems in proximity to the proposed factory. Describe the ecosystem location, highlighting areas most vulnerable.	What are the human activities that are currently impacting the ecosystem? What is the current air quality of the ecosystem? How will you measure this? Think about the PocketLab sensor. Where are the stresses or pressures in the ecosystem?	What types of interactions are expected between the proposed factory and the surrounding ecosystems? • Ground water • Air quality • Soil • Flora & Fauna disruption • Other infrastructure? (roadways, consumption of water, etc.) • Other?	As a result of the interactions between the proposed mill and the ecosystem, what are the possible or likely impacts expected? • To flora, fauna • Water • Air • Soil • Other • How could these impacts be measured or monitored?



Field Journal

Name:

Date:

Location:

Weather:

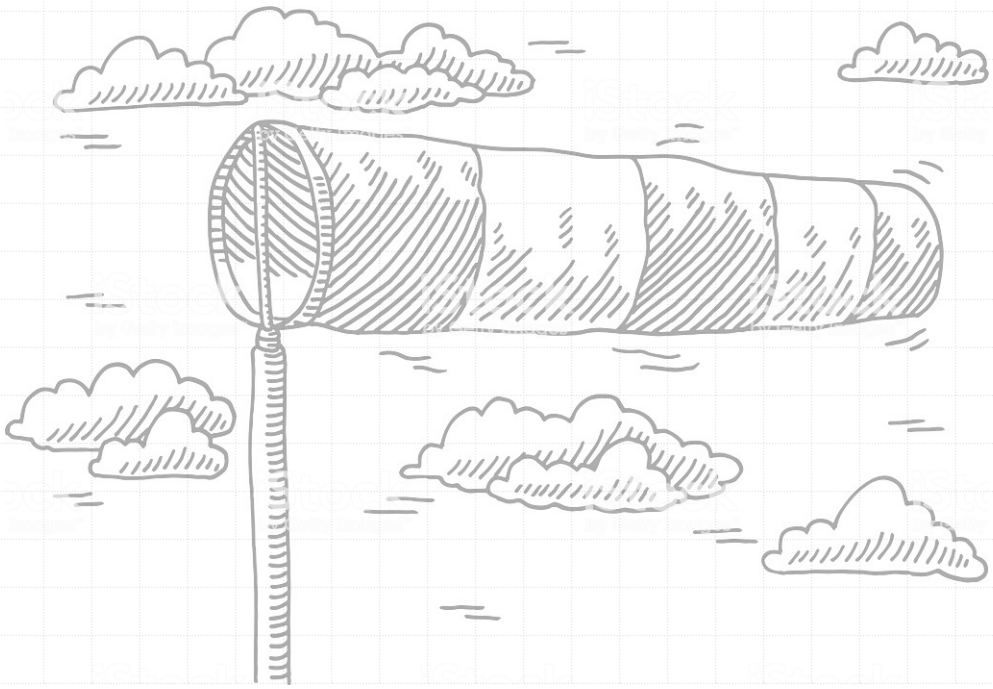
Observations/Data/Activity (include time of day):

Sketches:

Questions:

Airborne Pollutants

Pollutant	Source(s)	Environmental Impact	Health Concerns
Carbon Monoxide			
Nitrogen Dioxide			
Ozone			
Particulate Matter			
Sulfur Dioxide			



Teaching Notes

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

Introduction – 5 minutes

We've already learned that human activity can have huge impacts on ecosystems, including air quality. We also know that air pollution affects our health and the health of the environment. Luckily, we have ways of measuring air pollution and monitoring its environmental impacts.

Today we are going to learn about how air pollution is measured, and where we can find information about the quality of the air in our area.

Body – 5 to 8 hours

This lesson has been broken down into numerous phases to help guide the students through the research process and help them become familiar with air pollution science. You may choose to rearrange the order in which you deliver each phase.

Phase 1 – Project Introduction, Alberta AQHI and Pollutants

Introduce your students to the Ecologists in Training research project. Set the stage by describing the notice members of the community have received regarding the development of a new pulp and paper mill. Explain that their job is to assess the local ecosystem and make predictions about how the new development will impact the environment.

Students will work in groups of three to complete this assignment. Handout the inquiry package to each group which includes:

- Ecologists in Training Inquiry Activity
- Field Journal Template
- Guiding Research Questions
- Pearly White Paper Products Project Proposal and Ecosystem Description
- Air Pollutants worksheet

Note: Please review all materials prior to lesson.

Explain the inquiry question to the students:

- How will the development of a new pulp mill affect a local ecosystem and the air quality of your community?

This question will drive the remainder of the activity.

Introduce students to Alberta's AQHI.

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 much pollution 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 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.

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.

For the remainder of the class students will be using the AQHI mapping to tool to research each of these pollutants and complete the Air Pollutants worksheet. Students will need to list the source, environmental impacts, and health concerns for each pollutant. Most of this information is available on the mapping tool, but

some may need to be supplemented with other sources. Encourage students to explore using other functions of the tool during this activity.

Connect back to the project throughout this phase. Encourage students to think about which of the pollutants they are researching could come from a pulp and paper mill.

Phase 2 – Pollution dispersion and PocketLab Air

Review the previous phase of the lesson, and discuss what the students discovered about each of the pollutants that inform Alberta's AQHI (review the Air Pollutants worksheet).

Remember, air quality is a measure of how clean our air is. It is determined by the rate at which pollutants are emitted into the atmosphere and how effectively the atmosphere can disperse those contaminants. Things like wind, temperature, turbulence and local topography affect how effectively pollutants are dispersed, or diluted in the local atmosphere.

High winds disperse pollutants rapidly, while calm winds can cause pollutants to build up in an area and slow dispersal rates. Temperature changes across atmospheric layers can also cause pollutants to concentrate in an area. Typically temperature decreases with height in the lower atmosphere (higher elevation = lower temperature), but sometimes a temperature inversion occurs. Under these conditions temperature actually increases with height (higher elevation = higher temperature). During an inversion atmospheric mixing decreases which causes pollution dispersion to slow. Temperature inversions are common in Alberta during the winter months and can last up to several days. What would you expect to happen to air quality if we were in a temperature inversion?

Turbulence is the random movement of air in the atmosphere. This movement allows pollutants to disperse more readily. Topographical features (mountains, valleys, etc.) can also affect pollutant dispersal rates because these features can greatly impact wind speeds. Pollutants can become concentrated in valleys due to slow wind conditions.

How might these factors impact pollutants that come from a pulp and paper mill? How might they impact the environmental impacts to our ecosystem?

Now, introduce students to the PocketLab air sensor and the pollutants it is able to monitor (see PocketLab User Manual). In small groups, allow the students to test the device, showing them how the sensor is used to collect data, and how it can be interpreted.

How could we use the PocketLab Air for your project? Would this tool be useful for a baseline study or environmental impact assessment? How?

Encourage students to explore ways in which they might use the sensor to complete their projects. For example, they might use the sensor to determine the current levels of pollutants in the ecosystem before making predictions about how air quality will be impacted by the new development.

Phase 3 – Ecosystem study review; begin inquiry activity

Review what the students have previously learned about ecosystem studies, including baseline reports and environmental impact assessments. Alternatively, you may choose to use this phase to introduce this topic. The goal of this phase is to help the students understand how they might go about completing the Ecologists in Training activity using the tools that are available.

Following this lesson students will be prepared to begin work on their Ecologists in Training project. The activity is meant to be largely self-guided. Some students will need more support than others.

Working in groups of three, students will be required to conduct in-depth research on environmental impacts of a fictional pulp mill development and the baseline conditions of a local ecosystem. Provide each group with the Pearly White Paper Products Project Proposal and Ecosystem Description hand out. The pulp mill is fictional; you may wish to adjust the Project Proposal to reflect your community. You will need to select an area located

close to the school to serve as the "ecosystem" for this project. This area may be a section of the playground, a nearby marsh, soccer field, or any outdoor space that is easily accessible. Select your area and adjust the Ecosystem Description section of the worksheet to reflect this area. It is important that the students have a physical space in which to conduct their research.

Each group should also receive a Guiding Research Questions hand out. This document will help to guide them through the activity both in researching the impacts of the pulp mill, the baseline condition of the ecosystem, and the air quality of the area. They will use the Field Journal template to record all of their observations throughout the project.

To help guide the students through the activity consider the following:

- Research Skills: encourage students to explore multiple methods for gathering the information required for each of the project requirements. For example, they may observe a study plot to collect baseline data, conduct library and web-based research to understand the environmental impacts of a pulp and paper mill, etc.
- Focus on air quality. Prompt the students to identify how they will monitor air quality (i.e. the sensor that has been provided), and how they will use that information. They may need guidance throughout the data interpretation process. Encourage them to synthesize the data and offer an overall picture of the air quality for the ecosystem. Refer to the PocketLab User Manual for more information.
- Environmental Impact Assessment. Prompt the students to consider both the direct and indirect impacts of the pulp mill. For example, construction of the mill directly results in habitat loss, while the release of air pollutants resulting in acid deposition indirectly impacts the ecosystem.

At the end of the project, students should submit all of their field journal notes, a final report that meets all of the project requirements and be prepared to make a presentation. Schedule time for final presentation to occur as a mock public engagement session. The presenters will play the role of the ecologists while their observing classmates will act as concerned community members. Encourage the students to ask questions of one another.

Phase 4 – Project Completion

Following the completion of the Ecologists in Training project, each group will present their findings to their class. The students who are presenting are the "ecologists," and the rest of the class will act as the concerned community members. Encourage the class to ask questions following each presentation.

You may consider asking the groups the following questions:

- Based on your assessment, what is your biggest concern regarding the new pulp mill? What aspect of the ecosystem will be impacted the most?
- How might you prevent or mitigate the impacts you have identified?
- What might be missing from your predictions? Is there anything we don't know? How could you fill these gaps? Where else might we find information?
- Would you recommend the pulp mill be built or not? Why?

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 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 (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 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 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

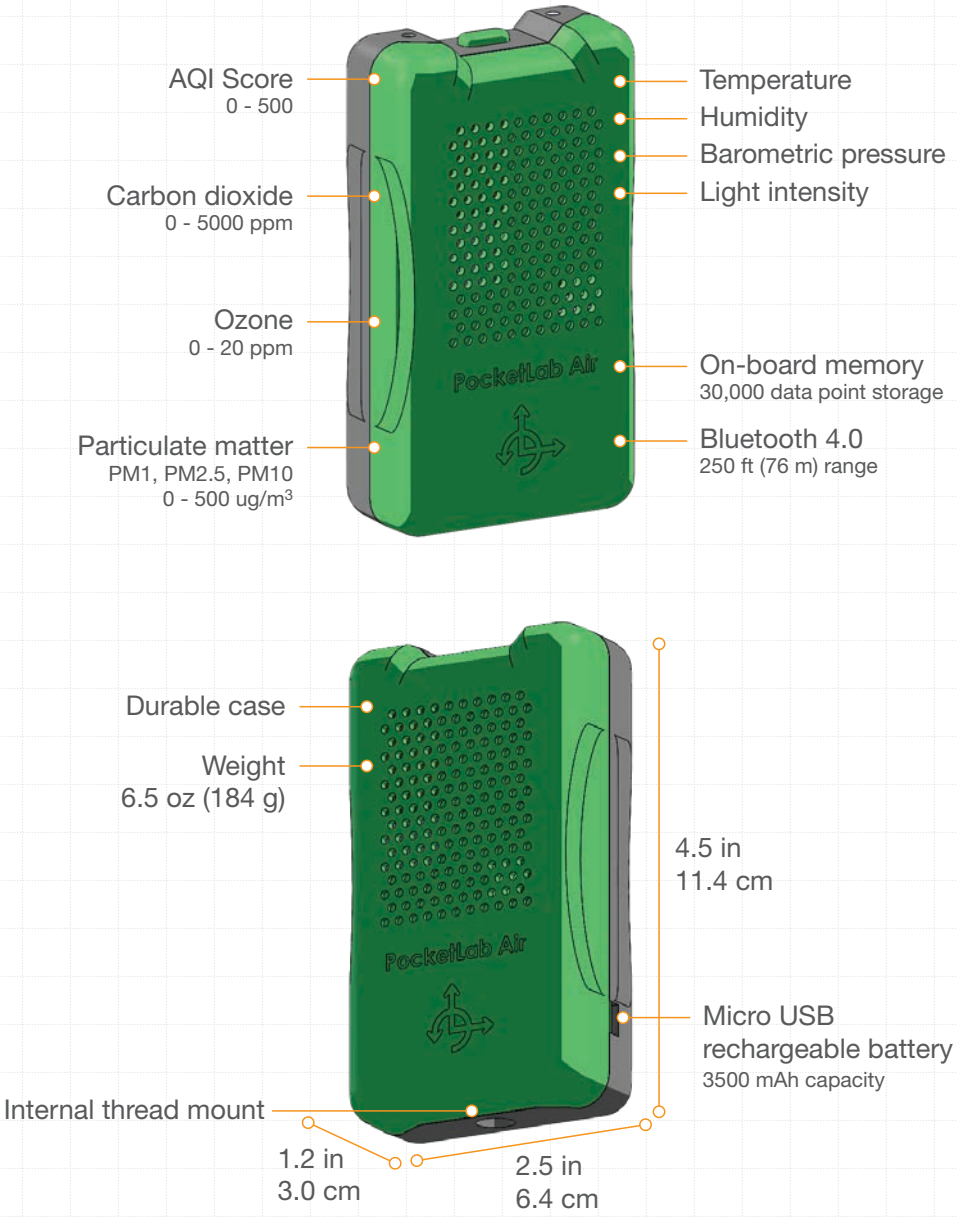
Alberta Environment and Parks Data Warehouse: airdata

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.

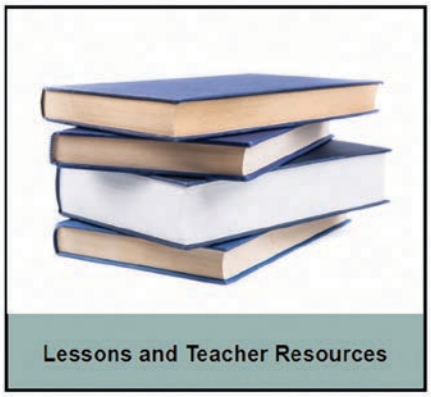
Disconnect the Sensor

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.

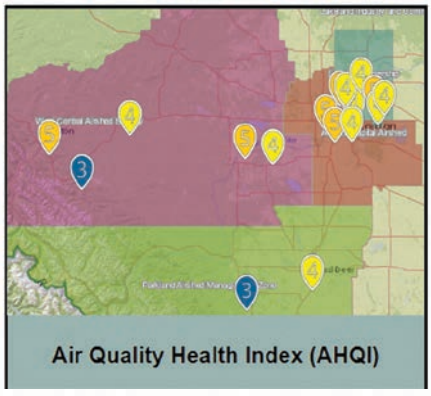
AQHI MAPPING TOOL USER MANUAL
AIR QUALITY MATTERS

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/.

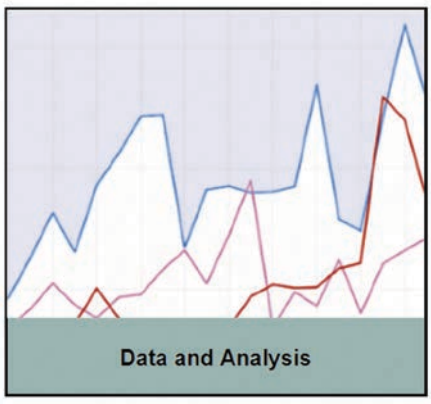
How to use your PocketLab Air, including detailed instructions, updates, possible extensions, and more.



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.



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



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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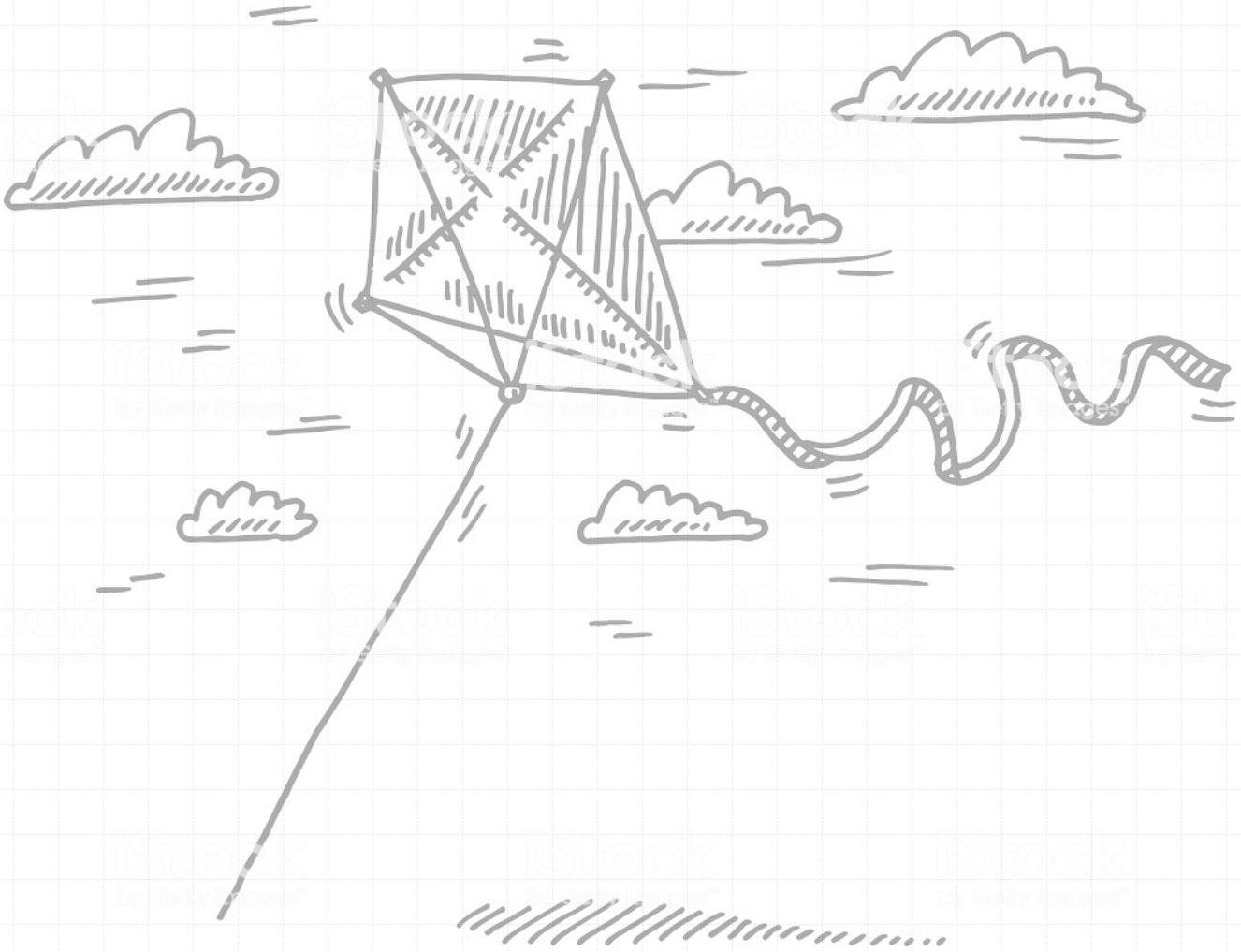

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