Pollution Patrol

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Lesson Focus

This lesson focuses on devices that are used to detect air pollution. Teams of students construct outdoor air pollution detectors from everyday materials. They then test their devices to see how much particulate pollutants they can capture.

Lesson Synopsis

The "Pollution Patrol" lesson explores how engineers design devices that can detect the presence of pollutants in the air. Students work in teams of "engineers" to design and build their own outdoor air pollution detectors out of everyday items. They then test their air pollution detectors, evaluate their results, and present to the class.

Age Levels

8-18.

Objectives

Students will:

- Design and build an outdoor air pollution detector
- Test and refine their designs
- Communicate their design process and results

Anticipated Learner Outcomes

As a result of this lesson students will have:

- Designed and built an outdoor air pollution detector
- Tested and refined their designs
- Communicated their design process and results

Lesson Activities

In this lesson, students work in teams of "engineers" to design and build their own outdoor air pollution detectors out of everyday items. They then test their devices, evaluate their results, and present to the class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Worksheets (attached)
- Student Resource Sheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- Particulate Matter (www.epa.gov/pm/basic.html)
- WHO Air Quality Guidelines (www.who.int/phe/health_topics/outdoorair_aqg/en/)
- TryEngineering (www.tryengineering.org)
- Curriculum Links (www.acara.edu.au)

Recommended Reading

- Air Pollution. (ISBN: 9780761432203)
- Air Pollution: Measurement, Modelling and Mitigation (ISBN: 978-0415479325)

Optional Writing Activity

- Write a letter to your local politician about ways air pollution can be reduced in your community.

For Teachers:
Teacher Resources

◆ Lesson Goal
The goal of this lesson is for students to design and build an outdoor air pollution detector out of everyday materials.

◆ Lesson Objectives
Students will:

- Design and build an outdoor air pollution detector
- Test and refine their designs
- Communicate their design process and results

◆ Materials
- Construction paper, cardboard, plastic wrap, wax paper, fabric, felt, coffee filters, index cards, paper plates, paper cups, scissors, double sided tape, petroleum jelly, Karo syrup, hangers, string, rulers, hand lenses, graph paper
- Microscopes or digital camera if available (optional)

◆ Procedure
1. To begin, ask students to share some sources of air pollution, how they think it is measured and how it impacts society. Discuss that engineers design instruments that can detect the presence of different types of pollutants in the air.
2. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework.
3. Divide students into groups of 2-3 students, providing a set of materials per group.
4. Explain that each team must design a particulate air pollution detection device. It must have a flat collection area which is at least 5 cm x 5 cm. The device should have relative protection from the elements and should be able to be secured.
5. Students then meet and develop a plan for their device. They agree on materials they will need, write or draw their plan, and then present their plan to the class.
6. Next, student groups execute their plans. They may need to rethink their plan, request other materials, trade with other teams, or start over.
7. Each team should place their detector at a different location around the school (near school buses, parking lot, playing field etc.).
8. After 72 hours, students can examine the particulate matter collected by their devices using hand lenses (or microscopes/digital cameras, if available).
9. Students should record and describe all the different types of particles they see (dust, pollen, dirt etc.) in terms of size, color, shape and texture.
10. Students should then create a grid of 1 cm squares over their device's collection area with string, securing it with tape. They should then count the number of particles in five random squares and take an average. Students can then compare and graph findings for the different locations tested by the class.
11. Students can then develop a scale to rate air quality/air pollution at the different locations tested around the school.
12. Teams then complete an evaluation/reflection worksheet, and present their findings to the class.
13. This project can be extended over the school year for additional data analysis.

◆ Time Needed
- 2-3 forty-five minute class periods.

Student Resource: Air Pollution

◆ Air Pollution

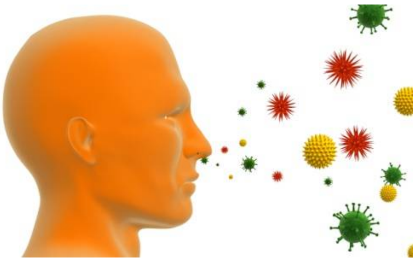
Air is essential to life. The air around us is comprised primarily of the elements nitrogen and oxygen. When other substances such as chemicals, natural materials, or particles enter the air, this is known as air pollution. Air pollution can occur both indoors as well as outdoors. It can have both natural and human induced causes. Air pollution impacts humans, animals and the environment in a number of different ways.

smog

Air pollution can be the result of a number of different types of human activity. When pollutants from smokestacks and automobile emissions are released into the air, chemical reactions occur in the atmosphere which can lead to a number of problems. Smog occurs when pollutants in the air mix with ozone, causing hazy atmospheric conditions and respiratory problems in humans. Smog typically occurs over large cities or industrial areas. London, Los Angeles, Mexico City and Southeast Asia all have significant problems with smog. Acid rain occurs when pollutants such as sulfuric acid mix with water in the air, causing rain and snow to become too acidic. This acidity is very harmful to the environment and as a result kills plants, trees, fishes and animals. When fuels are burned for energy in automobiles, factories, fireplaces and barbecues, tiny particles are released into the air. These particles make up what is known as particulate matter pollution.

◆ Particulate Matter

Pollution caused by particles, also known as particulate matter, consists of a mixture of small particles and liquid droplets in the air. Particulate matter can include both coarse particles and fine particles. Coarse particles are larger than 2.5 microns but less than 10 microns in diameter (A human hair is roughly 70 microns in diameter). These can include smoke, dust, dirt mold and pollen. Fine particles are less than 2.5 microns in diameter. Fine particles can include toxic compounds and heavy metals.



Particulate pollution, particularly fine particle pollution, is very harmful to humans when inhaled. Particulate matter disrupts ecosystems. Particles in the air also cause hazy atmospheric conditions. The amount of particulate matter in the air varies depending on the time of the year and the weather. For example, the amount of particulate matter may be higher in the winter due to an increase in the use of fireplaces and wood burning stoves.

Particulate pollution is also categorized by its source. Primary particles can be traced directly to their sources, such as smokestacks, idling vehicles or power plants. Secondary particles on the other hand, are created through reactions in the atmosphere and are therefore much more difficult to trace.

◆Particle Matter Samplers and Counters

Particulate matter samplers collect particulate matter to determine how much is in the air and so that particles may be examined later in a laboratory. One type of particulate matter sampler draws air through a filter attached to a glass tube. The weight of the filter is taken before the sampling occurs. After the filter has collected some particles, it is then weighed again. The amount of particulate matter is calculated using the weight of the particulate matter collected by the filter and the amount of air sampled. Another type of particulate matter sampler collects particulate matter on a reel of filter tape, which is weighed before and after the sampling.

Instruments known as particle counters detect and count the number of particles in the air. Aerosol particle counters count the number of particles in the air and measure their size. Light blocking particle counters detect the amount of particles in the air by passing light through an air sample and measuring how much of that light is being blocked by the particles. This method can be used to assess particles that are larger than 1 micrometer. Smaller particles (larger than .05 micrometer) can be detecting using the light scattering method. This method measures how much light is scattered by particles in an air sample. Lasers can also be used to illuminate an air sample so the silhouettes of particulate matter can be captured with a digital camera for magnification and examination.

◆ Rating Air Quality

The World Health Organization has established guidelines for air quality based on the negative health effects of pollution on humans. Many countries have established scales that rate the quality of the air in a particular region at a given time. These scales rate air quality based on the concentration of pollutants in the air, but vary by location and also as to which type of pollution they assess. Despite evidence of the negative impact of air pollution on health, many countries still do not monitor and rate air quality.

smokestacks

In Mexico City, the Sistema de Monitoreo Atmosférico de la Ciudad de México (SIMAT) uses a rating system known as Índice Metropolitano de la Calidad del Aire (IMECA) to measure concentrations of pollutants including fine particulate matter, carbon monoxide, sulphur dioxide, nitrogen dioxide and ozone. A 200 point rating scale consisting of five categories ranging from “buena” (good) to “extremadamente mala” (extremely bad) is used to rate and describe air quality conditions. In the United States, the Environmental Protection Agency uses the Air Quality Index which examines concentrations of these same pollutants and assigns a rating on a scale of 0 to 500. Within this scale there are six categories that describe the quality of the air ranging from “Good” to “Hazardous”. The Hong Kong Environmental Protection Department also rates air pollution on a 500 point scale with five categories ranging from “low” to “severe” based on concentrations of pollutants in the air. In March 2010, Hong Kong’s air pollution hit record levels (over 500!) after a serious sandstorm occurred in southern China.

Student Worksheet:

◆ You are a team of engineers who have been given the challenge to design a device that can detect the presence of particulate pollutants outside of your school. The device must have a flat collection area which is at least 5 cm x 5 cm. The device needs to have relative protection from the elements and should be able to be secured (so it does not blow away).

◆ Planning Stage
Meet as a team and discuss the problem you need to solve. Then develop and agree on a design for your air pollution detector. You'll need to determine what materials you want to use.

Draw your design in the box below, and be sure to indicate the description and number of parts you plan to use. Present your design to the class.

You may choose to revise your teams' plan after you receive feedback from class.

Design:

Student Worksheet (continued):

◆ Construction Phase
Build your air pollution detector. During construction you may decide you need additional materials or that your design needs to change. This is ok – just make a new sketch and revise your materials list.

◆ Testing Phase
Each team will test their air pollution detector by placing it at a different location around their school. After 72 hours, check to see whether your tester collected any particles. Use a hand lens, microscope, or digital camera to examine the particles collected. Document the different types of particles you see (e.g. dust, pollen, dirt etc) as well as their size, color, shape and texture.

Use string to create a grid of 1 cm squares over your device's collection area, securing it with tape. Count the number of particles in five random squares. If there are too many to count, estimate. Calculate the average number of particles per square. Compare and graph the findings for the different locations tested in the class. Develop a scale to rate air quality/air pollution at the locations tested around your school.

◆ Evaluation Phase
Evaluate your teams' results, complete the evaluation worksheet, and present your findings to the class.

Use this worksheet to evaluate your team's results in the "Pollution Patrol" Lesson:

1. Did you succeed in creating an air pollution detector that could detect the presence of particles in the air? If not, why did it fail?

2. Did you decide to revise your original design or request additional materials while in the construction phase? Why?

3. Did you negotiate any material trades with other teams? How did that process work for you?

Student Worksheet (continued):

4. If you could have had access to materials that were different than those provided, what would your team have requested? Why?

5. Do you think that engineers have to adapt their original plans during the construction of systems or products? Why might they?

6. If you had to do it all over again, how would your planned design change? Why?

7. What designs/methods did you see other teams try that you thought worked well?

8. Do you think you would have been able to complete this project easier if you were working alone? Explain…

9. What type of particulate pollution did you find the largest quantity of? Why do you think that is?

10. What do you think can be done to reduce particulate pollution around your school?

For Teachers:
Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the Australian Curriculum for both Science and Mathematics.

	Year Level					
	5	**6**	**7**	**8**	**9**	**10**
Science as a human endeavour	Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives **(ACSHE083 – Yr 5); (ACSHE100 – Yr 6)**		Scientific knowledge changes as new evidence becomes available **(ACSHE119 – Yr 7); (ACSHE 134 – Yr 8)** Science knowledge can be developed through collaboration and connecting ideas across the disciplines of Science **(ACSHE223 – Yr 7); (ACSHE226 – Yr 8)**		Advances in scientific understandings often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE158 – Yr 9); (ACSHE192 – Yr 10)**	
Science Inquiry Skills	With guidance, select appropriate investigation methods to answer questions or solve problems **(ACSIS086 – Yr 5); (ACSIS103 – Yr 6)** Use equipment and materials safely, identifying potential risks **(ACSIS088 – Yr 5); (ACSIS105 – Yr 6)** Compare data with predictions and use as evidence in developing explanations **(ACSIS218 – Yr 5); (ACSIS221 – Yr 6)** Suggest improvements to the methods used to investigate a question or solve a problem **(ACSIS091 – Yr 5); (ACSIS108 – Yr 6)** Communicate ideas, explanations and processes in a variety of ways **(ACSISI093 – Yr 5); (ACSIS110 – Yr 6)**		Summarise data from investigations and use scientific understanding to identify relationships and draw conclusions **(ACSIS130 – Yr 7); (ACSIS145 – Yr 8)** Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of data collected, and identify improvements to the method **(ACSIS131 – Yr 7); (ACSIS 146 – Yr 8)** Use scientific knowledge and findings from investigations to evaluate claims **(ACSIS132 – Yr 7); (ACSIS234 – Yr 8)** Communicate scientific ideas and information for a particular purpose **(ACSIS133 – Yr 7); (ACSIS148 – Yr 8)**		Critically analyse the validity of information in secondary sources and evaluate the approaches used to solve problems **(ACSIS172 – Yr 9); (ACSIS206 – Yr 10)** Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations **(ACSIS174 – Yr 9); (ACSIS208 – Yr 10)**	

Mathematics Links

Activity	Concept / Year Level							
	Number and Algebra				Measurement and Geometry		Statistics and Probability	
	Number and place value	Real numbers	Money and financial maths	Linear and non-linear relationships	Using units of measurement	Geometric reasoning	Data and representation and interpretation	Shape
Pollution Patrol	Qualitative data							

Mathematics Links with Science Curriculum (Skills used in this activity)	General Capabilities	Cross-Curriculum Priorities
• Process data using simple tables • Analysis of patterns and trends	• Literacy • Numeracy • Critical and creative thinking • Personal and social capacity • ICT capability	• Sustainability

Science Achievement Standards

Year 5

By the end of Year 5, students classify substances according to their observable properties and behaviours. They explain everyday phenomena associated with the transfer of light. They describe the key features of our solar system. They analyse how the form of living things enables them to function in their environments. ***Students discuss how scientific developments have affected people's lives and how science knowledge develops from many people's contributions.***

Students follow instructions to pose questions for investigation, predict what might happen when variables are changed, and plan investigation methods. They use equipment in ways that are safe and improve the accuracy of their observations. Students construct tables and graphs to ***organise and identify patterns. They use patterns in their data to suggest explanations and refer to data when they report their findings***. They ***describe ways to improve the fairness of their methods and communicate their ideas, methods and findings using a range of texts.***

Year 6

By the end of Year 6, students compare and classify different types of observable changes in materials. They analyse requirements for the transfer of electricity and describe how energy can be transformed from one form to another to generate electricity. They explain how natural events cause rapid changes to the Earth's surface. They decide and predict the effect of environmental changes on individual living things. Students ***explain how scientific knowledge is used in decision making*** and identify contributions to the development of science by people from a range of cultures.

Students follow procedures to develop investigable questions and ***design investigations into simple cause-and-effect relationships***. They ***identify variables to be changed and measured and describe potential safety risks when planning methods. They collect, organise and interpret their data, identifying where improvements to their methods or research could improve the data. They describe and analyse relationships*** in data using graphic representations and construct multi-modal texts to ***communicate ideas, methods and findings***.

Year 7

By the end of Year 7, students describe techniques to separate pure substances from mixtures. They represent and predict the effects of unbalanced forces, including Earth's gravity, on motion. They explain how the relative positions of the Earth, sun and moon affect phenomena on Earth. They analyse how the sustainable use of resources depends on the way they are formed and cycled through Earth systems. They predict the effect of environmental changes on feeding relationships and classify and organise diverse organisms based on observable differences. Students ***describe situations where scientific knowledge from different science disciplines has been used to solve a real-world problem***. They explain how the solution was viewed by, and impacted on, different groups in society.

Students identify questions that can be investigated scientifically. They ***plan fair experimental methods, identify variables to be changed and measured. They select equipment that improves fairness and accuracy and describe how they considered safety. Students draw on evidence to support their conclusions. They summarise data from different sources, describe trends and refer to the quality of their data when suggesting improvements to their methods. They communicate their ideas, methods and findings using scientific language and appropriate representations.***

Year 8

By the end of Year 8, students compare physical and chemical changes and use the particle model to explain and predict the properties and behaviours of substances. They identify different forms of energy and describe how energy transfers and transformations cause change in simple systems. They compare processes of rock formation, including the time scales involved. They analyse the relationship between structure and function at cell, organ and body system levels. Students examine the different science knowledge used in occupations. They ***explain how evidence has led to an improved understanding of a scientific idea and describe situations in which scientists collaborate to generate solutions to contemporary problems***.

Students identify and construct questions and problems that they can investigate scientifically. They ***consider safety and ethics when planning investigations, including designing field or experimental methods. They identify variables to be changed, measured and controlled. Students construct representations of***

their data to reveal and analyse patterns and trends, and use these when justifying their conclusions. They explain how modifications to methods could improve the quality of their data and apply their own scientific knowledge and investigation findings to evaluate claims made by others. They use appropriate language and representations to communicate science ideas, methods and findings in a range of texts types.

Year 9

By the end of Year 9, students explain chemical processes and natural radioactivity in terms of atoms and energy transfers and describe examples of important chemical reactions. They describe models of energy transfer and apply these to explain phenomena. They explain global features and events in terms of geological processes and timescales. They analyse how biological systems function and respond to external changes with reference to interdependencies, energy transfers and flows of matter. They ***describe social and technological factors that have influenced scientific developments and predict how future applications of science and technology may affect people's lives.***

Students design questions that can be investigated using a range of inquiry skills. They ***design methods that include the control and accurate measurement of variables and systematic collection of data and describe how they considered ethics and safety. They analyse trend in data, identify relationships between variables and reveal inconsistencies in results. They analyse their methods and the quality of their data, and explain specific actions to improve the quality of their evidence. They evaluate others 'methods and explanations from a scientific perspective and use appropriate language and representations when communicating their findings and ideas to specific audiences.***

Year 10

By the end of Year 10, students analyse how the periodic table organises elements and use it to make predictions about the properties of elements. They explain how chemical reactions are used to produce particular products and how different factors influence the rate of reactions. They explain the concept of energy conservation and represent energy transfer and transformation within systems. They apply relationships between force, mass and acceleration to predict changes in the motions of objects. Students describe and analyse interactions and cycles within and between Earth's spheres. They evaluate the evidence for scientific theories that explain the origin of the universe and the diversity of life on Earth. They explain the processes that underpin heredity and evolution. Students analyse how the models and theories they use have developed over time and discuss the factors that prompted their view.

Students develop questions and hypotheses and ***independently design and improve appropriate methods of investigation***, including field work and laboratory experimentation. ***They explain how they have considered reliability, safety, fairness and ethical actions in their methods*** and identify where digital technologies can be used to enhance the quality of their data. ***When analysing data, selecting evidence and developing and justifying conclusions, they identify alternative explanations for findings and explain any sources of uncertainty. Students evaluate the validity and reliability of claims made in secondary sources with reference to currently held scientific views, the quality of methodology and the evidence cited. They construct evidence-based arguments and select appropriate representations and text types to communicate science ideas for specific purposes.***