Air quality investigation

for KS3 Science

Unit of work: overview

In session one, your students will learn about the Great Smog of 1952 and the dangers of air pollution today. They will be introduced to the make up of the air we breathe and its most common pollutants. They will then investigate the causes of these pollutants and think about poor air quality can been measured. They will learn about sampling and work scientifically to design an experiment that tests air quality in their local area.

In the second session, your students will then carry out an experiment that measures levels of nitrous dioxide (NO_2) in a number of locations in and around your school grounds.

The third session must take place four weeks after the NO_2 are placed. Your students will start this session by learning about an example of successful citizen action against air pollution. They will then analyse, critique and present the information gathered in their research. Finally, your students will select a course of action to take with the aim of improving the air quality of their local area.

Learning outcomes

- ask questions and develop a line of enquiry based on observations, and make predictions using scientific knowledge
- use appropriate techniques, apparatus and materials during fieldwork
- make and record observations and measurements using a range of methods, and apply sampling techniques
- biology: how organisms affect, and are affected by, their environment, including the accumulation of toxic materials
- chemistry: the composition of the atmosphere, the production of carbon dioxide and other gases by human activity and their impact

You will need

- Scissors and sticky tack
- Maps of your local area
- A computer screen
- Internet access
- NO_2 tubes
- Risk assessment for fieldwork

Suggested minimum time

Three sessions of one hour. The second of these sessions involves fieldwork.

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Session one

Opener: Great Smog of 1952
5 mins

As your class come in, display a gallery of images from the Great Smog of 1952. The Guardian has a good collection: www.tinyurl.com/smog1952.

Explain that smog is a kind of polluted fog. In 1952, fog mixed with the enormous amounts of pollution from factories and smoke from domestic coal used for heating, creating a highly toxic blend. This smog was so toxic and thick that it brought traffic to a standstill, asphixiated cows, and led to many people experiencing breathing problems and at least 4,000 human deaths.

The terrible conditions and resulting deaths caused public outrage. In response, parliament passed the Clean Air Act of 1956, banning emissions of black smoke and requiring all factories and urban households to use smokeless fuels.

Group work: Continuum of death
10 mins

Spilt your class into pairs or groups and distribute Worksheet one: Continuum of death with a pair of scissors. Ask your students to cut out the different causes of death and place them along the continuum based on number of deaths per year in the UK.

Once your students have had some time to complete this activity, ask the class to help you arrange the causes of death at the front of the class. Referring to Teacher notes one: Continuum of death for the statistics, you can then re-arrange the causes of death in the correct order.

Class discussion: Air pollution
10 mins

Did the class expect air pollution to be so deadly? Does the air they are breathing now look as polluted as it did in the Great Smog? Ask your class to take a deep breath and think about what is going into their lungs. Air is a cocktail of gases, which we imbibe thousands of times a day. The cocktail recipe changes depending on where we are and what we (or others) are doing.

Distribute Worksheet two: The air we breathe and talk your students through the basic make up of air and the listed pollutants. Based on this information, where might they find places of air pollution? Write any answers on your whiteboard.

Stretch learning

Take a look at how gases and particulate matter enter the respiratory system then think about why particles less than 2.5 micrometers in diameter (far smaller than a single human hair at 100 micrometers) are so dangerous?

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Session one (cont)

Classwork: designing an experiment
35 mins

Tell your class that, in Europe, the amount of NO_2 is not supposed to exceed 40 micrograms (µg) per cubic meter (m^3). However, readings taken in cities are often over double the legal limit. Show your class a sample NO_2 diffusion tube. Explain that it is a device that determines NO_2 concentration levels, and that they will be distributing a number of them in and around the school grounds.

Ask your students to get into groups and distribute maps of your school grounds and the surrounding area. Ask them to label areas that they expect to show high or low levels of different types of air pollution. Where might be the best places to put an NO_2 diffusion tube?

Hand out copies of Worksheet three: fair experiment checklist. Explain that there are a number of factors that could influence their results so we must carefully plan a fair experiment. If appropriate for your class, you can introduce the different ways of sampling here when discussing method.

Your students should determine that the location of the tubes should be the only independent variable. How will they control for other factors? Prompt your students to think about the height of the tubes and how exposed it is on each side (i.e. in a corner versus on a pole). The checklist should be completed in preparation for the next session.

Session two

Opener: final experiment preparation
15 mins

As a class, revisit Worksheet three: fair experiment checklist, ensuring your students have carefully thought about controlling their variables. Next, hand out Worksheet four: diffusion tube record along with the NO_2 tubes and their fittings. Finally, work with your students to decide the locations for the NO_2 tubes based on the mapping exercise they did in the last session.

Fieldwork: installing NO_2 tubes
45 mins

Depending on the context of your classroom, you may decide to allow your students to work in groups installing the NO_2 tubes, or you may wish to work as a full class. In either case, ensure your students document the installation correctly using Worksheet four: diffusion tube record. Make sure your students label the tubes correctly and make good notes about each of the chosen locations, including geographic data, photography and/or annotated sketches, and site use (e.g. car park, bus stop, open field).

The final session should be scheduled for 4 weeks later, or as recommended in the instructions that come from your chosen NO_2 tube supplier.

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Session three

Before the session starts
10 mins

In preparation for the final session, collect the tubes from the various locations. Ensure they are correctly labelled before returning them to the classroom.

Opener: reverse graffiti
5 mins

As students come in, show a short video or display images of Brazilian artist Alexandre Orion's work (both available on www.alexandreorion.com under the project Ossario). He chose to protest his city's pollution levels using reverse graffiti: cleaning patterns in the residue the pollution left on the walls.
When the police came to investigate they listened to his arguments and ended up protecting the artists from traffic as they worked. The art sparked a big conversation about air quality and pollution, and as a result the city council cleaned up every tunnel in the city.

Individual/group work: examining results
45 mins

Divide your class into groups and hand out the collected NO_2 tubes and the appropriate diffusion tube record. Using the the instructions that come from your chosen NO_2 tube supplier, ask your students to record the results for each tube. Ask each group to feed back to the class by adding their results to a map at the front of the class.

Use this collaborative map as a basis for a class discussion. What are their first impressions? What differences can the class see in the evidence collected at each of the sites? What does that mean? Does the evidence line up with their expectations? Can they see any flaws in the data or the experiment as a whole? Looking back, would they have done anything differently?

Divide the class back into groups or pairs and ask students to work in more depth on the evidence to produce a report that communicates their findings and suggests ways the school and local community can take positive action based on the evidence from the experiment. The report should include the following:

- an introduction to the experiment
- an explanation of their methodology
- an accurate map with annotations
- their interpretation of the results
- a suggestion for action

Group/individual work: take action
10 mins

Now that your students have an understanding of the dangers of air pollution and evidence of different levels of air quality in their local area, ask

Session three (cont)

them if they think they can positively impact their area in the way that Alexandre Orion did? Ask each student or group to choose one action to take – or they can come up with their own! Ask each student or group to choose one action to take, to be started in class and completed as homework.

- Write to your MP (www.theyworkforyou.com) with your evidence. Attach your report and tell them what action you want them to take. They should reply!
- Get permission to reverse graffiti a message about air pollution. You can do this a sturdy stencil, a wire brush and some ecologically-friendly detergent.
- Remix the BBC News website with Mozilla X Ray Goggles. Write your own news articles about air pollution with photos of your local area. Make a screen grab and share it on social media.
- Present your findings to the rest of the school with a marketing campaign including posters, and talking at an assembly.
- Share your eco-friendly journey to school making a video, animation or using time lapse photography. Publish it to YouTube.

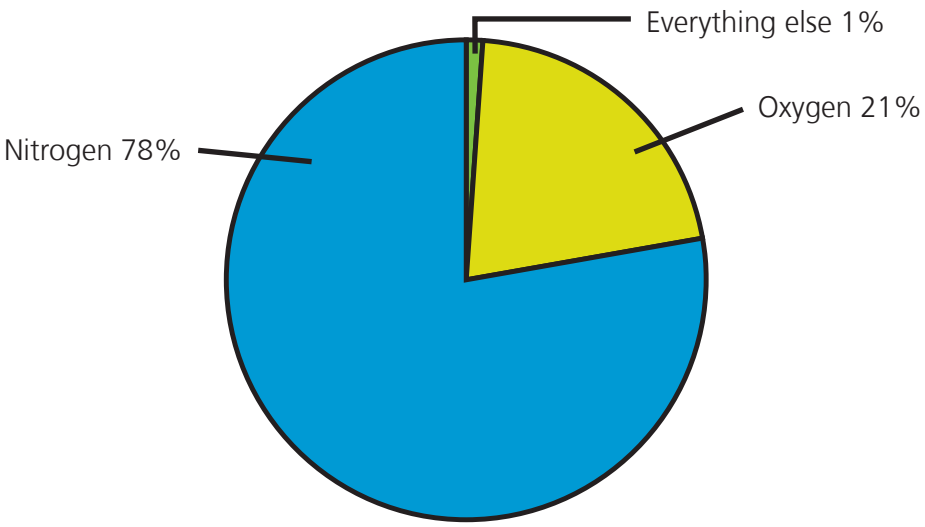
Worksheet one: Continuum of death

ZERO
DEATHS

MANY
DEATHS

Worksheet one (cont): Continuum of death

Worksheet two: the air that we breathe



The most common trace elements are argon at 0.93% and carbon dioxide at 0.04%. Water vapour varies depending on the temperature and humidity, ranging from 0.1% to over 4%.

Pollutants

› CO: Carbon monoxide
This harmful toxin comes from burning fossil fuels. You'll find it whereever there are cars, taxis, buses, or fires. It causes headaches, fainting and eventually suffocation.

› CO_2: Carbon dioxide
You breathe this out. At high enough doses it has the same toxic result as CO. Increased CO_2 is why a room filled with people feels stuffy (besides temperature). Other sources of CO_2 are fires, waste incineration, volcanoes and aeroplanes.

› NO and NO_2: Nitric oxide and nitrogen dioxide
Comes out of car exhausts, burning fuel in power plants and as a byproduct of thunderstorms. They are both very toxic. Attributed to decreased immune systems and increased asthma symptoms. High concentrations can contribute to acid rain and depletion of the ozone layer. Inhaling NO_2 will poison you at higher doses.

› SO_2: Sulfur dioxide
This smelly chemical comes from volcanos, factories and burning coal. It is highly toxic, resulting in a range of respiratory conditions. It is also used to make sulphuric acid and in really small doses to preserve apricots and help make wine.

› PM2.5 and PM10: Particulates
Particulates aren't gases but lots of bits floating around in our air, including aerosols, smoke, fumes, dust, ash and pollen. Particulate matter is sorted according to size because of the different health effects associated with particles of different sizes. PM2.5 (smaller than 2.5 micrometers) is classified as fine particulate matter, while PM10 (smaller than 10 micrometers) is classified as coarse particulate matter. PM2.5 is the most dangerous because it goes much further into the respiratory system, contributing to asthma and lung disease.

Worksheet three: fair experiment checklist

› Experiment details:
(overview of the experiment, where it will be and how long it will run for)

› Hypothesis:
(what you think will happen)

› Method:
(what you will do)

› Independent variable:
(what you will change)

› Dependent variable:
(what will respond to the independent variable)

› Controlled variables:
(what needs to stay the same)

Worksheet four: diffusion tube record

date and time	tube code	location data	site information and other notes

Teacher notes one: Continuum of death

BEE STINGS
Typically, fewer than five people a year die because of bee or wasps stings.

AIR POLLUTION
40,000 deaths a year are linked to a number of different types of indoor and outdoor air pollution in the UK.

LIGHTNING
Typically, 30 to 60 people are struck by lightning each year in the UK, with an annual death toll of fewer than five.

ALCOHOL
Alcohol poisoning and long-term alcohol abuse killed 6,592 people in 2015.

LIONS
Unsuprisingly, no one was killed by a lion in the UK in recent years. Globally, lions kill about 250 people a year.

SMOKING
Smoking is responsible for 96,000 deaths a year in the UK, mainly from cancer, respiratory diseases and circulatory diseases.

TRAFFIC ACCIDENTS
1,775 people died because of traffic accidents in 2015.

ILLEGAL DRUGS
Narcotics or hallucinogens killed 1,605 people in 2015.

SELFIES
Zero deaths in the UK were caused by selfies. However, there were 28 selfie-related deaths worldwide in 2015. That's 20 more than deaths by sharks!

OBESITY
Obesity and complications arising from obesity were responsible for 34,100 deaths in 2015.