

From mountain to sea

AIR QUALITY



Air Quality Teaching Toolkit

Activity Guidance

Guidance Notes	
Activity	Air quality levels in your area.
Description	Workshop to look at air quality levels in different areas where you live. Discuss why levels may differ in different places and what actions you can take forward with these results. The workshop is broken down into 6 separate workshops.
Age	Level 2
Equipment	Equipment required is stated below, worksheets are at the end of this document, pre-book Air Quality Measurement Devices.
CFE Outcomes	HEALTH AND WELLBEING: HWB 2-15a SCIENCE: SCN 2-04b, SCN 2-12a SOCIAL STUDIES: SOC 2-08a, SOC 2-09a TECHNOLOGY: TCH 2-02b, TCH 2-06a LITERACY & ENGLISH: LIT 2-07a MATHEMATICS: MTH 2-21a
Timescale	Estimated times given for individual tasks.
Ratio	School ratios for outdoor activities where applicable.



Air Quality Teaching Toolkit

Activity Guidance

Introduction

This toolkit has been developed as part of Aberdeenshire Council's School Travel Planning initiatives with the aim to encourage sustainable, active and safe travel to school. This workshop explores the themes of air quality, what impact air pollution has and how you can improve air quality.

This toolkit is made up of the following six individual lesson plans:

1. Introducing Air Quality and Planning an Investigation
2. Investigating Air Quality
3. Analysing the Data
4. Action Planning
5. Taking Action
6. Evaluating Success

Some extra activities with Bioindicators are also included in the end of this tool kit.

Aims

This toolkit is designed to offer fun and engaging activities to:

- Identify areas of poor air quality around your school and community;
- Promote pupil understanding of the causes and impacts of air pollution;
- Engage staff, pupils, and parents/carers in improving air quality; and
- Help identify measures that could reduce children's exposure to air pollutants, within the school and through their travel.



Information on Air Quality to help aid discussion in tasks

Question	Answer
What is air pollution?	Air pollution occurs when gases, dust particles, fumes (or smoke) or odour are introduced into the atmosphere in a way that makes it harmful to humans, animals and plants.
Types of air pollution?	<p>Things that pollute the air are called pollutants. Examples of pollutants include nitrogen oxides, carbon oxides, hydrocarbons, sulphur oxides, dust particles, and organic compounds that can evaporate and enter the atmosphere. The major air pollutants we have problems within Scotland are:</p> <ul style="list-style-type: none"> • Nitrogen Dioxide (NO₂) • Carbon Monoxide (CO) • Fine particles (PM10 and PM2.5)
What causes air pollution?	<p>Air pollution can result from both human and natural actions. Natural Sources include forest fires, volcanic eruptions, wind erosion, pollen dispersal, evaporation of organic compounds, sea salt, deserts and natural radioactivity.</p> <p>Human activities that result in air pollution include:</p> <ol style="list-style-type: none"> 1. Emissions from industries and manufacturing activities. To generate electricity, fuels such as coal, gas or oil are burned at power stations. When these fuels are burnt, they release nitrogen oxides, sulphur dioxide and particulate matter as well as greenhouse gases which can cause climate change. 2. Burning fossil fuels for transportation fuel. After the industrial age, transportation has become a key part of our lives. Cars and heavy-duty trucks, trains, shipping vessels and airplanes all burn lots of fossils fuels to work. Fumes from car exhausts contain dangerous gases such as carbon monoxide, oxides of nitrogen, hydrocarbons and particulates. On their own, they cause great harm to people who breathe them. Additionally, they react with environmental gases to create further toxic gases. 3. Agriculture. Animals like cows and sheep release a massive amount of methane through belching and breaking wind. Across the whole world, livestock is the biggest source of methane. After carbon dioxide, methane is the greenhouse gas which contributes most to climate change. 4. Waste. In the UK, methane emitted from waste disposal is the largest emitter with agriculture and livestock coming second. Methane is released into the atmosphere when the waste that we throw away decomposes. After carbon dioxide, methane is the greenhouse gas which contributes most to climate change. <p>In Scotland, Nitrogen Dioxide and Fine Particles from vehicles are a big problem in many towns and cities.</p>

Information on Air Quality to help aid discussion in tasks

Question	Answer
What are the effects of air pollution?	<ol style="list-style-type: none"> 1. Health impacts. Air pollution at very high levels can have negative health impacts. It is estimated that you breathe 20,000 litres of air each day, meaning the more polluted the air is, the more dangerous chemicals we breathe into our lungs. Depending on the level of exposure and the type of pollutant inhaled, health effects can vary, ranging from simple symptoms like coughing and the irritation of the respiratory tract to acute conditions like asthma and chronic lung diseases. 2. Acid rain. Sometimes when an air pollutant, such as sulphuric acid combines with the water droplets that make up clouds, the water droplets become acidic, forming acid rain. When acid rain falls over an area, it can kill trees and harm animals, fish, and other wildlife. 3. Eutrophication. Rain can carry and deposit the nitrogen in some pollutants on rivers and soils. This will negatively affect the nutrients in the soil and water bodies. This can result in algae growth in lakes and water bodies, and make conditions for other living organisms harmful
How can we make our air cleaner?	<ol style="list-style-type: none"> 1. Travel to School Walk, cycle or scooter to school – it is good exercise and can reduce air pollution Use public transport – take the bus or train instead of the car if you can If you have to travel to school by car, try car-sharing with other friends 2. No idling If you have to be picked up by car, tell your parents not to leave the engine on while they wait for you. This is called 'idling' and it is a big cause of air pollution around schools. It is also illegal in Scotland. Turning off the engine could reduce air pollution and also save your parents money. 3. Spread the word Discuss air quality issues with your teachers, friends, and family Make sure everyone you know is aware of the dangers of air pollution 4. Simple actions at home Energy saving actions such as: switch on equipment only when needed, set the thermostat at the lowest comfortable temperature, turn off the lights in rooms you are not using.

Main resource - Children and Air Quality website for Scotland <http://children.scottishairquality.scot/>

Other useful resources:

- 3 minute video on the impacts of air pollution <http://www.londonair.org.uk/LondonAir/guide/Soundslides/HealthEffects/HealthEffectsVideo.aspx>
- Further reading: Introduction to air pollution: <http://eschooltoday.com/pollution/air-pollution/what-is-air-pollution.html>
- DEFRA UK-AIR – air quality forecasts, current pollution levels and related news and information: <https://uk-air.defra.gov.uk/>

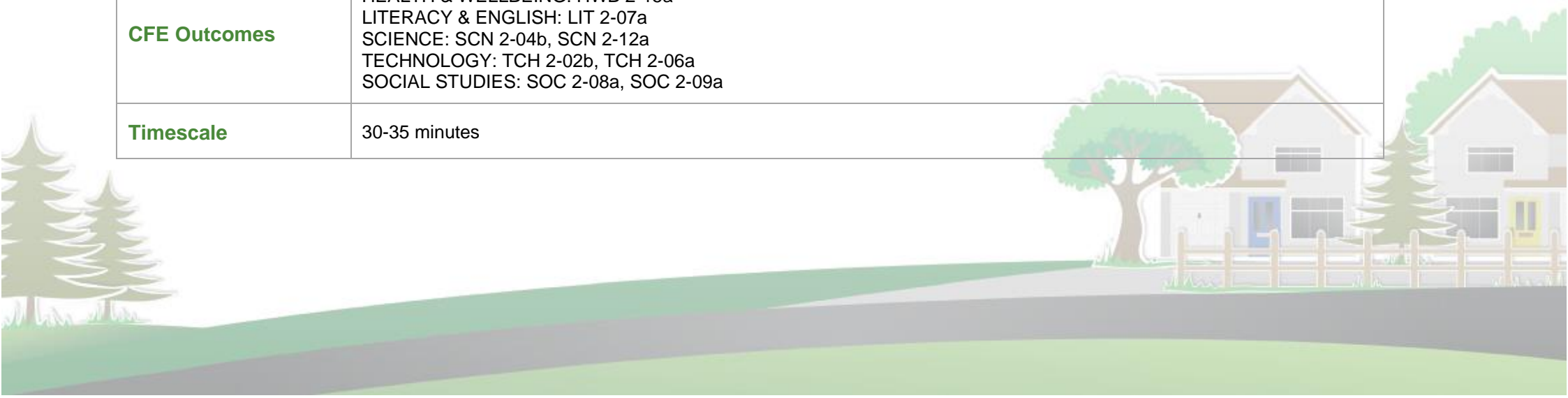
The Open Air Laboratories (OPAL) Network – Kids Zone with quizzes, activity sheets and games: <https://www.opalexplornature.org/kidszone>

Task 1

Introducing Air Quality and planning an investigation

Take a small group out on to a safe area outside of the school (pavement if necessary). It is most useful for pupils to experience real life situations by taking them on to pavements alongside roads around the school, but it may not always be possible to do this due to road conditions or pupil ratios. Creating pavements and roads with cones of chalk within the playground is an alternative.

Guidance Notes	
Activity	In Class introduction and discussion.
Description	Pupils will learn what air pollution is, what causes it, how it affects us and what we can do to make our air cleaner. Pupils will also learn how to make predictions, ask scientific questions, plan how to answer their questions, use large-scale maps and research and discuss topical issues.
Age	Level 2
Equipment	Air pollution lesson sheet; a big large-scale map of the school and surrounding area; A4 copies of maps showing the same area; red and green sticky dots; pens and paper.
CFE Outcomes	HEALTH & WELLBEING: HWB 2-15a LITERACY & ENGLISH: LIT 2-07a SCIENCE: SCN 2-04b, SCN 2-12a TECHNOLOGY: TCH 2-02b, TCH 2-06a SOCIAL STUDIES: SOC 2-08a, SOC 2-09a
Timescale	30-35 minutes



Task 1

Introducing Air Quality and planning an investigation

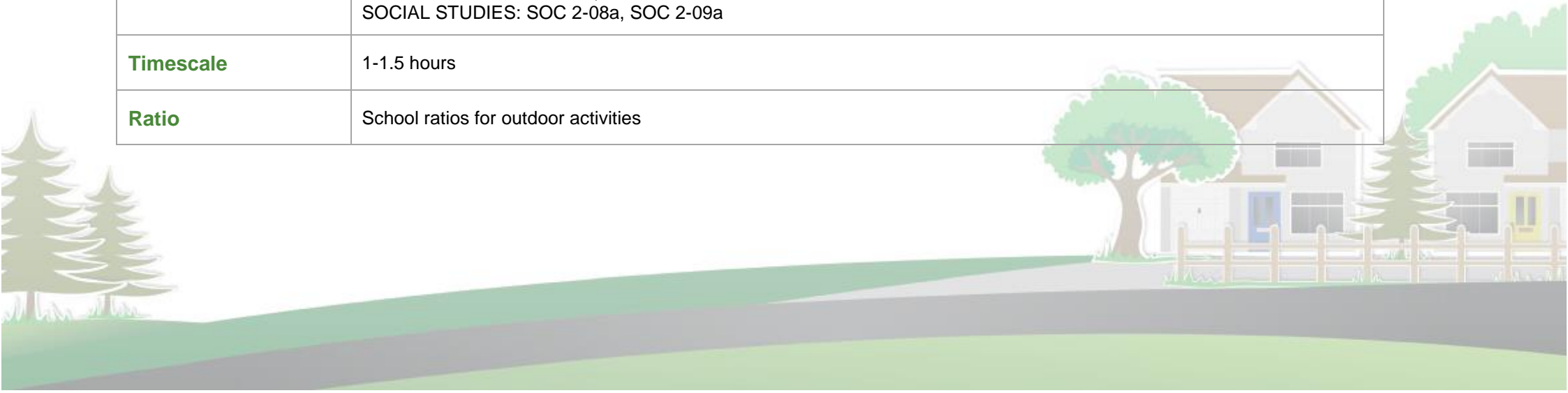
Take a small group out on to a safe area outside of the school (pavement if necessary). It is most useful for pupils to experience real life situations by taking them on to pavements alongside roads around the school, but it may not always be possible to do this due to road conditions or pupil ratios. Creating pavements and roads with cones of chalk within the playground is an alternative.

Instructions	
a)	<p>Introduce the topic of air pollution (using the air pollution lesson sheet and the introduction to air pollution section) - as a class, explore what air pollution is, types of pollution, what causes pollution and what are the effects.</p> <p>Ask pupils:</p> <ul style="list-style-type: none">How they think air quality might be different on a busy road and in a quiet area away from traffic;To turn their predictions into a scientific question that can be investigated; andHow they think they could find an answer to their question. <p>Types of pollution online activity: http://www.learnaboutair.com/primary/pollutants.html</p> <p>Causes of pollution online activity: http://children.scottishairquality.scot/crime-scene</p>
b)	<p>Tell pupils some examples of the ways air quality can be measured:</p> <ul style="list-style-type: none">Lichen Bio-Indicator Study – identification of different types of lichen on trees and other surfaces;Diffusion Tube Samples – diffusion tubes used to measure the level of harmful nitrogen dioxide in the airGhost Wipes – measure the amount of heavy metals in air-borne particulate pollutants that collect on surfaces;Surface Wipe Analysis sticky tape or cotton wool is used to sample the particulate matter that is deposited on surface
c)	<p>Tell pupils that they will be using an Air Quality Measurement Device in the next lesson (Task 2). These are used to easily identify Fine Particles in the air – PM10 and PM 2.5, and provide an immediate result displayed in the device's screen. Check understanding of Fine Particles with the class - microscopic solid or liquid matter suspended in the air. Ambient particulate matter is responsible for harmful effects on health, in particular the respiratory system.</p>
d)	<p>Group Activity: Organise pupils into groups of 4 or 5 and provide each group with an A4 map of the area and some red and green sticky dots. Pupils should discuss in their groups where they think the air will be most polluted and why, and they should mark these locations on the map with the red dots. They should then discuss where they think the air will be cleanest and mark these on the map with the green dots.</p>
e)	<p>Ask one group to tell the class one of the places where they thought the air would be most polluted and why. Do the other groups agree? Mark this place with a red dot on the large map displayed at the front of the class. Then ask the next group to say a different place and repeat the process until all the most polluted places have been marked. Now do the same with the least polluted places. Mark these with green dots. As a class, select 3 locations that pupils can visit during the investigation. Ensure that these locations are varied e.g. school, road or busy main street and a park or green area. Give each site a name and number so that data can easily be referenced back to the map. If it's not possible to leave the school, try to pick areas with some variety within the school grounds.</p>

Task 2

Investigating into Air Quality

Guidance Notes	
Activity	On street activity gathering data on air quality levels.
Description	Pupils will learn to collect scientific evidence that will be used to identify concentrations of Fine Particulates in the air. Pupils will learn to use scientific equipment, carry out fieldwork investigations and make a labelled field sketch.
Age	Level 2
Equipment	Air Quality Measurement Devices, Activity Sheet, Record Form, pencils.
CFE Outcomes	HEALTH & WELLBEING: HWB 2-15a LITERACY & ENGLISH: LIT 2-07a SCIENCE: SCN 2 04b, SCN 2 12a TECHNOLOGY: TCH 2-02b, TCH 2-06a SOCIAL STUDIES: SOC 2-08a, SOC 2-09a
Timescale	1-1.5 hours
Ratio	School ratios for outdoor activities



Task 2

Investigating into Air Quality

Instructions

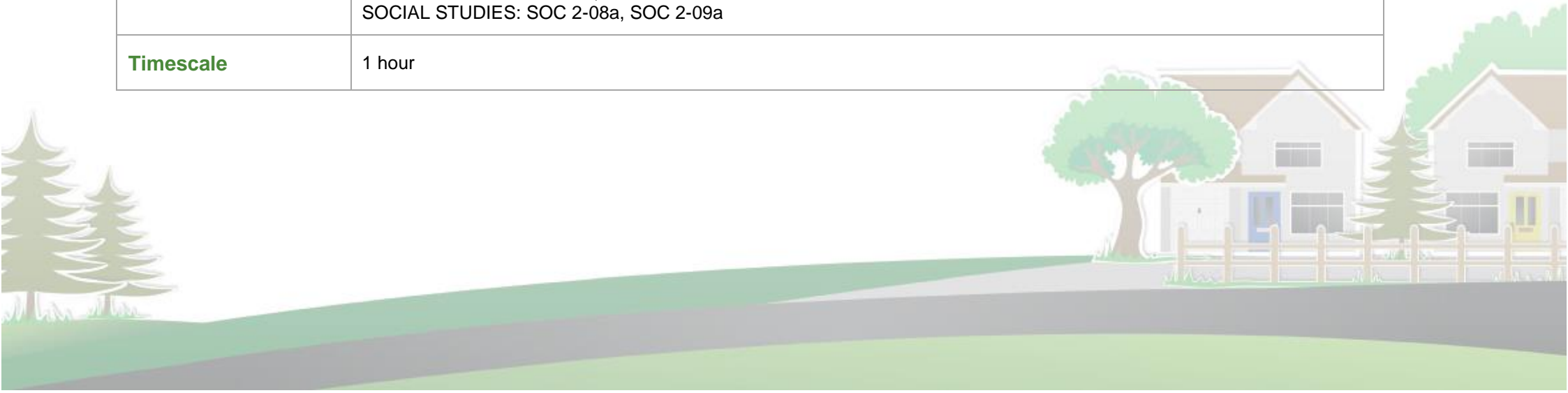
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|----|---|
| a) | As a class attend each of the 3 selected sites to conduct your Air Quality assessments. Each pupil takes the Air Quality Measurement Device and writes down the values on the screen for both PM10 and PM 2.5 on the Record Form. |
| b) | If there is sufficient time to do so, pupils could complete a labelled sketch of the place or places where they carry out their data gathering. |



Task 3

Analysing the Data

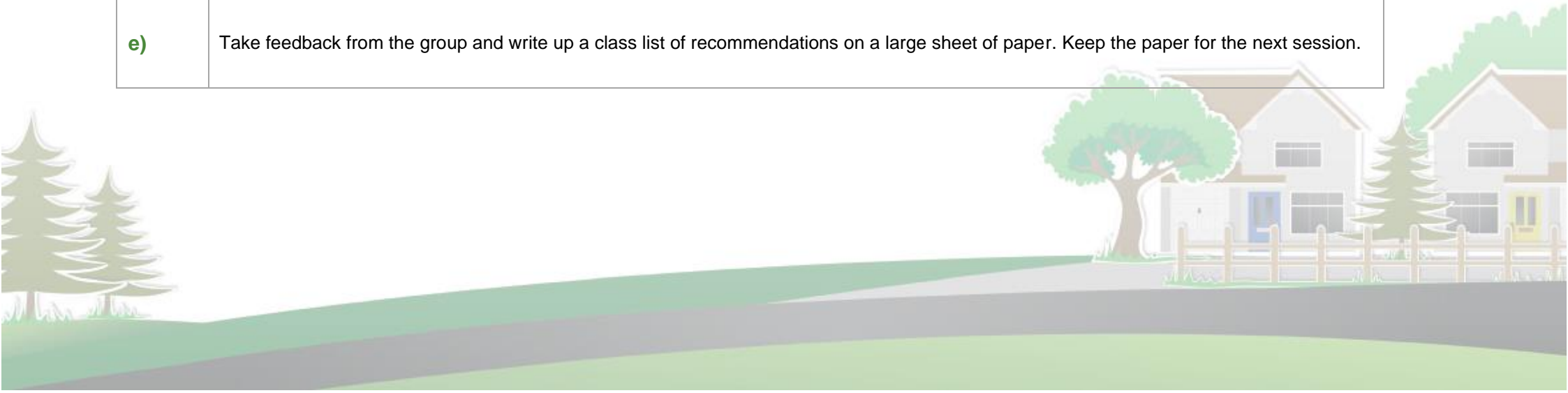
Guidance Notes	
Activity	On street activity gathering data on air quality levels.
Description	Pupils will learn to collect scientific evidence that will be used to identify concentrations of harmful Fine Particulates in the air. Pupils will learn to use scientific equipment, carry out fieldwork investigations and make a labelled field sketch.
Age	Level 2
Equipment	Air Quality Measurement Devices, Activity Sheet, Record Form, pencils
CFE Outcomes	HEALTH & WELLBEING: HWB 2-14a MATHEMATICS: MTH 2-21a SCIENCE: SCN 2-04b, SCN 2-12a TECHNOLOGY: TCH 2-02b, TCH 2-06a SOCIAL STUDIES: SOC 2-08a, SOC 2-09a
Timescale	1 hour



Task 3

Analysing the Data

Instructions	
a)	Discuss results as a class. What are they?
b)	Discuss the impact of these results. In what kinds of places is the air most polluted? Did the evidence confirm or contradict their predictions? Did anything surprise them? What do they think happens when people breathe in air in the most polluted places? What could be done to reduce the amount of pollution in the air? What could they do to limit their exposure to air pollution
c)	As a class, decide on the best way to present the data (e.g. bar graph, line graph etc.). This could then be done as a class, group or individual activity
d)	In groups of 4 or 5, ask pupils to make a list of recommendations based on their findings. These could be long term (e.g. reduce traffic, promote electric cars, redesign engines to use less petrol), medium term (e.g. campaign to reduce idling outside school gates, develop a school travel plan), or short term (e.g. take a different route to school).
e)	Take feedback from the group and write up a class list of recommendations on a large sheet of paper. Keep the paper for the next session.



Task 4

Action Planning

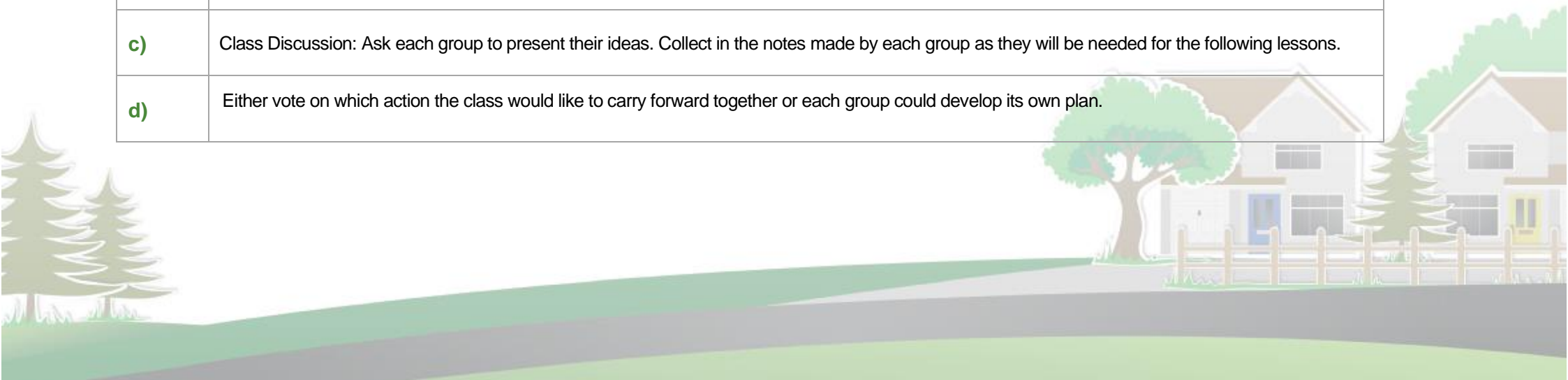
Guidance Notes	
Description	Pupils will learn how decisions and actions can affect the quality of people's lives, different ways in which people can improve their environment, how to present a persuasive argument and to make real choices and decisions.
Age	
Equipment	Class list of recommendations from session; scrap and one previous paper pencils – one per group.
CFE Outcomes	HEALTH & WELLBEING: HWB 2-15a SCIENCE SCN 2-04b, SCN 2-12a TECHNOLOGY: TCH 2-02b, TCH 2-06a SOCIAL STUDIES: SOC 2-08a, SOC 2-09a LITERACY: LIT 2-29a
Timescale	1 hour



Task 4

Action Planning

Instructions	
a)	As a class, read through the list of recommendations from the last session.
b)	<p>In groups of 4 or 5, pupils should discuss the 4 points below and one person in each group should note down the group decisions:</p> <ol style="list-style-type: none">1. Decide on one recommendation that they would like to take action on.2. Discuss what would be the best way to take action for example<ul style="list-style-type: none">- Influence someone in a position of power (e.g. an MSP or Local Councillor or Council Officer) by writing a letter or inviting them into school to respond to questions- Influence their parents or local people by designing a leaflet, putting on a play, or sharing their site visit findings in the school newsletter- Take action as a school by developing a school travel plan, running a campaign to encourage more walking/ cycling- Inform other pupils through an assembly presentation, designing posters, or by promoting quieter walking and cycling routes3. Think about the most effective way to influence others by:<ul style="list-style-type: none">- Deciding on the message they want to get across- Deciding who they want to share their message with- Thinking about what will appeal to this group of people – would the audience respond best to facts, stories, pictures etc.?4. Decide how they would know whether their action has been successful
c)	Class Discussion: Ask each group to present their ideas. Collect in the notes made by each group as they will be needed for the following lessons.
d)	Either vote on which action the class would like to carry forward together or each group could develop its own plan.



Task 5

Taking Action

Guidance Notes	
Description	Notes from Lesson 4; other resources will depend on the actions / methods chosen during the lesson.
Age	
Equipment	Notes from Lesson 4; other resources will depend on the actions / methods chosen during the lesson.
CFE Outcomes	EXPRESSIVE ARTS: EXA 2-01a, EXA 2-05a
Timescale	Flexible – approximately 1.5 hours

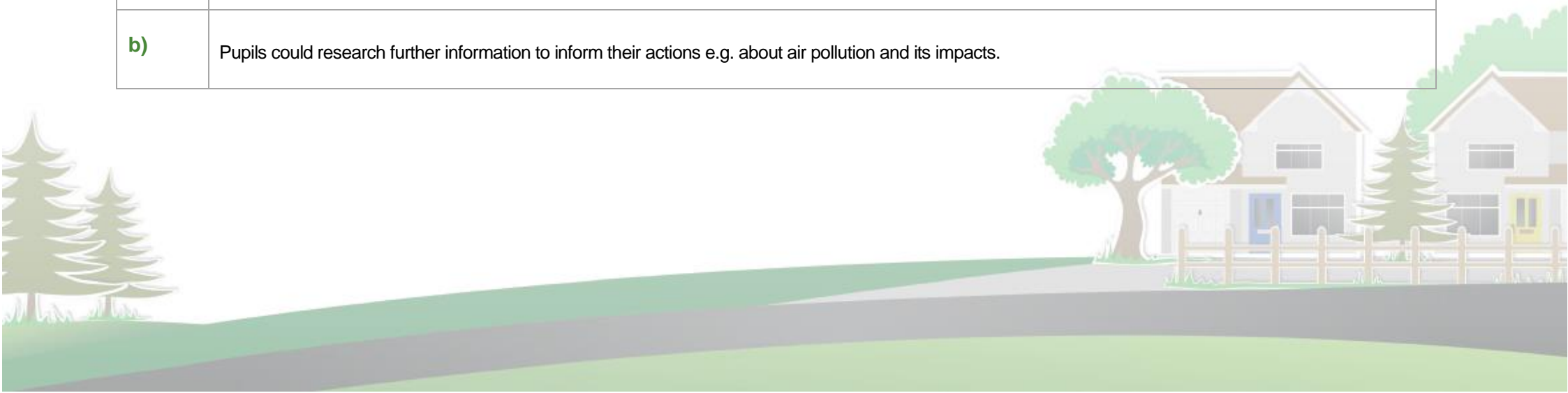


Task 5

Taking Action

Instructions

a)	<p>As individuals or in groups, proceed with the chosen method of 'taking action'. Ideas include:</p> <p>Letter Writing: Pupils could write a letter to influence someone in a position of power or to invite them into school to respond to questions.</p> <p>Leaflet Design: Pupils could design a leaflet to inform parents and local people about air quality issues.</p> <p>School gate banner design: Pupils could design a school gate banner to display messages around vehicle idling to parents and carers. Use a local print shop to get it printed in hardwearing material.</p> <p>Putting on a Play: Pupils could make up a play to inform fellow pupils, parents and members of the community about air quality issues.</p> <p>Poster Design: Pupils could design posters that can be displayed throughout the school to inform other pupils and parents about air quality issues.</p> <p>School Newsletter: Pupils could share the findings of their air quality investigation in the school newsletter.</p> <p>Assembly: Pupils could write and deliver a presentation for assembly.</p> <p>Moth Competition: Pupils could draw and cut out a big black moth. Each member of the class can make an air quality pledge (e.g. to walk or cycle to school). Each morning the class can put a white dot on the black moth if they have done their pledge until the black moth is covered in white dots, symbolising less pollution (N.B. there is an accompanying story and activity sheet to go with this activity).</p> <p>Badge/ Banner Competition: Pupils can compete to design badges/ banner which best represent their understanding of air quality. The winning badge could be made into design for air quality champions to wear. Banners displayed at school gate.</p>
b)	<p>Pupils could research further information to inform their actions e.g. about air pollution and its impacts.</p>



Task 6

Evaluating Success

Guidance Notes	
Description	Pupils will learn how to evaluate the effectiveness of their chosen actions and identify what they need to do next to achieve their aims.
Age	
Equipment	Notes from Lesson 4; pencils, scrap paper.
CFE Outcomes	LITERACY AND ENGLISH: LIT 2-23a
Timescale	45 min – 1 hour



Task 6

Evaluating Success

Instructions	
a)	After the actions have been completed, discuss with the class: <ul style="list-style-type: none">- Do they think their actions have achieved their aims?- How do they know?- How could they find evidence that their actions worked?
b)	As a class, look at the suggestions that groups made during Lesson 4 and discuss these.
c)	Evaluating success will depend on the action taken. Examples include: <ul style="list-style-type: none">- Survey pupils to see if any more are walking, cycling, scooting or travelling to school by park & stride.- Survey routes of travel to school to see if more pupils are using walking and cycling routes to avoid air pollution hotspots.- Consider the kinds of responses they have had from parents, the local community or other pupils to an article or leaflet.- Re-measure air quality outside the school gate after discouraging idling cars and encouraging more pupils to travel actively to school.
d)	Once they have evaluated the effectiveness of their actions, they should: <ul style="list-style-type: none">- Decide how best to publicise results to the target audience.- Plan the next steps.

For further information, please contact Aberdeenshire Council

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Air Pollution Lesson Activity Sheet

What is air pollution?

Air pollution is anything that causes the air to become contaminated with pollutants at levels harmful to our health or the environment.



What makes air dirty?

Generally, air pollution comes from the burning of fossil fuels such as coal, oil, natural gas, petrol or diesel. This happens when we use energy supplies to do everyday activities, such as cooking or washing at home and travelling by cars.



London has suffered from air pollution since the beginning of the Industrial Revolution in the 18th century. Smoke and fog together create 'smog' which makes it really hard to breathe and see clearly. More than 4000 people died in the Great London Smog in 1952! Industrial processes and domestic heating were the main contributors to air pollution in London until the 1970s.

Air pollution today

Today, when we think of air pollution, we should think of transport, especially cars. Today there are about 23 million vehicles on the road in Britain, and 20 million of them are cars! The fuel they use - petrol and diesel - cause bad gases to be ejected from the exhaust. These gases can be very dangerous for children.



Health Alert- how does air pollution affect you?

Air pollution is known to cause breathing problems, lung and heart diseases, such as asthma. Children are particularly at risk, as your bodies are less resilient and the pollutants have a more concentrated effect. Air pollution can:

- Affect your immune system, so that you can catch infections more easily.
- Make you cough, splutter, wheeze, sneeze, dizzy and it can make your eyes itch.
- Give you green snot, and more boogies than your nostrils have space for.
- Pollution can be blamed for an estimated 200 premature deaths in the capital each year. An additional 1,200 or so serious health incidents requiring hospital admission can be attributed to pollution.



What are the pollutants?

Most pollutants are much too small to see without a microscope, but they still get into our lungs and affect our health. The main nasty pollutants in the UK are O_3 , SO_2 , NO_2 , $PM_{2.5}$ and PM_{10} . The most severe pollutants NO_2 and Particulates including:

- NO_2 (Nitrogen oxides) - NO_2 also contributes to acid rain, which damages trees and the stone on buildings. You can see the effect of NO_2 on a hot day in summer, when it combines with other chemicals to make the sky look heavy and brownish grey.
- Fine Particulates (particulate matter, PM) - tiny particles of dust and soot that are released into the air. When you breathe them in, they settle in the lower parts of your lungs. There are natural sources of particulates, however usually the largest source of PM_{10} is road traffic. Lorries and diesel vehicles produce the most particulates in cities.

Air Quality Record Form

School: _____ Date: _____ Weather: _____

Participants: _____

[illegible]

Everyone can help make our air cleaner!

Actions CHILDREN can take

■ Travel to school

- ✓ Walk, cycle or scooter to school! It is good exercise and can reduce air pollution.
- ✓ Use public transport: take the bus, tube or train instead of the car.
- ✓ If you have to travel to school by car, try car-sharing with other friends.



■ No idling

- ✓ If you have to be picked up by car, tell your parents not to leave the engine on while they wait for you. This is called 'idling' and it is a big cause of air pollution around schools. Turning off the engine could reduce air pollution and also save your parents' money.
- ✓ You can design signs and posters to tell people 'no idling' around your school.



■ Spread the word!

- ✓ Discuss air quality issues with your teachers, friends and family.
- ✓ Make sure everyone you know is aware of the dangers of air pollution.

■ Simple actions at home!

- ✓ Energy saving actions: such as switch on equipment only when needed, set the thermostat at the lowest comfortable temperature within an average of 18°C and 21°C. These simple actions can reduce CO₂ emitted which contribute to air pollution.

Actions PARENTS & TEACHERS can take

■ Promote sustainable travel

- ✓ Encourage your children and their friends to walk and cycle.
- ✓ Encourage friends and family to walk and cycle or car-share.
- ✓ Reduce the amount your family uses the car.
- ✓ Discuss air quality issues with your school, friends and family.



■ If you must drive

- ✓ Fully inflate car tyres so your car uses less petrol.
- ✓ Switch the engine off while waiting for your child after school.
- ✓ Ensure that you have your vehicle serviced at regular intervals.
- ✓ Try to use your car less frequently to reduce pollution, particularly for journeys under 2km.
- ✓ Don't start your engine until you're ready to travel. Turn the engine off if you are waiting or stuck in a traffic jam.
- ✓ Avoid rapid acceleration and heavy braking: they both increase fuel consumption and air pollution.
- ✓ Stay within the speed limit: you use 30% more fuel to travel the same distance at 70mph instead of 50mph.



Bioindicators Activity 1

Peppered Moth

Air pollution affects not only people but also plants and animals. The Peppered Moth is a good example that students can learn air quality and air pollution!

The Peppered Moth

The Peppered Moth is widespread in Britain and Ireland and is frequently found in back gardens. It is one of the best-known examples of evolution by natural selection, Darwin's great discovery, and is often referred to as 'Darwin's moth'.

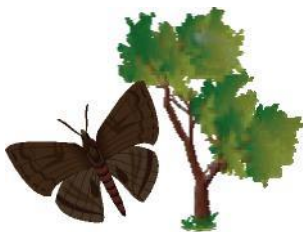


The Peppered Moth and Air Pollution

Peppered Moths are normally white with black speckles across the wings, giving it its name. Originally, the peppered moths wing colours camouflaged them against the light-coloured trees and lichens that they rested on.

However, in the nineteenth century, during the Industrial Revolution in England, widespread pollution killed off lichens and blackened urban tree trunks and walls. Therefore, the normal, pale, speckled forms of the Peppered Moth were no longer camouflaged from predators on the soot-blackened trees. Black Peppered Moths thrived in these situations and the normal pale form became rare. Over successive generations, the black moths came to outnumber the pale forms in our towns and cities.

In the mid-twentieth century controls were introduced to reduce air pollution and as the air quality improved tree trunks became cleaner and lichen growth increased. As pollution has been greatly reduced, the balance swung back the other way.



Peppered Moth Activities

- Key Message: White peppered moths indicate less pollution, better air quality
- The peppered moth story: Tell students about the story, including the relationship between the moth and air quality, its evolution in UK history.
- Observation: Ask pupils if they have seen peppered moths before? What colour are they? Encourage pupils to observe moths in school, gardens, parks, and other places they visit.
- Moth competition: It can be an activity to promote sustainable travel. Get your class to draw and cut out a big black moth. Each member of the class can make an air quality pledge, eg to walk or cycle to school. Each morning the class can put a white dot on the black moth if they have done their pledge until covered in white dots. It can be competition between classes in your school, or between groups in one class.

Bioindicators Activity 2

Tar Spot on Sycamore

Sycamore tree (*Acer pseudoplatanus*) is native to central, eastern and southern Europe. It is thought to have been introduced to the United Kingdom by the Romans around the 1500s. More widespread planting occurred in the 1700s and the earliest reports of the species naturalising in the United Kingdom date from the mid-1800s. The seed is extremely fertile, so sycamore has spread quickly across the UK and colonised many woodlands to the detriment of native species.



You may have seen 'tar spots' on the leaves of sycamore trees. These are caused by the parasitic fungus *Rhytisma acerinum*. The fungus is widely distributed across the United Kingdom; fungal spores spend the winter in dead leaves on the ground and infect the tree's new leaves in late spring. After infection the disease develops into large, easily identified black spots ('tar spots'), up to 15 mm wide, in July and August.

Many factors affect the performance of fungi, including climate and air pollution. Studies have shown that tar spot fungus is reduced by sulphur dioxide and oxides of nitrogen. This means that where there are more tar spots, it is likely that the levels of these pollutants will be lower.

1 Site characteristics

Choose 2–4 sycamore trees. There is no need to remove any of the leaves. Either choose leaves still attached to the tree or collect fallen leaves from under the tree.

2 Record leaf information

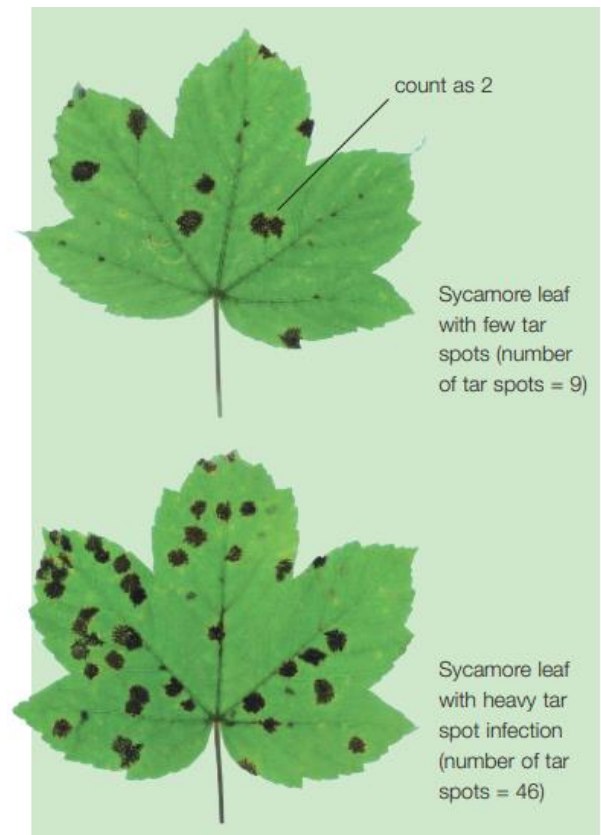
Choose 10 leaves randomly from each tree.

Record for each leaf the number of tar spots, including any partial (not full) spots

3 Discussion

Can you make any assumptions related to air quality in the area?

You can repeat this exercise in other areas and compare the amount of tar spots.



Bioindicators Activity 3

Lichens

Lichens

Lichens have long been known to be sensitive indicators of air quality. They were used in the past to map areas affected by sulphur dioxide pollution from industrial and domestic sources. Today, lichens occur widely in our towns, cities and countryside, on a diverse range of surfaces from concrete pavements to park and woodland trees.



Lichens as bioindicators

Lichen monitoring is an easy way to observe the level of air pollution in your surrounding area, simply by identifying types of lichens that are present. This provides a basic idea of the extent of air pollution in your area, by identifying the presence of lichens which are sensitive to nitrogen and those which flourish in environments with high nitrogen level.

How to use it:

See the lichen identification guide and monitoring sheets for information on how to conduct your study. Lichen monitoring can be carried out as part of a lesson activity in and directly around the school or as an activity by those walking to and from school. This will help to identify levels of air pollution not just at the school site itself, but also along the primary travel routes to and from the school. As some lichens change colour in the rain, this activity is ideally carried out when the weather is dry.

Indicator lichens we are looking for

We have selected nine lichens that can be used as indicators of local air quality. We know that some lichens are sensitive to nitrogen in the form of ammonia or nitrogen oxides (so called 'nitrogen-sensitive' lichens), and that they are unable to survive in areas with high levels of these pollutants. Others thrive with increased levels of nitrogen compounds ('nitrogen-loving' lichens), and yet others (intermediates) can be found in both clean and polluted conditions.

Lichens on trees

Lichens on trees will vary with bark type and the age of the bark, as well as with air quality and climate. Lichens on the trunks of older trees may have been there for many years, while young trees or twigs may support lichens that have recently colonised new bark. We would like to find out if the lichens on the trunk (the oldest part of the tree) are different from the lichens on the twigs (youngest part of the tree). Do trunks or twigs have more pollution-sensitive indicator species?

Bioindicators Activity 3

Lichens

1 Site characteristics

First choose your site. Look for a site with deciduous trees and lots of light. We suggest oak, ash or sycamore. Avoid evergreen trees and trees which are heavily shaded (e.g. beech and horse chestnut) or covered in ivy. If sampling in woodland, use trees at the edge rather than the centre. Choose 2–4 trees of the same type if possible.

2 Tree characteristics

Record for each tree:

- the type (species) of tree, or answer 'unknown' if you are not sure
- the girth of the trunk at 1 m above the ground

3 Record indicator lichens on the trunk

Choose the side of the trunk with the most lichens. Focus just on the lichens at 50–200 cm above ground level.

Although there may be many different types of lichen growing on the trunk, we are only interested in the nine indicator lichens shown in the photographs.

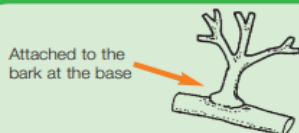
4 Record indicator lichens on twigs

Can you reach the twigs? If so, check if any of the indicator lichens are present. Don't spend more than 5 minutes looking. Take care to avoid twigs in the eye!

Avoid dead or fallen twigs

Only record from twigs under 2 cm in diameter up to a length of 1 m

The nine types of lichen shown in the photographs are all bushy or leafy



Bushy lichen

Branched and shrub-like, attached to the bark at the base



Leafy lichen

Leaf-like lobes closely or loosely attached to the bark from the lower surface



Crusty lichen

Closely attached as if pressed on the bark. Crusty lichens are difficult to identify, so are not included in this survey, but you can find pictures of some on the OPAL and iSpot websites

Can you find any of these lichens?

Look for the nine lichens in the photographs

Nitrogen-sensitive lichens are outlined in **blue**

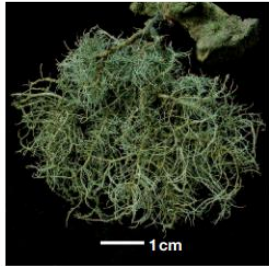
Nitrogen-loving lichens are outlined in **red**

Intermediate lichens can be found in clean and polluted conditions and are outlined in **grey**

Bioindicators Activity 3 - Guide to indicator Lichens

Nitrogen-sensitive

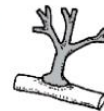
1. *Usnea*



- branches thread-like
- grey-green all round

Nitrogen-sensitive

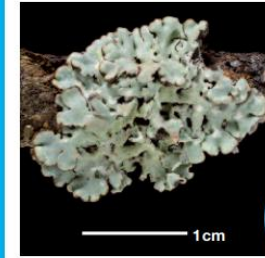
2. *Evernia*



- lobes flattened, strap-like
- grey-green on top, white below

Nitrogen-sensitive

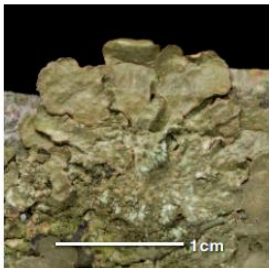
3. *Hypogymnia*



- lobes greyish on top, pale brown below
- lobe ends often become powdery
- lobes puffed up and hollow

Intermediate

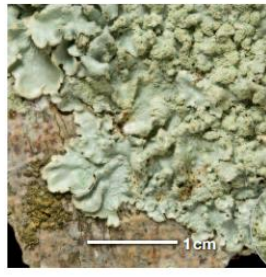
4. *Melanelixia*



- dull brown lobes, closely attached to the bark
- paler areas show when surface is rubbed

Intermediate

5. *Flavoparmelia*



- broad, apple-green lobes
- wrinkled surface on which powdery spots may develop

Intermediate

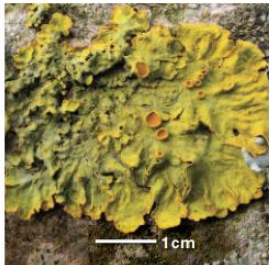
6. *Parmelia*



- lobes thin, loosely attached to the bark
- lobes grey on top, dark brown below
- pattern of white lines on the surface

Nitrogen-loving

7. *Leafy Xanthoria*



- lobes broad and spreading
- lobes yellow/orange to greenish yellow
- orange fruiting bodies often present

Nitrogen-loving

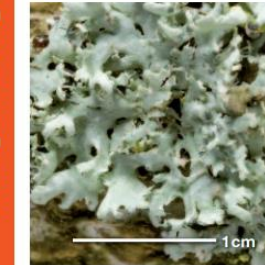
8. *Cushion Xanthoria*



- lobes small and clustered
- lobes yellow to green-grey
- orange fruiting bodies usually present

Nitrogen-loving

9. *Physcia*



- lobes grey on top, whitish below
- lobe ends raised up becoming powdery
- black-tipped whiskers on the lobe edges

Carbon Dioxide

A colourless, odourless gas, that occurs naturally in the environment. It's the main ingredient in photosynthesis, the process plants use to make food and energy

Carbon Dioxide (CO₂) also comes from man made sources, like industry, transport and deforestation. Man made sources are the biggest producer of CO₂.

CO₂ is considered to be the main greenhouse gas, with levels increasing drastically over the past 50 years. Anything that burns fossil fuels, has a CO₂ ticket attached to it.

There are two reasons for the drastic increase:

- The number of products emitting CO₂
- When CO₂ is released into the atmosphere, it can stay in the atmosphere for decades, and sometimes even up to centuries.

Carbon Dioxide and Global Warming are closely link

- Carbon dioxide traps radiation at ground level, creating ground level ozone – this prevents the earth from cooling at night
- One result of this is the warming of the oceans – oceans absorb carbon dioxide from the atmosphere, with the warmer sea temperatures, this effects the oceans abilities to absorb carbon dioxide.
- This creates a cycle



Activity 1

Working in pairs

Draw the cycle of Carbon Dioxide emissions

Explain this to your class

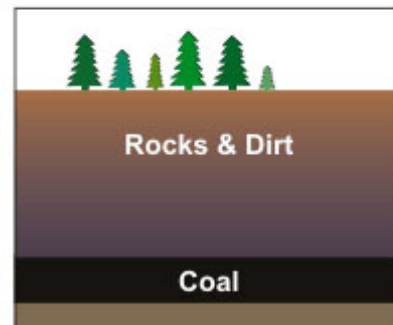
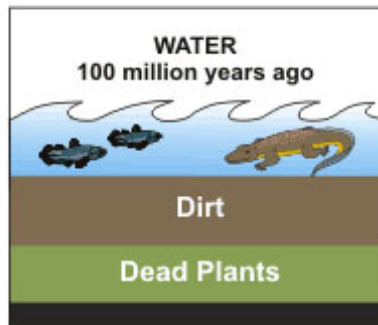
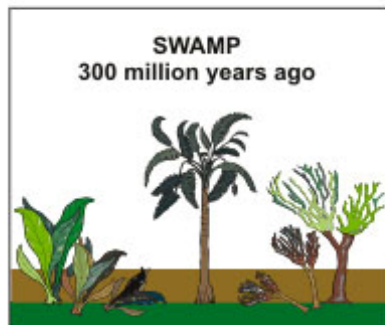
Activity 2

What makes Carbon Dioxide emissions so bad for the environment

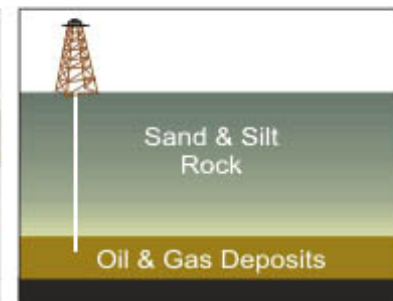
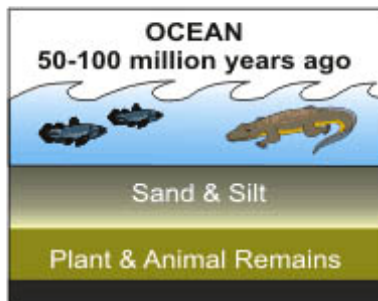
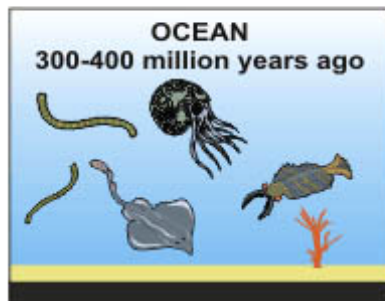
Fossil Fuels

Fossil fuel is the name given to fuel which is formed deep under ground. It comes from decayed plants and animals that have turned into oil, gas, or coal over hundreds of years

HOW COAL WAS FORMED



PETROLEUM & NATURAL GAS FORMATION



Both cases dead plants and animals are buried over time and the extreme heat and pressure, from the Earth, turn these dead organisms into either coal, gas or oil

We depend on fossil fuels to heat our homes, run our cars, power industry and provide us with electricity

All Fossil fuels emit Carbon Dioxide (CO_2) which is the main greenhouse gas responsible for climate change

Activity

Ask the pupils to think of everything that uses fossil fuels. You can help by giving clues by acting sources out

Once you have completed this, ask the pupils to think about everything they use that is a source of fossil fuels.

Carbon Footprint - give hand out of foot.

For every day you travel to school using a source of fossil fuel - colour a toe in red.

If you use a sustainable mode, colour green

Activity

Making a model of how fossil fuels were created

Materials

Clear test tubes

Different material (rocks, plants)

Soil

Give each pupil a test tube to make a model of how fossil fuels were formed. Ask pupils to describe their model

Activity

Make a detailed picture of how each type of fossil fuel was formed – noting the different environment they were created in, but also the similarities

Materials

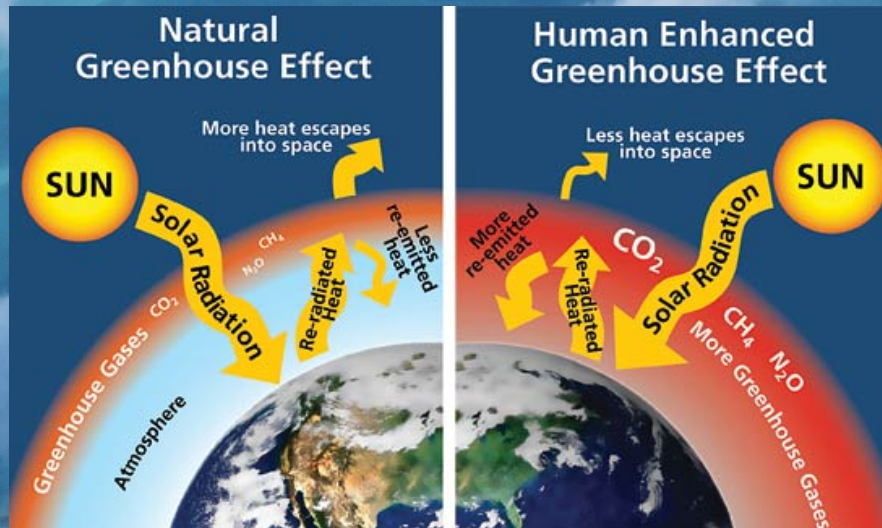
Coloured pens

Paper

Basic art supplies

Greenhouse Gases

Greenhouse gases are gases that let sunlight pass through the atmosphere, but they prevent the heat, that sunlight brings, from leaving the atmosphere - just like a greenhouse would, which is where they got their name from



The Greenhouse gas that causes most harm is Carbon Dioxide (CO₂)

- There are so many sources giving off CO₂, meaning there is just a lot of CO₂ being released into the atmosphere
- Once it's been released, it's hard to get rid of, it stays in the atmosphere for thousands of years

How are they formed?

Greenhouse gases do happen naturally; for example, humans, plants and animals breathe out CO₂

We need some naturally occurring sources of greenhouse gas, without it, all the heat would leave the Earth and it would be far too cold for life to exist. We have a problem because humans have been pumping too many greenhouse gases into the atmosphere. Along with the already naturally occurring sources, this means there is so much greenhouse gas now, keeping too much heat in the atmosphere, which is making the earth too hot.

The main source of greenhouse gases is from human activity - burning of Fossil Fuels.

An aerial photograph of a tropical atoll, showing a series of small islands with white sand beaches and lush green vegetation, surrounded by shallow turquoise water with visible sandbars and deeper blue water further out. The sky is filled with soft, white clouds.

Activity 1

Creating the Greenhouse Effect in the classroom

Materials

Two bowls

Two thermometers

Cling film

Sunlight

Fill two bowls with cold water, place the thermometer in each bowl. Cover up one bowl with cling film. Leave the other bowl uncovered. Place both bowls in direct sunlight for the duration of the class.

Note down each temperature at the end of the class.

Activity 2

In groups discuss the relationships between Global Warming and Air Pollution and how it affects the Earth and all living things

Activity 3

Create an art piece, detailing how Global Warming affects the Earth and all living things

Particulate Matter

This is the term given to solid particles and liquid droplets found in the atmosphere

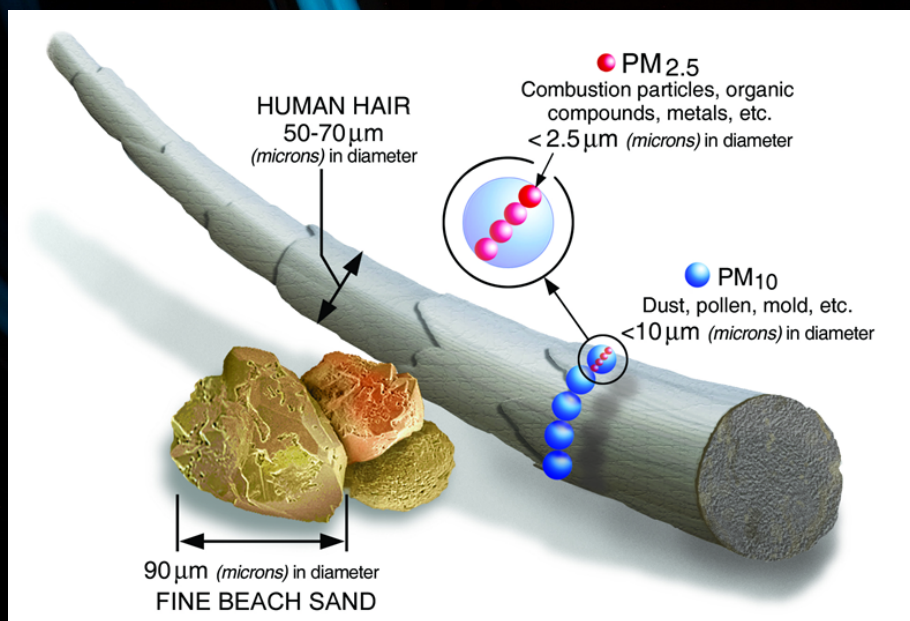
It is not a greenhouse gas. But it is created by the burning of Fossil Fuel. It can come from both primary and secondary pollutants

Primary Sources: Cars, construction sites, fields

Secondary Sources: Power Plants, Industry and cars

Particulate Matter (PM) can sometimes be seen by the naked eye, this is PM with a diameter of 10 micrometres or smaller.

Other particles are so small that they are invisible, and these particles have a diameter of 2.5 micrometres or smaller



They are considered dangerous, because they can easily be breathed in, and can damage lungs. The smallest particles PM2.5 are the worse for health, because they can get into your blood stream and cause serious health problems

Activity 1

In groups, discuss the possible different sources of PM₁₀ & PM_{2.5}

Why is this type of pollution so bad for health?

Activity 2

Create a model showing the different sizes of Particulate Matter.