Unit 9G Environmental chemistry

About the unit

In this unit pupils:
- learn that rocks, soils and building materials have a variety of chemical characteristics
- learn that chemical weathering alters rocks and building materials over time
- consider how the atmosphere and water resources are affected by natural processes and the activity of humans
- consider how environmental conditions are monitored and controlled
- distinguish between different environmental issues

In scientific enquiry pupils:
- consider how scientists work to monitor the environment
- decide on the suitability of secondary sources for providing information on a particular question
- consider how evidence for climate and environmental change needs careful interpretation
- evaluate the evidence obtained
- investigate environmental change using evidence from secondary sources

This unit is expected to take approximately 7 hours.

Where the unit fits in

This unit builds on unit 7E 'Acids and alkalis', unit 7F 'Simple chemical reactions', unit 8G 'Rocks and weathering' and unit 8H 'The rock cycle', and on work on the reactions of acids in unit 9E 'Reactions of metals and metal compounds'. It relates to work on growing plants in unit 9D 'Plants for food' and work on using energy resources in unit 9I 'Energy and electricity'.

The unit builds on the use of sensors in unit 7 'Measuring physical data' in the ICT scheme of work. There are opportunities for citizenship education in this unit in the activities concerning the environment and sustainable development. It also relates to unit 14 'Can the earth cope? Ecosystems, population and resources' and unit 23 'Local action, global effects' in the geography scheme of work.

This unit provides opportunities to revisit and revise topics met in other units in years 7 and 8. With some pupils, teachers may wish to concentrate on some of the new topics, extending activities, and with others to spend more time on revision of previous work.

The unit provides the foundation for work in key stage 4 on changes to the atmosphere and Earth.

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: make effective use of secondary sources of information about the relationship of soil type to plant growth and record their findings using ICT; identify and describe possible sources of information about the environment and select from these evidence about environmental change over time, identifying some strengths and weaknesses in the evidence

some pupils will not have made so much progress and will: select information from secondary sources relating plants to soil type and record findings using ICT; describe how some sources provide evidence about environmental change

some pupils will have progressed further and will: identify and explain the strengths and weaknesses of the evidence about environmental change obtained from secondary sources

in terms of materials and their properties

most pupils will: describe in terms of chemical reactions how acid rain arises and how it affects rocks, building materials and living things; describe how air and water pollution are monitored and how they might be controlled; distinguish between different environmental problems

some pupils will not have made so much progress and will: describe some of the consequences of acid rain and of other forms of pollution; identify why it is important to monitor and control pollution

some pupils will have progressed further and will: describe a variety of environmental issues and explain the implications of these

Prior learning

It is helpful if pupils:

- know that there are differences between soils which relate to the rocks they were formed from
- have experience of finding the pH of a variety of solutions and can relate the pH scale to the acidity of a solution

Health and safety

Risk assessments are required for any hazardous activity. In this unit pupils:

- investigate soils
- use a solution of sulfur dioxide
- use dilute solutions of acids

Model risk assessments used by most employers for normal science activities can be found in the publications listed in the *Teacher's guide*. Teachers need to follow these as indicated in the guidance notes for the activities, and consider what modifications are needed for individual classroom situations.

Language for learning

Through the activities in this unit pupils will be able to understand, use and spell correctly words and phrases:

- relating to environmental conditions and change
- with a more precise meaning in scientific contexts, *eg ozone depletion, global warming*
- relating to the environment, *eg vegetation cover, acid rain, catalytic converter, air and water quality, global warming*
- relating to scientific enquiry and sources of evidence, *eg reliable, biased, insufficient data*

Through the activities pupils could:

- appraise texts quickly and effectively for their usefulness
- recognise the standpoint of the author of a text and how it affects the meaning
- discuss and evaluate conflicting evidence to arrive at a considered viewpoint

Resources

Resources include:

- photographs and video clips of different rock formations, buildings, and rocks to illustrate weathering and sedimentation
- photographs of Cleopatra's Needle in London and similar obelisks in Egypt, illustrating weathering
- carbonate rocks, lime-cemented sandstone
- secondary sources for identifying local plants
- information about local environmental monitoring, *eg of air and water quality*, including ICT sources
- evidence indicative of air and/or water pollution at a particular time in the past, *eg pictures, descriptions, records of legislation, medical records, extracts from novels*
- simplified accounts, *eg video information about climate change*, of the greenhouse effect and the hole in the ozone layer

Out-of-school learning

Pupils could:

- read books, newspaper articles and periodicals about the environment, weather and climate changes. Activities relating to geological change will also support this unit
- watch feature films set in unfamiliar parts of the globe, *eg Arizona, deserts, volcanic regions*
- notice where lichens grow or do not grow in the locality
- look for information about air quality in local and national newspapers

1	Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How are soils different from each other?				
	• that different soils have different characteristics, including pH ranges, and that this affects the plants that grow in them • to locate information about plants and preferred soil types in secondary sources • to use knowledge about acids, alkalis and neutralisation to suggest ways of reducing the acidity of soils	• Use secondary sources, *eg photographs, video clips,* to remind pupils about sedimentation and ask them what else they think plays a role in soil formation. Establish that vegetation and soil animals are also important. • Present pupils with information about different soils and show them soil-testing kits. Ask them to use secondary sources to find out why soils are acidic or alkaline, and to identify problems that this might cause and suggest possible cures. • Ask pupils to use the kits to test local and other soils. Use secondary sources to identify plants often found in particular soil types, *eg in the locality of the school,* the implications of soil type for agriculture and effects on some plants, *eg hydrangea colour.* Help pupils to summarise what they have found out in a database and use this to produce an information sheet.	• identify a range of differences between soils • use the results from work with soil-testing kits to rank soils in terms of acidity • identify and make a record of plants that are likely to grow well in a particular soil, *eg in the locality of the school*, and some that are not • suggest suitable methods of reducing acidity or alkalinity of soils	• In key stage 2 pupils are likely to have investigated some aspects of different soils, and animals and plants that are found in these. They are not likely to have considered the pH of soils. Soils could be tested with pH paper of an appropriate range rather than soil-testing kits. • See unit 3D 'Rocks and soils' and unit 6A 'Interdependence and adaptation' in the key stage 2 scheme of work. Unit 8G 'Rocks and weathering' covers the formation of sediment. The pH scale is introduced in unit 7E 'Acids and alkalis'. • It is important to make sure that pupils do not attribute all acidity in soils to acid rain. Contact with vegetation (roots) amplifies acidity. • Extension: pupils could survey wild flowers found in their immediate locality, relating this to preferred soil type, and exchange information with other schools via e-mail or the internet. ⚠ **Safety** – if soils collected locally are used, check they are not contaminated with dog faeces. Wash hands after handling soils
What happens to rocks and building materials over time?				
	• that rocks and building materials change over time • about factors that affect the way in which materials change	• As a quick introductory activity, remind pupils of earlier work on local rocks and building materials and ask them to describe changes and compile a list of possible causes. Reinforce by showing video clips and/or photographs of a wide range of non-local weathered buildings and/or rocks and ask pupils to suggest a range of factors affecting weathering, *eg nature of rock, climate, local conditions of air, water, soil, position, vegetation cover*. • Ask pupils to identify factors that lead to extensive chemical weathering.	• describe how the appearance of landforms and/or buildings may change over time • identify factors, *eg low pH of air and rain together with high rainfall,* that favour chemical weathering	• Pupils could be shown photographs of Cleopatra's Needle in London and a corresponding obelisk in Egypt to compare the two. • The effect of vegetation could be illustrated by showing a photograph of a boulder of granite that has not weathered above the surface but beneath the soil and vegetation has been eaten away.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What causes acid rain?			
• that the atmosphere contains carbon dioxide from natural sources and the burning of fossil fuels, and this gas can dissolve in rainwater, causing it to be weakly acidic • that dissolved oxides of sulfur increase the acidity of rain • that oxides of sulfur in the air can arise from human activity and geological activity	• Ask pupils what they know about the importance of carbon dioxide in the air to plants and animals from their work on photosynthesis, and remind them that the atmosphere contains carbon dioxide from natural sources. Provide pupils with a range of solutions, *eg rainwater, water with dissolved carbon dioxide, water with dissolved sulfur dioxide*, and ask them to carry out tests to rank them according to pH. • Help pupils make a summary of the processes involved, *eg as a flow diagram.* Use video clips to illustrate how sulfur dioxide and oxides of nitrogen get into the air, *eg through volcanic eruptions, burning of fossil fuels*, and are transported away.	• identify which solutions are acidic • recognise that solutions with lower pH will be more corrosive • identify burning of fossil fuels, *eg in vehicles*, and volcanic activity as leading to acids in the environment • represent, *eg by drawing flow diagrams or equations*, a sequence of reactions in which acid rain is formed	• Pupils will have learnt in unit 7F 'Simple chemical reactions' that oxides are formed when materials burn. This may need to be reinforced in the context of burning carbon and sulfur. • Carbon dioxide as a raw material for photosynthesis is covered in unit 9C 'Plants and photosynthesis'. It is important that pupils realise that carbon dioxide in the air is essential for food production. • Some internet sites provide information about, and pictures of, recent volcanic eruptions. • Extension: pupils will already have represented some combustion reactions by word equations. It may be appropriate to introduce symbol equations to some pupils. ⚠ **Safety** – sulfur dioxide is toxic and corrosive. Solutions should be left in stoppered bottles. Warn pupils with asthma not to inhale

3	Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What are the effects of acid rain and how can they be reduced?				
	• about the effects of acid rain on rocks and building materials • why acid rain will dissolve some building stones • that acids in the environment can lead to corrosion of metal • to make careful observations over a period of time	• Provide pupils with named samples of a number of rocks, including some sandstones and some carbonates, *eg chalk, marble*, and metals, *eg zinc, iron, lead*, together with a very dilute solution of sulfuric acid (to represent acid rain), and ask pupils to investigate the effect of the acid on the materials. Ask them to suggest how to make and record careful observations of small changes over a period of time. Ask pupils to contribute results to a class record and bring together all the results.	• identify that acid rain affects some metals and carbonate-containing rocks • record observations accurately, indicating the time intervals between them	• Lime-cemented sandstone, *eg Cotswold type*, should be used. The sand grains fall apart as the cement dissolves. Before pupils use them, clay-cemented sandstones need to be investigated to see if water causes as much effect as 'acid rain'. • Pupils will have encountered the reactions of acids with carbonates and metals in unit 7F 'Simple chemical reactions' and unit 9E 'Reactions of metals and metal compounds'. • Extension: pupils could be asked to suggest what would happen if acid rain were to run into a stream passing through carbonate rocks, and to find out about the formation of limestone caves. ⚠ **Safety** – a very dilute solution of sulfuric acid (0.005 mol dm^{-3}) is suitable for this activity
	• that acid rain damages living organisms and materials • about ways in which emissions of oxides causing acid rain can be reduced • to use secondary sources to find information about key questions	• Ask pupils to use reference materials to identify the effect of acid rain on plants and animals in a particular location, and to identify the source(s) of the acid rain. • Ask them also to find out about ways, *eg catalytic converters, sulfur precipitators,* in which acidic emissions can be reduced. Summarise both sets of information in a class display or set of information cards.	• identify a source of acid rain and its effect on living organisms within a particular environment • describe how emissions from a particular source causing acid rain could be reduced	• Information about the effects and origins of acid rain can be found on the internet, *eg www.epa.gov/acidrain/student* • Extension: pupils could use very dilute acid to investigate the effect of acid rain on the germination of cress seeds.
Is pollution worse now?				
	• how air or water pollution is monitored and controlled	• Invite an adult responsible for environmental matters, *eg an environmental health officer*, to talk about their work. Ask pupils to prepare questions to ask, *eg about the way in which air quality and water pollution are monitored, how the information is made public, what is done when air pollution rises.* Using the information from the talk and other sources, ask pupils to compile a summary sheet of what is done to protect their local environment, *eg the air and water quality.*	• describe ways in which pollution in their locality is monitored • identify steps taken to reduce pollution	• Indicator organisms, *eg lichens, tar spot of sycamore*, are susceptible to high acidity in air. The latter can be found in suburban areas.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
• to decide what evidence should be collected • to collect evidence to answer a question • how to decide whether evidence is good enough to answer a question • to appraise texts quickly and effectively for their usefulness • to recognise the author's standpoint and how it affects the meaning	• Review with pupils ways in which quality of air and/or water is monitored or controlled and ask them whether they think there is more pollution, *eg of air or of water*, now than there was at a specific time in the past. Ask them to suggest the basis for their answers and then to think what evidence might be collected, *eg photographs, public records, paintings, individual medical records showing outbreaks of disease, descriptions of domestic and working environments, Clean Air Act and other legislation.* Consider a selection of available evidence and compare it with today's evidence. Ask pupils to decide whether the evidence is good enough to come to a firm conclusion, and to explain their decisions.	• identify and evaluate sources of information about the past, *eg photographs of city centres, contemporary descriptions of domestic/urban/rural life* • identify and evaluate sources of information about the present, *eg local and national monitoring records, media reports* • identify and describe differences between evidence from the past and present-day evidence • explain the strengths and weaknesses of present-day and past evidence	• Alternative questions relating to pollution in different localities could be investigated. • In this activity the emphasis should be on pupils' decisions about the strength of the evidence, rather than on the answer to the question about pollution.
Is global warming happening?			
• to use secondary sources to answer scientific questions • how to decide whether evidence is good enough to answer a question • to evaluate evidence put forward by others • to discuss and evaluate conflicting evidence to arrive at a considered viewpoint	• Present pupils with selected and simplified information, *eg on video*, about global changes in climate and ask groups to use it to prepare answers to questions, *eg* – *Have there been climate changes in the past?* – *What were the effects of these?* – *Is the Earth warming up? What evidence is there for this?* – *If the Earth is warming, what are the possible causes of this? What role does the burning of fossil fuels play? What evidence is there?* • Ask pupils to make brief presentations of their answers to the questions, making clear the evidence on which they are based. Ask other pupils to ask questions about the evidence. • Discuss pupils' presentations with them and examine the ways in which fuel is used and the impact of this on the environment and ways in which fuel consumption might be usefully limited.	• identify key trends in data and draw conclusions from these • explain how they used the evidence to draw conclusions • recognise where data is not sufficiently strong to support conclusions or can be interpreted in another way	• There are CD-ROMs offering information about global warming from a variety of perspectives. • This activity could be developed as role play, with pupils playing scientists who have different opinions. With some groups it may be helpful to prepare the information, suggest conclusions which can be drawn from it, and challenge pupils to identify whether the data supports the conclusions drawn. • Pupils may confuse the greenhouse effect and the hole in the ozone layer. It may be helpful to provide them with a simplified explanation of both effects.
Reviewing work			
• to identify the causes and effects of acid rain • to use scientific terminology accurately and with understanding	• Provide pupils with summary sheets about ways in which the environment is monitored and ask them to check their understanding using a series of prepared questions. • Consolidate key points with pupils.	• distinguish between different processes of environmental significance	• Aspects of sustainable development are also covered in unit 9D 'Plants for food', unit 9H 'Using chemistry' and unit 9I 'Energy and electricity'.

