Unit 3: Science for Environmental Technicians

Unit code: D/502/5569

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to enable learners to understand the essential principles and processes which underpin an environmental worker's understanding of the Earth, its natural forces and the effects of plants and animals on the environment. Learners will develop knowledge related to atmospheric changes, processes involved in water cycles and maintaining environmental balance. They will investigate soil and rock processes and the management of materials.

Unit introduction

Understanding the environment, its dynamic character and delicate balances is probably more important today than ever before. This unit looks at the changes in the atmospheric conditions and the processes that have sculptured the Earth's surface and brought about the rise and fall of plant and animal species over millions of years.

Our environment is continually changing and we need to consider:

- gaseous exchanges in the atmosphere and possible implications
- interactions of plant and animal species
- human and natural effects causing soil erosion
- dependability of water supply
- alternative energy resources and their viability
- global waste management and recycling.

Environmental workers need a good understanding of the Earth's processes in order to closely monitor the changes that may occur as a result of environmental imbalances. This unit looks at the atmosphere and explores our present understanding of climate and energy transfers through the various atmospheric levels. It deals with aspects of climate and the effect of human activity on the atmospheric composition.

Learners will explore the issues of renewable and non-renewable energy sources. They will also explore the origins and characteristics of major rock types, soil formation, weathering and erosion. Learners will develop fieldwork skills and use scientific methods to identify rocks and soils using safe practices.

This unit introduces the fundamental biological processes essential to all plant and animal life. It deals with organisms which adapt to a variety of conditions, and looks specifically at photosynthesis in plants and respiration in animals. Learners will explore the importance of water and its physical and chemical properties. Industrial management of water and related issues will also be examined, together with the issues raised by water pollution. Learners will be able to contextualise the subject material in this part with a study of the Environment Agency.

Learners will then discuss the issues and processes involved in the use of natural resources in the production of energy and in manufacturing. They will consider recycling and the industrial use of minerals and rocks. Learners will develop their knowledge by means of useful projects on 'green' themes and begin to appreciate the importance of careful waste disposal and the complexity of the issues.

Learning outcomes

On completion of this unit a learner should:

1 Know the scientific principles and processes which influence changes in the atmosphere

2 Be able to investigate processes associated with soil and rock formation

3 Understand the processes involved with the water cycle and our management of water

4 Understand the factors associated with life forms and natural environmental balance

5 Understand the management of materials.

Unit content

1 Know the scientific principles and processes which influence changes in the atmosphere

Composition and structure of the atmosphere: gaseous composition of troposphere and stratosphere; layered structure of whole atmosphere; temperature and pressure changes; the ozone layer in the stratosphere; mesosphere and ionosphere

Solar energy and energy in the atmosphere: absorption and scattering of radiation, reflection and albedo of surface; energy and energy transfers, first and second laws of thermodynamics; the greenhouse effect (evidence for CO_2 increase, evidence of lower atmosphere temperature rise); ozone protection in the stratosphere, human influence on composition of atmosphere; historical atmospheric composition and changes (early atmosphere), convection zones and coriolis forces

Seasonal variations and weather: rotation of the Earth on its axis (day and night) and its effects; orbital path; the Earth's tilt and variation of global climate; ocean currents, eg El Niño, Gulf stream, Labrador current; air movement over land and in the atmosphere; temperature variations of oceans and consequent air circulation; general climate of the UK

2 Be able to investigate processes associated with soil and rock formation

Physical and chemical processes associated with soil formation: soil properties (texture, structure, acidity, moisture, organic content and cation exchange); processes of soil formation (leaching, humification, podsolisation, calcification and gleying); typical soil types (podsol, brown earth, rendzina, gley and peat); the effect of human activity on soil formation and management, eg deforestation

Physical and chemical processes associated with rock formation: rock cycle; major rock types; weathering and erosion

3 Understand the processes involved with the water cycle and our management of water

The water cycle: processes in the water cycle; precipitation; infiltration; interception; transpiration; evaporation; surface run-off; through-flow; groundwater and storage; essential use of water for life

Water management: water supplies; demand and availability of water; abstraction; water treatment and distribution; water table variations; aquifer storage; water quality and control measures

Water pollution: chemical analysis; industrial pollution and problems associated with thermal, organic and countryside management; pollution causes and effects; pollution monitoring; work of the Environment Agency

4 Understand the factors associated with life forms and natural environmental balance

Photosynthesis and energy transfer: investigative approach to factors affecting photosynthesis rates, yield and plant production or growth; limiting factors; plant adaptation to environmental change, eg temperature, water and light levels

Respiration and energy transfer: aerobic and anaerobic respiration; absorption and assimilation of food by animal's energy transfers

Carbon and nitrogen cycles: balance of both cycles and importance to environment of sustaining the balance; human activity and carbon dioxide emissions; production of ammonia by decomposition; production of nitrogen by denitrifying bacteria

5 Understand the management of materials

Energy resources: non-renewable energy resources and environmental impact, eg coal, oil and gas; renewable resources, eg wind, hydroelectric, waves, tidal, solar power and biomass; development of nuclear power stations

Metals, mineral and organics: extraction of aluminium, rocks, minerals; forest cultivation for paper and pulp; processes and resources used for, eg glass making, separation of hydrocarbons (fractional distillation), polymer production (use of oil fractions), steel manufacture (raw materials); use of fossil fuels

Recycling and re-use of materials: products which can be recycled to form new items, eg aluminium, plastics, glass, steel, paper; re-use of materials, eg textiles, glass

Waste management: problems, eg of site availability for landfill; quantitative analysis of domestic and industrial waste

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 outline the structure of the Earth's atmosphere [IE1, 2]	**M1** describe human and natural factors that affect the Earth's atmosphere	**D1** evaluate the changes which can occur in the structure of the Earth's atmosphere as a result of human and natural factors
P2 describe the factors affecting energy transfers in the Earth's atmosphere [CT2]	**M2** explain the patterns of climate associated with energy transfers in the atmosphere	**D2** explain the human and natural effects of energy and gaseous changes in the atmosphere on climate
P3 carry out practical investigations to identify soil types and composition [TW1, 2]	**M3** describe the composition of soil types	**D3** evaluate the effects of human and natural processes on soil composition
P4 carry out practical investigations to identify rock types [TW1, 2]	**M4** describe the characteristics of the major rock types	**D4** explain the influence of natural erosion and human development on rock features
P5 explain the factors associated with maintaining a suitable water supply	**M5** describe the factors which influence a sustainable water supply	**D5** analyse the primary causes of water pollution, its effects and treatment
P6 explain the links between life forms and a sustained environmental balance [CT2]	**M6** discuss the effects of human activity on carbon dioxide levels	**D6** evaluate the importance of sustaining a balance of carbon and nitrogen in the environment
P7 review the management of materials. [EP3]	**M7** explain the advantages and disadvantages of renewable and non-renewable energy sources.	**D7** analyse the issues involved in management of industrial and domestic waste.

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Discussion, presentation, practical assignment, research study, project development and fieldwork can all be used to motivate learners and to maintain their interest.

Health and safety issues must be addressed by tutors concerning outdoor aspects of this unit, especially when undertaking soil and water sampling. Visits to waste and water management sites will also need careful planning, and tutors should identify areas of concern in relation to these prior to contacting the sites.

Learning outcome 1 should be delivered in the context of providing 'the whole picture' in relation to the role of the Earth and the complex relationships of the land, sea and atmosphere. Learners should appreciate the heat balance that occurs in the atmosphere and understand that the Earth and its atmosphere are reflecting and re-radiating the same amount of energy as they are receiving. Links can then be made to the study of global warming evidence and debate.

Soil examination can produce a range of data which can be analysed and processed to provide essential evidence for learning outcome 2. The effect of human activity on soil formation and retention can be studied using case studies of regions around the world suffering the most serious effects of deforestation, for example. The processes involved in the rock cycle can be studied together with surface erosion and deposition. Practical study can be incorporated into this topic to good effect.

Learning outcome 3 can be delivered by formal lecture, discussion, site visits to reservoirs or water treatment plants and a case study of the Environment Agency. Problems associated with water supply can be linked with issues within the water cycle and the fluctuations in climate.

Learning outcome 4 addresses the biological processes and the balance of nature. There is an abundance of DVD material available on plant adaptation and growth. Tutors should focus on the energy transfers and ecological links between plants and animals. Photosynthesis and growth-limiting factors can be investigated practically and then compared with industrial crop production, for example.

For learning outcome 5, recycling issues can best be addressed with an in-depth research project and associated lectures on present-day recycling trends. Tutors can draw on local government resources and data tables to inform learners of the materials used and recycled.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction of unit and programme structure
1. *Theory*: analysis in groups of atmospheric composition. • Consideration of all aspects associated with weather patterns and circulation of gases in the atmosphere. • Study of evidence for and against global warming and initiated by human intervention or natural processes (project based).
Assignment 1: The Atmosphere, Energy and Climate (P1, P2, M1, M2 ,D1, D2)
2. *Fieldwork investigations*: practical investigations. • Determination of soil characteristics, organic and inorganic content, soil profile at various locations, soil and rock association. • Rock classification and laboratory analysis, effects of weathering and erosion.
Assignment 2: Soil and Rock Formation (P3, P4, M3, M4, D3, D4)
3. *Investigation and project*: water storage – visit to industrial complexes. • Reservoir and sampling of water at various locations of river course. • Case study of Environment Agency monitoring. • Case study of water authority for problems with supply and demand.
Assignment 3: Water, Water Everywhere! (P5, M5, D5)
4. *Theory*: group study. • Natural balances between plants/animals. • Implications of adaptation and effects on species if natural balance of atmospheric gases is disturbed, consideration of crop failure etc (project guided).
Assignment 4: Environmental Balance (P6, M6, D6)
5. *Site visits*: investigating methods of producing electrical energy. • Fossil fuel power station. • Nuclear power station. • Alternative *clean* energy type. • Comparison of output and environmental effects.
6. *Investigation of land use*: development of full presentation. • Site visit to quarry, uses of rock types and use of land fill quarries. • Extraction of raw materials and their effects. • Case study of recycling achievements, targets, materials and uses, site visit, qualitative and quantitative analysis.
Assignment 5: Resources, Waste and Recycling (P7, M7, D7)
Review and evaluation of unit.

Assessment

Pass grade learners will require significant tutor assistance to achieve all the outcomes of this unit. Assessment for most learning outcomes should use practical investigation strategies where possible.

To achieve P1 learners must outline the structure of the Earth's atmosphere and for P2, describe the factors affecting energy transfers in the Earth's atmosphere. The evidence could take the form of a short report, presentation, information leaflet or model.

For M1 and M2, learners are looking at changes in the Earth's atmosphere. They should describe the human and natural factors that affect the atmosphere (M1) and explain the associated patterns of climate (M2). This may be presented as a report through which learners must demonstrate their understanding of the underlying science. The climate of the UK can be used as a 'case study' and learners can follow studies of climate on a global scale. Ocean currents, such as El Niño, and air currents can be used as effective evidence for seasonal variations or variations in climate over a longer period of time.

For D1 and D2, learners will work with greater autonomy and should be able to demonstrate a clear understanding of the transfer of energy within the atmosphere and its effects. Work could include links between natural energy changes and weather variations and an effective evaluation of the global warming debate.

For P3 and P4, learners need to carry out practical investigations to identify major soil and rock types. This can take the form of a classification poster or identification keys using evidence gathered in field study. Composition of soils and rocks needs to form the basis of work produced.

For M3 and M4, learners should produce more independent work relating to soil and rock descriptions and identification. Experimental analysis will focus on soil content, organic and inorganic proportions, and properties.

For D3 and D4, learners should demonstrate a clear understanding of the difficulties of well-defined boundaries in both classification systems and account for soil erosion and weathering characteristics in field investigations or research studies. Tutor support will be minimal and advisory.

For P5, learners should produce evidence which clearly shows the water cycle and the demand for water to cover learning outcome 3. They should explain water pollution and chemical and physical testing of water samples. Evidence may take the form of experimental investigation such as pH testing or hardness, and may be assessed directly by the tutor during practical activities.

For M5, learners must produce an in-depth report or account of the problems associated with maintaining a regular, clean water supply in the UK. Learners can provide data on transfer of water costs, maintenance, leakage and other important points and attempt to consider the difficulties faced by the water authorities.

For D5, learners must clearly analyse the primary causes of water contamination in respect to significant pollution agents and illustrate the effects these have on water, plant and animal life and human consumption. Learners can present key pollution issues by local observations or analytical investigation using techniques in operation by regulating bodies. Tutors can assess directly from practical investigation certain aspects of the analysis and should carefully consider the validity of the monitoring techniques used. If a report is produced, a comprehensive appraisal of monitoring techniques must be given.

For P6, learners must explain the main factors associated with plant energy use, animal biological processes and natural environmental balance. Learners must consider the natural balance of gases between plants and animals and the importance of plants in the production and maintenance of atmospheric gases. Evidence may be presented as an informative leaflet or presentation.

For M6, learners must study and discuss the effects of human activity on global climate and attempt to ascertain whether the effects are conclusive. Carbon dioxide levels over the last 50 years and increases in eustatic sea levels or temperatures are possible areas of study to follow.

To achieve D6 learners must show a clear understanding of both the carbon and nitrogen cycles, how they are related and how human activity affects these cycles. They must evaluate how this delicate balance is maintained and the importance of doing so. Work generated will be almost entirely independent.

For P7, learners should review the management of materials as listed in the *Unit content* for learning outcome 5. A list of re-usable or recyclable items and brief descriptions of these together with alternative ways to generate electricity should be accompanied by a report on a raw material, its products and how it is recycled, for example oil or aluminium.

For M7, learners must carefully itemise and explain the advantages and disadvantages of renewable and non-renewable energy resources. Linked with environmental consideration, a table providing specific advantages and disadvantages of each can provide enough evidence. The detail and arguments addressed must be well researched and explained.

For D7, learners could carry out a case study of a known landfill site and its associated issues. Learners can highlight the problems unique to industrial waste and those common to domestic waste. Local authorities have to justify their recycling programmes in terms of cost effectiveness, and learners can highlight this in their documents. Evidence could be presented as a film-style documentary or a generalised magazine article, photographed and annotated. Learners must produce detailed analysis of complex issues regarding waste management, and tutors should emphasise that the final presentation needs to show comprehensive study.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1, M2, D1, D2	The Atmosphere, Energy and Climate	Environmental data handling/ recording technician who has been asked to produce a presentation for a school energy awareness day.	Presentation covering: • atmospheric layers • energy transfers and global climate patterns • evidence for change from human activity.
P3, P4, M3, M4, D3, D4	Soil and Rock Formation	Technician producing a practical report on soil and rocks.	Practical work including: • classification tables • chemical and physical laboratory analysis.
P5, M5, D5	Water, Water Everywhere!	Water authority training manager producing a report for newly recruited apprentices.	Report which includes: • details of the water cycle • economic factors • investigative analysis of water pollution/case study.
P6, M6, D6	Environmental Balance	Journalist for scientific educational material producing leaflets for a conference.	Information leaflet on carbon and nitrogen cycles. Links with human and plant life. Study of rise in CO_2 levels.

Criteria covered	Assignment title	Scenario	Assessment method
P7, M7, D7	Resources, Waste and Recycling	Marketing manager has requested some case studies to give the public for information.	Case study report which includes: • uses and extraction of resources • waste processing and problems • recycling industry and practicalities.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Applied Science sector suite. This unit has particular links with the following units in the BTEC Applied Science suite and the BTEC Environmental Sustainability suite:

Level 2	Level 3
Chemistry and Our Earth	Fundamentals of Science
Energy and Our Universe	Scientific Investigation
Biology and Our Environment	Scientific Practical Techniques
Monitoring an Ecosystem	Perceptions of Science
Using Mathematical Tools in Science	Chemical Laboratory Techniques
	Principles of Plant and Soil Science
	Mathematical Calculations for Science
	Practical Chemical Analysis
	Undertake an Investigative Project in the Environmental Sustainability Sector

Essential resources

Learners need access to local authority waste disposal and landfill sites. Information can be found from industrial websites, journals and newspapers.

Water treatment and reservoir access should be made available by permission of the local water authority. Chemical/physical laboratory usage is essential. Learners also need computer access for reporting and internet use.

In addition, learners require:

- laboratory equipment for chemical analysis including BDH soil testing kit and centrifuge
- various natural history videos of suitable quality and focus
- access to ICT facility
- first-aid kit.

Tutors should be suitably qualified and have experience of environmental and chemical studies.

Employer engagement and vocational contexts

Where possible, learners should visit an industrial extractor of raw materials and manufacturer of usable products, eg a limestone quarry and packaging company.

Learners also need access to forestry commission grounds with guidance provided, and access to national parkland to follow geological and soil surveys.

Visits to local recycling depots can be arranged.

Water treatment and reservoir access should be made available by permission of the local water authority.

Work placements can be made available by liaising with careers development networks.

Indicative reading for learners

Textbooks

Boeker E and van Grondelle R – *Environmental Science: Physical Principles and Applications* (Wiley-Blackwell, 2001) ISBN 9780471495772

Graham I – *Soil (Earth's Precious Resources Series)* (Heinemann, 2004) ISBN 9780431115542

Jones A et al – *Practical Skills in Environmental Sciences* (Prentice Hall, 1999) ISBN 9780582328730

Kent M – *Advanced Biology* (Oxford University Press, 2000) ISBN 9780199141951

Muller D W – *Atmospheric Environmental Research* (Springer-Verlag, 1999) ISBN 9783540635598

Pickering W R – *Advanced Biology Through Diagrams* (Oxford University Press, 2001) ISBN 9780199141975

Water Environment Federation – *Industrial Wastewater Management, Treatment and Disposal* (McGraw-Hill, 2008) ISBN 9780071592383

Waugh D – *Geography – An Integrated Approach: Supplement* (Nelson Thornes, 2005) ISBN 9780748794621

Waugh D – *Geography: An Integrated Approach* (Nelson Thornes, 2000) ISBN 97801744470727

Waugh D – *The New Wider World* (Nelson Thornes, 2003) ISBN 9780748773763

Woodfield J – *Ecosystems and Human Activity (A-level Geography Series)* (Collins Educational, 2000) ISBN 9780003266528

Websites

BBC	www.bbc.co.uk
British Society of Soil Science	www.soils.org.uk
Columbia University, New York	www.columbia.edu
Envirowise helps companies become more efficient	www.envirowisegov.uk
Guardian newspaper online	www.guardian.co.uk
Local businesses reviewed	www.touchlocal.com
Pennine Water Treatment Services	www.penninewatertreatment.co.uk
Recycling information	www.recyclenow.com
Recycling information and news	www.recycling-guide.org.uk
Science News	www.physorg.com
The Washington Post online	www.washingtonpost.com
Windows to the Universe	www.windows.ucar.edu

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	researching the Earth's atmospheric composition and analysing climatic variation
Creative thinkers	asking questions to extend own thinking about the factors affecting energy transfers in the Earth's atmosphere
Team workers	gathering evidence and laboratory analysis of water samples, soil and rock materials
Effective participators	conducting practical investigation into resource extraction and associated site visits.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Creative thinkers	reporting on the evidence for and against human effect on climate change
Reflective learners	assessing personal changes which can be made in recycling materials, water usage etc
Self-managers	compiling reports, gathering evidence and collating data from practical and research work.

Functional skills – Level 2

Skill	When learners are ...
ICT – Using ICT	
Plan solutions to complex tasks by analysing the necessary stages	preparing and planning for fieldwork and site visits
ICT – Finding and selecting information	
Use appropriate search techniques to locate and select relevant information	researching information on climate change
ICT – Developing, presenting and communicating information	
Enter, develop and refine information using appropriate software to meet requirements of a complex task	producing reports
Use appropriate software to meet the requirements of a complex data-handling task	analysing results of fieldwork and site visits
Mathematics – interpreting	
Interpret and communicate solutions to multistage practical problems in familiar and unfamiliar contexts and situations	comparing and justifying costs of production and recycling
Draw conclusions and provide mathematical justifications	comparing and justifying costs of production and recycling
English – Speaking, Listening and Communication	
Make a range of contributions to discussions in a range of contexts, including those that are unfamiliar, and make effective presentations	evaluating effectiveness of recycling
English – Reading	
Select, read, understand and compare texts and use them to gather information, ideas, arguments and opinions	researching deforestation
English – Writing	
Write a range of texts, including extended written documents, communicating information, ideas and opinions, effectively and persuasively	producing a report on plant and animal adaptation.