



SECOND EDITION

**INTRODUCTION TO
ENVIRONMENTAL MANAGEMENT**
for the NEBOSH Certificate in
Environmental Management

Brian Waters



Introduction to Environmental Management

This book is directly aligned to the NEBOSH Certificate in Environmental Management, which is a qualification aimed primarily at those in business who influence the environmental performance of their organisation by the decisions that they make as managers or the actions that they take as operators. This book aims to provide an introduction to the main areas of concern and how the challenges can be addressed.

This new edition takes account of recent changes in international guidance and legislation and the recent update of the International Standard in Environmental Management ISO 14001. The contents are important for businesses that wish to stay within the law and avoid adverse publicity. It explains how the concept of sustainability can be achieved in practice and what benefits – especially financial – can accrue. Recent developments in the definitions of sustainability and the growing interest in the circular economy are introduced. It pays to be ahead of the game because decisions made now need to reflect an awareness of the coming pressures and there are opportunities available that can bring other benefits.

This book is intended for candidates for the NEBOSH qualification, but it will also be useful to anyone who wishes to understand the problems and how they can be tackled within their own organisations, be they industry, public service, voluntary bodies, or even as individuals.

Brian Waters spent 15 years in the water supply industry, principally with Severn Trent Water, covering water treatment and supply, waste water and industrial waste treatment and the management of river and groundwater quality. He then joined the National Rivers Authority and subsequently the Environment Agency, gaining experience and senior management responsibility for all of the different functions across the Midlands. Since retiring from the Environment Agency he has worked in consultancy and training and as an examiner for NEBOSH.



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Introduction

TO Environmental Management

**For the NEBOSH Certificate
in Environmental Management**

Second Edition

Brian Waters

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Abbreviations

This list contains abbreviations that recur. Some abbreviations that appear only once are defined in the text.

BAT	best available technology
BOD	biochemical oxygen demand
BPEO	best practicable environmental option
BS	British Standard
BSI	British Standards Institute
CFC	chlorofluorocarbon
CHP	combined heat and power
CNG	compressed natural gas
COD	chemical oxygen demand
COMAH	Control of Major Accident Hazards
COSHH	Control of Substances Hazardous to Health
CSR	corporate social responsibility
DECC	Department of Energy and Climate Change (UK)
DEFRA	Department for Environment, Food and Rural Affairs (UK)
EC	European Commission
EIA	environmental impact assessment
EEPA	European Environment Protection Agency
EMAS	Eco-Management and Audit Scheme
EMS	environmental management system
EPA	Environment Protection Agency (US)
ESG	Environmental, Social and Governance
EU	European Union
HSE	Health and Safety Executive (UK)
ISO	International Standards Organisation
IPPC	integrated pollution prevention and control
LEV	local exhaust ventilation
LCA	life cycle analysis
LPG	liquefied petroleum gas
MSDS	material safety data sheet
NIEA	Northern Ireland Environment Agency
NOX	oxides of nitrogen
PPE	personal protective equipment
PPG	Pollution Prevention Guidelines (UK)
SEPA	Scottish Environment Protection Agency
SI	System International
SOX	oxides of sulphur
TOD	total oxygen demand
UKCIP	United Kingdom Climate Impact programme
UN	United Nations
UNEP	United Nations Environment Programme
UNFAO	United Nations Food and Agriculture Organisation
UV	ultraviolet light
VOC	volatile organic compound
WHO	World Health Organisation

Preface to the second edition

Hardly a day goes by without some reference to the environment in the news. Usually the news is bad – a serious pollution incident, political disputes over climate change, the growing demand for and cost of energy, damage to the rain forests, flooding, drought, food shortages. The list seems endless. Occasionally there is a good news story about otters returning to rivers or renewable energy sources coming on stream but it is not surprising that the bad news dominates and that the public look for someone to blame.

This quotation is from the Preface to the first edition of this book written in 2012. If anything has altered it is that the profile and pressure for change has increased. In 2018 a Swedish teenager, Greta Thunberg, captured the public imagination, especially of the young, in her protest about a climate emergency by striking outside her school. Her enthusiasm took her all the way to a speech at the United Nations. The movement has become more activist as 'Extinction Rebellion' which is campaigning to get governments world-wide to respond more rapidly to climate change and ecological damage. These two issues are widely recognised as the consequences of unconstrained growth, consumption of resources and energy, damaging emissions to the environment and exploitation of the biosphere. The causes are multiple and are as much the fault of the wider population as the businesses that get caught in the spotlight.

But business is a major cause and industries such as oil exploration, power generation or chemical manufacture are obvious culprits. They operate in such a way and on such a scale that the potential risks of environmental damage are high and fairly obvious. However, looking more closely at other businesses, the use of energy, demand for raw materials, production of waste and emissions to air and water apply to virtually every activity and drive the activities of those bigger companies. Many things that we do at work have an impact on the environment in one way or another even if we are in a service industry or a public or charitable body. The same can be said of our home and leisure activities. At any level these may be small but collectively they add up such that the potential availability of some raw materials is becoming a global problem, prices are rising and we are making changes to the atmosphere and seas that could be

irreversible and have the potential to cause severe problems for future generations. This vague concept is our children and grandchildren.

Responsibility to deal with these issues falls to everyone but business is often seen as an easy target. Business exists to meet the demands of its customers and they must be the ultimate culprits by demanding the latest gadget or faster cars or the right to wander about at home in a tee shirt in freezing weather. Of course the public is fickle: it demands the goods and services that make life easier and more enjoyable but castigates the businesses that meet those needs. Tackling that broader issue is not the purpose of this book but businesses in the firing line can do a lot to mitigate the damage that these demands place so that they can continue to operate, supply their customers and reduce the impact that they have. This book is aimed at that purpose.

Public perception is important for most businesses and the rise of social media such as Twitter and Facebook can spread information (and misinformation) rapidly around the globe. Public concerns are reinforced in many cases by the law. Stricter controls are applied to reflect those concerns and understanding and complying with the requirements is becoming more difficult and costly. Larger companies often employ environmental managers to advise and monitor what is happening but compliance is usually down to those who carry out the tasks that are at the heart of the problem. Whether or not an environmental manager is in post, it is those who specify, design, produce, purchase, market, deliver and dispose who have the potential impact. They are overseen by directors, managers and supervisors who influence what they do.

So the easily identifiable risks to business are reputation, legal liability and cost escalation. There is also the risk to the environment which most responsible people at any level in a business would wish to avoid. However, the risk is not always easy to spot and may be even harder to manage. The broader relationships among environmental risk, economic development, social progress and resource issues are now rolled into the concept of sustainability. Sustainability can apply at the global level down to the very local and is becoming the overarching measure for the future. The sustainability of their business may be what matters most to the business manager and that can be at risk from bad behaviour but there are business opportunities through reduced costs and new markets for those that are prepared to rise to the challenge. Understanding and then responding to the issues that apply at the business level

will help to meet the global objectives for a sustainable world more able to deliver a brighter outlook for future generations.

The National Examination Board in Occupational Safety and Health (NEBOSH) operates an Environmental Certificate for those who are not environmental managers (for whom there is a Diploma) as a means to gain the knowledge and a recognised qualification to help their businesses meet these challenges. It has proved popular outside of the UK and the syllabus reflects the international reach of the qualification. The syllabus contents are

relevant in some way or other to every level in a business from the most senior manager to the cleaner. They may not wish to take the examination but the principles are still relevant. This book is structured around the syllabus of the Certificate. It is split into logical sections to make for easy identification of the key issues. It is not aimed at the specialist; the target audience is those who can make a difference on the ground as outlined above. It assumes limited background knowledge and there are explanations of technical content where this is necessary to understand the detail.

About the author

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Fellow Royal Society of Chemistry, Fellow Chartered Institution of Water and Environmental Management, Member Institute of Environmental Management, Member Chartered Management Institute. Brian spent 15 years in the water supply industry, principally with Severn Trent Water, covering water treatment and supply, waste

water and industrial waste treatment and the management of river and groundwater quality. He then joined the National Rivers Authority and subsequently the Environment Agency, gaining experience and senior management responsibility for all of the different functions across the Midlands. Since retiring from the Environment Agency he has worked in consultancy and training and as an examiner for NEBOSH.



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working with over many years and who taught me a lot. I must also acknowledge the few environmental rogues that crossed my path who added even more to my education.

A special mention is due to my wife, Janet, who has put up with my isolation and deferred projects at home to enable this book to be completed.

All of the content is my responsibility. I apologise for any errors but would be pleased to be told about them and to receive any other comments.

Introduction

This book is in support of the NEBOSH Certificate in Environmental Management. It is targeted at those in business who can influence the impact that an organisation can have on the environment by virtue of the decisions made and the activities carried out. The objective is to improve the understanding of the issues involved and the ways that businesses can avoid damaging the environment and their own reputations in the process. In many cases there are opportunities to reduce costs and other benefits may also accrue. There are also legal issues in environmental management of which the people in the organisations need to be aware. Most countries now have laws to protect the environment with penalties of fines and prison terms for breaches. Some of the fines may be on companies but they can also be on individuals as would terms of imprisonment.

The book is not aimed at environmental professionals such as an Environmental Manager. NEBOSH offers a Diploma qualification for them with more legal and technical information. At Certificate level the technical content is more restricted and some of that and additional background information is presented in red boxes. However, to understand the content it has been necessary to assume some background knowledge. The main areas considered necessary are:

- The ability to recognise and use some units of measurement not in general use.
- Limited understanding of some sciences, mainly chemistry and biology, and particularly the terms used.

It is recognised that some readers may have not formally studied these subjects or that it was such a time ago that it is a distant memory. If you have a recent relevant GCSE or above from a UK school or an equivalent in these subjects you certainly ought to be able to manage. There are two appendices to help those with limited background knowledge or who need some revision. Do not be put off – it is not difficult.

The other hurdle for some examination candidates is that English is not their first language. However English is the language of international trade and many candidates for NEBOSH examinations see them as a way to help gain employment in companies that have international businesses. The language has been kept as simple as possible and the book should help them recognise any terms that are not in general use and that they will need to know.

Other readers of this book may be studying for their own satisfaction or to seek ideas for improving the environmental performance of the organisation that they work for. There is no obligation to take the examination. If you do, the NEBOSH Certificate is examined in two stages: a written examination on the content of the syllabus and a practical application in the workplace or other suitable location. The purpose of the practical application is for the candidate to demonstrate the ability to apply the knowledge gained in the first stage. This should present no problem to a candidate who has studied and understood the syllabus.

As this book is aimed at an international audience the legal requirements are stated in general terms in the main text with examples taken from UK practice. Unfortunately for the reader, UK legal requirements are not consistent as there are differences among the different administrations of England, Northern Ireland, Scotland and Wales. Reference to UK regulations and practices is mostly for England and Wales and may not be valid in the other devolved administrations in all cases but the principles should still be constant, as they are mainly derived from EU directives, and they should also be applicable more generally. Recognising that many readers will be from the UK or from countries with a similar legal system, there are boxes with the more detail on some of the legal points. These are mainly for information and are distinguished by being with a blue background and collected together in Appendix 4. More detailed legal information can also be obtained by consulting the relevant legislation or the various compendiums and summaries provided commercially in book form or electronically. Nothing in the text should be taken as legal advice!

Although the legal content has been limited, there may be a need for a reader to follow something up to help understanding or to deal with a local problem. The text includes references to international, European and UK legislation and guidance. Do bear in mind that these are subject to change and if you want to be up to date check that you are consulting the latest version. Change is constant, particularly in the UK where every change of government seems to result in a shuffling of responsibilities among different departments and a switch in emphasis on what is important. At the time of writing (late 2019) the UK is in a long, tortured process of planning to leave the EU and at the start of an election. If it does leave much existing legislation will initially be carried forward but it is probable, depending on the final terms agreed, that there will be changes over time. It is fortunate now that most of the

necessary information can be found on the internet and downloaded in pdf format. The web site references given were valid in November 2019 but they do have a habit of moving to archives or some other site. A search engine should track them down if the reference given is no longer valid. References for European Directives are from the Official Journal but these can also be found on the internet.

The structure of the book is based on the NEBOSH syllabus. The chapter numbers and titles refer to the elements within the syllabus and the sections are similarly structured. The headings for the sections are mainly the same but a few headings or their order have been changed to help the flow of the text. The content does go beyond the limits of the syllabus as the aim of the book is to help candidates understand the environment and use that knowledge to protect and enhance it. In addition they will help their organisation to keep within the law, save money and protect its reputation. The aim is not just to gain a piece of paper.

As with most textbooks you do not have to read it in the order presented. However, environmental topics are

inter-related: air quality can affect both water and land quality, for example, in a number of ways. This means that there are cross-references between chapters to avoid too much repetition.

The final chapter is about the examination for the certificate and includes some example questions. Even if you are not contemplating taking the examination, you may find them useful to check your understanding.

Hopefully you will not see this as the end of your learning. It is important to keep up to date with changes in the topics in the chapters but, more importantly, to be aware of developments in technology if you maintain an interest in the subject. Developments in lighting technology have already reduced energy demand dramatically; vehicle design is changing and will be very different in a few years' time; sources of energy, their supply and use will continue to change; the production and management of waste has to be tackled to avoid more environmental damage; everyone will have to play a part in minimising climate change but also in adapting to some which will be inevitable.



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Foundations in environmental management

After this chapter you should be able to:

1. Outline the scope and nature of environmental management
2. Explain the ethical, legal and financial reasons for maintaining and promoting environmental management
3. Outline the importance of sustainability and its relationship with corporate social responsibility
4. Explain the role of national governments and international bodies in formulating a framework for the regulation of environmental management.

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INTRODUCTION

This chapter starts with a look at what we mean by 'the environment' and 'environmental management' and why it is considered important to protect it. This leads into a study of the meaning of 'sustainability' and how this fits into the way that a business may project its image to the wider world, followed by the legal issues surrounding environmental protection. This background forms the basis for the following chapters which elaborate on some of the topics raised here, giving more detail on why they are important and how they can be managed.

1.1 The scope and nature of environmental management

1.1.1 Some definitions

Words like environment and pollution are in everyday use and may mean slightly different things to different people. They will most likely reflect their immediate surroundings or their concerns. For example, my immediate environment may be my home or work site but could extend to include the garden or cultivated area, village, adjacent park, surrounding farmland or forest, coastal stretch or the sea (see Figure 1.1). However, increasingly people are concerned about the wider environment such as the change in climate or the impact of plastic waste on wildlife. This is usually in response to publicity by pressure groups or in response to documentaries on television illustrating the events in dramatic ways.

Generally, though, our concerns about what affects our environment are usually those which we can easily sense and have a direct impact: noise, smell, visual intrusion, flooding, perhaps something that is causing illness or killing our plants. We may refer to these as pollution. To complicate it further our response to these effects is coloured by our expectations. We expect some factories to be noisy but escape to the quiet of the countryside. The smell of animal manure being spread will be less acceptable to the local villagers than to the farmer. The sea environment is important to fishermen who rely on it for their livelihood. Before reading further think about the environments that you come across

regularly and what you like about them and if there are things happening around them that concern you; why do they concern you?

In order to study our subject comprehensively we need to adopt standard definitions because, as we shall see, decisions we make have implications that can extend well beyond our immediate surroundings. A good example concerns waste disposal: as societies develop they produce more waste. In a simple society the waste may be just food and crop residues which can be dealt with locally by composting along with limited quantities of other materials such as paper or metal, many of which will be put to other uses. In an urbanised industrial society households and businesses produce larger volumes of waste which cannot be dealt with on site and have to be removed and dealt with elsewhere. This involves transferring a potential local problem to somewhere else and in a globalised economy that could be another country. Our waste does not affect our environment directly but can affect somewhere far away.

In Chapter 2 we shall learn about environmental management systems and the international standard ISO 14001. This has a definition of **environment** which should suit our purposes well:

The surroundings in which an organization operates including air, water, land, natural resources, flora, fauna, humans, and their interrelation.

ISO 14001 adds a note that surroundings in this context extend from within an organisation to the global system (ISO 2015).

There is no similar internationally accepted definition of **pollution**. If you try to look it up in a dictionary you will find several definitions, some specific to a medium such as water, air or land, or related to specific issues such as noise or visual intrusion. We also need a definition that does not become too restrictive. Consider water: it evaporates from the earth, leaving any contaminants behind and condenses in clouds as 'pure' water. When it falls as rain it dissolves gases and picks up solids from the air before dissolving more contaminants in its passage over and through the land. But for most people it is not considered polluted unless it has been exposed to

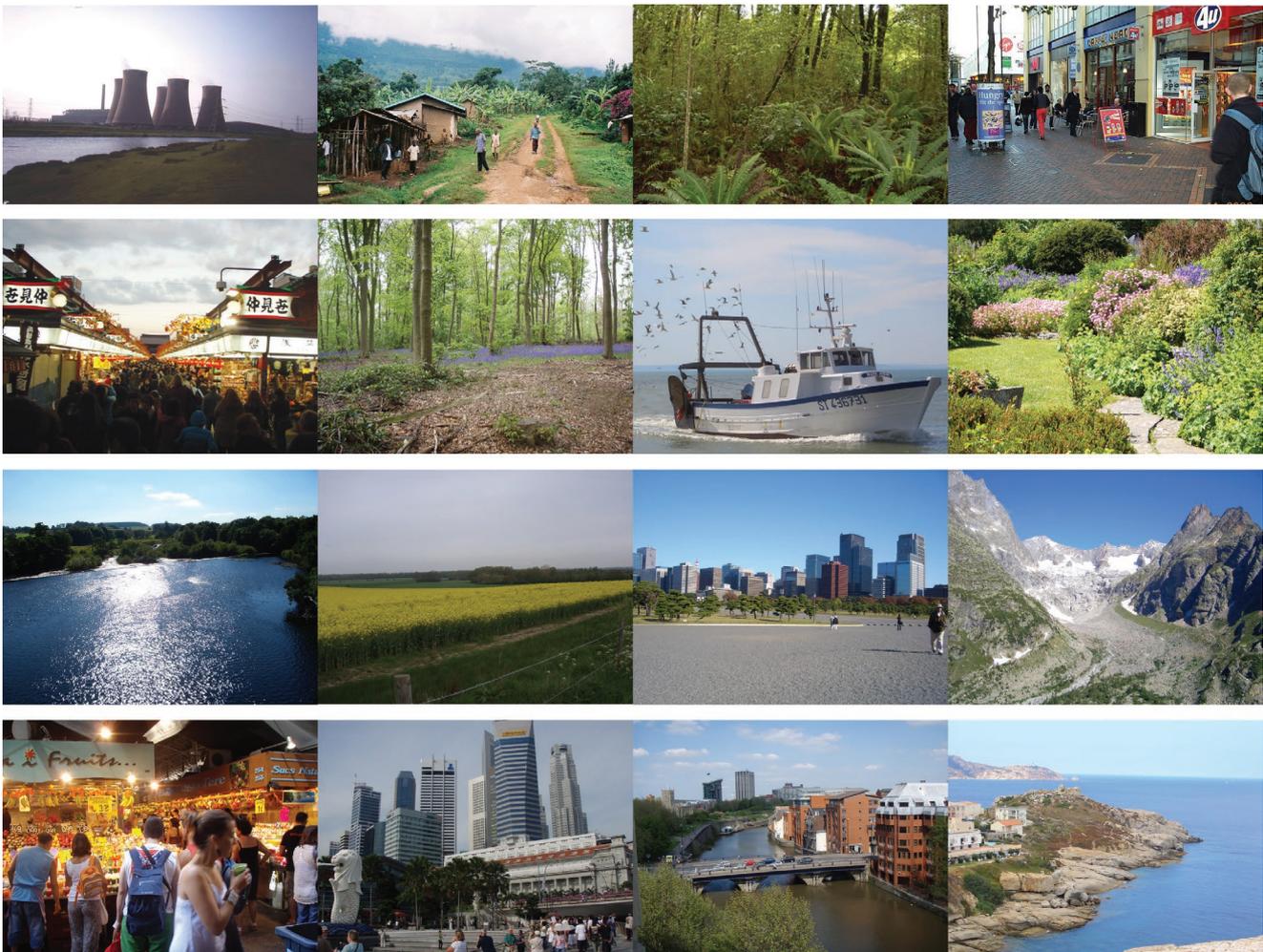


Figure 1.1 Environment

something toxic; indeed, many may drink it directly. For our purposes we need a general definition that does not include benign contaminants. One such is:

The presence of substances or objects in the environment which may cause adverse effects on the natural environment or on life.

This definition brings in the requirement to cause harm. It should be recognised that the substances referred to could arise from natural causes (such as a volcano) as much as from man’s activities and that objects can extend to large structures causing visual pollution. The effects on life may be confined to human beings but could extend to any form of life.

1.1.2 The meaning of environmental management

Man has tried to manage the environment for millennia. The earliest humans were hunter-gatherers who took small quantities of food relative to the amounts available. They then progressively cleared forest for farming

and extracted timber and stone for building materials. As societies developed technology, they extracted minerals and converted them to useful materials such as bricks and metals. Modern man does all of this on a much bigger scale and builds roads and bridges, flies aircraft round the world, wages war on a more destructive scale and consumes energy at an ever increasing rate. These activities all have an impact on the environment and most are humanity trying to exploit it for some direct benefit such as feeding the population and providing goods and services. Our reason for studying environmental management though is understand the consequences of this and to minimise the damage to the environment from human activities. As the population grows and expects a higher standard of living, the degree of exploitation is causing extensive environmental damage on a scale not seen before – as we shall see in the next section.

The challenge is becoming more complex. Small-scale operations such as farming or mining or waste disposal did not present a problem to earlier communities. Such damage as was caused was of a similar small scale and confined to the immediate neighbourhood. If one person upset his neighbours by his activities they would likely take direct action. Now food is grown on an industrial

scale. Resources such as oil or minerals are extracted far from the centres of demand. The link between the demand and the damage caused is remote. Further, in an increasingly complex society, a simple action can have multiple consequences: inappropriate disposal of waste can cause pollution of water, land and air. Washing contaminants out of an air stream converts it to water pollution; removing that pollution can result in solid waste that may pollute land. The nature of environmental management has become more complex, involving the basic sciences of chemistry, biology and physics and the more complicated sciences such as climate modelling, toxicology and hydrology. It has become multi-disciplinary. This book will not go into the detail of all of these but rather give an overview of the main issues. However, it is important to bear in mind the inter-relationships that can be involved in the media (air, water and land) and the processes taking place in the environment.

The factors that complicate environmental management do not stop there. Within any business or community there are competing and conflicting demands. People want adequate food, housing and energy as a minimum. In many societies this is still a wish whereas in others there is excessive use and wastage. Few people give thought to where their food, energy or raw materials come from – it is likely to be well away from their immediate environment. As population and prosperity grow, demand increases, people expect more and competition for resources increases. Energy and minerals are extracted from increasingly remote and difficult places, often in sites previously considered wild or in their natural state and even on another continent. The consumers may not be aware or just ignore this, but if there is a proposal to develop a quarry near to their homes they are likely to use every available avenue to object. We want the benefits that technology can bring but not the problems, especially if they impinge on our quality of life.

As prosperity grows not only do we consume more but we waste more. Items that were routinely repaired a generation ago are now replaced if they fail. Some items are too complex to be economically repaired (such as electronic goods), others are replaced often because there is a new model available (consider mobile phones), demand for new clothes is driven by fashion rather than need. The effects of these decisions are remote from the decision maker and even if they are aware of the consequences they take a simplistic view that their lone action cannot have major implications. It is the individual decisions of 7.7 billion people that have compounding consequences.

1.1.3 The scale of the environmental problems

We have already realised that some pollution problems remain local. Noise does not travel far and odour rarely goes far before dilution or some chemical change renders it harmless. Light pollution is the presence of light from street lights and urban areas that causes background illumination which can disturb wildlife and hide the

night sky. (See <http://apod.nasa.gov/apod/ap020810.html> for an image from space of the sources of light – set aside some time if you get lost exploring the many other images available from satellites!). It is an increasing problem changing animal behaviour and interfering with other people's lives – not just astronomers. Contamination of land by waste, chemicals, oil, etc. is also likely to be mainly local although some contaminants can migrate to cause pollution further away as we shall see in later chapters. Many of these local effects can be mitigated at source or dealt with locally in other ways but even if little is done the impact remains local. It is the pollution that arises locally but has an impact over a wide area, even globally, that is more of a problem. Some important examples are considered below.

1.1.4 Population growth

The world population grew slowly up until the beginning of the last century. In 1972 it was estimated at 3.85 billion and had grown to 6.1 billion by mid-2000. It is estimated to grow to over 9 billion by 2050 but the rate of growth is slowing down so that the population will reach nearly 11 billion by 2100 (Our world in data 2019). These additional people will drive up consumption of materials and the production of pollution, especially as all peoples aspire to a higher standard of living.

In 2019 the United Nations Food and Agriculture Organisation estimated that over 800 million people were undernourished (UNFAO 2019), just over 10 per cent of the total population. Increasing food production to meet the current shortfall, let alone the projected increase in population, will require more land, fertiliser and energy as well as the lesser items such as pesticides, farming implements, etc. These hungry people also consume little else of the world's resources at the moment.

1.1.5 Sourcing raw materials

Phosphate fertilizer to help meet the need for food is extracted from large mines and quarries. But we get many of our other raw materials in the same way: ores for the production of metals such as iron and copper, gold, building stone, sand and gravel, limestone for various uses such as cement production and clay for making bricks and pottery. Production of the end products has moved from craft industries to major industrial factories requiring large volumes of raw materials to keep them supplied. To make matters worse, the quality of metal ores is declining; those with a high metal content are becoming exhausted or too expensive to extract and poorer quality ores are being used. The lower content means that more material has to be extracted for the same yield of finished metal (if the metal content falls from 2 per cent to 1 per cent then twice as much is required). This is more expensive in transport and processing costs, uses more energy to process, produces more waste material (the residue after the metal has been extracted) and damages more of the environment adjacent to the mine. There is more on



this in Chapter 3. There are often land rights issues associated with increasing food production or the exploitation of minerals in remote areas as forest is cleared or land is exploited that has a history of traditional rights for indigenous peoples such as being the source of food and timber.

1.1.6 Energy supplies

Similar issues apply to sourcing energy. Although some developing rural communities still burn wood for cooking, this can be difficult to find. Urban and industrialised communities rely mainly on coal, gas and oil products as primary sources of energy. Electricity has traditionally been produced from these primary sources although, as we shall see, this is changing. Burning these primary sources causes air pollution in ways described below but finding them is becoming a problem as well. Coal is available in some countries in plentiful supply but is potentially the most polluting. In some cases it is close to the surface and can be open-cast mined. Elsewhere it involves deep underground tunnels which are often dangerous due to poor health and safety practice. Either way coal extraction also produces large quantities of solid waste known as ‘spoil’. Coal is being replaced by gas as a fuel for generation of electricity in many countries, although China and India are still building new coal-fired stations on a large scale. Oil and gas are extracted from wells into suitable geological strata. Reserves are declining or becoming uneconomic in many of the existing sources as consumption continues to rise. There is a school of thought that we are close to the point where rising consumption will overtake falling supply, especially of oil – referred to as ‘peak oil’. Political risk associated with some supply countries also drives a search for new supplies and so wells are being drilled in more remote areas such as the Arctic and in deeper seas such as off the Falkland Islands. Extracting gas by fracturing the rocks holding it (hydraulic fracturing or fracking) is also being used. All

of these have potential problems, particularly those of pollution and these are detailed further in Chapter 7. The point here is that energy demand increases as standards of living rise and the demand for energy has similar consequences as that for other raw materials.

1.1.7 Emissions of carbon dioxide and climate change

Burning fossil fuels such as coal, oil and gas produces carbon dioxide – the carbon in the fuel is combined with oxygen in the atmosphere, releasing heat at the same time. It has been known for over 100 years that the concentration of carbon dioxide in the atmosphere was responsible for maintaining the earth’s climate within a range suitable to support life. The concentration has varied significantly over geological time but in more recent centuries it has been constant at about 260 to 280ppmv (see Appendix 1 on units and Section 4.1.1 for measurements in air). It started to rise with the industrial revolution in the 19th century as coal was used to fire the factories and produce energy. The concentration is now about 410ppmv, over 50 per cent higher (Mauna Loa Observatory 2019) and has risen in parallel with the increasing use of fossil fuels to produce energy.

The carbon dioxide is evenly dispersed throughout the atmosphere by atmospheric currents and plays a key role in absorbing infra-red radiation from the sun. The detailed mechanism by which this occurs is complex (Houghton 2009) but can be briefly summarised as follows. As the radiation falls on the earth it is absorbed by the carbon dioxide and by water vapour. This warms up the atmosphere and the earth’s surface. Some of the radiation is radiated back into space again but the carbon dioxide absorbs this as well. If the carbon dioxide concentration is constant a balance is achieved such that the temperature remains fairly constant but as the concentration rises, less is radiated back into space and the temperature rises. A simplified illustration is given in Figure 1.2.

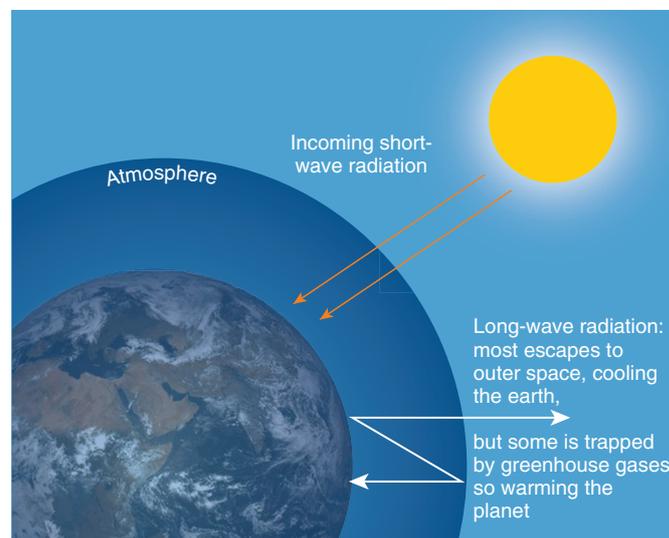


Figure 1.2 The greenhouse effect