‘MANAGING THE ENVIRONMENT’

January 2013

Toby Clark BSc CFIOSH AIEMA Cert Ed

Managing The Environment

By Toby Clark

Smashwords Edition

Dear Reader,

Welcome to 'Managing the Environment'. I hope that it will influence your way of thinking, even your way of life, both at home and at work.

Ever since the Industrial Revolution, all the indicators of environmental crisis have pointed to the 21st Century. I can recall an illustrated World Atlas in 1950 which included a demographic section, projected forward to the year 2000, where it stopped with every graph either going steeply upwards (population) or else going steeply downwards (everything else). Now we have arrived and are almost a decade beyond! Unhappily, it is only in recent years that we have begun to take the situation with the seriousness which it merits and to seek to place control in the only hands which can really do anything about it all, namely managers.

It is worth here quoting from 'Our Common Future', the Report of the World Commission on Environment and Development published in April 1987.

'Most of today's decision makers will be dead before the planet suffers the full consequences of acid rain, global warming, ozone depletion, widespread desertification, and species loss. Most of today's young voters will still be alive.'

The World Commission on Environment and Development, headed by Gro Harlem Brundtland, Prime Minister of Norway, was set up as an independent body in 1983 by the United Nations. Its brief was to re-examine the critical environment and development problems on the planet and to formulate realistic proposals to solve them, and to ensure that human progress will be sustained through development without bankrupting the resources of future generations.

'Our Common Future serves notice that the time has come for a marriage of economy and ecology, so that governments and their people can take responsibility not just for environmental damage, but for the policies that cause the damage. Some of these policies threaten the survival of the human race. They can be changed. But we must act now.'

Alas, all the indicators now point towards global warming of up to 6^{o}C, an earlier and agreed target of 2.1^{o}C seems to have been abandoned as the world's leaders are distracted by financial crisis. A World Bank scientific report (Nov 2012) says , even at 4^{o}C"triggering a cascade of cataclysmic changes that include extreme heat-waves, declining global food stocks and a sea-level rise affecting hundreds of millions of people"

This course will chart the responses which are being made to that challenge, and it is a picture which, although depressing at times, still takes the perspective that disaster is not inevitable even though it is most urgent that we globally take sufficient steps pretty well immediately

It is expected that you already do the things a good citizen should do. I am sure that you use recycling facilities, make prudent decisions about energy consuming plant such as motor cars and heating systems and that you attend to the insulation of your house. This course is intended to take you far beyond that point, it is to empower you so that you can play your vital part in doing just that, managing the environment.

Welcome to the club!

Toby Clark

PS A book is out of date, usually before it is even written. In the field of environmental management, that is particularly so. Legislation and practice changes with bewildering speed in response to the ever evolving pressures upon our planet and our home. Whist I have attempted to keep things current, they will inevitably date. The first edition, as an example contained reference to the World Trade Center!

Most of the technical content remains current and changes only relatively gradually so that hopefully this work will continue to be informative for some time to come!

Managing the Environment

Acknowledgements

The support of The Institution of Occupational Safety and Health (IOSH) in developing the concept and syllabus of 'Managing the Environment' was crucial to its production. Also the Department for Chemistry in Industry at Hull University for ongoing support and encouragement.

Many other persons and organisations have provided source material and illustrations, notably the National Society for Clean Air and Environmental Protection, The Department of Environment, Food & Rural Affairs (DEFRA), The Environment Agency, The Institute of Environmental Management and Assessment, Shanks & McEwan Ltd., RRC Business Training Ltd, British Telecom Plc., Greenpeace and Friends of the Earth.

An Introduction to Environmental Chemistry by J.E. Andrews, P. , T.D. Jickells & P.S. Liss. Pub. Blackwell Science ISBN 0-632-03854-3 (1996) inspired much of Unit2

Special thanks to Chris Hilder MIOSH LicIPD AIEMA MISM who contributed Unit 10.3 (hospitals) and who proof read and made many helpful suggestions to update and improve the text. If any source has been omitted it is the responsibility of the author.

It is important to note that this coursebook is not a distance learning package, though its contents should prove helpful to persons who wish to gain insight into environmental management issues. A properly designed, interactive, distance learning programme which will lead to an IOSH 'Managing Environmental Responsibilities' Certificate is available from RRC Business Training Ltd., (www.rrc.co.uk)

A distance learning pack covering the NEBOSH Certificate in Environmental Management is available from Paul Randall & Associates (www.praa.org.uk)

A NEBOSH Environmental Certificate taught programme is available from Hull University and a number of course providers can be identified via the NEBOSH website (www.nebosh.org.uk).

Disclaimer

ISBN 0 9535772 0 1

Managing the Environment - Contents

4.7 Contaminated Land
4.7.1 Classification of Hazards
4.7.2 Hazard Pathways
4.7.3 Remediation of Contaminated Land
Unit 5 Water Pollution
5.1 Pollution of water
5.1.1 Dissolved and suspended substances
5.1.2 Dissolved air
5.1.3 Temperature
5.1.4 Oxygen Sag
5.2 Kinds of Water
5.3 Groundwater
5.4 Sewage Treatment
5.5 Water Quality Objectives
5.6 Emergency Action
5.7.1 The Legal Framework
5.7.2 The Regulatory framework
Unit 6 Air Pollution
6.1 Air Pollution and its effects
6.2 Industrial emissions
6.3 Nature of pollutants
6.4 Air Pollution Control
6.5 Air Monitoring Strategy
6.5.1 Monitoring networks.
6.5.2 Air Quality Objectives (AQOs).
6.6 Air Cleaning Systems
6.7 The Legal Framework
6.8 The Regulatory Framework
Unit 7 Surveying the Environment
7.1 Environmental Assessment.
7.2 Management commitment
7.3 Legal Compliance
7.4 Contamination
7.4.1 Oils and Chemicals
7.4.2 Contaminated land
7.4.3 Underground storage tanks
7.5 Other hazards
7.5.1 Polychlorinated Biphenyls (PCBs)
7.5.2 Asbestos
7.5.3 Lead
7.5.4 Polyaromatic compounds (PAHs)
7.6 Waste
7.7 Energy management
7.8 Nuisances
7.9 Conclusions of the EA
7.10 Environmental risk assessment
7.10.1 Environment
7.10.2 Hazard
7.10.3 Risk
7.10.4 Stakeholders
7.10.5 Danger
7.11 Carrying out environmental risk assessment
Unit 8 Energy Management
8.1.1 Energy Conservation Measures
8.1.2 Heating
8.1.3 Lighting
8.1.4 Water
8.1.5 Planned Maintenance

8.1.6 Air Conditioning Systems
8.2 Local Exhaust Ventilation
8.3 Energy Efficiency Best Practice Programme
8.4 Transport Management
8.4.1 Immediate cost savings in transportation and the operation of vehicles.
8.4.2 Purchasing Policy
8.4.3 Strategic Issues
Unit 9 Managing the Working Environment
9.1 Managing as a process, the Management Cycle
9.2 Management of Quality Systems, Health & Safety, and the Environment
9.3 Safety, Health & Environmental Policies (SHE Policies)
9.4 Implementing a Policy
9.4.1 Establishing a baseline (initial assessment).
9.4.2 Writing a policy Statement (commitment)
9.4.3 Systems for implementation (organisation)
9.4.4 Arrangements for carrying out the policy (training and resources).
9.4.5 Monitoring and review (auditing)
9.5 Developing an Audit Structure
9.6 Types of Audits
9.7 Continuous improvement.
9.8 Environmental Management systems
9.9 Project Acorn
9.10 Case Study
Unit 10 Industry specific Issues
10.1 Construction.
10.2 Agriculture
10.3 Hospitals

List of Abbreviations

ACE Association for the Conservation of Energy
ACBE Advisory committee on Business & the Environment
ACHS Advisory Committee on Hazardous Substances
AQO Air Quality Objective
AQS Air Quality Standard
BOD Biological Oxygen Demand
COD Chemical Oxygen Demand
BAT Best Available Techniques
BPEO Best Practicable Environmental Option
BPM Best Practical Means
BREFS BAT Reference Documents
BRESCU Building Research Centre Conservation Support Unit
CCL Climate Change Levy
CIWEM Chartered Institute of Water & Environmental Management
CIWM Chartered Institute of Wastes Management
COPA Control of Pollution Act (1974)
COSHH Control of Substances Hazardous to Health (Regulations 2003)
DEFRA Department of Environment, Food & Rural Affairs
EA Environment Agency
EA95 Environment Act 1995
EEA European Environment agency
EARA Environmental Auditors Registration Association
EEBPP Energy Efficiency Best Practice Programme
ETBPP Environmental Technology Best Practice Programme
EIA Environmental Impact Assessment
EIS Environmental Impact Statement
ELV Emission Limit Value
EMS Environmental Management System
EMAS Eco Management Audit Scheme
EPA90 Environmental Protection Act 1990
EPAQS Expert Panel on Air Quality Standards
EQO Environmental quality Objective
FEIS Fugitive Emissions Information System
FEPA Food & Environment Protection Act 1985
FGD Flue Gas Desulphurisation
FoE Friends of the Earth
GWP Global Warming Potential
HSW Act Health & Safety at Work etc. Act 1974
ICRCL Interdepartmental Committee on the Redevelopment of Contaminated Land
IEA Institute of Environmental Assessment
IEMA Institute of Environmental Management and Assessment
INCPEN Industry Council for Packaging & the Environment
IOSH Institution of Occupational Safety & Health
IPC Integrated Pollution Control
IPPC Integrated Pollution Prevention Control
LA Local Authority
LAAPC Local authority Air Pollution Control (also simply APC)
LAWDC Local Authority Waste Disposal Company
LCA Life Cycle Assessment or Analysis
LCI Life Cycle Inventory
LTRAP Long Range Transboundary Air Pollution
LUST Leaking Underground Storage Tank
MWI Municipal Waste Incinerator
NAZ Noise Abatement Zone
NAQS National Air Quality Strategy
NIEA Northern Ireland Environment Agency

NIMBY Not In My Back Yard
NSCA National Society for Clean Air and Environmental Protection
ODP Ozone Depleting Potential
OPRA Operator & Pollution Risk Appraisal
OFWAT Office of Water Services
PAH Polycyclic Aromatic Hydrocarbon
PCBs Polychlorinated Biphenyls
PG Process Guidance Note
PRN Packaging Recovery Note
POP Persistent Organic Pollutant
RCEP Royal Commission on Environmental Pollution (former)
RDF Refuse Derived Fuel
ROHS Restricting of Hazardous Substances (Directive)
SAC Special Area for Conservation
SDC Sustainable Development Commission (former)
SEPA Scottish Environment Protection Agency
SME Small to Medium Enterprise
SSSI Site of Special scientific Interest
S(U)DS Sustainable (Urban) Drainage Systems
SWQO Statutory Water Quality Objective
TGN Technical Guidance Note
TSS Total Suspended Solids
UKAS United Kingdom Accreditation Service
VOC Volatile Organic Compound
WAMITAB Waste Management Industry Training & Advisory Board
WDA Waste Disposal Authority
WEEE Waste Electrical & Electronic Equipment (Directive)
WQO Water Quality Objective
SWQO Statutory Water Quality Objective
WWF Worldwide Fund for Nature

Managing The Environment

Introduction

Aims

The aim of Managing The Environment is to help to empower you so that you are enabled to further the cause of environmental management. Whatever roles and functions you undertake in your working life, you should perceive also within their environmental context and thus help to 'spread the message' and promote a positive environmentalist culture within your workplace. Environmental Management has tended to grow out of Health & Safety Management and the philosophies and practice of both disciplines have much in common so that hopefully you will be able to contribute towards an integrated safe, healthy & environmentally positive 'she' management structure.

Objectives

Each study unit will have a set of objectives defined and these are expressed in terms of learning outcomes

Preknowledge

The book is written for persons working at management level or those who advise and work with managers, for example workers' representatives and safety & health practitioners. It is intended that the content will be sufficient as a starting point to take you into any environmental management matter. Although there is considerable technical content as well as the legal and managerial component, you should not be daunted by this. Environmental science is a huge multi-disciplinary area and you should be able to seek and get technical support for anything you need. The managerial role is central and therefore crucial, if you have an understanding of the process of management then you are well on your way.

Qualifications

Managing the Environment substantially covers the syllabi for the following qualifications:

The NEBOSH Certificate in Environmental Management

IOSH 'Managing Environmental Responsibilities

It also fulfils the criteria of the Institute of Environmental Management and Assessment (IEMA) Foundation and goes a long way towards those of the IEMA Associate Certificate.

If you wish to make further professional advancement in Environmental Management, an obvious route is by taking either the Iema Associate Certificate giving Associate Member status of the institute and the designation AIEMA as also is the alternative NEBOSH Environmental Diploma or iema Diploma. Postgraduate courses which contain an Environmental Management component (for example, the University of Portsmouth MSc in Occupational Health and Safety Management and Environmental Management) meet the same learning outcomes.

You are advised to make contact with IEMA to explore your professional development options more fully.

Sources of Information

This is the age of the information explosion. In any subject or discipline the body of knowledge and information is ever growing and, it seems, at an accelerating pace. Worse still, everything changes with time so that keeping informed and up to date is an on-going need and requires us all to make an effort to keep up. Environmental management is amongst the fastest growing and developing areas, driven by a plethora of new legislation and the activities of the Government and Non-Governmental Organisations (GOs and NGOs).

Publications.

As a UK student the most useful single book you could invest in is the NSCA Pollution Handbook. It offers the dual benefits of being authoritative and very readable. It is also relatively inexpensive so that most people can afford to buy the next updated version (usually annually).

NSCA Handbook, National Society for Clean Air and Environmental Protection,

136 North St, Brighton BN1 1RG. . You can purchase it by credit card on: 01273 878770 or online at www.nsca.org.uk.

Also very comprehensive and available both in loose-leaf and electronically on CD ROM are:

Croner's Environmental Management;

Croner's Waste Management.

Croner Publications Ltd, Croner House, London Road, Kingston upon Thames, Surrey KT2 6SR. Croner also periodically issue an Environmental law Update for its subscribers.

Gee Environmental Risk Manager

Gee publishing Ltd, 100 Avenue Road, Swiss Cottage, London NW3 3PG

Database systems are available on CD ROM which offer easy access to a large core of health, safety and environmental information. They are too expensive for individual purchase but many organisations subscribe to one or other of them. Perhaps the best known are:

Barbour Index plc, New Lodge, Drift Road, Windsor, Berkshire SL4 4RQ

Technical Indexes Ltd, Willoughby Road, Bracknell, Berkshire RG12 8DW

Silver Platter Information Ltd, 10 Barley Mow Passage, Chiswick, London W4 4PH

The Internet provides a modern on-line search facility which is cheaply available and seems set to become the universal means of obtaining information about anything. Some websites which you are advised to visit are:

Business Link (Environment & efficiency) www.businesslink.gov.uk
IEMA www.iema.net
Chartered Institute of Water & Environmental Management
http://ciwem.org
DEFRA www.environment.defra.gov.uk
FERA www.defra.gov.uk/fera
The Environment Agency www.environment-agency.gov.uk
Envirowise http://www.envirowise.gov.uk/
The Health and Safety Executive www.open.gov.uk/hse/hsehome.htm
Sustainable Development commission www.sd-commission.org.uk
UK BAP www.ukbap.org.uk
IOSH www.iosh.co.uk
European Foundation for susdev.eurofound.ie
Sustainable Development
Greenpeace www.greenpeace.org.uk
Friends of the Earth www.foe.co.uk
Green Futures www.greenfutures.org.uk
Pesticide Action Network

(formerly the Pesticides Trust) www.pan-uk.org
There is even a dedicated internet service provider who will offer you a free online service called 'Free and Edie', (produced by the Faversham House Group) which claims to be the only unlimited free Internet access designed specifically for environment, water and waste professionals - www.on-edie.net

Additionally

The author has found the following to be particularly fruitful sources of information.

The Chartered Institute of Environmental Management and Assessment (IEMA), Saracen House, Crusader Road, City Office Park, Tritton Road, Lincoln, LN6 7AS. You can benefit from joining this rapidly growing professional body. There is a very useful journal "The Environmentalist" and a regional membership structure. The Environmental Law Bulletin from Cameron McKenna can now be downloaded free of charge periodically from their website.

The Warmer Bulletin is concerned with the practicalities of waste management and recycling. There are a good range of technical briefs, some of which are reproduced on the CD ROM. and are available on request from Residua (formerly Warmer - the World Resource Foundation), 1st Floor, The British School, Otley Street, Skipton

North Yorkshire BD23 1EP. Website: www.residua.com

The Environment Agency (www.environment-agency.gov.uk) also provides excellent material currently free of charge. You can obtain a free video on Waste Minimisation along with an Environmental Good Practice Guide for Industry and also a Pollution Prevention Pays pack (via the Environment Agency website). A wealth of information is obtainable from their website, including a national pollution map from which you can key in your postcode and get an on-screen map of your locality (see 'your environment').

The Building Research Centre Energy conservation Unit (BRESCU) both supply free information on request. You can access them via the BRE homepage at the web address:

http://www.bre.co.uk/

The National Calculation Method allows the actual calculation to be carried out by a new simplified tool based on a set of CEN standards. That tool has been developed by BRE and is called SBEM - Simplified Building Energy Model. It is accompanied by a basic user interface - iSBEM. For housing: www.est.org.uk/housingbuildings, 0845 120 77 99 (over 80 publications for the domestic consumer. For all other buildings: www.thecarbontrust.co.uk/energy , 0800 58 57 94. (you are referred to Envirowise).

EMAS Competent Body, Institute of Environmental Assessment, Welton House, Limekiln Way, Lincoln LN2 4US (e-mail emas-iea@dial.pipex.com).

The Safety & Health Practitioner (IOSH) sometimes carries useful articles on environmental issues (e.g. see January 2000, 'Is ISO 14001 an opportunity for safety professionals'). IOSH's largest Special Interest Group is its Enviromental SIG.

Newspapers (the Guardian or The Times, for example) and a number of periodicals such as Environment Business (Monitor Press), Ends Report (environmental Data Services (www.ends.co.uk)) and, of course New Scientist

National Geographic Magazine, from time to time features articles of environmental significance which are excellent in both content and presentation.

Friends of the Earth sell a whole range of leaflets, briefings, books and reports, they will send you a catalogue on request. Their quarterly newsletter is entitled 'earthmatters'

Friends of the Earth, 56-58 Alma Street, Luton, Beds LU1 2YZ.

Greenpeace, Canonbury Villas, London N1 2PN produces regular campaign reports for its members.

The Open University runs professional environmental courses and you can watch OU programs on television.

Faculty of Technology, The Open University, Walton Hall, Milton Keynes MK7 6AA

Website: www.open.ac.uk

Unit 1 Environmental Issues in Perspective

Objectives

1 To appreciate how concerns for the global environment are developing into a legal and managerial framework intended to take the world forward to a position of sustainable development.

2. Be able to chart the progress at world level by protocols, conventions and treaties and how this has been translated into action within the European Parliament.

3. Know in outline how European Directives and Regulations are translated into UK law as Acts of Parliament and subordinate Regulations.

4. Know the main provisions of the Environmental Protection Act 1990 and other relevant legislation in outline.

5. Appreciate who are the main stakeholders and who does what in terms of protecting the environment.

1.1 Ethics

There can be no doubt that mankind faces threat to his very survival if he does not manage to come to terms with his environment. Concepts such as 'global warming', 'depletion of the ozone layer', 'acid rain', 'increasing ocean levels as the Poles begin to melt', 'desertification' and 'species loss' have moved from matters of scientific debate into harsh realities which we all must now acknowledge. We travel together on the 'Good Ship Earth' and whether we do it as first class passengers (the 'Developed' Nations) or as 'steerage' (the so called 'Third World') we all stand to metaphorically drown if we 'do a Titanic'.

A definition of the environment which will serve was used in the 1990 UK Government White Paper, 'this common Inheritance' (J. S. Mill):

'Is there not the Earth itself, its forests and waters, above and below the surface? These are the inheritance of the human race.... What rights, and under what conditions, a person shall be allowed to exercise over any portion of this common inheritance cannot be left undecided. No function of government is less optional than the regulation of these things, or more completely involved in the idea of a civilised society.'

'This Common Inheritance' passed through parliament as the 'Green Bill' and eventually became the Environmental Protection Act 1990.

However, NEBOSH (National Examination Board in Occupational Safety & Health) prefer:

"*the surroundings* in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans and their inter-relation*"

* surroundings can extend from within an organisation to the global system

The problems of environmental degradation are inextricably linked with those of population growth (6.91 billion at 2010). Although in terms of actual numbers, undeveloped countries are increasing their populations more rapidly, per capita consumption is something like 400 times less than that in the developed world. The Northern Hemisphere contains most of the developed nations and so in environmental terms the N/S divide is arguably more important than E/W.

1.2 Realities Coming Home to Roost?

India's population is set to exceed that of China within a generation, and both these countries are seen as having 'tiger' economies as they raise their standards of living. Their increased demand for basic resource is one of the main reasons why we have reached the point of permanent oil shortage. Prices have risen from $50 a barrel to $120 in a decade and it is unlikely that they will ever go down again to former levels. As the UK has exhausted it's offshore oil and gas reserves, the state of Qatar has been contracted to supply 25% of our gas needs for the next 25 years. LNG tankers (brightly coloured red and highly visible!) now discharge into our existing gas pipe network at Milford Haven and grain.

From gathering, through liquefaction, transportation and evaporation some 30% of the energy is lost. Pipelines are inherently more efficient but more vulnerable to supply interruption.

Our unquenchable love affair with the motor car continues. One unexpected side effect of this is the 12 square miles of London suburban front gardens which have disappeared under hard cover, increasing water runoff and flash flooding at a time when violent storms are perceived to be on the increase! Not only have we more vehicles, we have larger ones. The response to the infinitely tedious (and largely unproven) use of speed humps has lead to a renaissance of the Land Rover as being more comfortable in which to ride over them. Bigger vehicles, less fuel economy, more expensive in their manufacture! It is truly a kind of madness.

The awful destruction of New Orleans by Hurricane Catrina as it's poorly maintained levees collapsed point both to increasingly violent weather and rising water levels worldwide. It is difficult to decide whether a weather event is due to global climate change or just part of the 'normal' range, but scientific opinion now firmly says that it is so. Fist-sized hailstones destroying the roofs of houses in a small village in the Black Forest (29th July 2005) can probably be dismissed as an 'act of a rather angry god' but the storm of 1996 which devastated the region, bringing down huge swathes of trees is less easy to dismiss. Southeast England also, it should be remembered had it's own hurricane in 1987 which destroyed 5 million trees. That trees are linked to climate was unusually demonstrated in Qatar when the winter of 2004/5 was the worst in living memory. It rained! There has been a mass tree planting there to conceal the US airbase from which much of the 'shock and awe' was inflicted on Iraq.

And the species decline ever continues. We now speak of a mass extinction comparable at least to the Permian in which about 70% of all species disappeared. It is happening now and the effects are irreversible.

Destruction of forests has gone on since man learned how to fell trees. Burning down woodlands also has enjoyed a long history. The island of Madeira was wantonly torched in order to somehow make it more habitable and the same sort of approach is still practiced in Borneo. Recent studies suggest that wetland drainage and agricultural activity, slash and burn methods is likely to completely destroy the peat reserves there, releasing vastly more CO_2 than the Kyoto summit was ever pledged to contain. These events and many others (such as the desertification of much of Spain) lend urgency to the need to work for sustainable development.

1.3 Towards Environmental Management

Awareness of the environment as endangered by the activities of man is perhaps epitomised by Rachael Carson's book, 'Silent Spring' which pointed up the dangers of chemicals and pesticides spreading through and polluting the environment, with unforeseen, unpredictable and therefore potentially deadly consequences. Out of the growth of the Environmental Movement of the sixties and seventies came the 'Green Parties' and the ecological pressure groups, notably 'Friends of the Earth' and 'Greenpeace' (FoE tend to work 'within the system' by peaceful lobbying whilst Greenpeace prefers militant, active protest to stop, for example, excessive whaling). The atmosphere was one of concerned environmentalists crying warning in the face of the perceived threat posed by growth of international companies and political evils - the arms race and the fear of nuclear war. This was a time of considerable pessimism, expressed as concerned humanity fighting a desperate rearguard action to save the planet from the excesses of the rich and greedy multinationals, a viewpoint which has been sharpened by the so called 'Credit Crunch' recession.

This view can still have relevance because many acts of environmental vandalism still occur. Setting fire to oil wells in Kuwait and deliberate pollution of the Gulf are extreme examples from recent time, Gulf War I, (and Gulf War II – Iraq - can hardly be less environmentally harmful). The radiation release at Chernobyl, now likely to be overshadowed by the Fukushima meltdowns in Japan and set to become the watchword for nuclear disaster symbolise also that which pours out of 'Pandora's box' when the lid is blown open as it all too frequently still is - India, Pakistan & North Korea have all detonated nuclear devices.

But mankind has not been inactive and a growing awareness and commitment to the world environment gives cause for optimism, albeit cautious optimism!

1.3.1 Action at World Level

The United Nations commissioned 'a global agenda for change' in 1983 in the face of looming environmental crisis for which all the evidence was by then abundantly clear. Under the title of 'Our Common Future', headed by Gro Harlem Bruntland, Prime Minister of Norway, the World Commission on Environment and Development reported in 1987. As a direct result there have been world-wide initiatives to deal with world-wide environmental problems.

The Montreal Protocol 1987 dealt with depletion of the ozone layer by setting a timetable for phasing out the use of ozone depleting chemicals, notably the CFCs (chlorofluorocarbons).

The Earth Summit 1992, (Rio, Brazil) established:
- a framework Convention on the Atmosphere (Climate Treaty);
- a Convention on the conservation of biological diversity;
- Agenda 21 - an environmental work programme;
- Sustainable Development Commission;
- statement of principles for sustainable management of forests;
- declaration of principles for pursuit of sustainable development to relieve poverty and global environmental degradation;
- agreement on funding - stressing environmental aid.

The Kyoto Summit (Japan) 1997
- central issue involved atmospheric carbon dioxide emission levels;
- Signatories agree to reduce emissions to 1990 levels;
- By 2010, 191 countries have signed & ratified it, notably, the USA has at last signed but alas not yet ratified it.

A listing, which includes the Copenhagen treaty is available online as 'Table 25 – Status of Major International Environmental Treaties'

1.3.2 Action at European Level

Europe began acting as a unit following the Treaty of Rome (1957) and produced a series of Action Plans for the Environment.

The 1st Action Plan (1973) laid the objectives of an environmental policy.

The 2nd Action Plan (1978) described measures to reduce pollution and improve the environment.

The 3rd Action Plan (1983) developed an overall strategy.

The 4th Action Plan (1987) set specific objectives for acid rain and forest die-back, to focus overall control measures and develop environmental management systems.

The 5th Action Plan (1993) called for the achievement of sustainable development. The 6th EAP (2002 – 2012) takes a broad look at the environmental challenges and provided a strategic framework for the Commission's environmental policy up to 2012.

A proposal for an action plan **"Living well, within the limits of our planet",** to guide environment policy up to 2020. The proposal aims to enhance Europe's ecological resilience and transform the EU into an inclusive and sustainable green economy

The Single European Act (1986), Article 130R specifically set objectives to:

- Preserve, protect and improve the quality of the environment;
- Contribute towards protecting human health;
- Ensure a prudent and rational utilisation of resources

and the Maastricht Treaty extended them to:
- Contribute to international environmental measures.

Also that Community environmental action should be based on:
- Taking preventive action;
- Damage should be rectified at source;
- The polluter should pay;
- Environmental protection should be a component of all Community policy.

The Community should take account of scientific and technical data, environmental cost-benefit analysis as well as the variation of existing conditions across the regions and the need for balanced development.

The Maastricht Treaty (1992) contains as a principle objective promotion of sustainable growth respecting the environment, a high level of environmental protection and a policy for the environment. The concept of subsidiarity means ever closer union amongst the peoples of Europe and that decisions should be taken as closely as possible to the individual citizen.

All of these factors impinged on the Action Plans and created a torrent of Directives on environmental matters. Summarising them is difficult (a useful synopsis is given in the NSCA Pollution Handbook Appendix 6.1), they cover matters relating to:

APC (Air Pollution Control) Framework Directive 84/360/EEC
Large Combustion Plant
IPPC (Integrated Prevention & Pollution Control)
Motor Vehicles standards (from 1970), > 20 Directives
Air Quality Monitoring (1982)
Municipal Waste Incinerators (1989)
Noise and nuisances >30 Directives
Waste framework Directive 75/442/EEC and numerous Daughter Directives
Water for drinking, freshwaters, shellfish waters, bathing and groundwater.
Additionally there have been Conventions, some of the more relevant being:
Paris 1975 (marine pollution)
Rhine 1977 (pollution of the Rhine)
Barcelona 1977 (pollution of the Mediterranean Sea)
Geneva 1979 (Transboundary air pollution monitoring, control of NOx emissions)
LRTAP (long range Transboundary air pollution) Convention extended this to set limit values for lead, asbestos, NOx, SOx, Ozone and particulates.
Basel 1993 (Transboundary movement of hazardous waste)

Other initiatives relate to dangerous pollutants and the creation of black, red and grey lists and the setting of environmental quality objectives.

The Precautionary Principle is written into the Treaty on European Union, and is important because it requires that all emissions of pollutants shall be minimised even in the absence of conclusive proof of harm. The REACH Regulations are designed to address concerns of environmental dangers associated with new chemical products. An example of the application of the principle is that microwave transmitters (cellnet) shall not be erected on educational buildings (Australia & New Zealand).

1.3.2a Expansion of the European Union.

The EU has grown dramatically with its expansion taking in many of the former Eastern Bloc satellite countries and Turkey, hopefully in the near future. Russia could eventually join. In order to enable all these states to reach conformity with harmonised standards, a process of derogation is practiced which gives time for them to 'catch up.' Reunification of Germany was found to be enormously costly and difficult and may give an insight to the difficulties which lie ahead, though only eurosceptics doubt the value of the EU, and its effect on environmental performance is going to be profound.

1.3.3 Sustainable Development

Simple enough in principle, it means acting in a manner which will not undermine the ability of an organisation to continue to function in the future. In environmental terms, if the consumption of natural capital (resource depletion and degradation by waste and pollution) exceeds the ability to renew then the condition is not sustainable.

Traditionally, productive industry has applied 'end of pipe' solutions to the problem of pollution, but this is reactive and inherently inefficient. And the pipe might leak! A second stage is in applying 'clean technologies' in which waste and pollution are minimised but it is still inevitable that a certain amount of residue is left. A third stage is using 'cradle to grave' or 'lifecycle' analysis and considering the aggregate environmental costs involved (as an example, a motor car may produce more pollution during its manufacture than for the whole of its subsequent service life). In sustainability terms these approaches can be taken as a hierarchy.

The Gaia principle (Gaia hypothesis) makes the ultimate forward view that the whole Earth is a living organism and there is no cradle or grave – in nature everything is recycled

Sustainability is not an absolute and in calculating whether a process, product or service is sustainable, regard must be taken for the general or societal factors which surround it. Such constraints as regional development subsidies, common agricultural policy, distorted energy policy, transportation and taxation policy will effect the outcome.

According to the Environment Council:

'*Companies alone cannot and should not be expected to deliver sustainable development. This is a societal goal*...'

Thus, all must work together at operational, political and policy making level and move towards sustainable development. This is the true challenge.

1.3.4 Action at UK Level

Early UK Legislation was prescriptive, attempting to contain and control polluting industries. Hence:

The Alkali Acts;

The Clean Air Act 1953;

The Control of Pollution Act 1974 (COPA).

Whilst these acts had success in cleaning up pollution by such means as setting the heights of chimneys to carry away pollutants they were limited by being prescriptive, using end of pipe solutions. They did not establish a blueprint for environmental management.

The Health & Safety at Work etc. Act 1974, (HSW Act) Section 5(1) placed a general duty (thus requiring a management approach) on persons in control of premises to use best practicable means for preventing the emission into the air of noxious or offensive substances and/or rendering harmless and inoffensive such substances as were emitted. Some important regulations were made under the HSW Act:

Emissions into the Atmosphere Regulations 1983 (Amended 1989);

Control of Industrial Major Accident Hazard Regulations 1999 (COMAH);

Control of Substances Hazardous to Health Regulations 2003 (COSHH);

Control of Asbestos in the Air Regulations 1990;

Genetically Modified Organisms (Contained Use) Regulations 1992.

The Food and Environment Protection Act 1985 is also worth mentioning because it placed restrictions on dumping of waste at sea and also enabled the Control of Pesticides Regulations 1986.

Thus the framework was set for the key piece of legislation, which we need to look at in some detail, the Environmental Protection act 1990 and The Environment Act 1995 which latter created the Environment Agency from former enforcing bodies, the National Rivers Authority (NRA) and Her Majesty's Inspectorate of Pollution (HMIP), Waste Regulation Authorities and several smaller units from the DoE. (SEPA – Scotland) and NIEA (Northern Ireland) have similar structures. Also, a Memorandum of Agreement was signed between the Environment Agency and the Health & Safety Executive (HSE) to manage overlapping responsibilities and avoid duplication.

1.3.5 Environmental Protection Act 1990

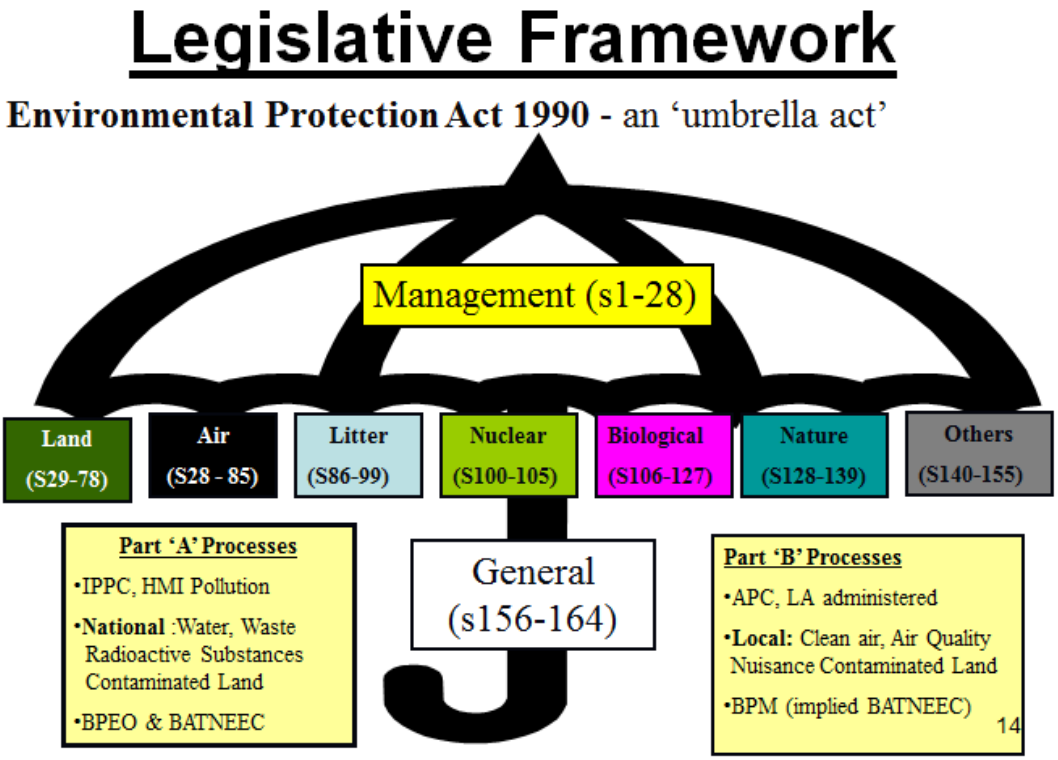


Figure 1.1 illustrates how the EPA 1990 acts as an 'umbrella' in the same way that the HSW Act does in health and safety matters.

The most important single aspect of this very large and wide-ranging act was the introduction of Integrated Pollution Control (IPC). Part A defined about 5000 processes or substances which are considered to be the most polluting in the UK and these were prescribed in the schedules to the Environmental Protection (Prescribed Processes and Substances) Regulations 1991, now repealed into the Environmental Permitting Regulations.

IPC required that discharges to all the media - land, water and air are considered and that the Best Practicable Environmental Option (BPEO) be chosen to minimise harm to the environment as a whole. An authorisation (and now EP Permit) will, furthermore, require that the Best Available Techniques (BAT) are used as a standard. Guidance in the S2 series is available online at the Environment Agency website The term BAT needs further amplification, thus:

Best means the optimal or most effective way of minimising or rendering harmless polluting releases.

Available or procurable by the operator of the process

Techniques, embracing concept, design and operation of the plant or process, the staff involved, their training and competency and the methods of working (can be summarised as the '4Ps', Plant, Process, People, Procedures).

Originally the term BATNEEC was used …not entailing excessive cost

Part B of the Act was (and still is) concerned with Local authority Air Pollution Control (LAAPC), covering about 13000 processes. LAAPC, as the term implies, is administered by local authorities and is also subject to BAT. A General Guidance Manual covers the requirements for an operating licence which must be obtained from the LA. It is the LAs duty to see that the guidance is being followed and also to police the operators to see that they adhere to their operating terms and conditions.

The Pollution Prevention and Control Regulations (IPPC) became law in August 2000, an example of the constantly shifting and tightening regulatory framework in response to an EC Directive (COM(96)306). The new regime has progressively taken over from IPC and LA-IPPC on a sectoral basis, completed by 2007 and harmonised by the use of BAT Reference documents (BREFS) - the approach taken is towards clean technology rather than merely cleaning up the emissions. The Environmental Permitting Regulations 2007 applies a standardised application process which is dedicated to reducing compliance costs and bureaucracy but without reducing policy or the rigour of regulation.

Application to operate a prescribed process must be made to the enforcing authority and a fee paid. Continuation fees may be incurred in respect of subsistence charges (for monitoring work) and variation fees (for changing the

process). This follows an important principle that the polluter pays. The fees pay towards running the enforcing authority and fines and remediation (clean-up) costs go towards repair of environmental damage.

The authority must decide whether the applicant is able to operate the process and may refuse or impose conditions. The application must be publicly advertised in a local paper and also in the London or Edinburgh Gazette, ensuring that public opinion is heard and suitable controls are set in place.

1.3.6 Powers of Inspectors

The powers held by Environment Agency inspectors are analogous to those of HSE, Fire authority, Local Authority and the former Factory Inspectors and are worth summarising. An inspector can:

enter premises at any reasonable time;
take along another authorised person + any necessary equipment;
carry out examination and investigation;
request that premises be left undisturbed pending investigation;
take and test samples, articles and substances, measurements and photographs;
require a person to answer questions and furnish any information held by another;
and to request another person to assist the inspector.
In addition, an inspector may seize and destroy articles and substances which present immediate danger to the environment.

An inspector may serve an Enforcement Notice if there is reason to believe that authorisation conditions of a prescribed process are being breached and a Prohibition Notice if there is imminent risk of serious pollution of the environment. S/he can also serve a Works notice (Anti-pollution Works Order) requiring improvements to be made where a risk of environmental pollution exists. It is usual, provided that no immediate environmental danger exists, for an enforcement officer to give 10 days notice of the intention to serve a formal notice to permit the operator to make representations back to the enforcing authority (presumably to prevent trivial issue of Notices). The law is powerful in respect of environmental issues in that a high Court Order can be obtained to compel compliance. Penalties in the magistrates court (summary conviction) are up to £20 000 and/or up to three months imprisonment per offence and unlimited fine and/or up to two years imprisonment in a higher court. Civil remediation costs may also be sought.

1.3.7 Civil Sanctions

As an aid to efficient enforcement without recourse to the courts, the Environment Agency has been given powers to impose 'civil Sanctions' :

Compliance Notice - a regulator's written notice requiring actions to comply with the law, or to return to compliance, within a specified period;
Restoration Notice - a regulator's written notice requiring steps to be taken, within a stated period, to restore harm caused by non-compliance, so far as possible;
Fixed Monetary Penalty - a low-level fine, fixed by legislation, that the regulator may impose for a specified minor offence;
Enforcement Undertaking - an offer, formally accepted by the regulator, to take steps that would make amends for non-compliance and its effects;
Variable Monetary Penalty - a proportionate monetary penalty, which the regulator may impose for a more serious offence;
Stop Notice - a written notice which requires an immediate stop to an activity that is causing serious harm or presents a significant risk of causing serious harm.

1.3.8 Command and Control versus Market Based

Increasingly it is becoming recognised that regulation and enforcement are blunt and often surprisingly ineffective devices for environmental management, emphasising reactive measures. The use of management devices and systems, environmental management systems (ISO14001, EMAS), environmental taxation (Climate Change Levy, Landfill Tax, eco-labelling etc..) are seen as being proactive drivers to improved environmental performance.

Producer Responsibility Obligation is also a performance driver. Originally applied to the Producer Responsibility Obligations (Packaging Waste) Regulations, it is becoming generalised as an approach, exemplified by the ELV, WEEE & ROHS Directives.

1.4 Environment Act 1995

The EA95 (Part 1) created the Environment Agency from the former National Rivers Authority, Waste Regulation authorities and the specialist inspectors in Her Majesty's Inspectorate of Pollution.

Part 11 laid the framework for dealing with contaminated land.

Part 1V set up the national air quality strategy

Part V set up national waste strategies, including Producer Responsibility.

1.5 Environmental Assessment

Directive EEC/337/85 requires that an environmental impact statement be prepared for any development which might have a significant environmental effect. In the UK, this is implemented under the Town and Country Planning Act 1990, Town and Country Planning (Environmental Impact assessment) (England and Wales) Regulations 1999 and the Planning and Compensation Act 1991 and becomes an Environmental Impact Assessment (EIA). The Regulations require that the environmental statement must also consider viable alternatives to the proposal.

An Environmental Statement is required for any proposed development which is prescribed in Schedule 1 of the regulations and may be required for a development covered in Schedule 2 (depending on the size, nature or location). Schedule 1 relates to oil refineries, power stations (including nuclear), radioactive waste, iron and steel works, asbestos extraction, chemical works, motorways, railways and larger aerodromes, ports and waterways and waste disposal. Schedule 2 is larger in scope and would cover, as an example construction of an industrial estate. Clearly the location and size of the operation will be highly significant - a greenfield development is unlikely to require assessment, whereas the same proposal in a town would certainly require an EIA.

Schedule 3 sets out the parameters of an EIA and what must appear in the environmental statement. It must include:

a description of the proposed development;
the information needed to assess the environmental effects;
a description of the likely environmental effects;
measures taken to minimise potential environmental harm;
a non-technical summary.

It may include other supporting information to support the assessment - e.g. physical appearance of the development, estimates of resource use and where materials will be taken from, and waste and emissions occurring. A good practice guide is available (DoE, 1995) to aid in presenting an EIA.

EIAs are often carried out in association with a Social Impact Assessment (SIA) – an assessment of effects of projects or policies on people and the quality of life, traditions, lifestyles, inter-personal relationships and the living environment.

EIAs will inevitably lengthen the time a project takes to completion. In the first instance, the local planning authority should be consulted and in the event of disagreement, appeals are determined by the Secretary of State. Disputes may arise, exemplified by the proposed south-east London River Crossing, for which most of the infrastructure roads are now completed but which has been stopped by local protest. This is the famous Oxleas Wood case and destruction of this ancient woodland was only prevented by intervention in the European Court of Justice. It has been remarked that the EEC cares more about the UK environment than its own people do!

1.6.1 Governmental and Non-Governmental Organisations (GOs & NGOs)

What follows can only be an outline of the various organisations which have an involvement with the environment and their duties and responsibilities. It is useful in giving you an overview of who does what and where overlap and even conflict may occur. Even as a summary, it tends to read like a shopping list and you will need to consult sources of information if you want the detail. There are differences between the English, Scottish, Welsh and Northern Ireland administrations but the organisations all have broadly parallel functions, this overview defaults to the English system for simplicity.

GOs – the important ones are referenced below but it should be borne in mind that HMG is dedicated to simplifying and clarifying the legislative framework. Thus, for example the Environmental Permitting Regulations repealed and simplified a raft of earlier ones into one much more workable system. There are also said to be too many Government sponsored websites and these are currently in process of being rationalised through Business Link

Department of Environment, Food and Rural Affairs

DEFRA is a massive organisation, headed by the Secretary of State and having a Directorate and Divisional structure summarised below. It is organised in 9 regional offices to which planning and policy guidance should be sought in the first instance. These offices form an obvious link to local authority planning departments.

Planning Directorate;
5 divisions deal with planning policy and controls, planning enquiry and environmental assessment, mineral extraction and hazardous substances.

Wildlife and Countryside Directorate;
- Countryside Division
- European and Wildlife Division
- Global Wildlife Division
- Rural Development Division

Water and Land Directorate;
- Drinking Water Inspectorate
- Water Supply and Regulation Division
- Water Quality Division
- Marine, Land and Liabilities Division

Environmental and International Directorate;
- Air and Environmental Quality Division
- Global Atmosphere Division
- Radioactive Substances Division
- Environment Protection, International Division
- Environment Protection Statistics and Information Management Division

Directorate of Environmental Protection, Strategy and Waste;
- Waste Policy Division
- Environment Protection Strategy and Europe Division
- Environment Agency Sponsorship and Navigation Division
- Environment Protection Economics Division

Environmental and Energy Management Directorate;
- Environmental and Energy Awareness Division
- Energy Efficiency Policy and Sponsorship Division
- Environment Business and Management Divisions
- Chief Scientist
- Planning Inspectorate
- Building Research Establishment

In addition, there are Interdepartmental Committees and advisory functions which do such things as issuing planning circulars to local authorities, pollution papers and reports (notably the waste management papers). Additionally, the Department may be involved in EC negotiations and attend at international conventions.

Business Link (Environment & Efficiency) is now the hub for dissemination of Government Guidance on Environmental matters, including NETREGs

The Department for Business Innovation & Skills (formerly DTI) is responsible for, has links to (given a policy of progressive privatisation) various laboratories (Laboratory of the Government Chemist, National Physical Laboratory, National Engineering Laboratory and National Environmental Technology Centre). It also promotes environmental awareness under such programmes as the Enterprise Initiative.

The Food Standards Agency is responsible for food safety policy and hygiene legislation in an attempt to restore consumer confidence in the food industry following outbreaks of salmonella, listeria, e-coli 157 and BSE With reported

cases of food poisoning now exceeding 100 000 pa (it is estimated that only 10% of cases are reported as such - simple arithmetic therefore suggests that every one of us will get food poisoning in our lifetime!).

Agencies of the Department for Environment, Food and Rural Affairs

Animal Health
Centre for Environment, Fisheries and Aquaculture Science
Forest Research
Forest Enterprise (England)
Food and Environment Research Agency
Marine and Fisheries Agency
The Rural Payments Agency
The Veterinary Laboratories Agency
The Veterinary Medicines Directorate
Health Protection Agency

Role is to provide an integrated approach to protecting UK public health through the provision of support and advice to the NHS, local authorities, emergency services, other arms length bodies, the Department of Health and the devolved administrations.

Other than the Ministries the government has established:

The Royal Commission on Environmental Pollution (RCEP) which is (was!), in effect, the UK's environmental watchdog. It produced many influential reports on environmental matters and has significantly altered policy thereby. For example, it proposed in its 5th Report (1976) that there should be a unified pollution inspectorate and the concept of BPEO should be used. The 22nd Report (2000) calls for radical action to combat climate change by limiting CO_2 emissions by carbon taxation and energy efficiency in line with, and going further than the measures proposed at the Kyoto summit. Cameron's Coalition government closed it down (March 2011) as part of the measures to take us forward into Austerity Britain and presumably for no better reason than that it was a Quango!.

The Environment Agency is charged to protect and enhance the environment and make a contribution towards attaining the objective of achieving sustainable development. To help in this achievement it must adopt a holistic integrated approach and work alongside and with relevant bodies and the public at large. Section 4 of the Environment Act 1995 details how this shall be done. It must moreover further the conservation and enhancement of natural beauty, flora and fauna. According to it's own literature:

'By combining the regulation of land, air and water, the Agency offers a comprehensive approach to environmental protection and improvement (in England & Wales). This is achieved with an emphasis on prevention and education and on vigorous enforcement where necessary'

This is now translated into 9 published aspirational goals which are summarised as:

peace of mind knowing that the environment is clean and safe;
improvement in urban and rural environmental quality;
management by commerce and industry to protect the environment;
sustainable waste management;
clean air;
clean water;
enhancement of the land;
flood prevention measures;
reduction of greenhouse gases.

More specifically it has pollution control responsibilities:

Authorise emissions, discharges and disposals to the various media by licensing, monitoring compliance and taking enforcement action;
Waste management licensing and regulation, including special and radioactive wastes and also import/export of waste. It must assess waste disposal needs and offer technical guidance on waste management;
Regulate and report on contaminated land;
Advise government in setting environmental quality objectives (EQOs);
Advise industry and others on best environmental practice.

The Agency also has an administrative and consultative role. It must set up and consult:

Regional Environment Protection Advisory Committees;
Regional and local Fisheries Advisory Committees;
Regional Flood Defence Committees;
Registration and exemption schemes for producer responsibility (e.g. Packaging).

It must also consult with the Natural England about SSSI's which its decisions might effect and relevant other bodies in respect of issuing discharge consents.

The National Environment Research Council (NERC)

The Biotechnology and Biological Science Research Council are the major bodies for promoting environmental research within higher education and internationally. They advise industry and the government and carry out research for government departments. The HPA's role is to provide an integrated approach to protecting UK public health through the provision of support and advice to the NHS, local authorities, emergency services, other arms length bodies, the Department of Health and the devolved administrations.)

English Nature, Scottish Natural Heritage, Countryside Council for Wales and Council for Nature Conservation and the Countryside (Northern Ireland). Their functions include:

Creating and managing nature reserves (National Parks);
Designating Sites of Special Scientific Interest (SSSI's);
Consultation on EIAs.

Local Authorities are responsible for:

strategic planning control;
air pollution control (LAAPC);
setting and monitoring air quality standards
nuisances (especially noise);
waste disposal (LAWDCs);
emergency planning (e.g. under the COMAH Regulations);
operating an Environmental Health Department;
overseeing drinking water quality;
identifying and assessing contaminated land.

1.6.2 Non Government Organisations

A large number (>1000) of these exist in the UK and it is only possible to point to a few who are particularly significant to environmental management (figure 1.3 shows the interface between environmental health, public health and the environment). Some other notable bodies are :

Chemical Industry association (CIA), Institute of Chemical Engineers (ICE);
Royal Town Planning Institute, Town and Country Planning Association;
Water Services Association;
Countryside Commission;
Friends of the Earth, Greenpeace, Green Alliance;
Industry Council on Packaging and the Environment (INCPEN);
National Association of Waste Disposal Contractors (NAWDC);
Institute of Ecology and Environmental Management (IEEM);
Institute of Environmental Management & Assessment (iema);
Chartered Institute of Wastes Management (CIWM);
Chartered Institution of Water & Environmental Management (CIWEM);
Environmental Protection UK;
National Trust, Royal Society for Nature Conservation.

Unit 2 - Dynamics of Environmental Pollution

Objectives

1. To gain an understanding of the natural cycles which operate within the global environment and perceive how pollutants enter the cycles and become distributed within them.

2. To appreciate how harm to the environment and to public health can occur due to environmental pollution and to be able to cite relevant examples.

3. To appreciate the dynamics of the environment and its burden of pollutants.

4. Know the main environmental concerns and the causative agents, acid rain, global climate change, toxic metals, toxic organic compounds (especially pesticides), species loss and atmospheric pollutants.

2.1 Natural cycles

2.1.1 The Water Cycle

The way in which substances move around as components of the dynamics of the planet Earth is often expressed in terms of natural cycles. Much study has gone into establishing how these cycles operate and, importantly, the mass balances involved. Of these, perhaps the simplest is the Water Cycle (Figure 2.1).

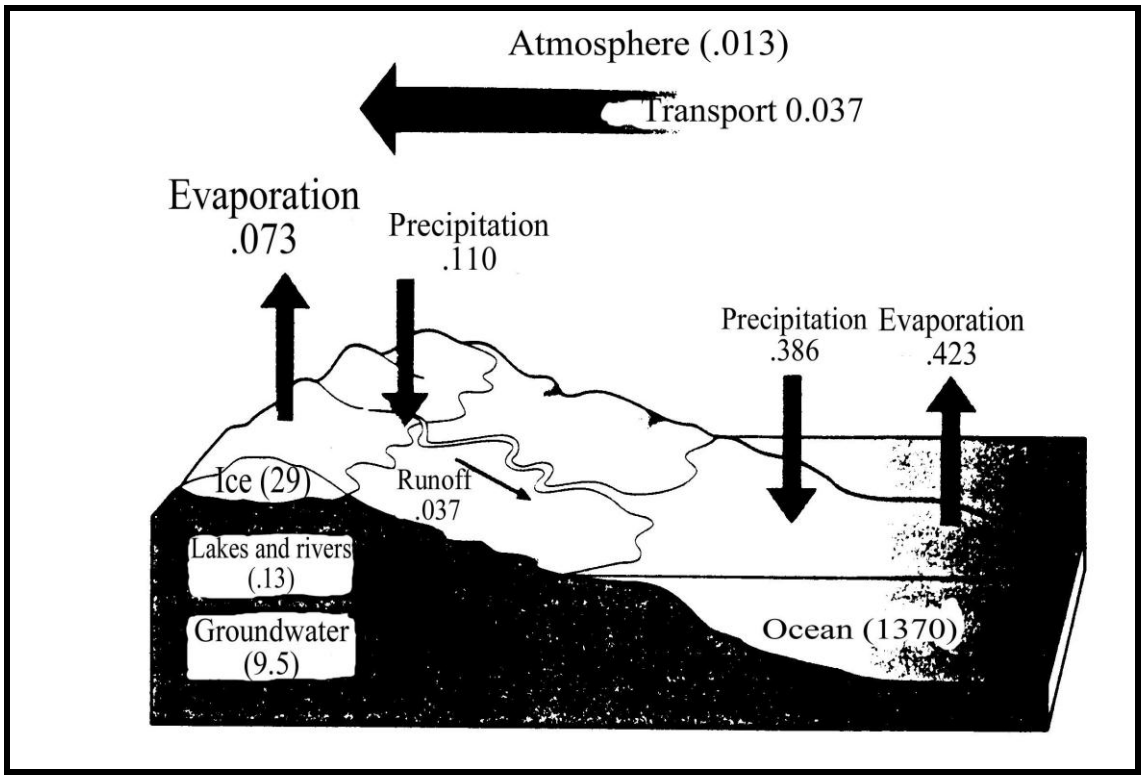


Figure 2.1 - the Water Cycle

Inventories (in brackets) are *reservoir capacities* (106km3).

Water flows (fluxes) are in 106km3 per year

For a more complete understanding of how the water cycle works you must know that:

liquid water takes in *latent heat* energy and becomes water vapour;
water vapour condenses to liquid water, releasing *latent heat* energy.

The amounts of energy are very large and act as the engine which drives the weather.

Some relevant properties of water:

it is a powerful solvent;
it reacts chemically with many substances or acts as a catalytic medium or a substrate in which reactions can take place;
it transports material via the water cycle;
it acts as a vast storage medium (the oceans).

Thus, for example, sulphur dioxide may be dissolved in raindrops, oxidised to sulphuric acid and then fall as acid rain where it reacts with metal ores, dissolving (leaching) them out and then transporting them into streams and ultimately to lakes or the sea where they may then be precipitated following further reactions and form into sediments on the lake or sea bed.

2.1.2 The Carbon Cycle

The water cycle is unique in that water is present throughout only as the molecule H_2O, albeit existing in three physical states, vapour, liquid and ice. It is not chemically transformed in any way although its acidity may vary – CO_2 increases it.

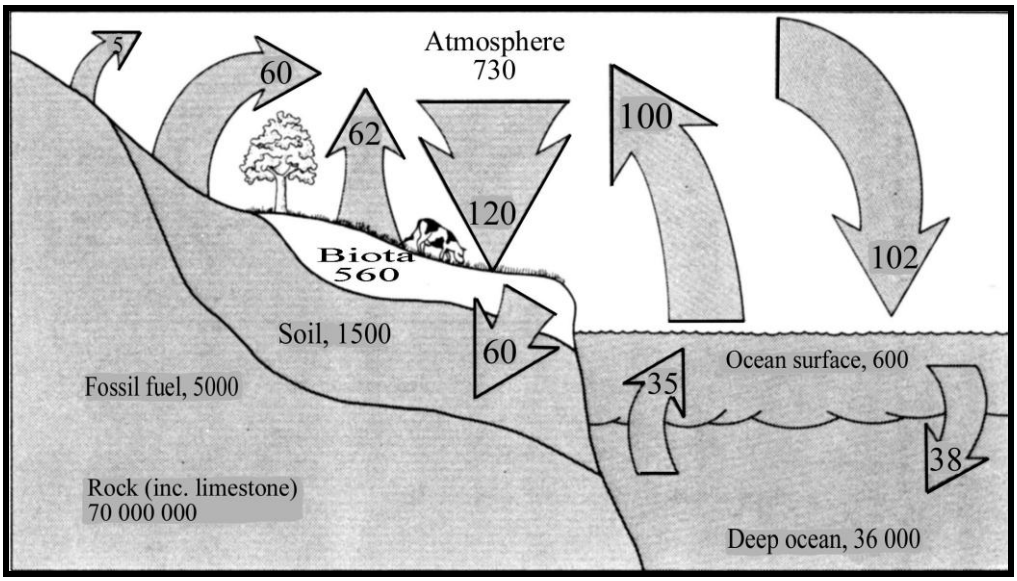


Figure 2.2 Schematic diagram of the Carbon Cycle. (Units are 106 tonnes)

Carbon is a chemical element, comprising perhaps 1% of the planetary mass. Carbon atoms are the building blocks making up the basis of life - *organic chemistry* is the chemistry of carbon and its compounds.

There are 4 main carbon storage pools:

Geochemical (carbonate rocks and fossil fuels)
Soil carbon
Biological organisms
Atmosphere and oceans

Exchange between these pools is via the atmosphere and the oceans as carbon dioxide gas (CO_2). The rate of exchange is greatest for biological organisms and least for the rocks. Figure 2.2 shows how carbon moves around between pools and gives the mass balance in billions of tonnes.

Great concern is now felt world-wide because the carbon dioxide content of the atmosphere is increasing as a result of mankind's activities since the Industrial Revolution - the burning of fossil fuels. This has dramatically increased the release rate from the geochemical pool, increasing the atmospheric concentration from 270ppm to 380ppm and still rising. The well-known 'greenhouse effect' refers to increased efficiency with which solar radiation is trapped by carbon dioxide proportionally to its concentration and consequently global warming and unpredictable climate change is likely to result with potentially undesirable consequences. That atmospheric CO_2 is increasing steadily is beyond doubt (figure 2.3).

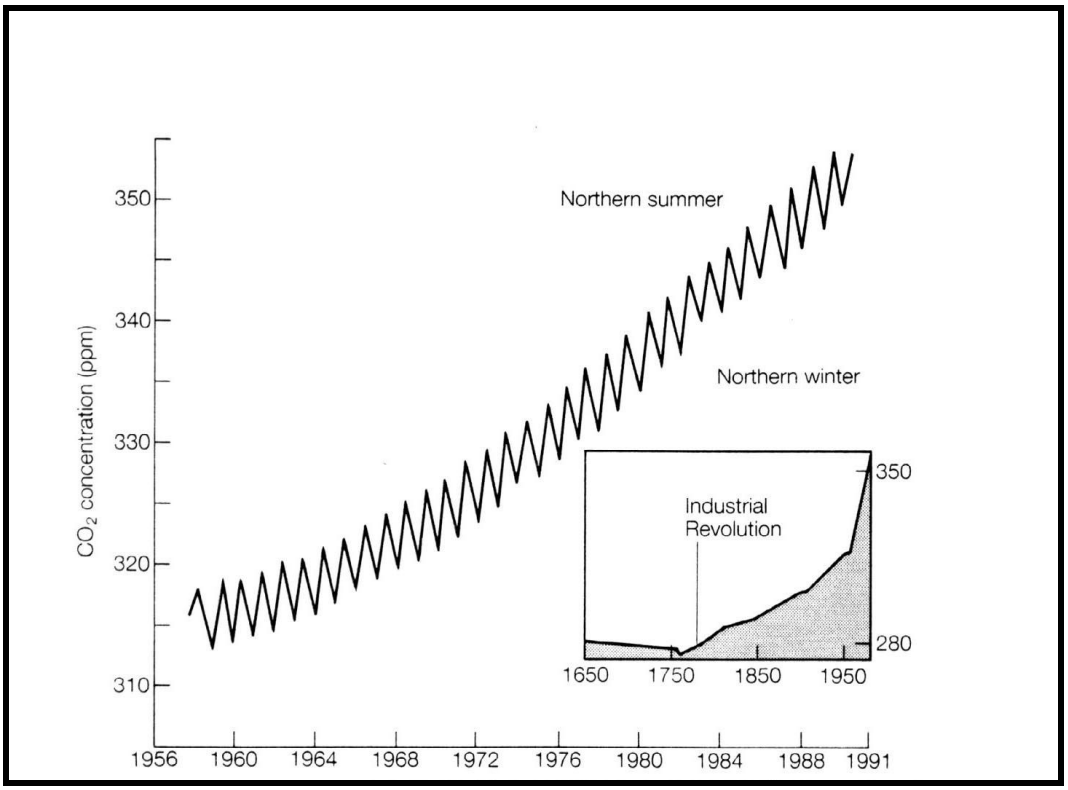


Figure 2.3 - Atmospheric Carbon Dioxide Levels

The concept of a natural cycle should not be confused with equilibrium conditions, there are usually net flows from one pool to another and this is evident for the carbon cycle over geological time - evidenced by the laying down of coal and oil reservoirs during the Carboniferous period. Hence, the concept of the balance of nature is not inviolate. Nature is a dynamic system and change is the norm. Species are constantly changing in response to the environment by adaptive processes (Darwinian natural selection). Material is constantly being transferred from one pool to another. Our concerns are that the activities of man may so disturb the natural cycles that ecological disasters occur. In the case of CO_2 emissions, Antarctic ice core samples have shown dramatic changes from time to time, perhaps coinciding with ice-ages during the last 160,000 years but by burning fossil fuels over the last 200 years, we have already wrought a change as large as any over that time.

There is also concern that increasing acidity of seawater due to rising levels of dissolved CO_2 is having a devastating effect on coral reefs. The Australian Great Barrier Reef may disappear within one or two generations!

(An interesting by-product of increasing CO_2 levels is increase in growth rates of plants because photosynthesis works better at higher CO_2 concentrations. Studies show that crop yields might be increased by 10% - 20% at doubled CO_2 levels. In terms of the cycle, here is a means of reducing atmospheric CO_2 which is controlled to some extent by the concentration and will tend to reduce it. If mankind stopped burning fossil fuels, CO_2 levels would be reduced by this process in the main over a time scale perhaps 2 or 3 times longer than that in which we have created the problem in the first place. Thus we have a feedback mechanism which tends to stabilise the atmospheric concentration).

Fossil fuel burning occurs largely in power stations and road vehicles. Any policy to reduce it therefore must contain the following elements:

1. Reduction of energy consumption, typically achievable by energy efficiency measures, e.g. improved insulation of buildings, double glazing, attention to heating and ventilation. Optimisation of journey routes and increased use of public transport.

2. Increasing efficiency of energy use by such measures as are promulgated by the Department of Energy & Climate Change (DECC) which has a comprehensive online library. Using fuel efficient vehicles (diesels give about 30% better performance than petrol driven vehicles, hybrids are now available).

3. Using alternative energy sources. Nuclear fission energy does not produce CO_2, but the disaster at the Chernobyl nuclear reactor and now that unfolding at Fukushima in Japan illustrate the appalling consequences of releasing radioactivity into the environment. There is a worldwide move towards nuclear (fission) power stations which may now stall. Renewables are being extensively developed as wind farms (North Sea offshore under construction is predicated to deliver 15% of the UK energy needs), photovoltaic solar panels (PV) and solar heat collectors, maybe wave energy collectors, however these devices are costly to install and payback times are so long as to be a deterrent to their use. An advantage of renewables can be that of local generation – giving local security of supply and avoiding losses associated with grid distribution. Ultimately nuclear fusion will come of age, a process which effectively replicates conditions within the sun in which deuterium (heavy hydrogen – from heavy water) and tritium (from neutron bombardment of Lithium atoms) fuse together, releasing energy. The potential for energy generation is effectively infinite and it is anticipated that the first full scale power station may be built by 2030. There is no doubt that if we succeed we have the means to secure our energy future and we may even be able to halt or even reverse global climate change. Thus mankind may go forward in hope!

4. Renewable energy sources. Geothermal and hydroelectric sources (including tidal barrages) have been extensively exploited but are limited in capacity in our energy-hungry world. Renewable fuels, wood in particular but also biofuels (bioethanol and biodiesel) and Waste Derived fuels (WDF) are now being exploited but coming up against capacity issues and especially competition with food production in an increasingly hungry and already overpopulated world.

5. Burn fuels which release less CO_2. The science involved is quite straightforward. The available fossil fuels are coal, oil and gas. Coal is basically carbon (although it may contain 1% to 2% of sulphur which produces sulphur dioxide, SO_2 as an undesirable by-product). The chemical reaction is:

$$C + O_2 = CO_2 + \text{Heat}$$

The calorific value of coal is about 26Mj/kg .

Fuel gas (natural gas) is methane, CH_4 and burns according to the equation:

$$CH_4 + 2O_2 = CO_2 + 2H_2O + \text{Heat}$$

In this case the calorific value is about 57Mj/Kg and for every kg of fuel burnt only 75% of the output is CO_2.

Oil is a hydrocarbon with intermediate chemical composition between coal and gas, thus gas is best (and cleanest because it doesn't contain sulphur). Hence, 'the Dash for Gas' policy which has exploited the UK offshore gas reserves to work towards achievement of our CO_2 emission targets with the additional benefit of less sulphur dioxide pollution. (and now the new 'Dash for Gas' – including 'Fracking' – mobilising trapped gas by high pressure water injection with the attendant risks of earthquakes and water pollution).

LPG (liquefied Petroleum Gas - although strictly it is a vapour, not a gas) is propane (C_3H_8) or butane (C_4H_{10}) or a mixture of them and is the next most 'carbon efficient' fuel compared to methane, offering the benefit of being available as a liquid and having a high calorific value. Both LPG and LNG (Liquefied Natural Gas – methane) are increasingly being used to fuel road vehicles because they are cleaner burning than diesel or petrol.

2.1.3 The Sulphur Cycle

The sulphur cycle is illustrated in figures 2.4 & 2.5 and shows the mass balances before mankind's activities began and the position today. The important difference is the six-fold increase in atmospheric transfer (note that the atmosphere does not store large amounts) and doubling of river runoff.

Sulphur in the air is regarded as a 'red list' pollutant and is a major component of acid rain. The mechanism is:

1. Sulphur burns to sulphur dioxide, SO_2 (sometimes referred to as SOx, acknowledging uncertain amounts of sulphur trioxide, SO_3).

2. SOx dissolves in atmospheric aerosol water droplets to form strong acids - H2SOx (a mixture of sulphurous and sulphuric acids which then fully oxidise to H_2SO_4).

3. Acid rain falls and this is much more localised, therefore intensified, in the northern hemisphere due to industrialisation, the pH of lake, river and soil waters decrease, (pH is a measure of acidity on a scale where 7 is neutral, low values increasingly acid, high values increasingly alkaline). pH values as low as 2.1 have been seen, the

equivalent of raining vinegar! Acidity adversely affects many plant and animal species. Thus fish, along with most other species in some Scandinavian lakes (perhaps downwind of the UK's output of 5 million tonnes per year of SOx from 'dirty' coal burning power stations) were dying out. Thankfully, this is now reduced by an order of magnitude as Britain complies with EC Directive requirements. In Europe's forests, conifers became distorted, diseased and died in large numbers. It has been estimated that 14% of all conifers in Europe show evidence of damage.

4. Metals; aluminium and heavy metals such as lead, tin, copper, manganese present in soils are mobilised in acid conditions, i.e. they dissolve and become leachate. Metals are toxic to plant and animal species.

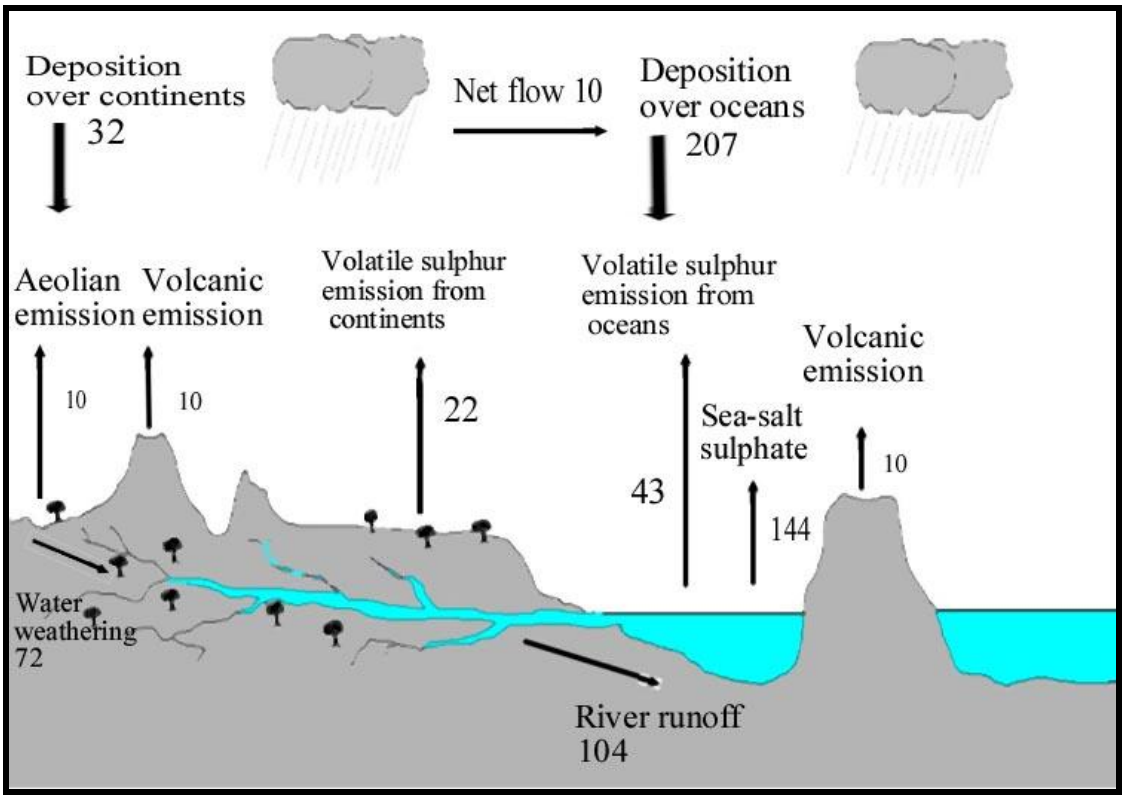


Figure 2.4 Sulphur cycle for the 'pristine earth'

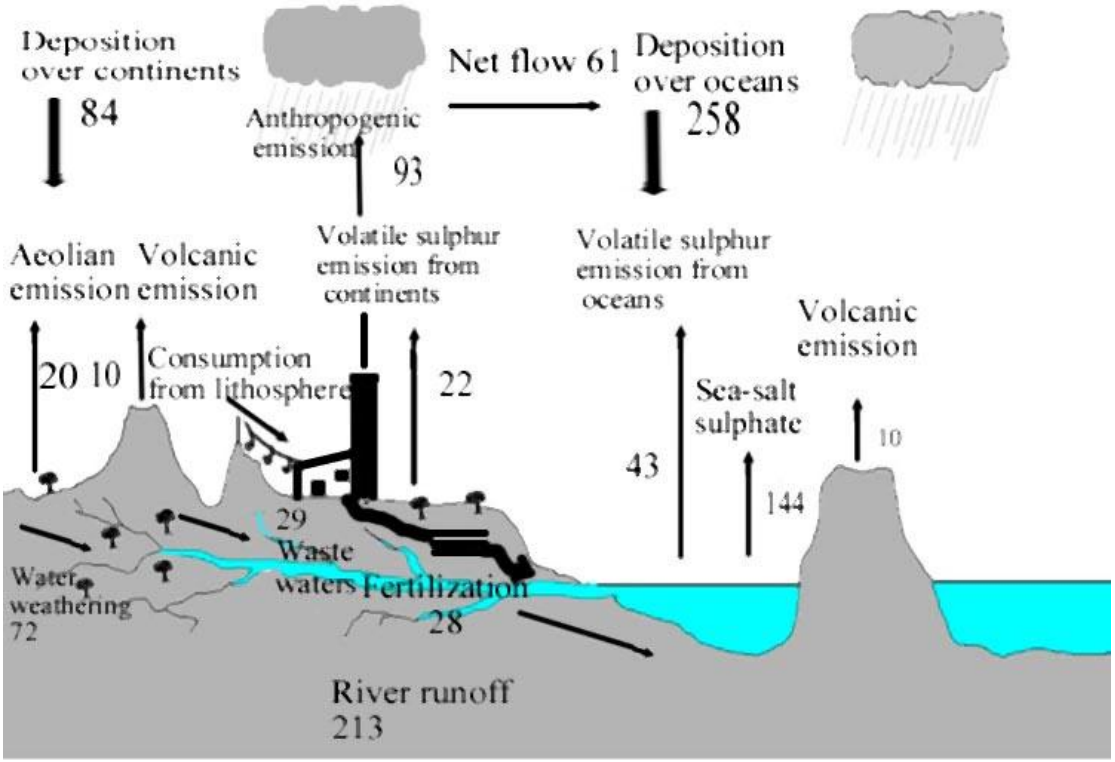


Figure 2.5 sulphur cycle including anthropogenic activity

2.1.4 Other Biogeochemical cycles

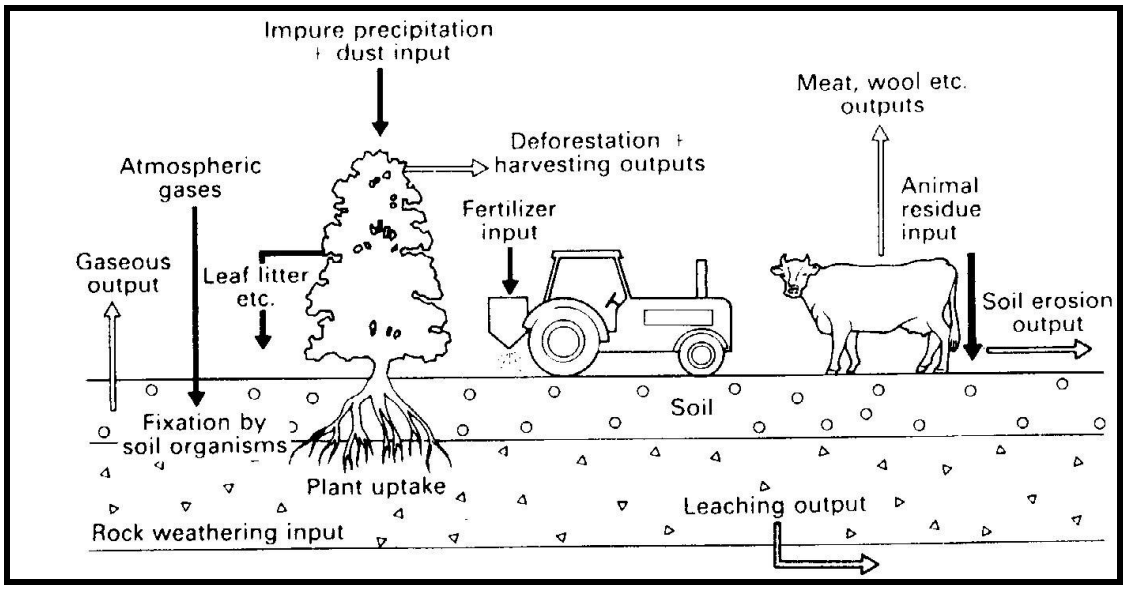


Figure 2.6 - Biogeochemical cycle (simplified)

Figure 2.6 shows a generalised cycle which can be applied to mass balances of important cycles, particularly the nitrogen and phosphorus cycles and is a component of the carbon and sulphur cycles already discussed.

The nitrogen cycle has many similarities to the sulphur cycle in that the atmospheric component NOx is analogous to SOx and the two are often quoted as total acidity. Nitric acid, HNO_3 is another strong acid. It is produced by direct reaction between oxygen and nitrogen at high temperature, thus is seen in stack emissions and the exhaust of internal combustion engines.

Sulphur is a contaminant of crude oil and must be removed during the refining process. This is an on-cost in terms of extra processing which is partly offset by recovered economic value in the sulphur. Basically, sulphur is dissolved in carbon disulphide, CS_2 - a substance which is immiscible with oil, separated by decanting it off and then distilling off the volatile CS_2 to recover the sulphur. CS_2 is a toxic, volatile and highly flammable liquid, requiring careful process control to use safely. *City Petrol and City diesel' were extra-refined versions of these fuels which had the sulphur stripped out down to much lower concentrations and have been offered at filling stations at a premium price (Sainsburys claimed 'the first petrol to be developed in line with the proposed World-wide Fuel Charter, a joint initiative of all the world's major car manufacturers in which they define the fuel quality that will be required to develop cleaner and more economical cars for the new millennium') - an interesting example of a voluntary 'green premium'*. Both fuels are now required to meet these higher (Directive) specifications as standard.

Nitrates and phospates are highly soluble in water and hence fertilisers (usually NPK) applied to farmland readily leach out into watercourses as agents of eutrophication where they promote plant growth, especially algae. Uncontrolled algal blooms have deleterious effects in that they consume the dissolved oxygen, denying it to higher species and also have a physical clogging effect. Other plant species cannot compete, essential minerals become depleted and the ecological balance is seriously disrupted. Some regions in the UK, notably Anglia have been declared 'nitrate sensitive areas' and policies put in hand to encourage changes in agricultural practice to reduce the impact of over-nitrating. Nitrate also occurs in groundwater and becomes a problem because it is toxic to humans and effects the quality of drinking water. It is not easy to remove. When purchasing bottled water always opt for the lowest, preferably zero nitrate assay as nitrate is a good indicator of the degree to which the eau de source is polluted with agrochemicals.

2.2.1 Disposal of Pollutants

The question 'what is a pollutant?' can be answered, at least in part by consulting legislation such as the Environmental Protection Act 1990 (EPA90) and the (former, now subsumed into the Environmental Permitting Regulations 2010) Trade Effluents (Prescribed Processes & Substances) Regulations 1989 and the Environmental Protection (Prescribed Processes & Substances) Regulations 1991. In these regulations, in various annexes appear lists of prescribed polluting substances and processes which are subject to specific limits, consents to discharge and in some cases, total prohibition.

For example, the so called 'Black List' or list 1 substances which are prohibited for discharge to water insofar as limit values are assigned to them. (A similar 'Red List' exists).

2.2.2 Black, Red and Grey Lists

Red and Black List substances have the properties of:

high toxicity
persistence in the environment
bio-accumulability

The black list comprises:
the extremely toxic metals mercury and cadmium;
organohalogens (typically DDT, lindane, aldrin, dieldrin, endrin);
organophosphorus compounds;
organotin compounds;
certain proven carcinogens (e.g. dioxins, furans);
persistent petroleum based or synthetic oils and minerals which would interfere with water use.

In the list, you can pick out notorious pollutants, organomercury, (responsible for the Minimata Bay Disaster in Japan) the pesticide DDT, organophosphates (used as sheep dip and also implicated in the officially non-existent 'Gulf War Syndrome'), organotin antifouling paint for ships etc.

The 'Grey List', list 11 comprises supposedly less polluting substances and to which limit values have not been assigned but which are controlled by licensing, bearing in mind environmental quality objectives.

List 11 contains:

toxic metals and their compounds
cyanides and fluorides
inorganic phosphorus
nitrites, ammonia (which affect dissolved oxygen in water)
biocides
certain silicon compounds
substances having adverse smell/taste.

Pollutants to water will leach from the ground and so land which has been contaminated by industrial activity (e.g. old gasworks) or mining activity which tends to mobilise metals and minerals, including from spoil heaps is looked at in that way.

Pollution of the atmosphere is rather different and we are mainly concerned with substances already encountered in the natural cycles, SOx, NOx, CO_2, CH_4 and others described under 'statutory nuisances' which define smells, effluvia etc. Also CFCs (the ozone depleters) should be mentioned.

Many pollutants occur naturally and thus may be said to have a natural 'background' level within the environment. We must consider pollution due to man's activity against this background who's existence does not mean that such levels are desirable and control measures may be pertinent if practicable. An example which illustrates this is the naturally occurring mineral fluoride which has high concentrations in the water in some areas (Derbyshire, where the mineral 'Blue John' (fluorspar) has been mined). There is much debate about the wisdom of fluoridation of drinking water because the dose needed to achieve the perceived improvement in dental health (the benefit) is only a factor of 2 or 3 times less than the toxic level.

Natural pollution occurs on a large scale all the time, e.g.:

CO_2 from fires, volcanic emissions, decay etc.;

SO_2 from volcanoes;
Dust from volcanic eruptions (Mount St Helens, Krakatoa).
Leakage of oil into the oceans

Sometimes the effects are profound, cause disasters and perturb the natural cycles. One such event was the Lake Nyos gas disaster. An enormous cloud of CO_2, estimated at 1000 million cubic metres ($109m^3$) erupted from the lake and thousands of persons were suffocated by the dense, low lying cloud.

However, the catastrophe was localised and would have had negligible effect on the global CO_2 level because the gas would have found its way into the atmosphere sooner or later anyway. By contrast, the immense volcanic explosion at Krakatoa in 1883 caused enormous dust clouds to obscure sunlight for years afterwards leading to a series of poor summers.

2.2.3 Environmental Tolerance

A study of the natural cycles shows that pollutants are being moved from one pool to another and that they spend time in transit media such as the atmosphere where they may do harm. It is often possible to quantify the damage in such terms as:

it is a greenhouse gas, 40 times more powerful than CO_2;

halving the thickness of the ozone layer causes X% increase in skin cancer in the human population;

a 10% increase in concentration may cause Y% increase in asthma in the population.

Of course, the effects may not be known, merely suspected but in all cases we will have a perception of what is an acceptable risk to society and thus what is the maximum tolerable burden of a pollutant in the environment. Another way to look at this is to consider what we want to use the environment for. The environmental quality of a salmonid river will be higher than that used for, say water sports so that we can set environmental quality objectives (EQOs) and the acceptable environmental burden will be determined by the EQO. Note: EQOs can be assessed based on emission limits or Environmental Quality standards (EQSs) – set tolerance levels within the ecosystem.

Whichever way we go about it, limits can be set which will do no more than a specified amount of harm to the environment. We need to know how the pollutant behaves within the natural cycles, where it goes to, how quickly and whether it changes form along the way. And we need to consider it against the natural background which is probably going to be subject to such variables as seasonality. Interaction with other pollutants will need to be considered and there may be synergistic interactions, which multiply the individual effects when combined.

2.2.4 'The solution to pollution is dilution'

When the amount of pollutant released is far below the tolerable burden, then almost nothing matters. Mankind has traditionally washed the problems away. The rivers will take sewage and clean it up. Problems only arise when our pressure of numbers cause pollution exceeding the tolerance level and degradation then occurs. Rivers become eutrophicated and poisoned and their capacity to deal with previous pollution levels is then impaired. In a severe case a lake or river will 'die', becoming an open sewer with very little marine life in it. Parliament in London in the 1850s was suspended from time to time because the stench of the polluted Thames had become intolerable.

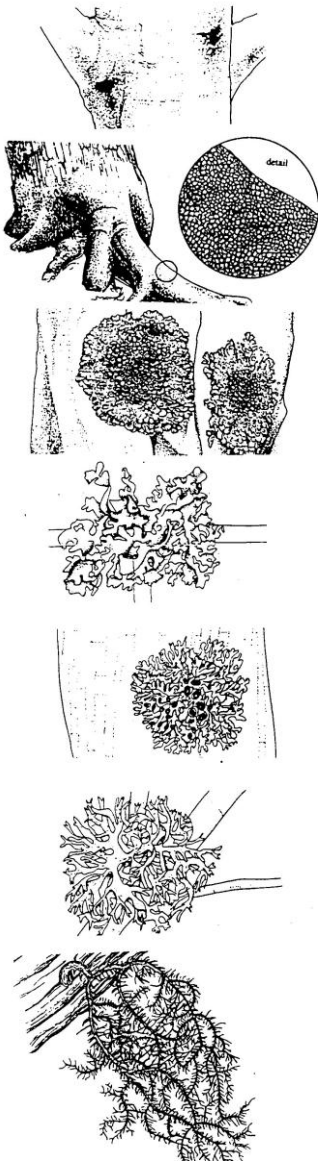
Air pollution has traditionally been subject to Best Practicable Means for disposal, in practice dispersed from a chimney. This is known as Air Pollution Control and has been administered via Environmental Health Departments of the Local Authorities (LAAPC). The criteria tended to be those of assessing statutory nuisance. Account was taken only of local effects although we now realise that such pollution can travel for thousands of miles.

Indicator species can be used as a rough measure of air pollution, figure 2.8 illustrates how lichen counting works.

Lichen Count

Zone 0. No lichens

Serious air pollution means a 'lichen desert'. Of course, you need to look very thoroughly, to be quite sure you haven't missed any, and you may find a green, powdery alga (Pleurococcus) just to confuse you. It grows on smooth stone surfaces, and on the trunks of sycamore trees. You can rub it off with your fingers, but it's not a lichen.



Zone 1. Crusty lichens

These lichens can survive in quite high levels of pollution, so you do find these in the middle of town -especially low down around the bottom of tree trunks. If you look through a magnifying glass (or the wrong way down a pair of binoculars), you'll see that the crusty lichens are like miniature crazy paving. 'Lecanora conizaeoides' is grey green, and the most common lichen of all. 'Lecanora dispersa', is pale grey.

Zone 2. Orange/yellow Xanthoria

This is pretty lichen, which grows as circu1ar rough patches, especially on limestone, concrete and asbestos. You often see it on the roof of farm buildings. but you never see it on trees. It grows when the air is beginning to get clean, and the reason it grows on limey materials, is because the lime helps to reduce the effect of the acid pollution.

Zone 3 . 'Leafy lichens' on walls

This is the first zone where the lichens really look like plants. The kind you're most likely to find is 'Parmefia saxatilis'. The colour is grey-green, and each lichen can grow to about the size of a saucer. The trees in zone 3 still only have crusty lichens and green powdery algae on them because they can't provide any helpful liminess to balance the acid pollution.

Zone 4. 'Leafy lichens' on trees

Parmelia starts to appear at the base of tree trunks once the air is free of the worst pollution. As it gets cleaner, leafy lichens grow higher and higher up the trees.

Zone 5. Shrubby lichens

These are much leafier than the flat 'leafy lichens' of zones 3 and 4, and they are a sure sign that pollution has almost disappeared. The toughest of them is called 'Evernia purnastria', and again, it's grey-green. 'Ramelina calicanis' is shinier green, a bit more upright. and may have pink tips at the ends of its 'leafy' bits.

Zone 6. 'Old Man's Beard'These really can be very straggly. and are quite common once you reach the unpolluted places. They have stems up to 1 5 cm long and hang from trees, held on only by small, disc-shaped attachments.

2.3.1 Concentration Mechanisms

Whilst mankind hopes to disperse his pollutants until they are in undetectably low concentrations, natural mechanisms tend to concentrate the pollutants back again. The metal cadmium is highly toxic, 50mg is sufficient to kill - limpets at Portishead (Severn Estuary) were found to be so contaminated that 'to eat even a handful of them could prove fatal'.

Thus in Minimata Bay, Japan, wastewater which was contaminated with low concentrations of the metal mercury in the form of inorganic salts was released into the bay.

It was taken up by marine plankton and entered the food chain

Metabolic processes turned it into methyl-mercury (methyl mercury is an example of an organo-metallic compound.). Organo-metallics are much more toxic than inorganic metal salts.

Passing through the food webs, it became more concentrated in the higher species.

Fishermen caught highly contaminated fish and people ate them.

Mercury accumulated in their bodies and caused neurological damage, many people became ill and died. Mentally and physically damaged children were born.

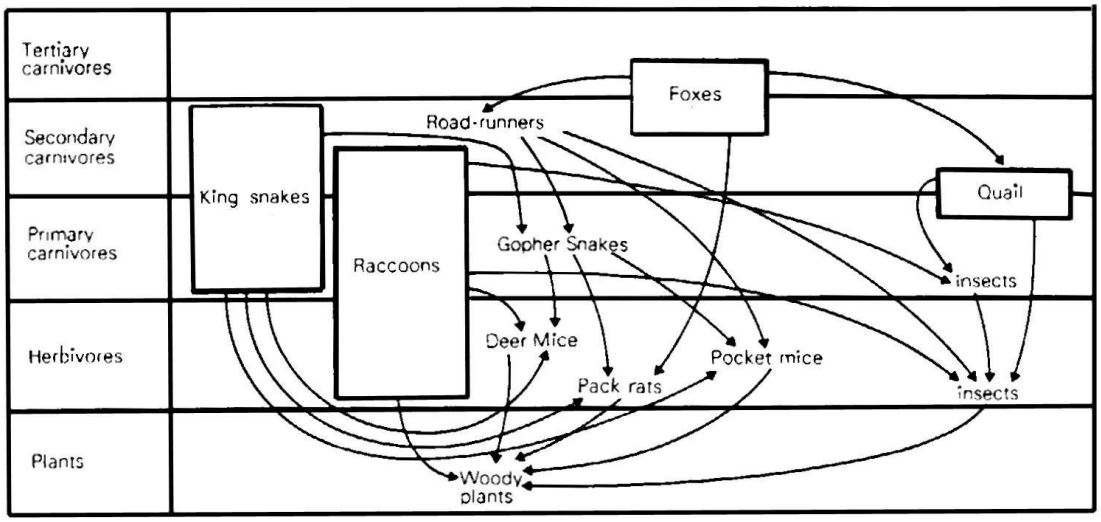


Figure 2.9 - A simple food web

Diluted toxic waste may become concentrated by precipitation in sludges. This effect is notable in estuarine conditions when rivers encounter salt water, insoluble chloride salts may be formed, colloidal suspensions may be precipitated.

The processes that created rich metal ores in hydrothermal veins are exactly those which tend to concentrate up toxic waste materials.

Contaminated groundwater percolating through porous strata (e.g. chalk) can concentrate contaminants by chromatography. It is rumoured that dispersal of medium and low-level nuclear waste by pumping it into deep mines had to be discontinued because it was becoming so concentrated that it was in danger of going critical and starting to heat up!

2.3.2 Half-life of pollutants

An important concept is that of half-life, in this case applied to a measure of the rate at which a pollutant is removed. The more stable the pollutant, the longer its half-life. The toxin dioxin is now thought to have a half-life of 40 years. Half-life is defined as the time it takes for something to decay to half its original concentration, a concept originally applied to radioactive substances.

Mechanisms which may remove pollutants are:

Decomposition (biological, chemical or radioactive decay);

Conversion to an immobile form;

Removal by leaching.

Metals will never decay, they are elemental substances, but they may change form to become less toxic (organometallic to inorganic metal) or fixed as insoluble compounds (oxides, sulphides, carbonates, sulphates - typical mineral ores).

The majority of organic compounds in, say, sewage are readily broken down by natural processes but a few are not. Those which present a problem are those which combine stability with toxicity (usually subtle effects - carcinogenic and mutagenic properties) and these are exemplified by DDT, dioxin, PCBs. Some fats and detergents can be harmful to the sewage treatment works and they also present problems.

2.3.3 Biodiversity.

We are said to be in the midst of the greatest species extinction since the Permian, in which some 70% of all species disappeared. The relentless growth of human numbers and our rapacious depletion of the planetary resources has put great pressure on habitat. In particular, loss of rainforest is considered to be a major aspect of species loss as land is converted to agricultural use (agricultural practice is to grow monocultures – basically, fields of crops and this is in effect the reverse of biodiversity!).

The Convention on Biological Diversity (CBD 1992) was implemented in the UK as the UK BAP. It describes the UK's biological resources, commits to a detailed action plan to protect them and implements the plan by species Action Plans, Habitat Action Plans and Local Biodiversity Action Plans. This is now extended to the Biodiversity Action Reporting System (April 2011).

Note that biodiversity appears as an aspect of local Agenda 21

 .

a pond on allotment land with the explicit aim of increasing biodiversity

Unit 3 Some types of pollutants and their specific problems

'Set *not thy nose above the phial my son, for by Allah, it stinketh!*'

Objectives

1 To have an understanding of some of the more important pollutants and the concerns which they cause.

3.1 Air pollutants

According to the National Air Quality Strategy there are 8 main health-threatening pollutants and these have been assigned control limits under Part 1V of the Environment Act 1995 (s80). They are:

Benzene is a VOC which forms a component of petroleum spirit. The control limit is a very low 5ppb (parts per billion). Most of it enters the atmosphere as fuel tanks are refilled, displacing the vapour into the air - it is part of the shimmering cloud you see as you fill up your car! Local concentrations are high actually within the vehicle itself - so give a thought for the children who tend to be sitting on the back seats. It is disgraceful that the simple technical measure of having a vapour return pipe is not universally available at filling stations. Benzene is a carcinogen and can cause leukaemia. It is also a product of incomplete combustion, especially of coal and oil products.

1,3 Butadiene is a reactive partial decomposition product of combustion, basically an irritant, causing sore throats and likely to aggravate asthmatics. Controlled to 1ppb. Catalytic converters will burn it off.

Carbon monoxide (CO) (control limit of 10ppm - note that this is 3 orders of magnitude greater than other pollutants). CO is a colourless, odourless gas of neutral buoyancy in air and is an acute, cumulative poison which works by blocking the action of haemoglobin and causing chemical suffocation. 1 part in 400 will kill in 20 minutes. At lower doses, there are chronic effects and the body's response is to increase heart rate and produce more red blood cells which, alas increases blood viscosity and hence blood pressure. CO is known to cause cardiac arrythmias. It is produced whenever carbonaceous material burns in a limited supply of air.

Car exhaust systems are tuned to give about 0.02% by volume of CO and also it is a major component of cigarette smoke (20 000ppm). Early experiments to determine CO levels in police on traffic duty at busy junctions were able to distinguish the smokers from the non smokers but otherwise inconclusive. It is the main reason why smoking causes heart disease.

Lead is present mainly from the additive tetraethyl lead in petroleum spirit, which will have been burnt through into lead oxide particles in the exhaust stream. It is controlled to 0.5micrograms per m3. Lead is a cumulative poison, having a half life residence in the body of 10 years. It causes a whole suite of unpleasant effects, most notably neurological disturbances and is thought to be particularly harmful to the developing brain and hence concern has been expressed about the effects on intelligence and development of children. Early studies were done on those living close to 'Spaghetti Junction' in Birmingham and were sufficiently disturbing to suggest the need for action.

Nitrogen dioxide, the main component of NOx is controlled to 150 ppb. It is brown in colour, highly acidic and emitted by internal combustion engines and all combustion plant. It causes irritation of mucous membranes and is a component of photochemical smog as well as acid rain in which it appears as nitric acid.

Ozone, with a limit of 50ppb is as undesirable at ground level as it is essential in the upper atmosphere. It is a powerful irritant - the irritation caused by its oxidising action, in effect burning of mucous membranes. It also causes premature ageing, particularly of the skin because it is a

powerful source of free radicals. Along with NOx and SOx it causes photochemical smog. It is produced by electrical discharges (hence the 'smell of electricity') and other oxidising processes. It is the one ground-level air pollutant which cannot be reduced by local action.

Sulphur dioxide at 100 ppb is produced whenever sulphur contaminated fuel burns. The use of low sulphur diesel fuel is a very significant improvement in fuel quality and the move away from coal as a primary fossil fuel is also intended to assist the UK in meeting international standards for air pollution. Like NO2 it is highly irritant and is particularly noted for bringing on asthma attacks.

Fine particles (pm10) at 50 micrograms per m3 are the respirable soot particles from diesel emissions and are inevitably under suspicion as carcinogens. It is remarkably difficult to clean up these emissions at source though systems are under development to do so. Pm 2.5 are also monitored.

Other gases which are considered to be pollutants but do not cause direct health effects are CO_2 and methane, CH_4 the main greenhouse gases and the ozone depleters, particularly the CFCs.

Sulphates and fluorides on the other hand, are solid particulates which have a toxic effect on soil and are responsible for land contamination downwind from brickworks. Particulate contamination from industrial processes over many years is an accepted source of land contamination and points up the limitation of using stack emissions as BPM.

3.2 Radon

Radon is a radioactive gas which has been the subject of much attention in recent years. It is a decay product of radium and uranium metals which occur naturally in various rocks, most notably granite. Inhalation of radon gives a risk of lung cancer which is in proportion to its concentration, time of exposure and, inevitably the risk is synergistically multiplied in smokers. Areas such as Cornwall which are on granite (Dartmoor and Exmoor) have unusually high radon levels but it presents no risk in the open air because it is dispersed. Within houses, it may percolate through the floor and accumulate in the living areas so that construction methods are important. A wooden boarded floor with a ventilation space below is safe, but concrete screeded floors are not and the gas will permeate through or via cracks. The DoE issued guidance to householders on whether precautions are necessary - basically pointing to locations and construction methods and then suggesting monitoring and remedial works if the monitoring showed elevated levels.

Radon also appears in mines and natural caves and thus is an additional component of occupational risk. The management of Dan-yr-Ogof show caves in South Wales fitted a forced ventilation system to the caves in order to protect the health of their employees, the guides and maintenance workers on suspicion of there being a radon problem.

3.3 Metals

There are about 60 metals, many of them are rare and not naturally found in other than trace quantities. Unhappily, man has mined large quantities of toxic metals since well before even Roman times and mining wastes are ubiquitous.

lead (Pb), the Latin name Plumbum, hence plumber and the use accordingly. It was found that tetraethyl lead (more toxic organolead) improved the performance of the internal combustion engine and we have spread it widely in the environment as a result (it has been shown to settle locally to major roads and is detectable there in soil and plants). Lead is a major component of car batteries, solder, pottery glazes, pipes and flashings and has been used extensively in paint (red lead paint is an excellent protective coating for ferrous metal). Because it has been widely used (it is less

so now) and accumulates insidiously within the body, The Control of Lead at Work Regulations were made to provide a legal control framework.

Copper (Cu), nickel (Ni), chromium (Cr), used in chromium plating also zinc (Zn), cadmium (Cd) and silver (Ag) and others used in the metal finishing industry. Some of them as catalysts in the chemical industry. All the heavy metals are more or less toxic and their effects generally are similar, they tend to accumulate in the body and cause neurological harm. There are target organ effects, for example radium, (a member of the same chemical family as calcium) collects in bone tissue and because it is radioactive, irradiates the bone marrow and causes leukaemia.

Cadmium is perhaps the most toxic, causing liver and kidney damage. It is also carcinogenic. Cadmium is an excellent plating medium but, as an example, yellowish residues were found in switchboxes on metro trains after a few years service which was found to be mainly cadmium salts from sacrificial breakdown of the plating. Electricians servicing the units were seen to be at risk. Other than electroplating, it is used in batteries, pigments, plastics manufacture and metal alloys. It enters the environment as wastes from these processes (cadmium containing batteries end up in landfill and eventually leach - it is invariably found as a component in sewage sludge.) and as by-products from steelmaking and zinc manufacture and can be released during metal recovery operations. It naturally appears in volcanic emissions.

Mercury (Hg) is widely used in instruments (e.g. the familiar clinical thermometer) and in the chemical industry especially in the dropping mercury cathode method of making chlorine, caustic soda and sodium hypochlorite bleach. It is also found in some kinds of lamps, in detonators (mercury fulminate) and fungicides (although it is now banned). A component of amalgam dental fillings it has caused considerable concern and persons may have to have their amalgam fillings replaced, especially if they have gold fillings as well because electrolytic corrosion may set in, breaking down the amalgam! In most cases, though, the main risk of absorbing mercury is when fillings are repaired or replaced - usually they are best left alone.

Mercury is volatile in the metal state and will gradually evaporate into the air. Thus older science laboratories, especially physics labs. have been said to be ‘afloat on a layer of mercury’ from accumulation in crevices and bench cracks. Often and by chance it has been sealed with a layer of water from general cleaning - and atmosphere sampling has shown up less than might have been expected. It is best to clear up spillages by first sprinkling a layer of sulphur over it, then sweeping it up. Mercury sulphide is involatile. The most environmentally and health damaging application currently practised is undoubtedly the use of mercury metal to collect gold during mining operations. Gold ore is crushed and mixed with mercury which is strained off and reprocessed. Especially under primitive 3rd World mining conditions the pollution and health risk to the miners is truly appalling.

Titanium (Ti), Vanadium (Va), Manganese (Mn) are other important examples of toxic metals. Concorde is made of titanium. Vanadium is a contaminant of old gasworks sites.

3.4 Asbestos

Asbestos is a major health problem. An otherwise excellent and useful mineral, extensively used in fire protective cladding and for insulation - the ubiquitous ‘Asbestos Mat’ of every school science laboratory it causes lung cancer and asbestosis (a form of fibrosis of the lung) and a dreadful cancer of the lining of the lungs and abdominal cavity known as pleural mesothelioma. The onset from exposure to illness may be many years and the risk is proportional to the exposure, inhaling the invisible fibres brings it about and the risk is further synergistically multiplied amongst smokers. It is estimated that about 1%, perhaps 2000 - 3000 per year of all male workers aged about 50 in the UK

will die from mesothelioma - there is no cure once symptoms begin and the prognosis is death in less than two years in all cases.

There are an estimated 15 million tons spread through the UK environment in various forms. The worst is lagging, because it is fibrous, asbestolux sheeting can be sealed in situ with emulsion paint and is harmless unless damaged and asbestos cement presents minimal risk because the asbestos fibres are effectively encapsulated. Sprayed asbestos was commonly used as a fire protective cladding for structural steelwork and can still be retained as long as it is adequately sealed and is in good condition.

Asbestos is a naturally occurring mineral which is in fine fibres which further break into invisible fibres which are respirable. The effects are mainly physical, causing mechanical cell damage and irritation, the most harmful fibres being about 2microns in length with a diameter of 1micron. An electron micrograph has been produced showing an asbestos fibre penetrating a cell nucleus! Blue asbestos (crocidolite) is considered to be worst, brown (amosite) less so and white (crysotile) less again, all asbestos use is now banned. Alas, many applications involved mixtures of all three types.

Removal is specialised work, expensive and involves elaborate precautions. The area to be cleared is enclosed in a polythene tent held under negative pressure by a fan and filter system within which the operatives work, wearing high specification breathing apparatus. Elaborate hygiene and welfare facilities are required. Sampling regimes are based on fibre counting methods which are, themselves, time consuming and involve counting specimens across a gridded filter under a polarising microscope.

If asbestos is to be left in situ, management controls must be in place to ensure that it is not disturbed. A local authority was recently fined for failing to inform sub-contractors of the existence of asbestos and employees were exposed to fibres when they drilled holes into it. It is important to display notices drawing attention to the material's existence.

Asbestos waste is designated special waste and should be double bagged in yellow bags labelled 'Asbestos' and removed with due care. Its ultimate destination is to be buried in dedicated landfill sites under a clay capping. It was a matter of sadness to come upon workers smashing up an asbestos roof into small, jagged pieces and cramming it into plastic bags despite all the publicity and legal framework of controls (Asbestos at Work Regulations). The sensible method, of course, is to wet it down and remove it in sheets with as little damage as possible.

3.5 Volatile Organic Compounds (VOCs)

Volatile Organic Chemicals (VOCs) is a generic term covering a wide range of chemicals, typically the solvents. They can be grouped for convenience as:

hydrocarbons (petroleum, benzene, toluene, xylene);

solvents and thinners (acetone, MEK, methanol, cellosolves);

halogenated (methylene chloride, methyl bromide, carbon tetrachloride, trichloroethylene, 1.1.1trichloroethane);

CFCs (chlorofluorocarbons, CFC-11, CCl_3F).

N.B. this *is not a complete or systematic classification, just some important examples.*

The VOCs are formally defined under the LRTAP Convention (1991) as *'all organic compounds of anthropogenic nature, other than methane, that are capable of producing photochemical oxidants by reactions with nitrogen oxides in the presence of sunlight.'* As such they increase photochemical

smog, deplete the ozone layer and are greenhouse gases and hence are seen as undesirable. They are used in a wide variety of applications to dissolve and spread materials and so appear in paints, polishes, varnishes..., the list is endless.

The intent is to phase them out in time (VOC Directive) using such techniques as water based paint substitution for gloss paint with the bonus that a fraction of the product, which has cost good money, does not simply disappear into thin air, and, adding insult to injury, pollute it. In practice, of course, such elimination or substitution is often difficult to achieve but it is also a requirement of the COSHH Regulations which have been in force since 1988. Solventless cleaning, use of non-volatile solvents and air-knives are some modern alternative methods.

3.6 Dioxins, furans, polyaromatics, PAHs (a subset of which is the so-called pm10s, soot particles from incomplete combustion in diesel engines falling into the human respirable range).

These are all compounds or mixtures of compounds which appear as a result of combustion processes (and in the case of TCDD, 2,3,7,8-tetrachlorodibenzo-p-dioxin - known simply as 'dioxin' as a by-product of the manufacture of 2,4,5-trichlorophenoxyacetic acid, 2,4,5T, a herbicide. It was accidentally released in the Seveso Incident due to plant malfunction). They are the main reason why very strict emission controls are set on incinerators because they can be produced in significant quantities. A member of this group of some notoriety is benzo-alpha pyrene, the principal carcinogen in cigarette tar.

Figure 3.1 summarises some example pollutants

Name	Use	Environmental impact
DDT (2,2-di(p-chlorophenyl)-	Non-selective Pesticide	Bioacumulates
PCBs (polychlorinated biphenyls)	Dielectric liquid	Resistant to breakdown chronic toxicity
TBT (tributyl tin)	Antifouling agent	Affects sexual reproduction in shellfish
1,1,1-trichloroethane	Dry cleaning fluid	Destruction of atmospheric ozone (ODS)
CFC (chlorofluorocarbons)	Aerosol propellant, Refrigerant Foam blowing agent	Destruction of atmospheric ozone (ODS)

Figure 3.1 - example pollutants - note that these are entirely man-made (anthropogenic)

3.7 Endocrine disrupters

These are chemical substances which have reproductive effects, i.e. a hormonal action. It has been known for some time that 'feminisation' is occurring in shellfish and fish in estuarine waters (up to 20% of flounder caught in the Mersey and Tyne estuaries are intersex). Perhaps more worryingly there are reports of falling sperm counts, increased testicular cancer and other disorders of the male genital tract in a variety of species, including humans. There are a wide variety of potential endocrine disrupters and this is an issue of current and growing concern. An obvious contender for endocrine activity is the contraceptive pill (increasing oestrogen levels in the environment), but another, less obvious substance is bisphenol A which has been used in, for example the linings of food cans and as dental sealant. This and related substances (e.g. phthalate esters) occur as plasticisers or softening agents in plastics from car seat leathercloth to clingfilm. It should be emphasised that such substances are biologically active at extremely low concentrations.

3.8 Aerobic & anaerobic decomposition

'Aerobic' means in the presence of oxygen, 'anaerobic' in its absence. Organic materials break down, decay differently according to the conditions. Bacteria called decomposers are responsible for the processes of decay and different types are found in aerobic and anaerobic conditions.

Aerobic	Anaerobic
Oxidising conditions	Reducing conditions
CO_2	CH_4
SO_2	H_2S**
NO_2	NH_3 (ammonia)
N_2	

The end product of aerobic decomposition is that CO_2 is released to atmosphere and much water is produced, leaving a fibrous organic residue which is used as compost. Sulphur goes to sulphate, nitrogen to nitrites and nitrates. (Nitrite is more of a pollutant than nitrate but tends to become oxidised into nitrate).

Anaerobic decomposition tends to be slower, CH_4 is released, H_2S and NH_3, along with more complex products produce odours and slimy, sludgy waste product.

Thus landfill gas which arises from mixed decomposition contains variable amounts of the gases. Under anaerobic conditions there may also be other more noxious vapours and gases which give unpleasant odours. Landfill gas is sometimes flared off to burn away offensive odours and, importantly, to convert CH_4 into CO_2 because CH_4 is a greenhouse gas, estimated to be 40 times more powerful than CO_2.

***Catalytic converters in motor vehicles reduce oxides of nitrogen to nitrogen itself but they may also reduce it partially to nitrous oxide, N2O which currently contributes about 6% to the greenhouse gases. The smells of bad eggs associated with catalytic converters is due to traces of H2S and is the reasons why your silverware turns black! This problem has diminished with the introduction of a lower sulphur in petrol standard.*

3.9 Pesticides

There are many pesticides which have been developed, exemplified by DDT, 2,2-di(p-chlorophenyl)-1,1,1-trichloroethane. Many are now strictly controlled or banned completely. Hailed as 'wonder chemicals,' problems emerged due to their persistence in the environment (stability) and their bio-accumulability, i.e. their tendency to concentrate through the food webs. They are fat soluble and become mobilised in the blood when species come under stress, typically as winter onsets and metabolise their reserves, with toxic results, causing population crashes in predatory birds. It is a sobering matter that the pesticide implicated in the Rhine pollution episode in 1969, endosulphan, is toxic to fish at a concentration of 0.00002 ppm!

And the insects rapidly became resistant to them so that ever larger doses were needed to obtain the same kill levels.

3.9.1 Control Measures

Pesticides are defined as products used to control or destroy unwanted creatures, plants and other organisms. They include:

Timber treatment products;

Chemicals used for the control of growths on masonry.

Such substances are: insecticides, rodenticides, fungicides and herbicides. Additionally substances used as: growth regulators, fumigants, insect repellents, defoliants and desiccants.

Concerns about the possible harmful effects of pesticides were first aroused into public consciousness by the book 'Silent Spring', by Rachael Carson (Pelican Books 1962). The complex of entirely man-made and now widely distributed organic chemicals must inevitably fall under suspicion of causing harm to human and animal species as unintended targets. The subtle effects of such chemicals are likely to be carcinogenic (cancer forming) and also mutagenic and teratogenic (basically effecting reproduction or the unborn offspring)

Reduction of pesticide use and conversion to 'integrated pest control methods' is an objective of the EC 5th Action Plan for the Environment. In the UK, regulation of the use of pesticides is through the Food & Environment Protection Act 1985 (FEPA) which aims to:

protect human health
provide safe and humane pest control
disclose information

The Control of Pesticides Regulations 1986, made under FEPA provides a framework for implementation of safe practices by;

a system of approvals
granting consents

The Control of Substances Hazardous to Health Regulations 2002 provides a hierarchy of control measures (eliminate, substitute, then control residual risks) which accords with the ethos of FEPA. There are also general duties under the HSW etc. Act 1974.

The ethos is that pesticides should only be used where necessary and if the benefit from such use outweighs the attendant risks to human health & the environment (this approach compares with that of the Ionising Radiations Regulations 2003).

There are two distinct overlapping strands to safe working with pesticides. Protection of workers is achieved by ensuring competence in those who use pesticides;

there is an Agricultural Safety Code of Practice which sets out certification requirements and an Approved Code of Practice for Safe use of Pesticides for Non-Agricultural Purposes;

the COSHH Regulations require suitable control measures in terms of:

methods of application, typically spraying or use of bait
personal protective equipment (impervious gloves, aprons, wellington boots etc. Possibly breathing apparatus.
Hygiene provision and procedures
First aid and emergency arrangements
Signage and product safety information.
Environmental control encompasses such matters as:
Control of supplies

Purchasing policy - variety reduction, only use approved pesticides, don't hold excessive stocks.

Methods of handling (dosing pumps etc.) and disposal of empty containers so that residues do not pollute. Secure transportation and storage.

Prevention of contamination of water is important, waste should not be discarded or washed into watercourses. Overspray should be prevented.

Only the correct agent should be used at the right dilution using the minimum to achieve the desired result.

Injudicious application may:

- cause harm to non-target organisms
- cause secondary infestation by removing predators
- contaminate food (Spanish Cooking Oil Tragedy)
- create resistant strains (cyclic use of different agents may reduce thi

Integrated Crop Management.

The value of pesticides is simply stated in terms of ensuring adequate food supplies, something we shouldn't forget! but potential harm to the environment is acknowledged also in terms of:

concerns about eating pesticide sprayed food;
reduction in species diversity (especially loss of bees);
pesticide resistance - 5 years ago there were only 7 resistant species, now there are 500);
natural predators have themselves been eradicated;
pests can become resistant to new herbicides within two years.

Integrated Crop Management techniques seek to minimise the use of pesticides by such techniques as:

crop rotation - traditionally seen as a means to keep crops viable by avoiding build-up of pests in the soil and also avoiding depletion of trace elements;

introduction of predator species - e.g. encarsia is a parasitic wasp which lays its eggs in the larvae of whitefly, a notorious pest and phytosieulus which preys on red spider mites. So effective that bees can be introduced into glasshouses to pollinate crops;

selective pesticides kill the target but have less effect on other, predatory species;

spraying as needed rather than routinely;

leaving grassed edges to fields to encourage ground beetles and ladybirds.

Organic foods are those that are produced using methods that do not involve modern synthetic inputs such as pesticides and chemical fertilizers, do not contain genetically modified organisms, and are not processed using irradiation, industrial solvents, or chemical food additives.[1]

For the vast majority of human history, agriculture can be described as "organic"; only during the 20th century was a large supply of new synthetic chemicals introduced to the food supply. The organic farming movement arose in the 1940s in response to the industrialization of agriculture known as the Green Revolution.[2]

Organic food production is a heavily regulated industry, distinct from private gardening. Currently, the European Union, the United States, Canada, Japan and many other countries require producers to obtain special certification in order to market food as "organic" within their borders. In the context of these regulations, "organic food" is food made in a way that complies with organic standards set by national governments and international organization

(*source Wikipedia*)

Unit 4 WASTE

'*Waste not, want not*'

Objectives

1 Know what waste is, and be able to distinguish between different categories of waste, including controlled waste, hazardous waste, clinical waste and packaging waste.

2. Understand and give examples of the application of the hierarchy of waste management.

3. Know the requirements of the Waste Management Duty of Care.

4. Be able to describe the waste licensing system and the duties of participants in the handling and disposal of waste.

5. Understand the significance of the various options for waste disposal and be able to describe their practical application (landfill, composting, incineration, special waste incineration).

6. Appreciate the problems associated with contaminated land.

4.1 Definition of Waste:

According to the Waste Management Licensing Regulations 1994, waste is called Directive Waste (from the EC Waste Framework Directive) and is defined in terms of any substance or object in the categories set out in the schedules thereto and also schedule 22 of the Environment Act 1995.

The Waste Management Duty of Care, Code of Practice (HMSO) 1996 describes it as being defined from the point of view of the person discarding it. Anything discarded or dealt with as waste must be presumed to be waste unless proved otherwise.

Draft online guidance on the definition of waste is available from (Defra) (May 2011).

Controlled Waste is waste from households, commerce and industry It is defined in the Controlled Waste Regulations 1992 and extended to cover agricultural, mines & quarries under the Waste Management (England and Wales) Regulations SI 2006/937.

Municipal Waste is arisings from domestic premises which the Local authority has a duty to collect. Civic Amenity Waste is that which the Waste Disposal authority is obliged to collect from collection points (but is not industrial or commercial waste) under the Refuse disposal amenity Act 1978.

4.2 Hierarchy of Waste Management

Making Waste Work is the government's approach to a sustainable development strategy and sets out a hierarchy of waste management options.

a) Waste reduction. The emphasis is on not making it in the first place by process change and optimising process efficiency.

b) Re-use. Epitomised by the humble returnable milk bottle.

c) Recovery of waste. Options include

recycling (e.g. glass, metal, paper)

incineration with energy recovery

composting.

d) Disposal - generally to landfill

Currently, about 70% of controlled waste goes to landfill and there is an increasing shortage of suitable landfill sites. According to LPAC “there is a waste disposal crisis beckoning in London...and it is possible by 2005 that there will only be 18 months supply of landfill space to take London’s waste exports”

Government targets have been set to reduce controlled waste going to landfill to 60% and recovery of MSW to 40% by 2005. Somehow this is not going to be enough! Maybe we are going to see artificial mountains made of waste - one such example can be seen operating as a landfill site in Fürth, Bavaria (now completed, capped with soil and used as a recreational site).

The Waste Mountain approx 350m high, now covered in PV panels

4.3 Waste Minimisation

A systematic analysis of an organisation's waste arisings will always show opportunities for waste minimisation. An input - process - output model can be used to identify all the elements of an activity which contribute to waste arisings. Figure 4.1 shows a typical model. A waste minimisation strategy can be developed using this model. It will:

quantify losses due to waste arisings;
enable a focus on the greatest potentials for savings;

enable the setting of waste reduction targets;
provide evidence of continual improvement for ISO 14001.

Waste minimisation is an example of an iterative process in which improvement is a continuously sought aim rather than a once off exercise.

The aim should be:

to minimise waste arisings;
optimise reuse and recycling - perhaps in collaboration with other companies;
find the cleanest and least polluting waste disposal options.

A number of collaborative projects have been used to illustrate the opportunities. The *'Aire & Calder Project*' in which 12 companies cooperated to make £4m of savings and improve the local environment at the same time is one of these. Waste minimisation clubs should be encouraged using such vehicles as local chambers of commerce. A government sponsored initiative, Envirowise is a driver for this kind of activity.

4.4 Other Categories of Waste

4.4.1 Hazardous Waste

The Hazardous Waste Regs. 2005 control the stringent requirements for safe disposal of difficult or dangerous (hazardous) wastes, which are defined in the EC Hazardous Waste List and implemented in the List of Wastes (England) Regs 2005. Hazardous waste is subject to notification requirements and payment to the EA of a licence fee.

The different types of wastes in the List of Wastes are fully defined by a unique six-digit code (2-digits for the chapter) and may be awarded an absolute entry or a mirror entry in which further tests need to be applied (e.g. concentration in soiled packaging, percentage in a sludge).

Ultimately, whether a waste is hazardous needs to be determined by risk assessment. A guidance document is available : HWR01 – A guide to the Hazardous Waste Regulations is available.

Examples of hazardous wastes are: fluorescent tubes, waste oil, photographic chemicals, acids, alkalis, industrial solvents, fly ash, pesticides, batteries, prescription only medicines, wood preservatives.

Disposal of hazardous wastes is managed by specialist companies (e.g. Rechem) who have acquired expertise and operate dedicated chemical plant. Recovery of waste oils, solvents etc. is usually followed by incineration of the residues, which must be carefully controlled to minimise production of environmentally harmful substances such as dioxins and furans. This involves careful control of incinerator temperatures and cleaning of effluent gases.

Waste batteries (Waste Batteries & Accumulators Regs. 2009) set out requirements for waste battery collection, treatment, recycling and disposal for all battery types including arrangements by which the UK intends to meet waste portable battery separate collection targets of 25% by 2012 and 45% by 2016.

4.4.2 Clinical Waste

Generally taken to mean healthcare waste and, obviously, may contain various categories of hazardous waste. The framework of management for healthcare waste; a best practice guide is detailed in Department of Health:

Health Technical Memorandum 07-01: Safe management of healthcare waste

The guidance details:

definition and classification of infectious waste;
definition and classification of medicinal waste;
changes in transport legislation;
a revised colour-coded best practice waste segregation and packaging system;
use of European Waste Catalogue (EWC) Codes;
classification of microbiological cultures for carriage and disposal.

e.g. H9 – Infectious: 'Substances containing viable microorganisms or their toxins which are known or reliably believed to cause disease in man or other living organisms.'

In managing healthcare waste a risk assessment methodology is needed, first categorizing the waste as:

Infectious clinical waste
Hazardous waste
Offensive / hygiene waste (e.g. incontinence waste which is of low hazard)
Waste dangerous for carriage
Non-hazardous waste (black bag waste)

A waste assessment framework is described in detail in chapter 5 of the guidance

Clinical Waste costs can be reduced by enforcing segregation into yellow and black waste (always a battle to encourage staff to do this!) An alternative is to microwave bagged waste so reducing it to ordinary non-infectious 'black bag' waste.

4.4.3 Packaging Waste

The Packaging & Packaging Waste Directive 1994 is implemented in the UK as the Producer Responsibility Obligations (Packaging Waste) Regulations 2011 and sets binding recovery and recycling targets. Organisations producing 50tonnes of packaging per year (including wood waste e.g. pallets) and with a turnover of £2m + become obligated. A simplified scheme applies to companies in the £2m - £5m range). Bigger producers - £500tpa + must provide an operational plan. From October 2007 all recyclable waste must be segregated from landfill disposal and packaging waste dovetails into this requirement, reinforcing the need for collection and generation of PRNs (Packaging Recovery Notes).

Packaging is defined as 'all products made of materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods...'

An obligated producer must register with a compliance scheme.

Dedicated companies such as VALPAK, DIFPACK & WASTEPACK operate such schemes on behalf of client producers;

provide packaging data (by weight). They must calculate their obligation according to whether they are:

manufacturers of packaging, converters (raw materials into packaging), fillers (putting goods into packaging), suppliers (of packaging to the end user), lessor, hirer or franchiser of packaging, importer of packaging and/or importers of transit packaging destined to go to landfill.

Imported transit packaging (e.g. pallets, shrink wrap) are rated at 100% obligation by the importer.

You can use the National Packaging Waste Database to calculate your recovery and recycling obligations for each category of packaging material for the year. Amending regulations have set new recovery and recycling targets up to 2012, and the National Packaging Waste Database has been updated with these targets.

The system of electronic PRNs is used as proof that the obligation has been met (see Guidance NPWD02). An obligated producer must either collect PRNs directly until they fulfil their quota or else purchase them from somebody who has a surplus. The process has created a stockmarket in recovered packaging waste, in which the value of a PRN fluctuates according to the laws of supply and demand.

4.5 Waste Management and Licensing

4.5.1 The Duty of Care

Duty of Care guidance is now available online via Business Link. Along with other information such as NETREGs this is to do with simplification of government and environmental management information comes under the generic heading 'Environment & Efficiency.'

The duty of care is imposed on anyone within the waste handling chain who may import, produce, transport, store, treat and dispose of waste. Any such person automatically becomes a waste holder. The duty requires that any waste holder must keep the waste safe, they must act to prevent waste from deteriorating and escaping into the environment.

The Duty of Care Code specifies prevention of:

corrosion or wear of containers
accidental spills or leakages
breach of containment by weather
blowing away or falling from vehicles or storage
scavenging by vandals, thieves, children, trespassers or animals.

Thus leakage from waste into the ground may contaminate it and the contamination then pollute groundwater. *An important civil action here is Cambridge Water v Eastern Counties Leather in which Eastern Counties Leather used perchloroethylene to degrease skins. Over the years, spillages contaminated the ground and entered Cambridge Water's aquifer. The compensation amounted to £900 000.* Recent release of asbestos on to the streets of Birmingham represents a particularly unscrupulous example of flytipping.

Wasteholders duties are designed to prevent such abuses, which it was anticipated would increase following the introduction of the landfill tax at £2 per tonne for inactive waste (builders rubble) and a much higher cost for active (general waste) which is constantly being revised upwards.

The wasteholder must:

protect the waste while they have it

(cover skips, store liquids in bunded enclosures);
ensure that it reaches the next holder intact;

(if the next stage is a waste transfer station, it will be sorted and mixed so that excessive packaging is not needed)
segregate incompatible wastes;
(preventing cross contamination of waste)
ensure security
(secure against waste attractive to scavengers e.g. building materials).
Waste left for collection should be adequately secured and left for a minimum of time.

Waste should be labelled where appropriate and in accordance with the Chemicals Hazard Information Packaging (CHIP) Regulations).

4.5.2 Waste Carriers

Anyone who holds waste may transfer it to a waste carrier who must be registered with a Waste Regulation Authority (a list of whom must be available for public scrutiny). However, it is part of the Waste Holder's duty to ensure that such persons are fit & suitable to handle and dispose of the waste. The holder should remain alert to any sign that the waste may not be legally dealt with by a carrier. Thus the duty holder ultimately remains responsible for the fate of the waste so that if, for example it is taken by such a carrier and subsequently flytipped, it will be the duty holder's perhaps difficult task to persuade a court of law that he acted in accordance with the Code of Practice, which explicitly has legal standing.

It is for the Waste Holder to ensure the bona fides of any waste carrier who must be a registered carrier of controlled waste.

4.5.3 Some Relevant Terminology

Waste Regulation Authority (WRA) : charged with the issue of Waste Management Licences

Chartered Institute of Wastes Management CIWM: a charity dedicated to scientific research, education and competence in wastes management (6000 members).

Waste Disposal Authority: Local Authority charged with responsibility for disposal of publicly collected waste

Waste Collection Authority: Local Authority charged with collection of waste.

Licensed Waste Manager: one in possession of a Waste Management Licence. WAMITAB is the certification body responsible for ensuring technical competence to the appropriate level. NVQs are appropriate.

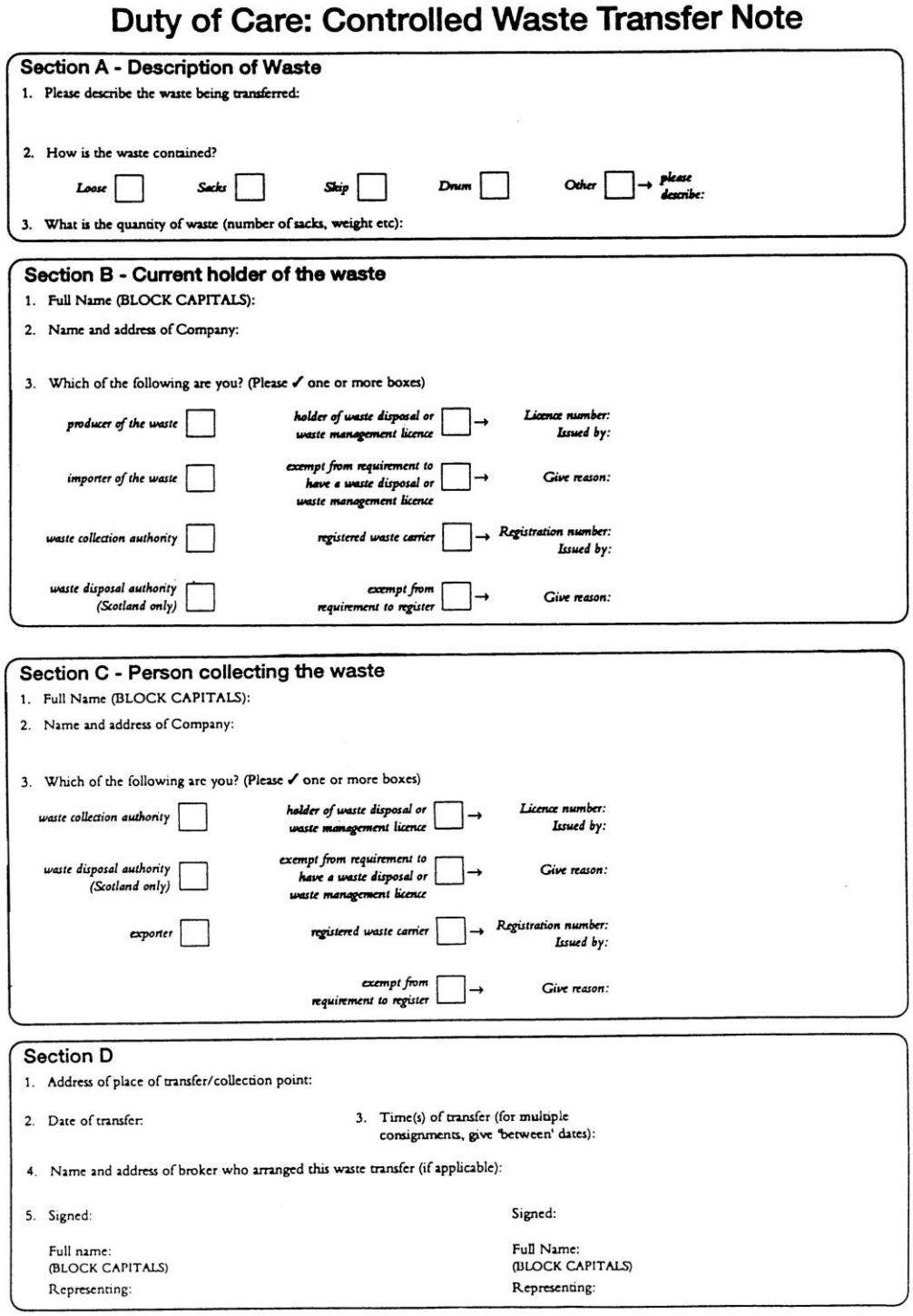
Fit and Proper Person: licensee for waste disposal who must show the WRA management capability and financial resource to manage the site including post closure monitoring and pollution control

WAMITAB: Waste Management Industry Training & Advisory Board. Issuing body for certificates of competence in Waste Management via statutory NVQs.

4.5.4 Waste Transfer Notes

The system operates by a system of Controlled Waste Transfer Notes which describe the parties to the transfer and the waste itself. Copies of all such transactions must be kept for a minimum of two years. The transfer note shown is the one used in the Duty of Care, but it is not mandatory to use it,

provided that an adequate system is adopted. It must describe the waste in sufficient detail that the transferee can safely manage it.



Duty of Care: Controlled Waste Transfer Note

Section A - Description of Waste

1. Please describe the waste being transferred:
2. How is the waste contained?

Loose ☐ Sacks ☐ Skip ☐ Drum ☐ Other ☐ → please describe:

3. What is the quantity of waste (number of sacks, weight etc):

Section B - Current holder of the waste

1. Full Name (BLOCK CAPITALS):
2. Name and address of Company:
3. Which of the following are you? (Please ✓ one or more boxes)

producer of the waste ☐	holder of waste disposal or waste management licence ☐ →	Licence number: Issued by:
importer of the waste ☐	exempt from requirement to have a waste disposal or waste management licence ☐ →	Give reason:
waste collection authority ☐	registered waste carrier ☐ →	Registration number: Issued by:
waste disposal authority (Scotland only) ☐	exempt from requirement to register ☐ →	Give reason:

Section C - Person collecting the waste

1. Full Name (BLOCK CAPITALS):
2. Name and address of Company:
3. Which of the following are you? (Please ✓ one or more boxes)

waste collection authority ☐	holder of waste disposal or waste management licence ☐ →	Licence number: Issued by:
waste disposal authority (Scotland only) ☐	exempt from requirement to have a waste disposal or waste management licence ☐ →	Give reason:
exporter ☐	registered waste carrier ☐ →	Registration number: Issued by:
	exempt from requirement to register ☐ →	Give reason:

Section D

1. Address of place of transfer/collection point:
2. Date of transfer:
3. Time(s) of transfer (for multiple consignments, give 'between' dates):
4. Name and address of broker who arranged this waste transfer (if applicable):
5. Signed:

Full name:
(BLOCK CAPITALS)
Representing:

Signed:

Full Name:
(BLOCK CAPITALS)
Representing:

Figure 4.2 illustrates a controlled waste transfer note

Waste Management Licensing

Under the EPA 1990, the Waste Management Licensing Regulations 1994 require that a system of licences are needed for

a) Deposit on land (landfill)
b) Treatment, storage and disposal on land
c) Use of mobile plant to treat, keep or dispose on land

4.6 Options for Waste Disposal

4.6.1 Landfilling

Landfill site management must adequately control and minimise any emissions, nuisances and litter and this has implications during filling and afterwards. An Environmental Impact Assessment (EIA) under the EPA90 will be needed before a licence is granted and must take into account all aspects of the operation, the kind of waste to be disposed and any other treatment. Most sites are multifill sites in which no attempt is made to mix wastes but there are a few codisposal operations in which waste is blended to take advantage of chemical reactions between waste components and produce a relatively inert product.

A site must be geologically suitable. Ideally it should be impervious, e.g. clay or sandstone but if not a membrane can be laid to make it so. The design should minimise ingress of groundwater which could arise due to changes in the local water table, flood conditions or the existence of springs or streams and be finished with an impervious clay dome to shed rainwater. A system of porous pipes may be laid to collect and encourage drainage of leachate.

Any leachate which accumulates is normally pumped to foul sewer following analysis to determine its constituents. If 'red list' contaminants, typically toxic metals, are present, pre-treatment will be required. Leachate management can be a problem with older sites which were not carefully designed and it may end up contaminating groundwater or invading local streams, especially in times of flood. Digging a French drain is one example of remedial action which can be taken to capture leachate.

Nuisances may arise in the guise of noise, odours, dust, litter and vermin and all these must be adequately controlled especially if the site is anywhere near a populated area.

Noise nuisance may arise due to heavy vehicle movements, both site traffic bringing waste for disposal and site plant. Care should be taken in planning traffic routes, coupled with limitation of acceptance times and on-site use of heavy plant. Licence conditions may specify working hours.

Odours can be minimised by using the cell method of filling, ensuring that the surface is covered with inert fill at the end of each working day, and generally operating to minimise exposed areas. A purpose of the landfill tax is to encourage waste segregation so that inert waste is available to build the cell walls and provide cover material. Residual odour problems can be controlled by using masking chemical sprays and this can be a solution to problems arising in unusual wind conditions.

Dust and litter can be minimised by damping down and good site practice. Cell filling is typically achieved by tipping down a gradual slope and using specially designed plant in the form of steel-wheeled compactors which bury litter and also increase the fill density, maximising the site capacity and minimising later settlement. This also reduces the possibility of fire starting in the waste. Obviously, fire is highly undesirable - producing smoke, offensive smells and contaminated leachate and often being difficult to extinguish once it becomes established.

Vermin usually appear as gulls which feed on exposed waste and rats, mice and even foxes. Good site practice as already described can do much to contain the problem of birds. Netting over the working slope has proved effective and also further controls litter. If rats become a problem, especially having regard to the risk of Leptospirosis (Weil's Disease), an eradication program will be necessary.

Site security with a 2m chain-link fence will keep unauthorised persons out and help to catch wind-blown litter.

Landfill gas, a combustible mix of methane and Carbon dioxide can present explosion and toxic hazards to premises near the site by permeating through soil. It can also injure site screening trees. MSW contains sufficient putrescibles to give a good supply - production may continue for in excess of 10 years. Such gas may be odourless and detailed risk assessment should be undertaken, along with a programme of monitoring. Landfill gas is normally collected in pipes laid within the waste and is either flared off or collected and used as fuel. Energy from landfill gas is a way of reducing the national requirement for fossil fuels and in the UK is of the order of 150MW which, though a small contribution, is nonetheless worth having

A well-managed landfill site – Courtesy Shanks & McEwan

4.6.2 Composting

The organic component of municipal waste (MSW), the putrescible fraction, can be broken down by aerobic bacterial decomposition to give compost, a fibrous residue which is used as a soil conditioner, organic fertiliser, mulch and potting medium. The process involves heaping the putrescible waste fraction and maintaining aerobic conditions by either frequently turning it over or else mechanically forcing air through it. The process raises the temperature to 60 - 700C, killing off undesirable pests, weed seeds and pathogens and the resulting product is innocuous. Drying out tends to occur so that moisture content must be controlled to around 40% or the reaction slows down. Fresh compost needs to be matured in order to increase the nitrogen:carbon ratio by further microbial activity and at the same time release gases which are toxic to plants. The process may take several weeks to complete after which the product is marketable or may be used 'in house' by Local Authorities' Parks Departments.

Compost made from waste which has been separated from the municipal stream inevitably contains some toxic metal content. Surprisingly, much of this originates from house dust which contains lead. Also, staples, batteries and wine bottle caps are difficult to remove, adding to the problem. Emphasis has gone towards separation at source from the MSW stream. The Germans collect it

separately from households, in the UK home composting is encouraged with subsidised or even free issue of small household units. Increasingly, separate collection is being practiced in line with EC Directive requirements.

It is estimated that 30 - 35% of UK MSW is compostable. Additionally, garden waste can also be turned into compost and an alternative is chipping of woody waste to produce mulch directly.

4.6.3 Incineration

Incineration with energy recovery is Europe's preferred solution to its waste problem. The process requires capital intensive plant and detailed planning. An EIA is required under EPA90. MSW has about 40% the calorific value of coal and is therefore a considerable source of energy. The BPEO for an incinerator project is usually combined heat & power (CHP). Waste reduction is 60 - 90% and results in clinker or bottom ash (useable for road building), fly ash (landfilled) and metal (recycled).

The Edmonton incinerator was commissioned in 1971, designed to burn 400 000tpa of MSW from 5 London boroughs. It takes 1330 tonnes of refuse each day, produces superheated steam and drives 4 turbines supplying electricity to the National Grid, earning £4m per annum. The South East London Combined Heat & Power Consortium (SELCHP) incinerator was commissioned in 1994 and burns 420 000 tonnes of MSW per annum, returning 32MW of electricity to the Grid. It is planned to recover another 80MW of thermal energy by installing a district heating system for 7 500 houses. A 'new wave' of incinerators are now under construction as landfill pressures inexorably increase!

Incinerator technology is now well developed and they run very cleanly. There is no visible stack emission when they are operating! Advanced moving grate design ensures that the waste dries, then burns efficiently. High temperatures and complete combustion are achieved followed by gas cleaning which removes fly ash and acid gases (mostly from combustion of the plastic PVC). Production of dioxin is minimised by rapid cooling of stack gases to below the critical temperature range at which formation may occur and further absorbing in activated carbon. Ammonia injection is used to react with NOx, converting it to nitrogen and steam.

District heating scheme – considerable infrastructure is required to be installed

Waste Derived Fuel is a term for pelletised fuel made from MSW and especially waste which has been separated of its glass and metal components. It can be burnt in an incinerator and has the advantage of portability. Properly processed it has about 60% of the calorific value of coal.

Waste derived fuel from shredded municipal plastic waste.

Hazardous Waste Incineration.

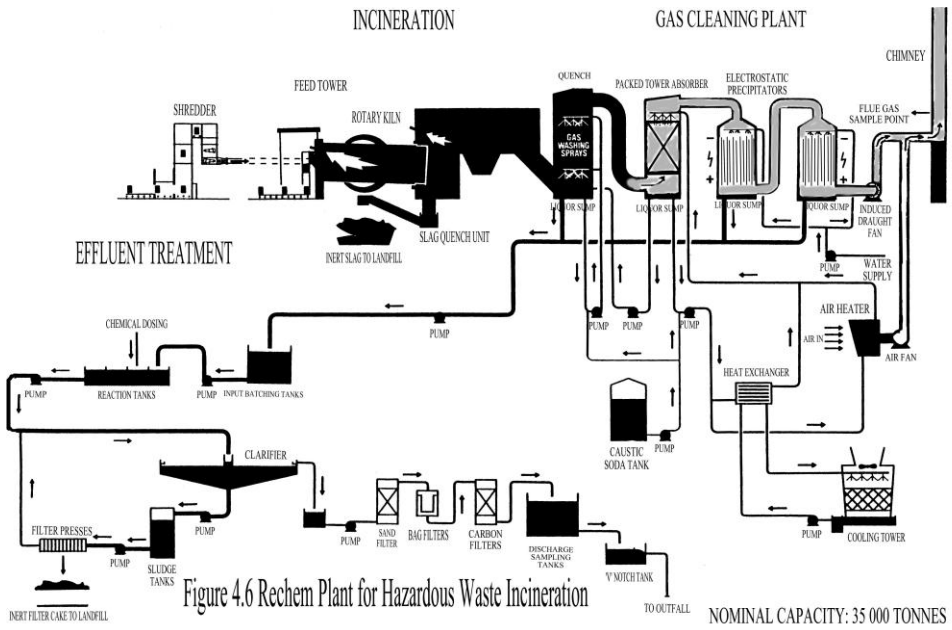
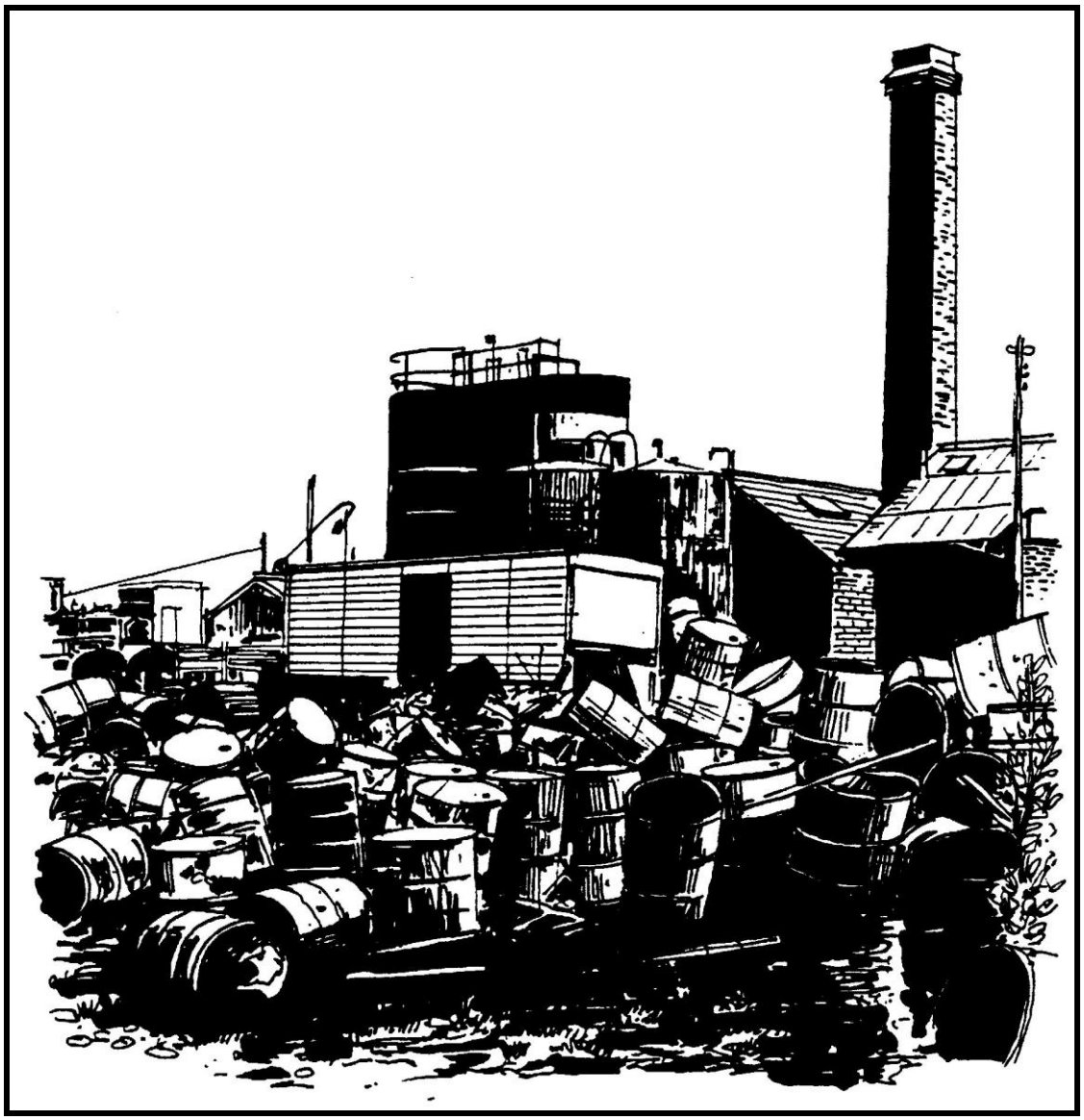


Figure 4.6 Rechem Plant for Hazardous Waste Incineration

Figure 4.7 illustrates the Rechem Plant at Pontypool (now owned by Shanks & McEwan Group plc). If you follow the flowlines through the plant, you arrive at the gaseous, liquid and solid waste

residues. Such a plant is subject to IPPC so that contaminant levels of prescribed substances must meet defined levels at all times.

4.7 Contaminated Land



Contaminated land is defined in the EPA90 (s78A(2) as 'any land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that:

significant harm is being caused or there is a possibility of same;

or

pollution of controlled waters is being or is likely…'

The Contaminated Land Regs 2006 set out the various duties and Guidance by the DEFRA (now via Business Link) is broadly based on the 'pollutant linkage' model (Figure 4.8). In order to identify contaminated land LAs have a duty (s78B) to inspect their area 'from time to time' , identify contaminated land and designate 'special sites'. Such sites present a risk of serious harm, or serious

pollution of controlled waters and require the expertise of the Environment agency. Once such a site has been designated the owner and occupiers of the land must be notified, an appropriate person identified and a remediation notice served by either the LA or the EA, specifying the remediation works which must be carried, along with a timescale for completion. An appropriate person is either Class A (who knowingly permitted the contamination) who should preferably sought or Class B (the current owner/occupier) and if both can be identified, costs should be apportioned between them. The intention is improvement in land quality and also that the polluter cannot walk away from their responsibilities.

Assessment of contaminated land is based on the concept that action is only required where there are 'unacceptable actual or potential risks to health or the environment' and 'there are appropriate and cost-effective means to do so, taking into account the actual or intended use of the site.'

4.7.1 Classification of Hazards

Numerous attempts at classification have been made and the list of contaminative uses which the former DoE proposed just before abandoning the concept of a register contained just 8 of the more serious polluters:

gasworks
metalworks
asbestos manufacture
refining of oil
manufacture
landfill sites
waste treatment works
scrap metal stores.

The above list gives useful insights into the kinds of contamination one might expect.

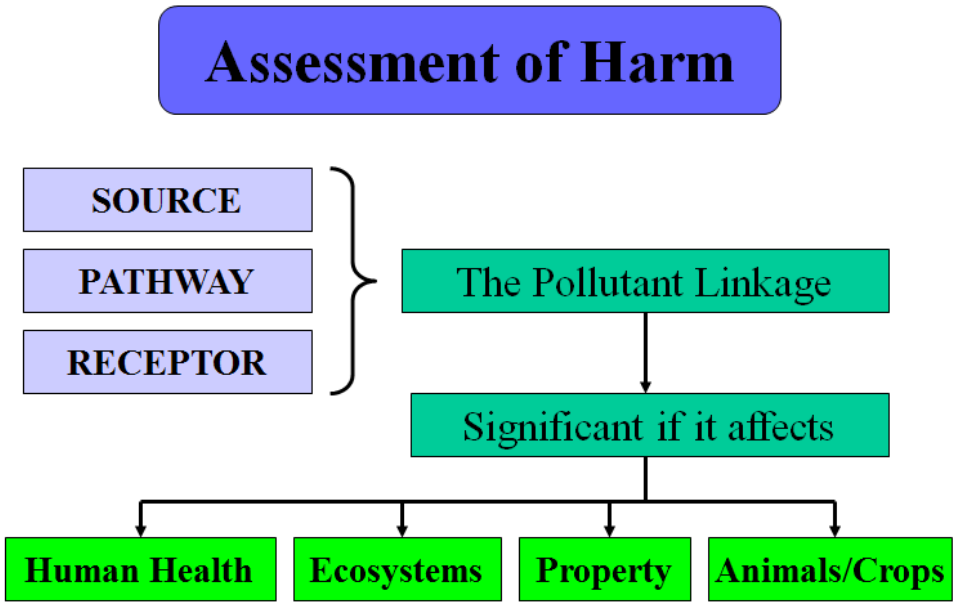


Figure 4. 10 links common contaminants with the environmental health hazards they present.

Toxicity to human or animals by ingestion of soil (esp. children) or home-grown produce	Heavy metals phenols, coal tar cyanides
Toxicity to humans or animals by direct contact	Oils, phenols, tars
Toxicity to humans by Inhalation	Hydrogen sulphide, ammonia asbestos
Attack on services (pipes) or Hazard	phenols, oils, coal tar Contaminant
Building materials (concrete)	sulphides, sulphates, chlorides
Risk of explosion or fire	landfill gas, combustible materials
Phytotoxicity	Zinc, copper, nickel, sulphates

Figure 4.11 Common contaminants and hazards associated with them

4.7.2 Hazard Pathways

There is direct risk to human health by ingestion, particularly of toxic metals which accumulate in the body. Lead and cadmium are particularly of concern, being commonly present and very toxic. Lead is known to be particularly harmful to children. Gardening must then be seen as a hazardous activity because contact with soil may be prolonged. Vegetables may also suffer both surface contamination and uptake of toxins.

Inhalation of dust, vapours (phenols and other aromatic compounds) and toxic gases may add to the exposure. Asbestos is another obvious risk here. Skin contact with coal tar residues can cause dermatitis, tar warts and skin cancer.

Water can be contaminated both directly by migration through plastic water pipes (esp. of phenols and cresols) into household water supplies and indirectly by leaching into groundwater.

Phytotoxicity is common, many ground contaminants will effect plant growth at low concentrations (toxic metals). Gases may also displace air from soil and further impede growth.

Problems of odours, fumes, effluvia may occur, particularly when gases (landfill gases) percolate the site. There is a risk of gas explosions from methane and petroleum vapours and also underground fires - the latter being responsible for odour, fumes etc. and ground subsidence. Such fires are notoriously difficult to extinguish and may burn for many years. A survey by the Fire Research Station in 1987 identified 64 incidents over 3 years - most of them in waste, 27 in domestic waste landfill.

Buildings can be damaged by soil contaminants, most notably high levels of sulphate (this can occur downwind of brickworks, along with fluorine as dry deposition on land over many years). A report entitled ‘Material Durability in Aggressive Ground’ (is available from CIRIA).

Case study 4.1 The Greenwich Millennium Site

The site abounds the river Thames and covers 20 hectares of old gasworks which had been operational for about 100 years, it is part of a much larger (120ha) site owned by British Gas. Gas processing changed over the years and there were a variety of pollutants present in large quantities. Reinstatement of the 20ha site had to be carried out in 6 months so that large scale in situ remediation was impractical and much contamination had to be removed from site as special waste to a codisposal landfill.. 222 000m^3 of contaminated ground had to be replaced with clean fill. A further problem was a tar well, 30m in diameter and estimated to contain 3 million litres of tar, mixed with rubble which had been hit by a bomb during the last war and was leaking tar into the gravels near the base. Tar from the well was used a local road surfacing.

In other areas of the site, large amounts of benzene and toluene had soaked into the ground until reaching a clay stratum, then spread out into underground pools. Vacuum extraction was used to draw off contaminated water for on-site treatment and discharge to foul sewer. Yet another problem concerned contaminated ground overlying a chalk aquifer where a gravel to chalk interface had been found so that groundwater was in danger of contamination. The contaminated fill was extracted, screeded to segregate hard-core and disposed into containment cells lined with clay from the Jubilee Line tunnelling works. (source: New Civil Engineer, 26.9.96)

4.7.3 Remediation of Contaminated Land

Remediation is not an easy matter, the commonest methods which are still largely UK practice are to either:

remove the contaminated soil and replace it with clean. This suffers the drawback that it doesn't ultimately solve the problem, just transfers it to a landfill site and we have already noted the serious shortage of landfill capacity. Also, it may not be practicable except for the smaller sites;

or encapsulate it in situ by covering it with a clay capping or a made up surface. It may also be necessary to build subterranean bund walls and even then, the danger of leachate remains.

There is current interest and investment in remediation technology, in particular the US Environmental Protection Agency is funding research and supporting demonstration projects and a number of viable techniques are emerging. It is only possible to give an overview here of methods that may be used singly or in a number of stages:

Physical methods, typically those evolved in the mining and extractive industries to concentrate minerals. Screening out rubble from the waste (ore?), washing and sluicing, grading, froth flotation are all well proven techniques giving a reduction in amount of residue, concentrating the contaminant, making it easier to further process. Particularly useful for metals and minerals.

Filling and stabilisation by adding inert or reactive fillers (cement, pozzolan) are aimed at filling up all voids and effectively sealing the site.

Thermal systems in which heating to high temperatures physically destroys or changes the contaminant. A system for thermal conversion of asbestos is available as mobile plant and operates at a cost of around £180 per tonne. At lower temperatures organic contaminants will degrade (pyrolyse) and evaporate and can then be either captured or burnt off.

Steam or hot air stripping may be carried out directly into the ground, in combination with suction pumps to remove volatiles and semi (steam volatile) substances. Even cold air can sometimes be effective.

Chemical treatment, in its simplest form, applying an agent such as lime to raise pH, lower acidity and 'fix' metals in an insoluble form so that they will not leach out. Various treatments can be applied, but usually the soil will need to be ground down into slurry, sometimes the groundwater can be used as a transport medium.

Bioremediation, in which natural or adapted bacteria are encouraged to feed on and thus break down contaminant. This is particularly suitable for organic compounds and, to give one example has proved effective with chlorinated hydrocarbons. Conditions have to be right, without unduly high concentrations which would be toxic to the bacteria, presence of moisture, adequate temperature and access of air. Natural bioremediation will tend to occur anyway and techniques aim to accelerate the processes. However, the method is always slow.

An interesting variant of bioremediation is growing 'poison-eating trees' which absorb toxic metals and can be harvested. Willow, poplar and alder are being used experimentally by the National Urban Forestry Unit (Wolverhampton).

Electrical systems in which electrodes are introduced into the ground and effectively 'plate out' toxics, especially metals are effective and well tried. Passing DC electric current through wet soil mobilises substances and causes them to migrate towards the electrodes.

Remediation is not an absolute matter and before deciding on a programme of often expensive and extensive works, the land use criteria should be established and remediation timescales worked out. It might be quite sufficient to leave a site to remediate itself, or apply a simple clay cover to it.

The Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL) have established trigger concentrations for various contaminants which are related to the proposed land use and the hazard presented. Domestic gardens and allotments are seen as the most sensitive and therefore having the lowest trigger values, with parks, playing fields and open spaces less so. Phytotoxics are assessed rather differently.

The Environment Agency 'State of the Environment' on-line report on Derelict and Contaminated Land can be accessed via their website.

'**A Perspective on Incineration**.'

Friends of the Earth issued a leaflet opposing MSW incineration which stated...

"There are currently proposals for new incinerators to burn waste in many places in the UK. Most of these would be able to convert some of the heat produced into electricity, or use it to heat homes. This is sometimes referred to as 'energy recovery'. At first sight, it can sound quite sensible for the environment. But don't be fooled!

What a waste

Burning things instead of recycling them wastes valuable resources. If you burn paper, for instance, more trees will be cut down to make more paper. If you recycle it, those trees will be saved.

A Waste of Energy, too

The amount of energy that can be generated by incineration is much less than the amount that could be saved by recycling things instead of making them from scratch.

Polluting the Air

Smoke and gases given off when waste is burned contain pollutants such as dioxins. New incinerators are cleaner than old ones, but still release these toxic chemicals which can damage health even at very low levels.

Polluting the Ground

Incineration produces toxic ash. Most of this is buried in landfill sites. Even if the landfill is modern and well-constructed, the toxins eventually seep out and cause pollution.

Incinerators Need Waste

Once an incinerator is built in an area, it needs 'feeding' with large amounts of waste for its lifetime, which could be 25 years. Incinerators are hungry monsters and will undermine schemes to reduce or recycle waste.

Expense

Incinerators are expensive to build, and generate few jobs. Waste reduction, repair and recycling schemes, on the other hand, can be set up much more quickly and cheaply, and do create local jobs.'

You might wish to critically evaluate each point in FoE's statement.

Unit 5 Water Pollution

'Water, water everywhere, but not a drop to drink'

Objectives

1 Know the main ways in which water may become polluted and be able to describe in outline the effects of such pollution.

2. Understand the mechanisms by which such pollutants may be removed.

3. Be able to explain the importance of temperature and dissolved oxygen in relation to water pollution and water quality.

4. Know the various kinds of controlled waters, drinking water, bathing water, groundwater, surface water.

5. Be able to describe the main sewage and trade effluent treatment processes.

6. Know the legal and regulatory framework which is applied to water.

Water is the universal solvent and the universal carrier for both solids and liquids in suspension. Its action has shaped the very planet, it is the main agent of weathering.

5.1 Pollution of water

5.1.1 Dissolved and suspended substances

Many substances dissolve in water, thus for example, the sea contains about 3.5% of dissolved solids, mainly common salt (sodium chloride). Soluble substances can become pollutants, you should note that there are invariably naturally occurring dissolved chemical substances in the water we use for our many purposes. Pure water, H_2O , sometimes referred to as 'distilled water' or 'deionised water' has a reputation for being tasteless. You might appreciate then, that a problem exists in defining what pollution actually is - we explore this theme later under the heading 'Water Quality Objectives'.

Substances which may dissolve in water, thus polluting it can be conveniently classified as:

inorganics - mineral salts e.g. chlorides (salinity), nitrates, phosphates;

organics - e.g. urea, detergent, sewage.

Inorganics are composed of cations (metal ions - and heavy metals can be both persistent and highly toxic pollutants) and anions, often referred to as radicals (nitrates and phosphates are nutrients, others e.g. chromates are highly toxic to aquatic life). The organics are a very diverse range of substances, many are relatively harmless but a few very toxic substances (e.g. the notorious dioxins and furans) in low concentrations give cause for concern. The problem here is that most substances will dissolve if only slightly or may be carried in suspension and so may become widespread in the environment (e.g. PCBs can be detected virtually anywhere within the mud of the Thames Estuary).

The pollutants may alter the water by changing its pH. Thus it may become either acidic or alkaline and have adverse effects.

Aquatic life is sensitive to pH, both plant and animal species are affected.

Acidity is particularly bad because, besides the direct harm, it mobilises any toxic metals the water may come into contact with and poison aquatic species.

Changes in pH may alter the turbidity of the water, for instance, lime (alkali) is sometimes used to precipitate fine (colloidal) clay particles and clarify the water. Turbidity in water blocks out light and stops aquatic plants from growing.

In addition to dissolved substances, material is carried in suspension, causing turbibidy. Organic material settles out only slowly, if at all, in moving water.

Both organic material and some inorganic salts, notably nitrates, phosphates and ammonium salts are nutrients and will promote rapid algal growth, forming blooms. Blue-green algae can be significantly toxic.

Mineral oil pollution has been in the public eye ever since the oil tanker 'Torrey Canyon' struck the Seven Stones reef, 9 miles off Lands End releasing 120 000 tonnes of crude oil from the Kuwait oilfields in 1967. This caused massive pollution of beaches on the coasts of Devon and Cornwall and Northern France, destroyed large numbers of sea birds and polluted oyster beds. Lack of emergency planning coupled with lack of knowledge led to a series of blunders which worsened the crisis. The ship's tanks were blown apart with bombs in order to release it all and it was then set alight. The intended effect was not achieved, all that happened is that an estimated 20 000 tonnes of the light fractions burned away leaving heavier and more difficult residues. The oceans deal with naturally occurring oil pollution all the time. Gradually, the lighter oil fractions evaporate and the heavier residues are eventually biodegraded. The main differences associated with oil spills is their higher concentration in space and time.

Experience now says that as much oil should be recovered as possible, requiring investment in special equipment and ships and that thereafter nature should be allowed to take its course. Detergent spraying of beaches at the time of the Torrey Canyon was estimated to have killed 80% of all marine life. As Lord Caithness (Minister for Shipping) said of the Braer Disaster, when a tanker went aground on the Shetland Isles, 'nature was on our side because the weather was so bad that it prevented the detergent spraying aircraft from flying!' Effective spill management is concentrated on deployment of booms and use of oil absorbing mats, detergents should only be used as a last resort. Interestingly, the French collected significant amounts from their beaches and allowed it to separate out in holes in the ground, from whence it was recovered.

Detergents first became a problem in the 1960s when synthetics were manufactured and marketed aggressively using the new medium of television to reinforce the message and encouraging overuse. Sewage works were overwhelmed with thick carpets of foam because the products were not biodegradeable. The main problem was solved by changing the formulation but phosphates in the detergent were still causing algal blooms which can lead to eutrophication of shallow lakes (e.g. the 'death' of Lake Erie). Low phosphate detergents are the answer. However, detergents remain a problem because they are harmful to aquatic life. A recent episode in which a large spill contaminated the river Irwell produced a carpet of foam estimated to be 30 feet thick.

5.1.2 Dissolved air

A small but important volume (around 4% in cold water) of dissolved air, especially oxygen, is essential to aquatic species. Oxygen is introduced to water by:

photosynthesis of aquatic plants, provided that there is enough light. Hence the problem of turbidity;

diffusion through the surface;

mixing with air, aeration. The river Thames has two fixed aeration points which are essential for its well being and these are supplemented by the 'Thames Bubbler' a boat which can act as a mobile aeration station;

Weirs are used in streams to encourage aeration.

Oxygen is removed by:

respiration of aquatic species, both plant and animal. Algal blooms, formed due to rapid growth of aquatic micro-organisms can seriously deplete the dissolved oxygen, denying it to higher species;

decomposition of organic pollutants;

increasing the temperature.

The effect of organic pollutants are measured by their chemical oxygen demand (COD). This test is applied to industrial wastewaters, a sample is boiled with a chemical oxidising agent and the amount required to oxidise up the pollutant is measured.

Biological oxygen demand (BOD) is applied to biodegradables, hence is suitable for assaying sewage. A sample is sealed up for 5 days at 200C in darkness and the amount of oxygen consumed measured directly.

COD will include BOD, hence generally gives a higher figure for any given sample. The Royal commission on the Environment set an effluent standard of 20mg/l BOD and 30 mg/l suspended solids (the Royal Commission effluent standard) for discharge to inland waters (20:30). This concept has been refined to include ammonia (NH_4+)and a typical modern standard could be 15:15:5 (NH_4+). The Urban Wastewater Directive required also COD.

More stringent standards, including phosphate and total nitrate can be applied to sensitive receiving waters, according to the WQO (Water Quality Objective) (hence nitrate sensitive areas and water protection zones).

5.1.3 Temperature

Increasing temperature of water has the effect of:

directly reducing the dissolved oxygen concentration;

increasing the rate of chemical reactions which deplete oxygen - as a rule of thumb, the rate doubles for a 100C rise in temperature;

increasing the rate of algal growth;

increasing the requirement for oxygen, especially in higher species (fish).

Maximum outlet water temperature was specified for Barking Power Station as a requirement of the Environmental Impact Assessment, acknowledging a sensitive stretch of the river Thames. If the outlet water temperature exceeds this, a cooling tower system is used to bring it down to safe levels.

5.1.4 Oxygen Sag

If an organic pollutant enters a stream then its BOD/COD reduces the concentration downstream until the oxygen demand has been substantially satisfied and the levels recover. This oxygen sag is shown schematically in figures 5.1 and 5.2 If too much pollutant is added for the system to cope with, all oxygen is removed and the aerobic conditions are lost, the bacterial decomposers die off

and the system loses its ability to recover. Anaerobic conditions now exist, other kinds of decomposers take over and decomposition follows a different pathway. Methane, CO_2 and sometimes hydrogen sulphide are produced, characterised by slimy conditions and unpleasant odours.. Bubbles of gas can be seen to be emanating from bottom mud, especially if it is disturbed. The problem is more likely to occur in static water and stagnant water is invariably anaerobic.

The capacity of a stream to clean up pollution *, typified by sewage, can be measured and limits set for discharging liquid wastes. It has been assumed that if the limits are set for the lowest water flow conditions that any other conditions will be safe, but recent work indicates that flood water does not spread evenly through the stream and that contrary to expectations, demands can be higher, especially if disturbance of bottom sediments is taken into account. Flood water tends to run through the middle of the streamway.

** Given that pure water contains about 9ml/litre of dissolved oxygen at 20^0C, 4ml/litre would be the minimum for a salmonid river(Royal Commission Standard) and 2ml/litre generally for other fish. The capacity has to be assessed against the use which is required of the water, hence EQOs come into the equation.*

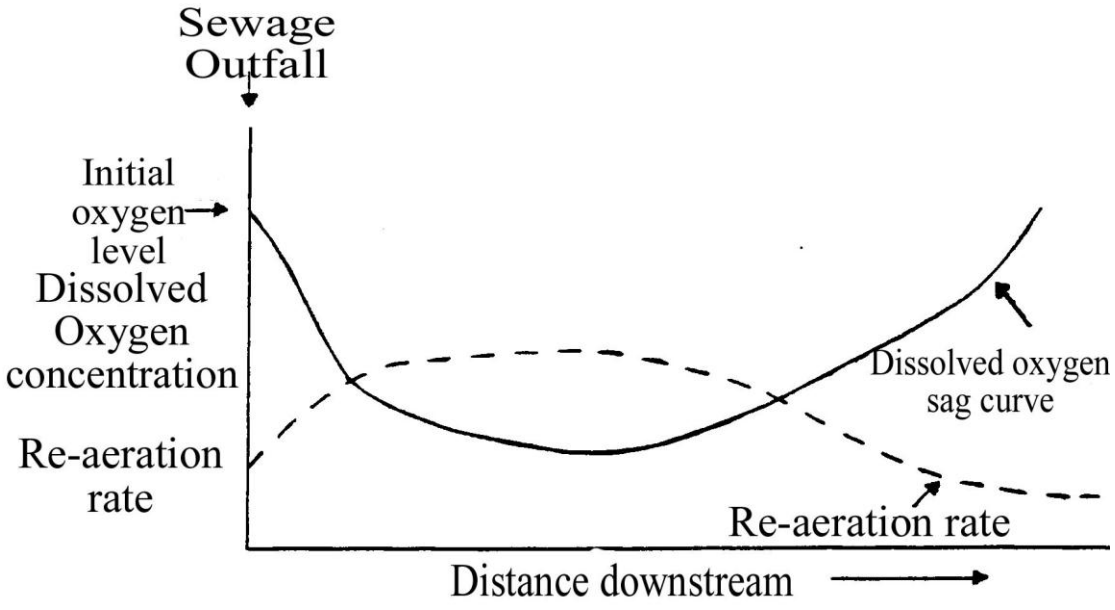


Figure 5.1 Effect of sewage contamination of a stream

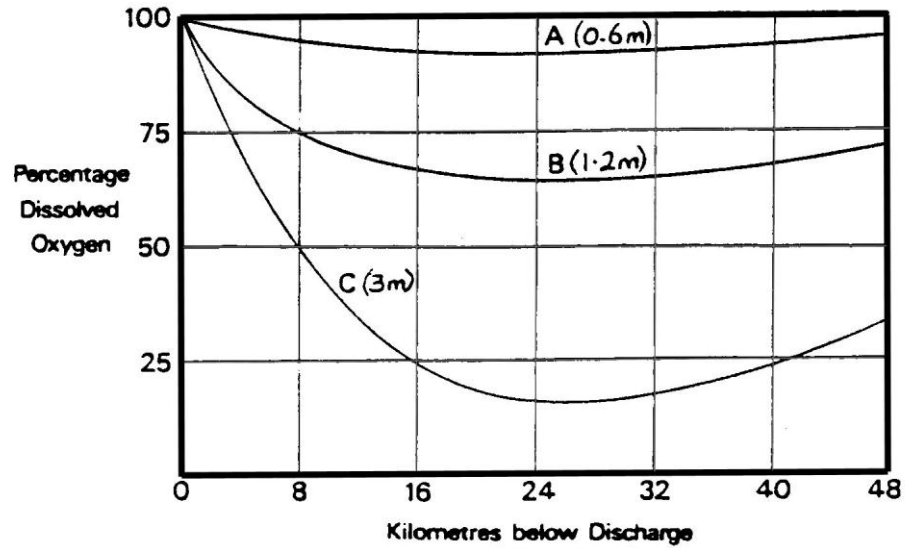


Figure 5.2 Oxygen levels are more seriously compromised at depth and hence aquatic life

5.2 Kinds of Water

In the workplace, there are four obvious kinds of water we have to deal with.

1 Potable water, supplied by a water undertaking and fit to drink as its name implies. It is delivered via a mains pipe network, which is notoriously leaky. The water is purified by filtration, pH adjustment and sterilised, usually by chlorinating it. Other sterilants are also used, ultraviolet irridiation, ozonation but these do not have the advantage of retaining a residual sterility while the water sits in the pipes so that chloramines (reaction products of chlorine and ammonia) are added as a top up. Eventually, this residual effect is lost as the small amount of chlorine is consumed. For this reason, water in static storage tanks is not considered to be potable and drinking water should be marked up as such where the chance of drinking from the wrong supply is a possibility. Potable water is subject to a battery of some 56 tests including for pathogens and toxics such as pesticide residues, dioxins and furans, nitrites and nitrates. Some toxic substances are chemically stable and must be removed by passing the water through an activated carbon filter. The requisite quality standards are much more demanding than those set for bottled water!

2 Sewage, the commonest wastewater is a mixture of washing and cooking water (grey wastewater), and toilet waste. The average output per person is 200 litres of liquid and 60 grammes of solids per day (known as a person equivalent load, used for calculating sewage treatment capacity).

3. Industrial wastewater contains contaminants which are specific to the industry concerned and a consent to discharge is required, generally if more than 5m3 per day is produced. If prescribed pollutants (EPA90, Part A) are discharged then much more stringent standards are applied. These are the Black List and Red List substances (the most serious), and Grey List substances (less harmful).

4. Storm water is considered to be clean and is run directly to streams and rivers without treatment. The obvious risk is that of pollution, especially in an emergency spillage or fire, when contaminated firefighting water can carry pollutants. Preventive measures are generally simple involving:

surveying the drainage system and maintaining a set of plans which are made available when required;
clear marking and segregation of storm drains (colour code green) from foul drains (colour code red);
provision of interceptors to catch oils;
ensuring that bunding will not leak or overflow to storm drains;
keeping drains properly clear and maintained.

Road runoff usually goes to foul sewer along with the rest because it is contaminated with hydrocarbon residues from fuel, oil and tyres (including polyaromatic hydrocarbons (PAH), some lead and pathogens, notably from canine excrement).

Black List (List 1) substances were the most serious pollutants for water as determined by The Framework Directive (76/464/EEC) and Daughter Directives made thereunder. Of 129 substances listed many fall temporarily into the Grey List (List 11) which are treated as less harmful.

Red List substances are those prescribed for IPPC.and available in the Environmental Permitting Regs. 2010

5.3 Groundwater

A whole system of water movement and storage exists below ground as above it. Reservoirs of groundwater are used for drinking and, for example, in Bangladesh are the preferred source of supply, being perceived as wholesome and free from pathogens. Alas, there is widespread arsenic contamination of that water supply. The London basin is an artesian well which was tapped into in order to supplement supplies to water the industrial revolution. Initially, a well could simply be sunk through the clay and into the chalk below to draw a wholesome supply but nobody considered that sewage could leak into the ground and contaminate it. (figure 5.3) An outbreak of cholera effecting maybe 10 000 persons in London in 1859 was traced to contaminated water from a pump in Broad Street by the pioneering epidemiological study of Dr John Snow. Figure 5.4 gives an illustration of the Broad Street Pump showing the distribution of cholera in relation to it.

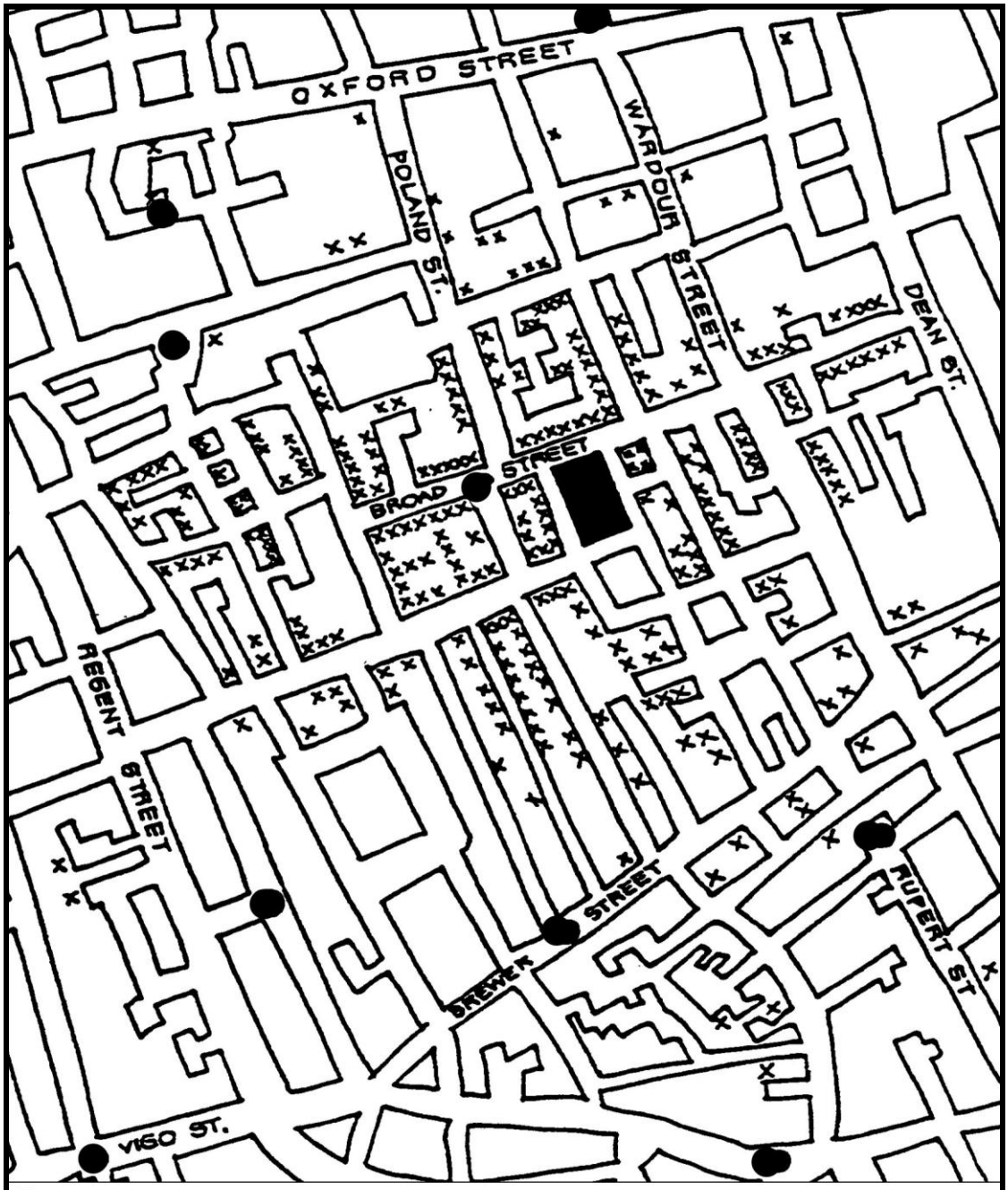


Figure 5.4 distribution of cholera deaths (John Snow) implicated the Broad Street Pump

By the time of the Second World War, London's groundwater had been pumped to minus 60m but with the reduced need for industrial supplies of water, the level has begun to rise again. Interestingly, it is in the process of bringing back with it the accumulated pollution which we have allowed over many years to disappear into the ground. It is well documented that petroleum is mobilised by such water movements and can generate explosive mixtures in the most unexpected places. At Bowling Green, Kentucky, a natural cave system beneath the city has led to a number of such emergencies in which spills and leaking tanks have caused petroleum vapours to enter homes. The potential exists of a massive explosion, similar to one in nearby Louisville which caused $43

million of damage. There is also a health risk from contaminated water and vapours emanating from it.

The pollution episode which led to the Cambridge Water v Eastern Counties Leather case (1993) was brought about by spilling trichloroethylene waste on to the ground. It was expected that it would evaporate easily but once below the surface it migrated into groundwater from which it is difficult to remove. Figure 5.5 illustrates some of the most common ways in which groundwater can be contaminated but the last word on groundwater pollution surely comes from Norbert Casteret in his book 'Ten Years Under the Earth' in which he describes finding in the Great Cavern of Cagire:

'Within the opening a hideous sight met my eyes: a crumbling stream of carcasses, entangled several deep, was working its way underground. Amid tangled rings of ribs were cattle skulls with menacing horns, and the open-jawed grin of horses and donkeys. A blackish, unspeakable layer at the foot of the slope moved in a venomous trickle down a vast chamber...empty but for the pestilential liquid thread from the carcasses..... We made an exact, detailed plan and were able to prove that a cool and limpid spring known throughout the neighbourhood was the deadly resurgence of the poisoned stream'

The Groundwater Regulations 1998 were introduced to prevent contamination of this vulnerable and important water resource, in particular from industrial and agricultural pollution (such as disposal of sheep dip and pesticide wastes on to the land). These have been replaced by the simpler 2009 Regs. Which divide pollutants into 'Non-hazardous' and 'Hazardous'. Thus:

Hazardous substances are the most toxic and must be prevented from entering groundwater. Substances in this list may be disposed of to the ground, under a permit, but must not reach groundwater. They include pesticides, sheep dip, solvents, hydrocarbons, mercury, cadmium and cyanide. Hazardous substances replace the previous List 1 substances which came under the 1998 GWR.

Non-hazardous pollutants are less dangerous, and can be discharged to groundwater under a permit, but must not cause pollution. Examples include sewage, trade effluent and most wastes. Non-hazardous pollutants include any substance capable of causing pollution and the list is much wider than the previous List 2 substances. For example, nitrate is included as a pollutant but it was excluded from List 2 in the 1998 GWR.

The Oil Storage Regulations 2001 aimed to tighten controls over the containment of any oil, the obvious oils being fuels – petrol, diesel, gas oil. Any oil storage unit >200 litres (which therefore includes the ubiquitous 205 litre (45 gallon) drum) is subject to extra precautions, basically the provision of bunding and maintenance of installations. An interesting anomaly to the regulations is the exclusion of waste oil!

There should also be emergency plans for the control of spillages – penstocks, drain covers, absorbents, spill kits etc, and of course training of those who may need to use them.

5.4 Sewage Treatment

There are numerous variations upon the theme of sewage treatment and no two sewage works seem to be the same although common principles are applied.

1 Raw sewage is strained to remove any large objects which may then be macerated and returned to the flow or else landfilled.

2 Grit is removed by allowing the sewage to flow at a set speed down a flume which allows the denser particles to settle out (including tomato pips!). The washed grit is landfilled.

3 Solid organic waste, the sludge, is settled in tanks and the primary liquid effluent decanted over a weir. A scum bar holds back grease, fat and any floating objects.

4 Primary effluent is most commonly purified by the activated sludge process. Air is blown through effluent in which flocculated clumps of bacteria are held in suspension. These rapidly digest the organic content and multiply. The settled final effluent is discharged and surplus bacteria returned to the influent sewage. Further refinement of the secondary effluent is possible, it may be UV irradiated to kill off any pathogens and it may be subject to a final stage of anoxic digestion which consumes (denitrifies) any nutrient in the form of nitrate (NO_3) (i.e. bacteria use the oxygen bound up in the nitrate, releasing nitrogen gas).

5 The sludge can be disposed of by spreading it on land and using it agriculturally. Attractive as this option appears to be, heavy metal contamination builds up in the soil, there is also a risk of pathogens. It may be dewatered and either landfilled or incinerated. Raw sludge contains about 95% water. It is thickened by adding coagulating chemicals and stirring it, then mechanically pressed into sludge cake which resembles loam soil and contains about 70% water. At this stage it can be landfilled but better incinerated - which reduces the volume to 1% - 2% of the original volume. As technology develops, highly dewatered sludge can be used as WDF (an argument put forward by Surfers Against Sewage).

Case Study 5.1

Crossness Sewage Works was designed to deal with London's southern outfall (with Becton as the northern outfall, just upriver from Barking Power Station). It operates on the activated sludge process and also recovered methane from anaerobic digestion of the sludge, carried out in large vessels. Some gas was burnt to keep the vessels at optimum temperature around 320C and the rest fuelled an array of converted marine diesel engines used as electrical generators, giving sufficient capacity to satisfy the electrical requirements of the works. The depleted residue from the process was discharged into the North Sea using specially designed barges to spread it over a wide area but is now incinerated in an on-site unit in order to conform to conventions and legislation which restricts dumping at sea effective from December 1998 (The Urban Waste Water Treatment Regulations 1994). With the change in technology, the anaerobic digestion stage had to be omitted because it reduced the calorific value of the solids, making it difficult to burn.

Secondary effluent has a final nitrate removal stage and is discharged to the river Thames.

The 50 tonnes per week of grit collected is spread on land on the site which grows a wonderful crop of tomatoes!

Interestingly, and in complete reverse, the new treatment works at Hull uses sludge digestion and supplies the spent sludge in pelletised form for land dressing to local farms.

An alternative to the activated sludge process is the well known use of trickling filters in which primary settled sewage is intermittently spread by a rotating distributor tube over a bed of gravel.

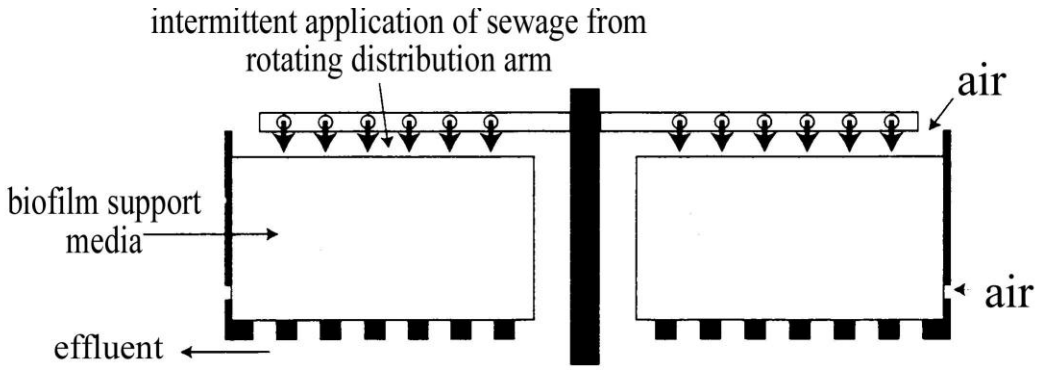


Figure 5.7 Cross-section through a trickling filter

(Figure 5.7 –shows in diagrammatic form how a trickling filter system works). Liquor flows over the surface on which a biofilm develops and grows by digesting the sewage. It seeps down and is collected at the bottom. It is important that they do not become waterlogged.

Rotating Biological Contactors work on the principle of a slowly rotating biofilm grown on vertical plates which are partially immersed in the sewage. They are compact and unobtrusive

Reed beds are sometimes used as a low-maintenance alternative to the more traditional sewage treatments but they require a large area of land. Gatwick airport operates one.

Reeds are grown on a thick bed of gravel through which effluent is percolated. The gravel and reed roots grow biofilms which clean up the sewage. An advantage is that heavy metal contaminants can be removed by periodically cropping the reeds.

Lagooning allows any final settlement to occur, giving treated effluent a final 'polish' and such lagoons can be made into an amenity by landscaping.

Figure 5.6 Typical sewage treatment works
the circular vessels are settling tanks, the rectangular structures in the centre are aeration tanks.
At the rear of the site are sludge digesters. Spent sludge is spread at the far end.

5.5 Water Quality Objectives

In controlling water pollution in the wider sense we must consider the different water types acknowledged in a series of EC Directives, in effect, imposing water quality objectives.

The concept of an Environmental Quality Objective (EQO) is used to set standards and discharge consent limits based on the needs of the locality.

The Surface Waters (River Ecosystem) (Classification) Regulations 1994 defines a 5 point classification of river quality with RE1, the best, suitable for all fish species through to RE5, poor quality, likely to limit coarse fish populations. Water quality can be assessed by the presence or otherwise of indicator species, with fish having the highest demand and sludgeworms the lowest, being all that may be found in severely eutrophicated water.

The Environment Agency is responsible for proposing WQOs for specific stretches of water to DEFRA, the Secretary of State consults with stakeholders and a WQO is normally binding for 5 years.

The existence of pathogens is another important indicator of quality. Coliform bacteria are usually taken as representative but others may be checked out. Levels should be safely below the Minimum Infective Dose which varies greatly from species to species. Usually quite high figures (salmonella has an MID of a million) but E Coli 157 had an MID of only 10!

The Bathing Water Directive sets standards for sewage treatment for large coastal towns and smaller towns discharging into sensitive areas such as the Norfolk Broads. Control is by monitoring for the presence of pathogens. At the time of writing, most British bathing waters are compliant, but Surfers Against Sewage claim that surfers are 3 times more likely to contract Hepatitis A than the general population because the virus can last for up to 100 days in seawater, whereas coliform bacteria are destroyed within hours. The implication is that discharging primary (sludge removed only) treated sewage through long outfalls is inadequate. They argue that secondary treatment to remove pathogens (e.g. ultraviolet irradiation) should be the standard and that anyway, discharge to sea is wasteful of water which is capable of being rendered potable and the solid sludge can now be dewatered to such a level that it can be used as waste derived fuel (WDF).

5.6 Emergency Action

Pollution of water episodes should be notified to the Environment Agency as quickly as possible. The agency operates through 26 regional offices and is in process of setting up customer service centres there.

The Agency is able to respond to emergencies such as overturning of a mobile crane into a dyke, releasing about 500 litres of oil (in this case a boom was deployed to catch it) as reported in the April/May 1997 edition of Environment Action. It also liases with other stakeholders e.g. local authorities to create emergency action plans. Deploying a boom across the River Ogmore is one such plan which has been fully practised. Fire brigade training now incorporates an environmental component.

5.7.1 The Legal Framework

As you might expect, there is a vast body of legislation which applies to water. Our main concern is with:

The Water Resources Act 1991 which deals with control of water pollution; and now amended 2009 to include the power to designate Water Protection Zones (WPZs), together with the powers to undertake anti-pollution works and serve notices to undertake such works.

The Water Industry Act 1999 which deals with provision of water supplies and sewerage.

Other relevant legislation is:

EPA (1990)
Food and Environment Protection Act 1985 and
Control of Pesticides Regulations 1986
Urban Waste Water Treatment Regulations 1994 (which identifies ‘sensitive areas’ and ‘high natural dispersion areas’
The Water Resources Act provides:

Definition of ‘Controlled Waters’ as:

Relevant territorial waters - the sea to the 3 mile limit
Coastal waters - the littoral zone
Inland fresh waters - rivers and lakes
Groundwaters - contained in underground strata.

The establishment of Water Quality Objectives (WQOs).

All relevant waters must have WQOs set, having regard to any EC Directives (e.g. the Bathing Water Directive).

Water quality standards must be developed to see that WQOs are achieved at all times.

WQOs are set according to a classification defined by:

the uses to which the water is put;
control of substances in the water;
specific requirements determined by stakeholders in terms of consultation, monitoring and establishment of local committees.

Issuing of Consents to Discharge in Controlled Waters.

This function is carried out by the Environment Agency. The Agency must:

monitor the consent system by sampling and inspection
keep registers of consents to abstract or discharge water
ensure that WQOs are achieved
take account of any Statutory WQOs (SWQOs)
undertake anti-pollution measures
maintain and develop flood defences this latter now stretches the limits to the point where the EA has publicly stated that it may not have sufficient resource for what may come!
organise regional advisory committees

As such it has powers to:

charge for consents;
remediate pollution;
prosecute offenders ,

it is a criminal offence to pollute controlled waters, punishable by £20 000 fine and up to 3 months imprisonment on summary conviction and unlimited fine and up to two years on indictment. Civil damages and remediation costs may also be incurred and these can be considerably greater.

Require precautions to be taken;

e.g. under the Control of Pollution (Silage, Slurry & Agricultural Fuel Oil) Regulations 1991.

The Water Industry Act provides for establishment of water and sewerage undertakings

A company supplying water must:

provide wholesome water supplies;
maintain flow and pressure;
develop the infrastructure (mains supply and service connections).

It has powers to:

disconnect for non payment;
disconnect for essential works (and must make emergency provision if interruption of supply exceeds 24 hours);
impose hosepipe bans;
add fluoride to the water.

A sewerage undertaking must:

maintain and improve the sewerage system;

empty sewers and operate sewage works;
issue consents for trade effluent discharge;
ensure disposal of trade effluent.

It has powers to:

refuse to issue a consent;
impose limits on discharge quantities, rates of discharge and times of day.

In addition, discharge of:

Part 1 prescribed (red list) substances;

Special category effluent; must be referred to the Environment Agency. (Special category is defined in the Trade Effluents (Prescribed Processes & Substances) Regulations 1989 (amended 1990,1992 – then into Permitting) and is basically to do with processes using chlorine and its compounds or asbestos.

The Mogden formula is used to calculate the fees which a company must pay to the sewerage undertaker to discharge trade effluent. It enables a calculation to be made based on the cost of its treatment. It is expressed as:

Charge = R + P + (Ot/Os)xB + (St/Ss)xS and the units are pence per m3

Where:

R = reception charge for the sewerage system
P = primary treatment cost
B = biological treatment cost (Os at a standard value of 921 mg/litre)
S = sludge treatment cost (Ss at a standard value of 333 mg/litre)
Ot = COD for trade effluent
Os = COD for domestic sewage
St = settled solids for trade effluent
Ss = settled solids for domestic sewage

5.7.2 The Regulatory framework

The Secretary of State for the Environment is the highest administrative level and is responsible for policy on conservation, water supply and sewerage matters, also pollution control. S/he must ensure that:

WQOs are established;
designate water protection zones;
create a Drinking Water Inspectorate;
approve agricultural Codes of Practice.

Duties of the former MAFF, now subsumed into DEFRA included:

land drainage;
protection of fisheries;
safe use of agricultural pesticides;
directing and assisting the Environment Agency;
designating Nitrate Sensitive Areas;
approving agricultural Codes of Practice.

The Ministry of Transport also has duties with respect to control of marine pollution by oil.

Enforcing Agencies are:

The Environment Agency;
The Drinking Water Inspectorate which monitors quality and reports annually;
Local and Unitary Authorities which have a duty to satisfy themselves that quality standards are met and adhered to;
OFWAT (Office of Water Services), a watchdog who protects the interests of the customers of the water and sewerage industries. OFWAT:

controls pricing;
stimulates competition to improve efficiency between water companies;
protects consumers by overseeing water company codes of practice.

As you can see from the above, control and management of water is a very complex business. The supply side has been subject to the machinations of politics and so we now have numerous privatised companies overlooked by a complex of regulators. It is worthy of note that despite all this, or perhaps because of it, Britain has never seen the construction of the national water grid which was promised in the aftermath of the drought year of 1976. It was a sobering matter to see Yorkshire Water transporting millions of gallons by road tanker to top up its reservoirs in the summer of 1996. The sight of an endless convoy of tankers, basically anything on wheels capable of picking up 9000 litres of water, going up and down the A1 was unforgettable.

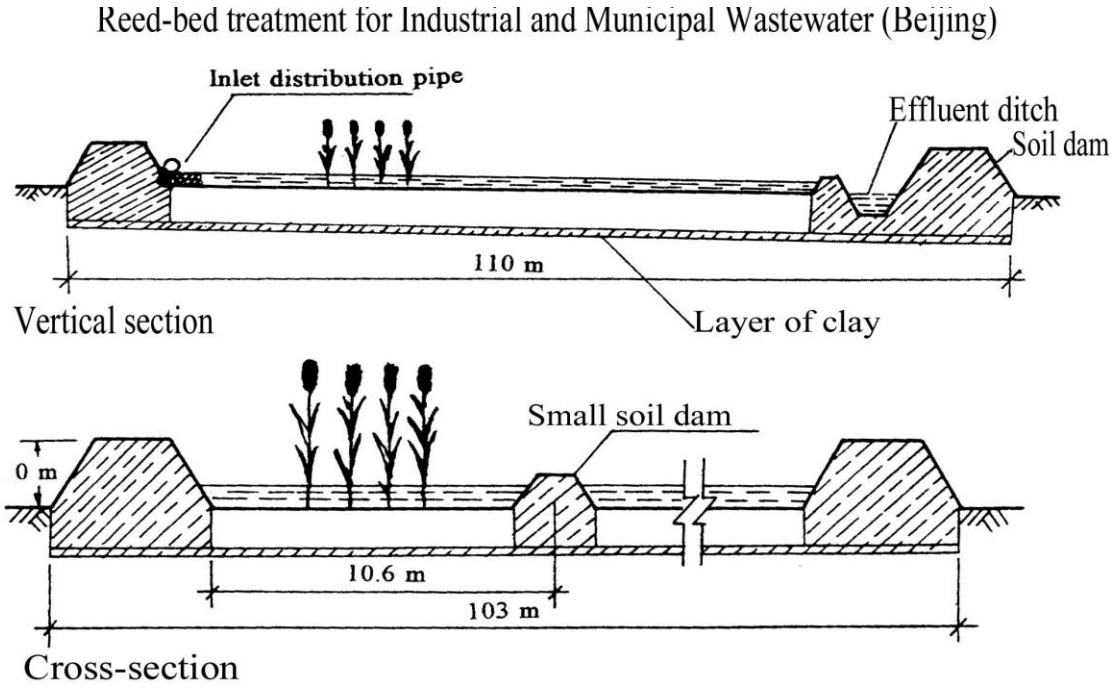


Figure 5.9 Reed-bed water purification system

Unit 6 Air Pollution

CAUTION.

EMISSION OF SMOKE

LIKELY TO CAUSE A NUISANCE

IS STRICTLY PROHIBITED

BY ORDER.

Objectives

1 Know the main ways in which air is polluted and appreciate the significance of its potential for global dispersion of pollutants.

2 Understand the physical form of pollutants and their significance to human health.

3 Appreciate the mechanisms for dispersal and the effect of weather and climate, especially temperature inversion and the limitations of Best Practical Means.

4 Know and be able to describe practical systems for cleaning air prior to discharge into the atmosphere.

5 Know the legal framework for control of air pollution under LAAPC and statutory nuisances.

6.1 Air Pollution and its effects

Summary of air pollution important causes and effects

Acid rain	Destructive to buildings, plants and aquatic life
Increasing CO_2	Global warming
Ozone depletion	Ultraviolet damage
Smog	Asthma and other respiratory diseases, plant damage
Specific chemical pollutants	Related ill health
Statutory nuisances	Quality of life diminished
Dust	Blocks out sunlight
Pollen	Hay fever

Many of the above occur naturally, for example, the Mount St. Helens eruption in the North American Rocky Mountains in 1980 injected enormous amounts of dust into the atmosphere, reducing sunlight and giving poor summers afterwards. It is the extra burdens imposed by man's activities which should give us most cause for concern, for example, the smog which engulfed Southeast Asia in the summer of 1997 due to uncontrolled 'slash and burn' agricultural practices. We ought to be able to control our own activities but it is often very difficult in practice because:

we have limited control over the activities of neighbouring countries (the Scandinavians protested for years about SO_2 emissions causing acid rain from the UK. *Surprisingly, the Norwegians still send us a Christmas tree each year!*);

limited political capability at home (what government would dare to impose draconian restrictions on the numbers of motor vehicles on our streets, yet it is patently obvious that the current asthma epidemic, among many other serious problems, is linked to it);

the global nature of air pollution (e.g. acid rain, radiation from the accident at Chernobyl which polluted the entire northern hemisphere: pm10s, (residual soot particles from diesel exhausts) are found in such remote places as the Shetland Isles.

Pm10 means particles of 10 microns diameter - as such they are close to the human respirable particle range which is usually taken to be 7 microns or less.

6.2 Industrial emissions

Discharges of pollutants are traditionally sent up the chimney, traditionally referred to as applying 'Best Practical Means' (BPM). Much science has therefore been devoted to stack emissions. Factors which effect the discharge from a chimney are:

temperature of the effluent gases (the hotter they are, the more buoyant);
discharge velocity (pushing the plume higher, sometimes enhanced by putting an external spiral swirl on the chimney);
composition of the effluent gases (dense gases will not rise so effectively);
change of state (e.g. condensation of steam);
weather conditions (efficiency of dispersion).

Case Study 6.1

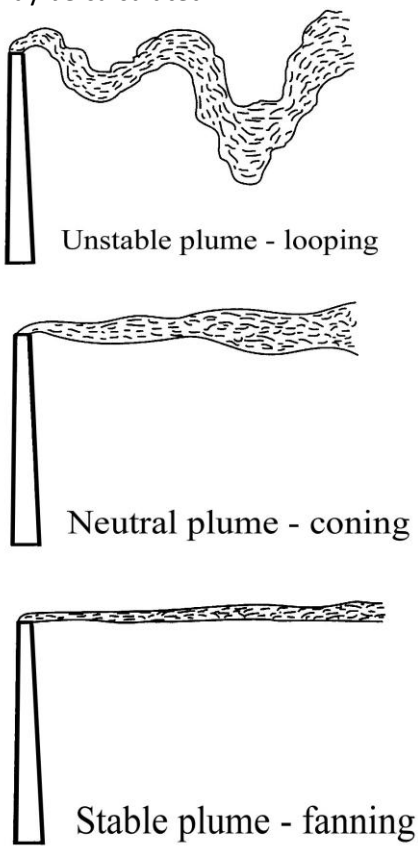
A new, 1000MW gas burning power station emitted a plume of pure steam. Whilst pollution was negligible, methane being a clean fuel, local rainfall increased downwind due to fallout, residents complained that the sun was frequently obscured by the man-made cloud and that an adverse microclimate was becoming established. The problem was overcome, at an energy penalty by raising the temperature of the flue gases, increasing buoyancy and delaying condensation until 300m higher up.

Weather **plays a critical role in pollutant dispersal in three main ways**.

Dispersion is thus related to wind conditions. Higher winds generally occur around low pressure areas (cyclones). High pressures (anticyclones) are usually associated with stable, windless weather. Local geology, physical features (buildings) and other nearby stacks plus the prevailing wind direction must all be taken into account in deciding the height and location of a chimney stack.

Wind and stack modelling. The behaviour of plumes in different weather conditions is well described by Pasquill's stability classes. Figure 6.1 (right) shows typical plume behaviour

As a general rule the concentration of a pollutant at ground level occurs downwind 10-15 x the height of the stack and is inversely proportional to the square of its height. Figure 6.2 (right) shows how contamination at ground level downwind from a stack may be calculated



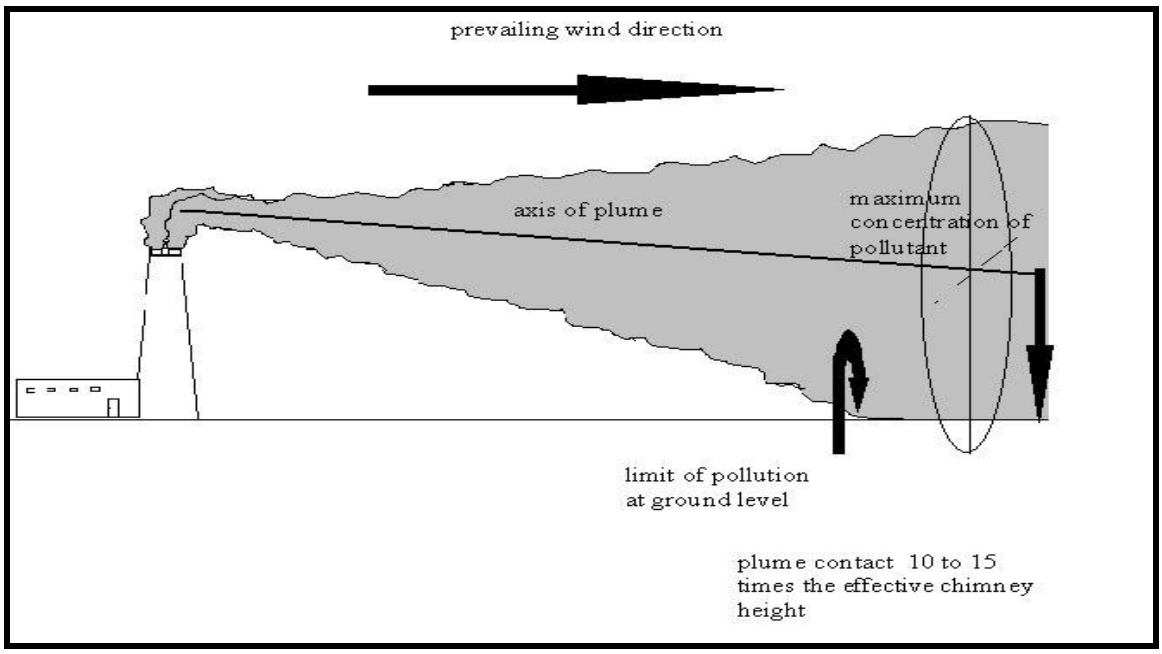
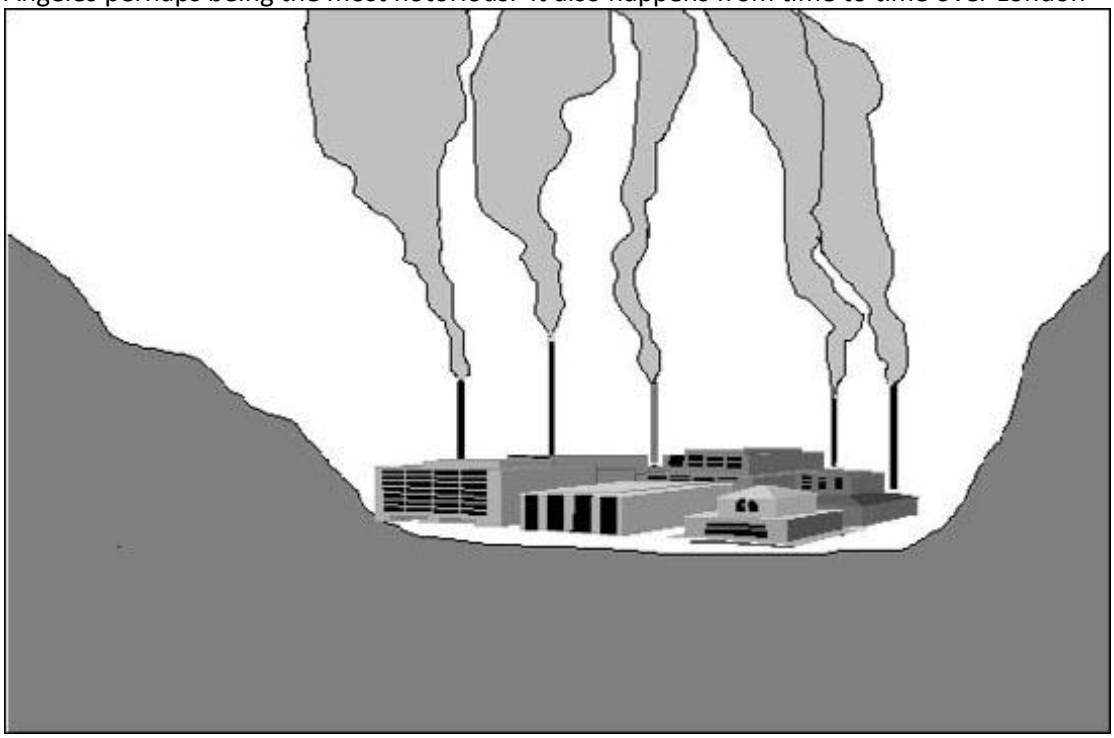


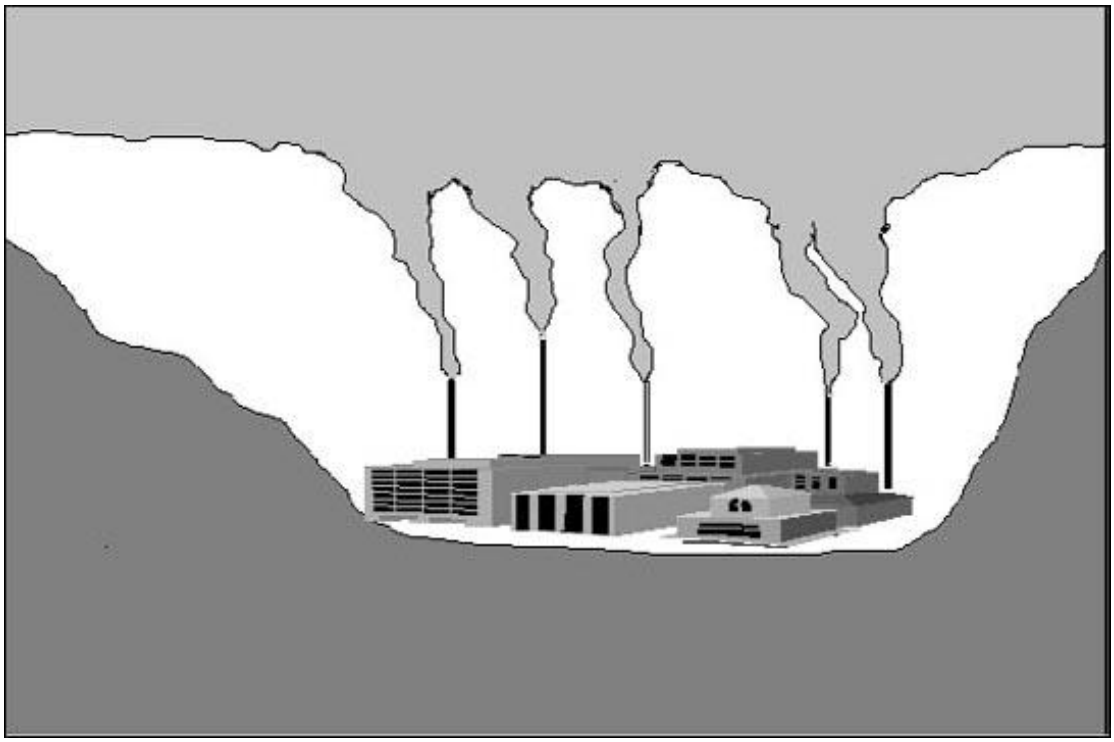
Figure 6.2 effect of dispersion from a chimney

Temperature inversion. A stable cold air layer overlying warm air stops it from mixing and can create very stable weather conditions. The warm, increasingly polluted air is trapped. A number of cities world-wide are prone to photochemical smog which is brought on in inverted conditions, Los Angeles perhaps being the most notorious. It also happens from time to time over London



6.3 . Figure illustrates how temperature inversion holds in pollution.

Without temperature inversion, pollutants rise buoyantly to higher altitudes and then disperse.



Temperature inversion above city blocks out sunlight and concentrates pollutants. Photochemical smog then occurs.

Rainfall cleans the air by washing down the pollutants, however, humid (muggy) air tends to enhance the effect of pollution by a synergistic interaction with the pollutants, encouraging formation of mists and ultimately, by more condensation into fogs.

6.3 Nature of pollutants

The physical form can be:

gaseous (e.g. CO_2, SO_2, NO_2, Cl_2, CO, NH_3, CH_4);

vapour (vocs) (e.g. petroleum, organic solvents, iodine);

liquid in the form of aerosol droplets (e.g. acid mist, paint spray)

solid in the form of fumes (e.g. emitted from lead above 5000C, PTFE - used as a

non-stick coating for cookware - above 400^0C)

dust (e.g. silica, asbestos, house mites, grain)

smoke (e.g. carbon black, fire products, pm10s)

grit (e.g. fly ash, pulverised fuel ash)

The technical terms can be somewhat confusing and are sometimes misapplied.

Gas is a permanent gas, vapour is liquifiable by pressure. Gases and vapours mix at the molecular level with air and become part of it – the air then becomes a carrier gas for the pollutant gas or vapour.

Aerosols are small, respirable droplets, can be liquid or solid, may start as liquid and dry out by evaporation very quickly, conversely may dissolve gases such as SO_2, concentrating them and carrying them into the deep lungs where they cause increased irritation.

Fume, smoke, dust and grit are size related, fume the smallest. Fumes and smoke are > 1 micron, therefore respirable and may cause fume fever because they act within the alveolar, gas exchange region of the lungs. Dust is also respirable (below 7microns -compare to pm10s at 10 microns) or inhalable (no size limit, it just has to persist in air for long enough to enter the breathing zone).

Grit is defined as >75 microns under the Clean Air Act 1993. Grit can be mobilised in fast airflows, hence fly ash. And particles tend to clump together as they age (agglomeration).

'Winter smog', a cocktail of smoke particles and sulphur dioxide in foggy weather held in by a stable temperature inversion, has not been seen in cities since the introduction of clean air measures, which permitted only the burning of smokeless fuels. The great London 'pea-soupers' culminating in the 1953 smog caused the death of several thousands of the city's more vulnerable citizens and caused widespread disruption. The production of smokeless fuel was carried out in coking plants in which coal is preburnt to drive off all the volatiles and then quenched with water. The citizens of places such as Mountain Ash in South Wales received (the coking plant has now been demolished) the pollutant emissions instead. Ultimately, the use of solid fuel has been largely superseded by oil and gas, which are particularly appropriate to central heating systems and the problem has thus been resolved.

'Photochemical smog' is a more modern phenomenon caused by the reaction of solar ultraviolet radiation with ozone, oxides of nitrogen and vocs to form the depressingly familiar brown colouration of the air. More likely to form in hot, humid conditions is sometimes called 'summer smog'. It has been linked with asthma.

Fugitive emissions are the sum total of all the leaks from a site and so generally are difficult to control and therefore often not controlled. However, they can represent a significant economic loss from, say a refinery, and plant design should seek to minimise emissions. There is a clear link to occupational health here and off site environmental standards are sometimes taken as a fraction of an existing occupational hygiene standard, such as WELs (workplace exposure limit) given in HSE Guidance note EH40, say 1% of the WEL. Reduction of fugitive emissions can be achieved by applying the general principles of the Control of Substances Hazardous to Health Regulations 2001 (COSHH 2001) which gives a hierarchy of control:

eliminate the need for the substance;
substitute a less harmful alternative;
change the process;
control and monitor safe systems of working;
ensure effective maintenance (change filters in extraction equipment);
have emergency procedures to contain leaks or spills.

6.4 Air Pollution Control

Eliminating the process altogether obviously stops the pollution. Locally. However the air is still polluted somewhere. NIMBY (Not in My Back Yard) is a powerful force which we see increasingly applied to any major project. We can have sympathy for those who don't want a nuclear reactor built next door to them. (A new MSW incinerator in the Southeast Thames corridor was bitterly opposed by BADAIR, a local pressure group with concerns that the additional pollution caused by the incinerator would increase problems in what is already seen as an asthma problem area.)

Eliminating the process should be altogether, not merely relocating it. An example of elimination is using building materials which do not need painting (UPVC - window frames, exterior cladding). Thus the vocs from the paint are eliminated.

Substitution for a less polluting process or substance (Acrylic paint, which is free of vocs is frequently specified by local authorities on occupational health grounds. It is relevant to observe that besides a reduction of fugitive emissions from painted surfaces, there is an implied saving because you aren't paying for something that then disappears into thin air!

Enclosure and process change (e.g. by enclosure - an MSW incinerator building draws combustion air from within the building, makes it negative pressure and all odours etc. are contained within the building).

Each time you fill a car's fuel tank with petrol (but much less so for diesel), the vapours in the tank are, often visibly, discharged to atmosphere. Look out to see if you can find examples of recycling hoses and meantime contemplate the economic loss, increased health and environment risk and fire hazard. Where such systems do exist, they are often at least partially ineffective because the seal between pipe end and fuel tank filling point is difficult in practice to make properly gas tight.

Control and monitoring of emissions is usually achieved by location of sensing equipment in critical locations on site. Stack emissions are constantly monitored within the discharge and give direct readings which are useful in quality and process control. Mass balance calculations are used in all chemical engineering projects, clearly, if material is lost from the inventory then it is likely to have gone up the chimney or escaped as fugitive emission. Operating procedures are important to ensure that plant runs efficiently (e.g. a motor car runs at peak efficiency and minimal fuel consumption at a speed well below its maximum capability. Driving styles should acknowledge this - there isn't much point in thrashing flat out from one traffic jam to the next).

Maintenance and emergency procedures. Any process should operate on a planned preventative maintenance scheme ensuring that efficiency is maintained. Regular servicing is essential to prevent gradual performance decline (sensing equipment was set up on a French péage to check tyre pressures. It was found that about a quarter of all cars had underinflated tyres. Underinflation increases tyre wear and reduces fuel efficiency). Regular maintenance also reduces the frequency of breakdowns, these being occasions where releases of pollutants are more likely to occur and under less controlled conditions.

6.5 Air Monitoring Strategy

The Environment Act 1995, Part IV requires a National Air Quality Strategy to be formulated. It identifies air quality standards for 8 priority pollutants, based on expert advice. In effect these are maximum values:

Ozone	50ppb
Benzene	5ppb
1,3 butadiene	1ppb
Carbon monoxide	10ppm
Sulphur dioxide	100ppb
Particulates (pm10)	50 micrograms/m^3
Nox	5ppb?
Lead	5 micrograms/m^3?

The air quality guidelines which are quoted in the media are taken with reference to these standards, thus for example for ozone:

<50 ppb	low
50-89 ppb	moderate
90-197 ppb	high
>180 ppb	very high

6.5.1 Monitoring networks.

National Atmospheric Emissions Inventory is prepared annually by the National Environmental Technology Centre for DEFRA. It is important because it provides an estimate of air pollution from all known sources and maintains an emission factors database of black smoke, SOx, NOx, VOCs, CH_4, CO_2, NH_3, metals, halogens. Defra Technical Guidance is available (LAQM.TG(09))

UK Smoke and SO_2 monitoring Network operates around 165 sites, including EC Directive sites and the basic urban network.

Automated Urban Network (AURN-UK) currently operates 132 sites monitoring the priority pollutants.

6.5.2 Air Quality Objectives (AQOs). The Air Quality Strategy, in effect, defines the AQOs. It must take into account:

EC Directive standards which have been set for various pollutants;
recommendations of the Government Expert Panel on Air Quality Standards;
World Health Organisation guidance.

Local Authorities are charged with reviewing the air quality within their jurisdiction and make an assessment whether the AQOs are being met. If they are not, then an air quality management area must be designated, monitoring should continue and an action plan created within 12 months setting target dates to meet the AQO.

6.6 Air Cleaning Systems

Particulate matter we have described as ranging from the finest fumes through to the largest grit and we pointed to the respirable range of <7 microns Generally, the finer the particles are the more difficult it becomes to remove them.

Large particles can be settled out in a settling chamber which is designed to reduce airflow speed as much as possible for as long as possible. Grit and large dust particles collect in hoppers beneath the chamber. This may be used as a first stage of more thorough cleaning and would be applicable to settling fly ash in a power station or MSW incinerator.

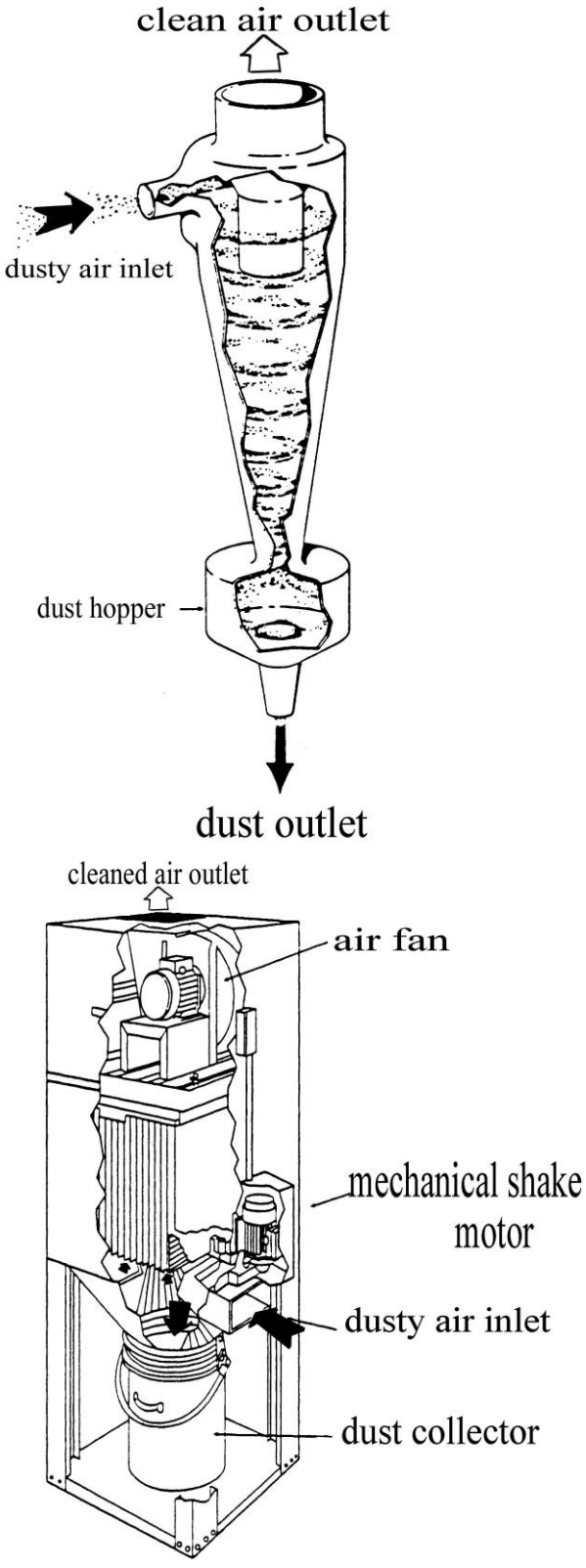
Cyclones are very commonly used as cheap, robust devices in which the air is spun at high speed and centrifuge action throws the particles to the outside for collection. Figure 6.4 shows a practical reverse flow cyclone.

They are inefficient devices, especially for finer particles and will not collect respirable dust (below 7 microns). Typically they are used to collect dust from woodworking machinery. It is prudent to design them for the possibility of a dust explosion by having blow-out panels and locating them in a restricted access area (they are often seen on the roof of a building).

Bag filters remove all particles by collection on the surface of a fabric, including the respirable fraction so that cleaned air can be recycled and returned to the workplace. This will save on heat loss which can be a problem with LEV systems. From time to time, the equipment is stopped

and the fabric filter bags mechanically agitated to shake off the cake which

has collected on them which drops into a hopper. Figure 6.5 shows a mechanical shake bag filter. The main limitation of the system is its capacity



For larger applications reverse-jet bag filters are used. Figure 6.6 illustrates this system. A reverse pulse of air is fed through the filter socks one by one while the system continues to run. Caked dust falls off and is collected in a hopper below.

Bag filters are very efficient and perform well provided that they are adequately maintained and the filters periodically replaced. They cannot handle very hot gas streams or wet ones

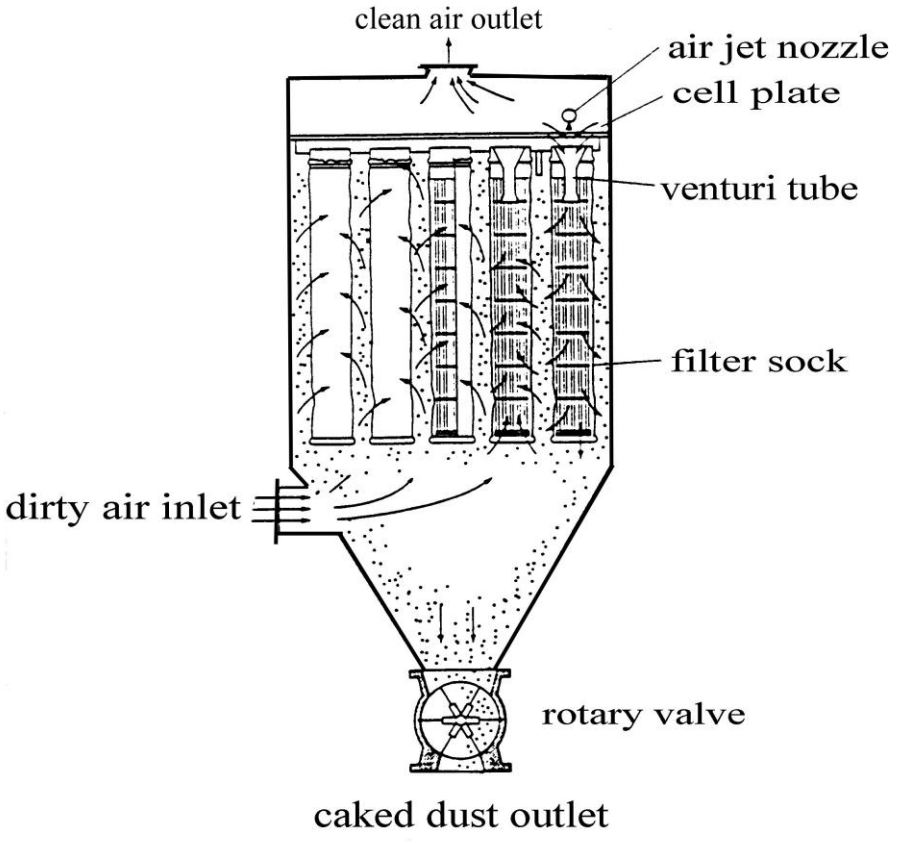


Figure 6.6 Reverse-jet Bag Filter

Electrostatic precipitators work on the principle that particles are attracted to high voltage (it is the reason why TV screens tend to get dirty Electrodes are charged to a typical voltage of 50kV and contaminated air passed through. Particles of virtually all sizes are removed by attachment to the electrode and an especial advantage is their ability to deal with particles of 1 micron or less. The cleaned dust is periodically rapped into a hopper. Electrostatic precipitators work equally in collecting liquids and are suitable for collecting oil mists. As high voltage equipment, easily able to kill, they should only be maintained under a permit to work

Wet Scrubbers. A simple spray tower will remove dust effectively down to about 7 microns, i.e. the respirable range. For complete cleaning it is necessary to combine wet scrubbing with a venturi and cyclone into a venturi scrubber. Figure 6.7 illustrates such a unit. An advantage is that wet scrubbing will also remove any soluble gases and vapours, unlike any of the others. The waste is removed as a slurry.

Gases and vapours cannot be removed in the same way as solids. The most usual treatments are:

Wet scrubbing in which a liquid, usually water, is sprayed into the air stream. Increased performance can be obtained by using a packed tower, forcing the airflow into long and tortuous paths, subjecting it to maximum liquid contact. Figure 6.8 shows typical arrangements. The liquid phase is usually a closed circuit system which is periodically treated to remove contaminant.

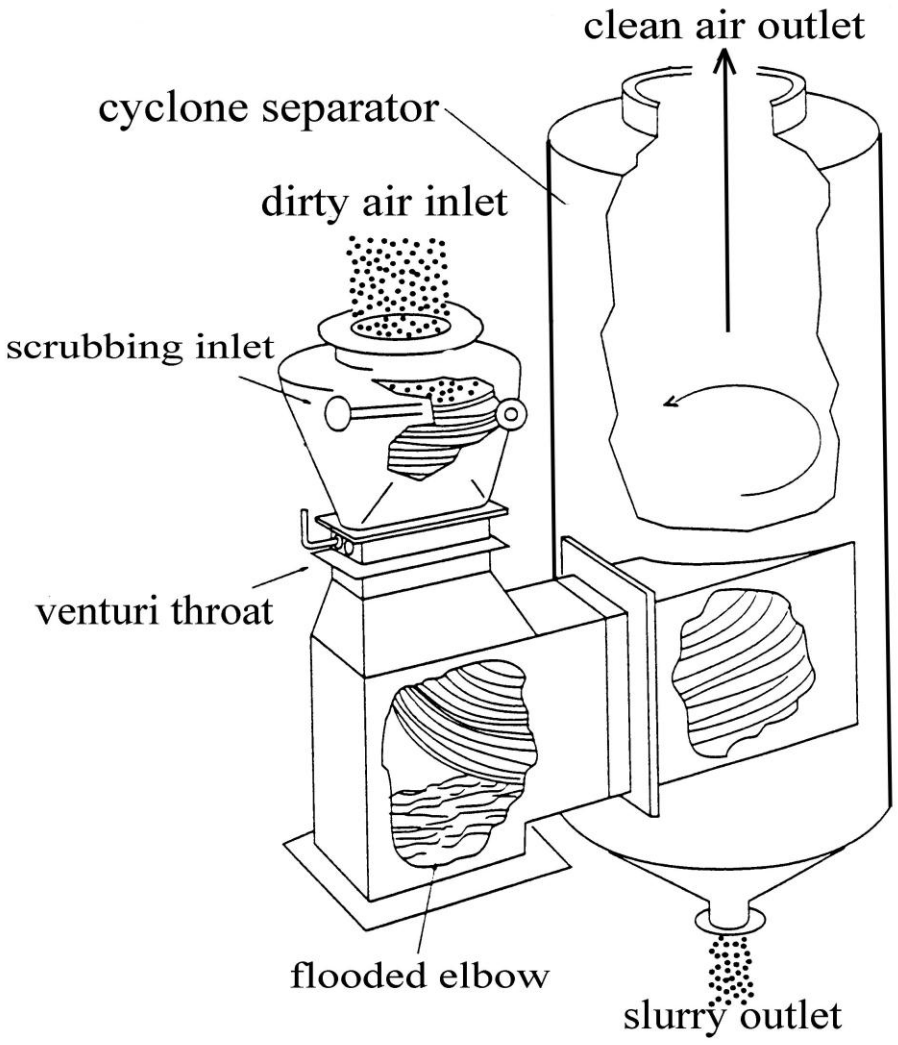


Figure 6.7 Venturi scrubber

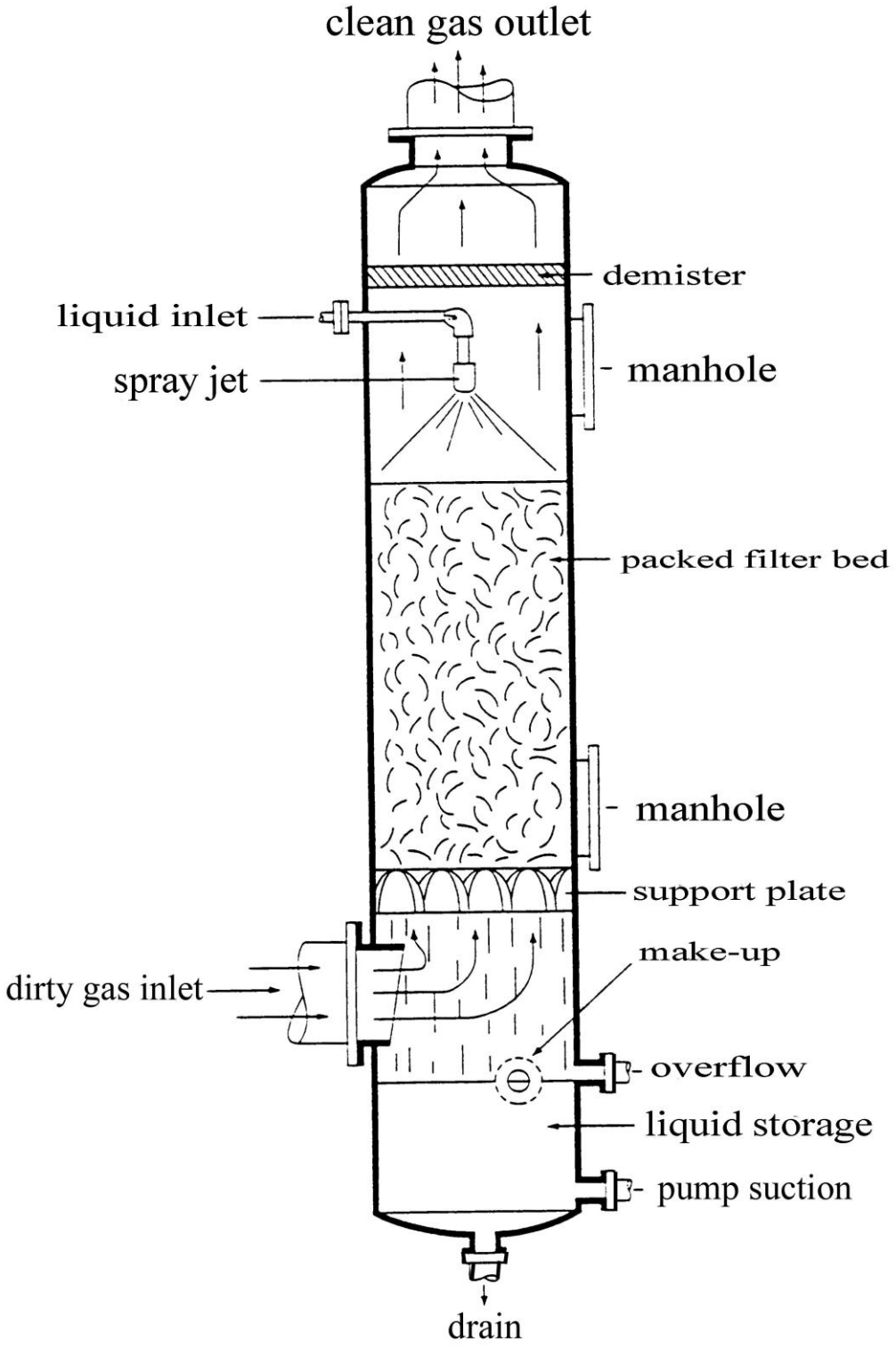


Figure 6.8 Packed absorber tower

Activated charcoal adsorption (though other adsorbents, molecular sieves, silicagel etc. may be used) in which the air passes through a porous bed of adsorbent. Heating regenerates the adsorbed material which may sometimes be worth recovering.

Figure 6.8 illustrates a practical unit.

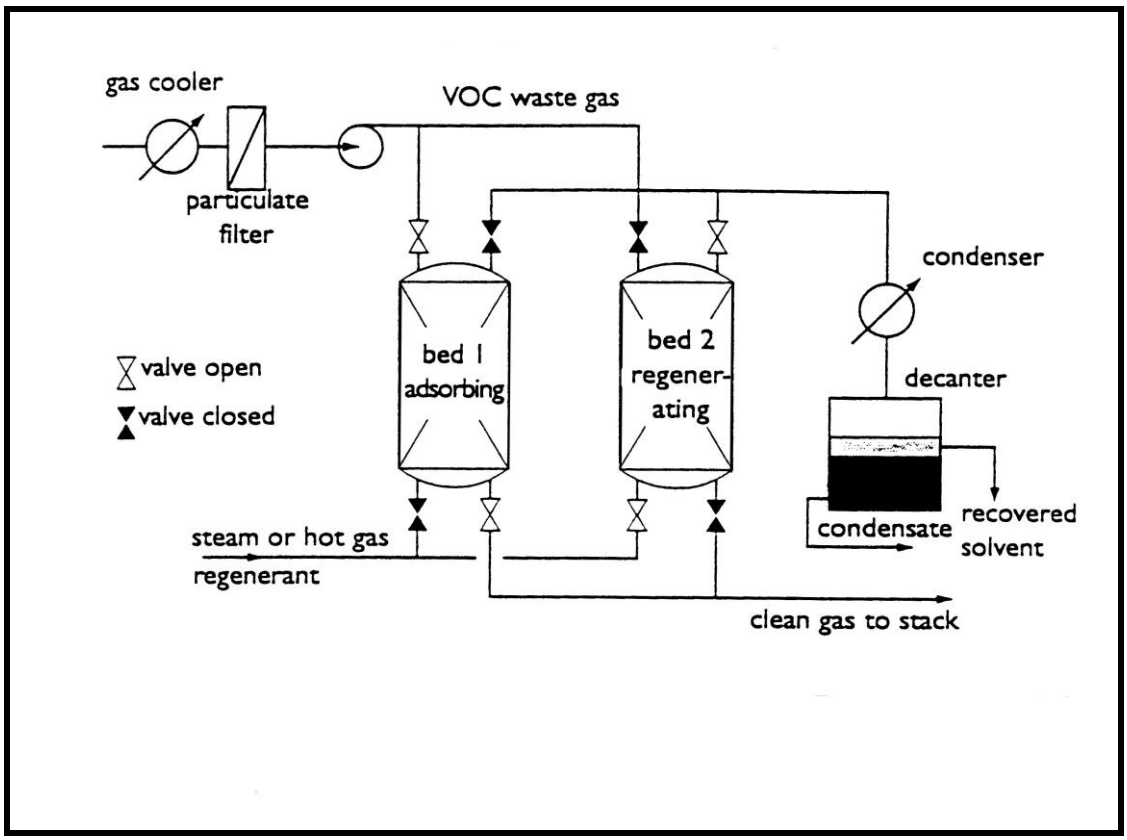


Figure 6.9 Activated charcoal recovery unit

Flue Gas Desulphurisation is a practical example of gas cleaning in which SO_2 in coal burning power stations is removed. Flue gases are passed over crushed limestone and react with it to produce calcium sulphate (gypsum). The problem with the process is the large amount of limestone needed (estimated at 300 000 tonnes per annum - unfortunate in that most of the UK's limestone is in national parks) and the large amount of waste gypsum. Only a fraction of this amount can be consumed in plasterboard and similar applications. British gypsum's mine at Robertsbridge has already closed. An alternative process can extract the Sulphur as SO_2 for conversion to sulphuric acid.

Catalytic converters are used in petrol driven motor vehicles to oxidise off any unburned petrol vapours and carbon monoxide. A small amount of finely divided platinum (or alternative metal) is dispersed on an inert fibrous substrate (asbestos would be ideal!) and the exhaust gases cleaned as they pass through. The smell of rotten eggs sometimes noticed from vehicle emissions is due to reactions of trace sulphur in fuel being converted to H2S by an over-zealous converter. Catalytic converters offer resistance to the passage of exhaust gases and so reduce vehicle efficiency. They are also prone to poisoning by lead - so that leaded petrol will immediately ruin the converter if it is accidentally used in an engine. In any case, they gradually deteriorate and should be replaced at manufacturers recommended intervals. Diesels cannot use them - pm10 particulate emissions present a different and more difficult problem. A further limitation of their usefulness arises from the fact that they do not function properly until the engine is thoroughly warm - given that most journeys are short, especially in urban environments where pollution is more of an issue than out on the open road they do relatively little to make the 'school run' more palatable.

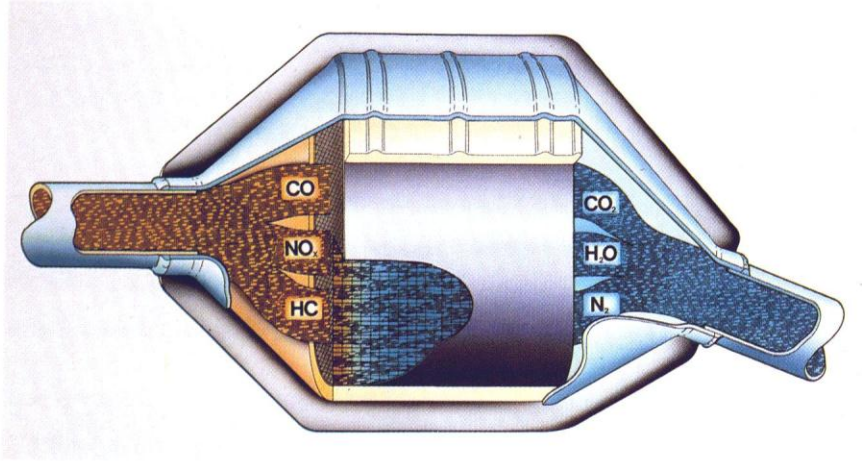


Figure 6.10 Catalytic Converter

6.7 The Legal Framework

Air pollution has been an issue of concern and complaint for many centuries but it was with the Industrial Revolution that vastly increased amounts of increasingly offensive and unhealthy emissions led to the first practical control measures being applied. The Alkali etc. Works Act of 1863 required a 95% reduction of process emissions and the remainder to be dispersed by a chimney of adequate height. A pollution inspectorate was created to enforce the legislation.

The second Alkali Act 1874 was more comprehensive and required the use of Best Practical Means (BPM) to prevent the escape of noxious emissions. This included fugitive emissions and covered gases or vapours, dust and so on.

The Alkali etc. Works Regulation Act 1906 drew together all previous piecemeal legislation and created a schedule of the most serious pollutants and processes (Works) to be controlled. The schedules were extended over time, culminating and consolidating in the Alkali etc. Works Order 1966.

The Health & Safety at Work etc. Act 1974 then enabled a more modern framework for control by regulation e.g. Health & Safety (Emissions into the atmosphere) Regulations 1983, requiring registration of scheduled works and BPM to be applied to them. The Control of Air Pollution (Registration of Works) Regulations 1989 specified information which had to be supplied to Her Majesty's Inspectorate of Pollution (HMIP) for various scheduled works, leading to Integrated Pollution Control (IPC) over these most polluting processes and substances under the Environmental Protection Act 1990 Part 1 (EPA90). Notes on Best Practical Means (APC Guidance) set presumptive limits for various pollutants and these could be tightened as technology evolved (they were not statutory limits, but conforming to them implied that BPM was being properly applied to the process).

A large number of APC Guidance Notes exist. As examples:

PG1/91 is for waste oil burners, less than 0.4MW output;

PG1/91 to PG11 deal with various small scale combustion plant. Large Scale Combustion Plant are subject to the Large Combustion Plant Directive (EC/609/88) which brings it under IPC and regulation by the Environment Agency (HMIP) and not Local Authority control.

PG2/1(91) is for furnaces for the extraction of non-ferrous metal from scrap.

PG2/1 to PG2/9 deal with various metal smelting processes.

and so on...

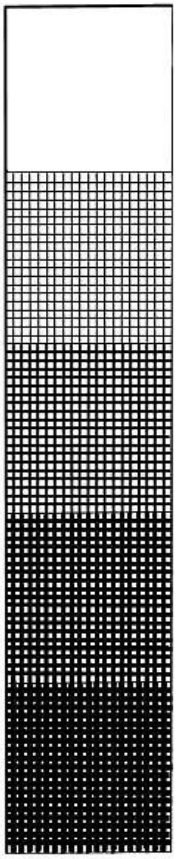
Meanwhile, there had been no controls over domestic emissions so that pollution of city air by the burning of dirty coal had gone on regardless. To quote from the NSCA Pollution Handbook 1997:

'Thus the atmosphere of Britain's urban areas was characterised by the pervading smell of smoke and sulphur fumes from countless stacks, chimneys and funnels. The lack of winter sunshine, the prevalence of pea-soup fogs, black buildings and even black snow, had become accepted as the price of progress and bronchitis, exacerbated by smoke and sulphur, was a common illness.'

The London winter smog of 1952 was the trigger event which led to a series of Clean Air Acts, the current one 1993. The legislation prohibits emission of 'dark smoke' and applies controls to the kinds of fuels which may be burned. Estimation of smoke is carried out by use of a 'Ringlemann Chart' (figure 6.12). The chart should be viewed vertically from a distance of more than 15m alongside the offending source of smoke and the darkness quoted as a Ringlemann Number.

Dark smoke is defined as Ringlemann 2 or greater (40% obscuration)

Black smoke is defined as Ringlemann 4 or greater (80% obscuration).



In addition, international conventions and protocols made under them, to which the UK has signed up impose global emission limits and these are implemented via the UK Programme for Climate Change 1994 and the Home Energy Conservation Act 1995 (Reduction of CO_2 to 1990 levels by the millennium). The Montreal Protocol 1992 requires phasing out of use of ozone depleters according to a complicated schedule.

A Geneva convention on Long-range Transboundary Air Pollution (1979) acknowledges that pollutants do not respect national boundaries so that a critical load approach is required. Critical Load maps are being constructed for the whole of Europe, DEFRA has such maps in the UK. Countries are expected to endeavour to limit, reduce and prevent such transboundary pollution. Other relevant protocols are:

the Helsinki Protocol 1985 controlling SOx emissions;
the Sofia Protocol 1988 controlling NOx emissions;

a protocol under the LARTAP Convention controls voc emissions.

The Ozone Depleting Substances Regulations 2000 (An EC Regulation, therefore directly binding on all member states) require a tight control framework for the prevention of release of ODS. On Jan 1 2002 they became applicable to domestic refrigeration equipment, a consequence of which was that old refrigerators and freezers which contained specified ODS in their insulating foam could only be destroyed by methods which reclaimed the substance. Some 2 million units per annum were thought to be involved and the duty to process them placed on our notoriously penurious local authorities. This led directly to the 'fridge mountain' debacle in which old fridges were either shunted around Europe for destruction or else stockpiled pending developmet of the technology. An unexpected casualty of this operation was the cessation of an export of fridge carcases to India where possession of a secure storage container played a part in food safety there. The latest chapter of this sad story involves huge stockpiles of them spontaneously catching fire, thereby releasing all the ODS that was in them. It is a classical example of how mismanagement of an environmental issue can make things worse, not better!

6.8 The Regulatory Framework

The most polluting processes are prescribed under EPA90 Part 1 for IPC. and latterly the IPPC regime is consolidating and tightening the control framework. As such, the processes are subject to BPEO which may require different processes to operate according to local conditions and IPC/IPPC acknowledges that all media must be considered in minimising pollution. The Environment Agency is the inspecting body and HMIP inspectorate enforces the standards. Non-compliance is a criminal offence. For example a waste operator was fined £3000 with £600 costs for illegally burning waste (Environment Action Issue7, April/May 1997).

However, civil costs are potentially much higher. In the case of Graham v Rechem International Ltd. (1993) concerning alleged poisoning of the Grahams' herd of cattle by Rechem's toxic waste incinerator, the claimants were suing for £1.5 million. Their herd suffered ill health and was eventually destroyed (allegedly) by ingestion of toxic emissions in the form of dioxins, furans and PCBs, alleged to have come from the incinerator. Rechem's defence was that poor husbandry, especially 'fat cow syndrome' caused the losses, not the incinerator emissions. Judgement was eventually given in favour of Rechem but 'with a heavy heart' by Mr Justice Forbes.

The smaller processes which are deemed to be less polluting and only of local significance are subject to Local Authority Air Pollution Control (LAAPC), and enforcement is administered by the Environmental Health Department. The PPC regulations are scheduling some thousands of processes which had previously been LAAPC regulated into the more stringent and integrated pollution control regime.

Complaints are usually in the form of nuisance. The Statutory Nuisances are now defined in Part 111 of the EPA90 as being (in each of the following cases) prejudicial to health or a nuisance:

any premises in such a state, or any smoke, fumes or gas emanating therefrom;
any dust, steam, smell or effluvia arising on industrial, trade or business premises;
any accumulation or deposit or any animal kept in such a place or manner;
noise. (under the IPPC regime noise nuisance is still subject to Local Authority control)
Recent addition (Defra Guidance available) includes insects and also light pollution.
Steam locomotives and aircraft noise are excluded along with certain military establishments.

Local Authorities have a duty to inspect their areas from time to time. They must investigate complaints and issue an abatement notice where necessary (known as a Section 80 notice). In the event of failure to comply, the Authority can take necessary direct measures to abate the nuisance. The Noise and Statutory Nuisance Act 1993 and the Noise Act 1996 along with local byelaws have

extended powers, mainly aimed at noise nuisance from amplified music, burglar alarms, car alarms etc. Public nuisance effects the public at large and precedent suggests a minimum of about 30 persons subjected to the nuisance. It is a criminal offence (and also a civil tort), usually enforced by the Local Authority, and can be either a common law offence and/or a breach of statutory duty, however applying the standard of BPM is a get-out and it is usually best to go for common law.

Private nuisance is tortious, civil action can be brought by an individual but only if his/her right to enjoyment of their property is affected. There have been enough such actions to establish ground rules so that in deciding whether nuisance is perpetrated:

the character of the neighbourhood must be taken into account, thus local standards apply - the expectations of a rural housing estate can be quite different to those of a mixed commercial/residential area;

standards of comfort do not allow for oversensitivity, this is the problem of the shift worker who's sleep may be disturbed by normal 'daytime' noises or the person who may become overly sensitive to a particular sound (tonal noise) - it is notable that once 'sensitised' to say, the ticking of a clock, an individual may become abnormally irritated by it.

duration of the nuisance must be repeated and prolonged, a trivial event does not count;

malicious intent by the author of the nuisance is taken as prima facie evidence of unreasonable behaviour and would be considered nuisance;

interference with a person's right to privacy, sleep, enjoyment of normal activity;

reasonableness insofar as no person should suffer needless nuisance, however slight it may be.

In establishing a case of nuisance, all the above should be taken into account. It is necessary to obtain detailed evidence of perpetration of nuisance and this is a skilled business. The legal defences to a charge of nuisance can be summarised as:

act of God or a trespasser;

action was taken with the plaintiff's consent (a bit like volenti non fit injuria);

the author was ignorant of causing nuisance;

prescription - a restricted defence based on long established practice (rather like the establishment of a public right of way);

statutory authority - (if the planners permitted construction of an oil refinery, its neighbours can't complain about the nuisance).

A number of defences have been shown to be ineffective, such as:

that the plaintiff came to the nuisance;
it was caused by contractors;
it was for the common good;
the location was suitable and all reasonable care had been taken.

The legal remedies are abatement, in which the nuisance can be literally stopped by the complainant, to seek damages or to gain an injunction requiring cessation of the nuisance. It is frequently the case that working hours will be restricted by injunction and this is often specified with respect to construction works in order to avoid nuisance. Statutory undertakings can usually ignore the normal constraints of reasonableness if they are carrying out emergency repairs, so if the water

company is drilling holes in the road at 3am just outside your house, your best defence is earplugs and the back bedroom!

The Local Authority can serve an Abatement Notice under s80 of EPA90 if it is satisfied that nuisance exists, in which it must specify the required noise abatement methods (insulation, time limitation etc.), and the time given for compliance.

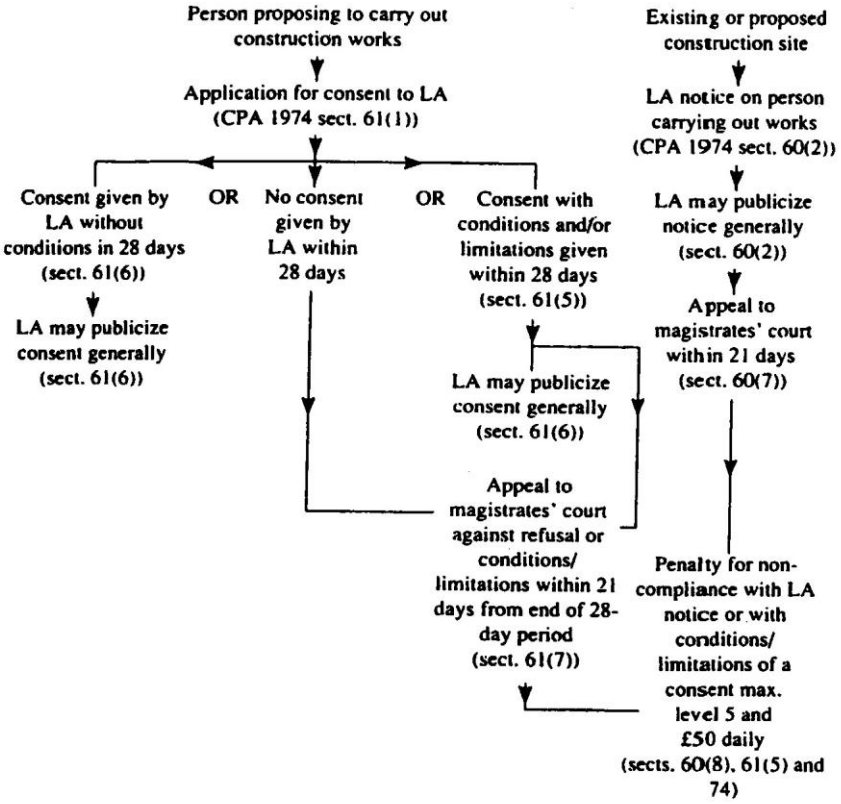
Noise is perhaps the most common and contentious of all nuisances, subjective and difficult to prove. Environmental noise measurement is described in BS4142 'Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas'. In future it is likely to be replaced by an EC harmonised procedure for assessing ambient noise exposure (ANE). Construction noise is regulated by The Control of Pollution Act 1974 (COPA) and BS5228 is approved (s71 of COPA) as guidance in the form of Codes of Practice, however, it is left to the Local Authority to set construction noise limits. Figure 6.13 and 6.14 show typical abatement notices served by the Local Authority Environmental Health Department.

Noise Abatement Zones (NAZ) can be set up by a Local Authority after due consultation, setting ambient levels which are registered and monitored and may not be exceeded. A Reduction Notice can later be served to reduce the noise levels further. Sadly, relatively few NAZs have been established.

Environmental noise and its control is a complex and evolving subject and more than a brief outline is beyond the scope of this course, however, two excellent sources of reference are:

NSCA Pollution Handbook
Croner's Environmental Management

FC57 Noise from construction sites



Note

1. There are no LA powers of default following the notice procedure.

Unit 7 Surveying the Environment

1 To understand the concept of environmental assessment and be able to carry out a simple environmental assessment of a workplace.

2 Be able to assess the management systems within an organisation and perceive how environmental management can be integrated into that which already exists.

3 Understand the principles and practice of Environmental Risk Assessment

7.1 Environmental Assessment.

This will be the point at which you need to consider your assignment to carry out an environmental assessment of a workplace. You will be carrying out an environmental hazard spotting exercise which is analogous to a health & safety hazard survey. The process can be refined into an environmental audit in just the same way as health & safety auditing is carried out. As we have seen, the strands of health, safety and environmental issues are intertwined inextricably but we can nonetheless separately recognise the environmental component of a wider management responsibility.

A logical and systematic approach will ensure that all issues are addressed.

7.2 Management commitment

It is essential that you interview key persons, managers, supervisors, shop floor operatives, union and other workers' representatives. You will need to establish whether there is a positive health, safety & environmentalist (SHE) culture. Attitudes of individuals matter and whether there is a corporate view or whether dissension exists. A well established health & safety management system can easily be used as a framework on which to graft an environmental management system.

Essential documents will include:

Health & Safety Policy
COSHH assessments
Risk assessments
Minutes of Health & Safety Committee meetings.

From these you will find out about the management structure and the effectiveness of its implementation.

Physically walking through will enable you to assess the state of general housekeeping. An untidy workplace bodes ill. Waste materials lying about, from cluttered waste bins and overflowing desks and workplaces through to rubbish around the buildings, overflowing skips, discarded pallets and so on. A neglected working environment shows up in many ways from a tatty appearance, through dirty furnishings and windows to flickering light fittings and uncontrolled heating.

The existence of any current environmental initiatives are of importance beyond their direct merits because they indicate a level of commitment which can be built upon. Simple initiatives may include paper collection for recycling, can and bottle segregation from general waste. Whether toner cartridges from printers are recycled.

7.3 Legal Compliance

There is a plethora of environmental legislation, some of which will apply to any workplace. An excellent starting point is NETREGs (now via Business Link to the Environment Agency). An online questionnaire points up which legislation applies to the workplace in question and can be stored as an item to support an Initial Status Review. You should establish:

whether any licences exist - such as a Controlled Waste Management licence;
whether any discharge consents exist - such as a trade effluent licence.
Consents to discharge are required generally if an excess of 5m3 per day of waste water is produced. This would normally be from the sewerage undertaking;
whether any prescribed pollutants are discharged, in which case the
Environment Agency will be involved in giving consent and determining the BPEO;
whether a licence is granted under Air Pollution Control by the Local Authority;
whether there are any injunctions in force with respect to nuisance (e.g. noise);
whether there are any special controls in force (e.g. COMAH Regulations) for large chemical risks.
Any previous or current interaction with the Local Authority Environmental Health Department, Environment Agency and any relevant planning matters should be noted.

7.4 Contamination

7.4.1 Oils and Chemicals

The buildings and particularly the surrounding site should be looked over for evidence of contamination. Any tanks should have their contents identified and a note made of the existence and condition of bunding. A bund should be imperforate and large enough to contain any spillage (110% of the capacity of the largest tank). Large accumulations of water could compromise the capacity. Oil, and waste materials in the bund represent danger from fire and should not be present. Condition of tanks and associated pipework should be looked at - whether there is evidence of leaks or corrosion, paintwork is in good order and labelling legible, also readability of sight glasses and gauges.

Storage and condition of materials in drums should be assessed. Drums kept outdoors and standing upright can accumulate rainwater within the top rim if they are unprotected. Direct sunlight can cause expansion of the contents, release of vapours, leakage from seams, perhaps weakened by corrosion. Evidence of abuse and damage by careless handling, injudicious stacking and poor location should be looked for. Drum stock does not age gracefully. Evidence should be sought of stock rotation and arrangements for the return or proper disposal of empties. Incompatible storage (combustibles and oxidising agents, cyanides and acids) is a technical matter but worth questioning for.

Spillage arrangements should include a supply of suitable absorbent such as sand or vermiculite. Bins of absorbent should be clearly marked up as such and should not be empty! Where there is a risk of water contamination, interceptors should set into the drains. Storm water drains should be colour coded and differentiated from foul sewage drains. Drains should be seen to be kept clear. Detergents will negate the effect of oil interceptors by emulsifying the oil and so waste water from e.g. vehicle washeries should not run to interceptors.

7.4.2 Contaminated land

The site should be checked over for signs of spillage, oil stains, odours, excessive corrosion and peeling paintwork. Discolouration of unmade ground, dead animals or plants, accumulation of empty containers and suspicious objects (such as discarded batteries) or substances are indicators that land contamination may have occurred. Further evidence of pollution may be apparent as staining, foam, or filming on the surface of any pools, puddles, ponds or lagoons. Condition of any

surface waters in general may show up eutrophication, often seen as green slimes or blue-green algae.

7.4.3 Underground storage tanks

You should find out whether any underground storage tanks exist. Their presence may be obvious or not, they may be in use or not, derelict or sound. The only indication may be vent pipes but drain covers should be examined, plans consulted, persons asked and so on. As an example, British Telecom are the owners of some 8000 underground diesel storage tanks which they inherited from the Post Office - past policy being to equip all their buildings with independent generating capacity from diesel generators. The location of a proportion of them is unknown.

The problem is that of leaking underground storage tanks (LUSTS). They are difficult, if not impossible to maintain and inevitably corrode. The USA Environmental Protection Agency estimated that they have perhaps a million such tanks, most containing fuel oil of which about a quarter may be leaking. Presence of water in quantity may mean ingress of groundwater through leaks. One anecdotal example is of a diesel storage tank on the site of a London fire station near to the river Thames who's contents rise and fall with the tide! Any old tanks, constructed to unknown standards should be identified with a view to having them surveyed and preferably taken out of service, emptied and either removed or sealed in situ.

It is a depressing thought that all pipe runs leak at some time in their lives and repeated, small leaks may cause worse contamination than a single large spill.

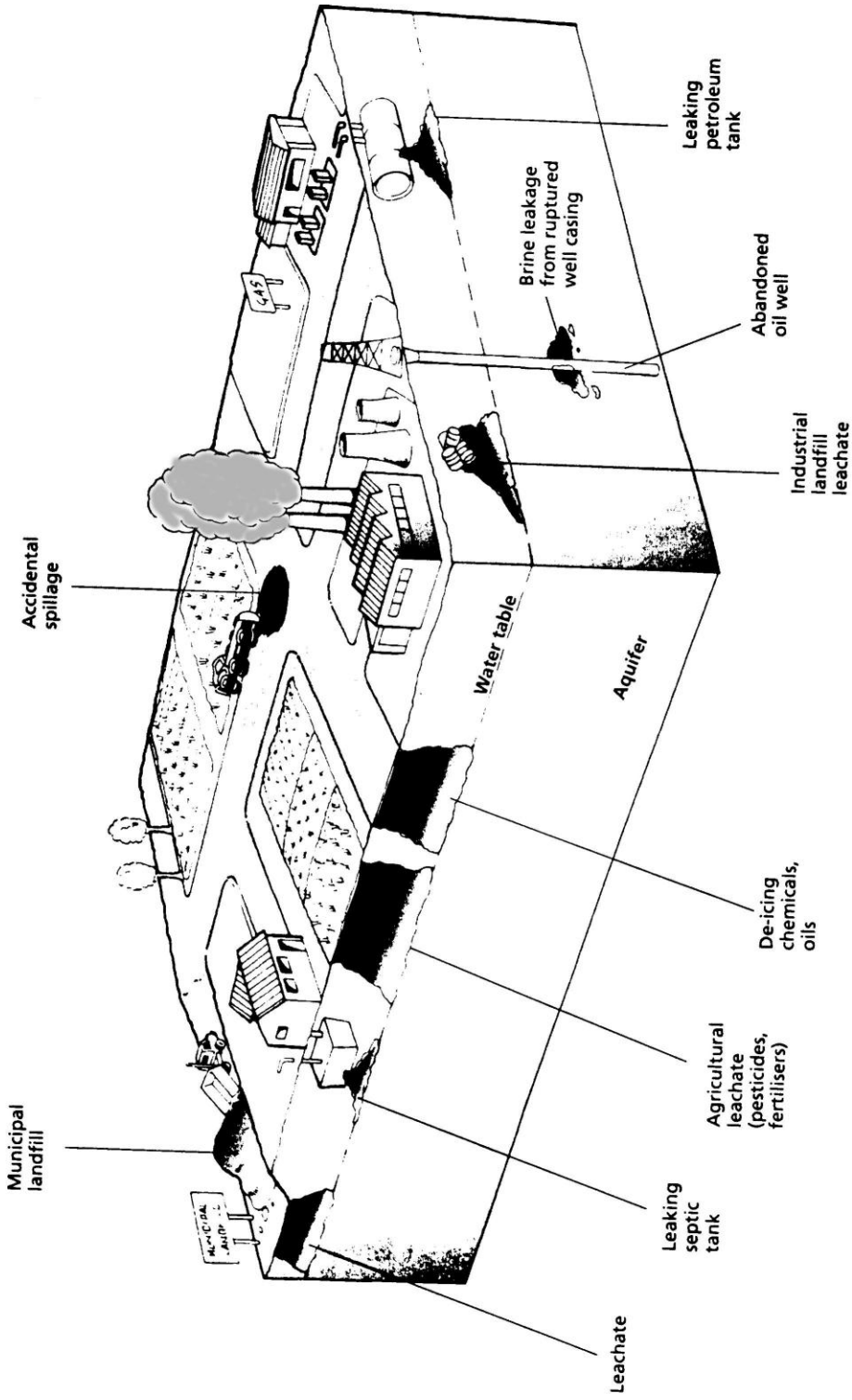


Figure 5.3 Illustration of ways in which groundwater may become contaminated

7.5 Other hazards

7.5.1 Polychlorinated Biphenyls (PCBs)

The presence of PCBs should be suspected if there are any oil filled transformers on site, especially old ones. PCBs were added in small quantities to the oil to improve its flame resistance. It may or may not have been replaced. PCBs were also present as dielectric media in capacitors and chokes in old style fluorescent strip lights.

7.5.2 Asbestos

Asbestos is likely to be present somewhere in all but modern sites. You should ascertain whether there has been an asbestos survey, whether any asbestos found has been removed or remains - in which case it should be marked up with physical signage and noted on site plans as well as being referred to in the health & safety policy. Dependant on age, type, condition and location it may be left in place and preferably sealed with PVA emulsion. Any fibrous light coloured material could be asbestos. Colour is no indication of type (blue, brown or white) and often asbestos is found as a glorious mixture. Important is to note its condition, basically the main risk comes from lagging rather than board, which may also be asbestos cement which is less dangerous again because the asbestos is substantially sealed in. However, frayed or damaged products should be noted. It is ubiquitous, the UK has an estimated 15 million tons of asbestos spread around in all applications where insulation or fire resistance is needed and as a sheeting material so it is bound to keep turning up. Check also for signs of asbestos buried in the ground or simply lying about.

7.5.3 Lead

Any old paint is likely to contain lead. Evidenced by cracked and flaking gloss paint. Other sources are old batteries, lead flashing and pipework. Lead containing solders are still used but are being phased out. Lead presents a health problem to workers who may be exposed to it and the Control of Lead Regulations 2000 set a framework for its control. The classical route for lead poisoning is by ingestion, gradually taking up small doses which are stored in the body and control is largely by practising good personal hygiene. However, lead fumes arise if the metal is heated to 5000C, if paint is burned off and so on and so airborne fumes and dust can be inhaled.

Lead pipes, which are very common in older premises can contaminate tap water and give a small but repeated dose with each glass of water or cup of tea. This is a problem in soft water areas where slight but sufficient acidity due to dissolved carbon dioxide mobilises the metal. It is not so in hard water areas where chalky deposits will help to seal it in place. Citizens of Birmingham have, in the past been advised to run their cold water to drain for 10 minutes each morning before using it and grants are now available to upgrade lead pipework (where the supply from your side of the street stopcock becomes your responsibility). The water supply should be artificially hardened (made alkaline) by the water supply company where this is a problem.

7.5.4 Polyaromatic compounds (PAHs)

Any tarry residues are dangerous because they are potential carcinogens. A classic example is the tar pit which may be found on old gasworks. One such pit 20m in diameter proved to be a problem on the Greenwich Millenium site, complicated by the fact that it had been breached by a bomb during WW11 and had contaminated the local water table.

Creosote, the well known timber treatment is one such substance and its use should be carefully controlled. Overspray and splashing is deleterious to plant and animal life. It is especially harmful to aquatic species. Successive painting of layers of preservative on telegraph poles has caused a build up of phenol and cresols in the local soil as well as on the pole itself.

7.6 Waste

Waste takes many forms, its amount and variety being determined by what the establishment does.

Production scrap may vary from complete rubbish, through off cuts to reject and substandard products or even overstock of good product from discontinued lines. In economic terms holding production waste at the very least occupies space. If not stored properly, materials and products will deteriorate. They may even become dangerous. You should look at what sort of waste is

produced, how it is managed and disposed of. Assess how well the Duty of Care is complied with. The following studies show what can be achieved by modest investment of resource and a little ingenuity.

Case study 7.1

A firm used a large number of small sub contractors to carry out minor building works amongst the local housing stock. The contractors were permitted to deposit their waste into two skips which were replaced when full, the waste going to landfill. No attempt was made to segregate or sort the waste and the skips were inefficiently filled, often containing large voids. A simple control strategy was devised so that any metal scrap was left to one side and one skip was dedicated to inert waste only, reducing disposal cost from (then!) £7 per tonne to £2 per tonne.

The other skip contained general waste from which timber could be removed and recycled via a nearby Local Authority amenity site. Low density waste (bagged rubbish) was likewise disposed via a compactor on the amenity site and the effective filling of both skips much improved.

Case Study 7.2

A firm of shopfitters used large cardboard cartons in which to send out shelving materials for their workforce to install on client premises. The boxes cost £28 but were supposed to be reusable. Around the warehouse, a number of them could be seen to be in a damaged condition, no longer fit for purpose, evidently they suffered from general rough handling. Others, out in the open yard contained left over shelving and brackets, some of which were damaged, perhaps along with the cartons and moreover they had been left out in the weather and were beginning to corrode. Some of these cartons had been serviceable but become ruined by rain. A nearby skip was half full of wrecked cartons, remains of shelving and general packaging waste and was located at the site boundary (a wire mesh fence) close to the wall of the warehouse.

The skip was moved away from the fence because it presented a fire risk - vandalism in the form of firesetting in skips is well known.

A system was set up whereby returned cartons were checked out for returned shelving components. Previously these had been written off on the grounds that the customer had paid for them. It was not considered worth segregating damaged shelving as metal scrap because it was very lightweight and painted, it was thrown into the skip. Cartons were brought into the warehouse unless they were unusable, in which case they were flattened and discarded.

Questioning revealed that the return rate from client sites was poor and both cartons and shelving leftovers were frequently ruined and then scrapped from there. The cartons were perceived to have little value, despite being clearly marked for return.

The long-term solution was to replace the cartons with more expensive metal stillages with the return details stencilled clearly on them. These were much more robust, thus protecting their contents better and the return rate dramatically increased. There was no longer need for a permanent skip and the fire risk was removed.

Case Study 7.3

Polyether foam waste in the form of ‘wet scrap’ from a large production unit was collected in skips, along with polythene sheeting and rolls of paper scrap, plus any general rubbish. There could be anything up to 3 skips on site at any one time. (Any dry scrap foam was crumbed and recycled into a reconstituted material sold as sound insulation and underlay). The waste was designated special

waste, having undesirable characteristics. It was contaminated with toxic chemicals and, due to its low density caused subsidence after landfilling. There was also a tendency for the buried waste to catch fire and produce particularly unpleasant and toxic fumes The nearest site which was licensed to receive the waste was 42km away and, on average one skip each day was required. The alternative of incineration would have required the construction of a dedicated incinerator with a wet scrubbing system for the flue gases.

A process was devised to break down the foam into liquid waste which could be transported in a bulk tanker to an existing special waste incinerator. The cost of chemical plant and storage tank was offset against the reduced waste disposal costs (reduction in number and distance of journeys, skip hire, extra landfill site fees). It paid for itself in the first year of operation Any wet scrap had to be segregated from other waste, avoiding most of the contamination and the rest was then acceptable to a local landfill. The on-site storage tank occupied space formerly taken up with skips.

7.7 Energy management

This subject is dealt with fully in Unit 8, it is an area in which it is very often possible to make considerable savings by simple and straightforward means. You should look at the arrangements for heating and lighting, looking for wasteful practice or simple negligence - usually pretty obvious to an observer, but invisible to those working in a place, having become normal custom and practice.

Case study 7.4

Students in a laboratory complained that it was too hot in winter. The air temperature was 280C even with all the doors and windows open, and an extra insult was the intrusive traffic noise from without. When the caretaker was approached, the reply given (with an alacrity borne of much practice) was that if the heating was reduced, those on the other side of the building would be too cold and would complain. The college's environmental representative was given a radiator key and a mandate to go to each room to ask the occupants whether they would like the heating adjusted. In two days the job was done, the reduced demand on the 'hot' side enabled the 'cold' side to be adequately heated - everybody was comfortable and an estimated 5000 litres of heating oil saved over the winter. Evidently the system had never been balanced in the 27 years of the building's life!

Case study 7.5

A large warehouse dedicated to the storage of construction materials in which 3 operatives routinely worked, was heated by two large, gas fired, forced air heaters. These each consisted of heating units with 4 sets of associated ducting which stopped in mid air a metre or so away, the open ends being directed around the warehouse. Thermostats fixed to the heating units controlled the heaters. The air temperature was only tolerable in the immediate vicinity of the heaters on this winter day. The thermostats were fixed directly to the metalwork of the heater and responded to conducted heat, having little relationship with the air temperature . The result was that the heaters were on about half the time. To make matters worse, from time to time, large roller-shutter doors were opened to admit or release stock.

The units had been taken from another building which the company had owned.

It was entirely the wrong kind of system. It is impossible to heat up the massive amount of air in such a vast space with anything much less than a nuclear reactor. What is needed is a bank of radiant heaters, mounted so as to heat the workers, not the workplace. Heat radiation travels through the air without heating it until it lands on a surface (preferably dark in colour) where it is absorbed

7.8 Nuisances

Nuisance can be either caused by the establishment's operations or subject to the depredations of its neighbours. You should consider any potential source of nuisance - the 'Statutory Nuisances', noise, dust, offensive smells, effluvia, steam - as defined in the EPA 1990. Environmental noise is not the same as 'occupational health' noise and is considered according to a set of parameters defined in BS4142. A few typical examples are:

An apparently quiet fan can cause insomnia in residents a hundred metres away if it is left on overnight;

Connex were served an injunction restricting the noise level of public address systems, following complaints from the neighbours. The reduced levels were set such they were virtually useless. Reliance entirely on visual systems overcomes the problem but creates problems for sight-impaired persons and the annunciator displays cannot be seen everywhere on the platforms.

"*following the receipt of a noise enforcement notice from Lambeth Council, Connex cannot raise the volume level of announcements at this station.*

Apologies for the inconvenience this will cause. Please ask staff for information regarding this train service."

Rubbish burning can produce offensive smoke and odours;

Vehicle movements, especially of large lorries can be disruptive to the neighbourhood and injunctions are sometimes placed on working hours. You should consider the extent of vehicle movement on and off the premises;

Dust blowing from bulk handling operations can dirty cars and windows.

7.9 Conclusions of the EA

You will have gathered a mass of data, hopefully under a logical series of headings and with the emphasis determined by the nature of the workplace which you have surveyed. This should give you an overall picture of the current state of environmental affairs so that you can begin to draw some worthwhile conclusions and as a basis for recommendations.

There are likely to be some 'quick fixes' which will yield positive results, be seen to have achieved something, and hopefully impress all stakeholders of the value of environmental management. There are certain to be more questions produced than answers at this stage, but you should have paved the way for a more structured analysis of the establishment's performance and you should be able to indicate some priorities.

Importantly, you should now be in a position to assist in formulating an environmental policy, leading ultimately towards implementation of an environmental management system.

7.10 Environmental Risk Assessment

Defining the terms

7.10.1 Environment has already been given a definition in Unit 1, however the direct and 'no nonsense' version quoted in the DEFRA Guidelines for Environmental Risk Assessment and Management (Revised August 2000) and which in turn is drawn from the EPA90 reads as follows:

'the environment consists of all, or any of the following media, namely the air, water and land.'

The guidelines are published jointly with the Environment Agency and the Institute for Environment and Health and can be freely downloaded from the DEFRA website. They make essential reading for anyone who seriously intends to undertake environmental risk assessment and it is noteworthy that by following the guidance, the risk assessor is taking the same focus as these august bodies. However, you should note that it is concerned in the main with larger scale activities and intentions than are appropriate to most workplaces although the thought processes remain the same.

A copy of the DEFRA document is included with the accompanying CD Rom.

7.10.2 Hazard is generally taken as being 'the potential to cause harm'. In the environmental sense it means having the potential to be significantly detrimental to the environment (as defined above). You should note that the creation of a register of significant environmental effects is an explicit requirement of ISO14001. It is not a simple activity and the register should be maintained and modified in the light of information gathered during the routine business of operating a management system. Evidence that the register is being refined can be used to demonstrate 'continual improvement', another requirement of ISO14001.

A hazard needs to be significant, and not trivial. Thus, as an example, a company using a salt spray test cabinet consumed two x 25kg bags of salt per month (approx.) which was discharged to foul sewer. This is an insignificant quantity and would have no discernable effect on the operation of the sewage works. There will be activities in any workplace which are 'de minimis' in terms of their effect and can be discounted (though it is important to count them before discounting them).

Hazards can be manifestly fairly immediate (eg. pollution of a watercourse by leaking fuel oil) or take many years to realise the harm (pollution of groundwater by the same fuel oil) or may have very indirect consequences (eg. ozone depletion, climate change). The environmentalist must take a very broad and long term view of hazards in addition to the more obvious and immediate. You can gain perspective on this by considering:

Hazard type	timescale	examples

safety	may cause immediate injury	slips, trips & falls
health	may take years to become apparent	deafness, asbestos disease
environment	may take decades to become apparent	species loss, desert encroachment

There is a difference between an environmental accident (eg. the Exxon Valdiz pollution of Alaska's shoreline) and an intentional and therefore planned release of pollutant for which a consent licence may have to be sought (eg. stack emissions from a power station). The accident scenario we can regard as a 'one off' event requiring an emergency response procedure designed to mitigate the effects and restore normality. The planned release, however, is hopefully designed not to exceed the tolerable environmental burden of the receiving media based on current knowledge and best practice and taking account of sustainability issues and the precautionary principle. Nonetheless there exists an environmental risk which needs to be assessed.

A thought-provoking example of the indirectness of potential and actual harm is the introduction of the plastic PVC during the 1960s. A useful material but containing a high proportion of chlorine. Upon combustion this appears as the stable acid HCl (hydrochloric acid - once it has dissolved in water) and it becomes a significant component of acid rain. Municipal Waste Incinerators must be fitted with neutralising equipment to remove it. However, a much worse problem lies in the production of dioxins and other polychlorinated organic chemicals when PVC is burnt in the waste stream. These are prevented by a carefully controlled combustion cycle which is set up to minimise their occurence and any residues are collected on activated charcoal absorbers. The problem is that such substances are extremely toxic in sophisticated ways and also may bioaccumulate. Incinerator emission standards, therefore must be extremely high and rigidly enforced. Unfortunately the problem then becomes that an aware general public, to whom the word 'dioxin' has become anathema to their ears (i.e. they have a very low risk tolerance to it) will oppose any incinerator project, whatever its merits and we are left with a growing waste mountain with no space left in which to bury it!

There are many examples of such indirect and long-term hazards.

7.10.3 Risk is generally taken to mean the likelihood of realising the hazard. The risk of an accident occurring can often be calculated statistically using one or more of a battery of specialised techniques (eg. fault tree and event tree analysis, failure mode and effects analysis, HAZOP) as are used routinely in the chemical industry and are a requirement of safety management systems therein. The outcomes of an accident should be assessed in safety (direct consequences), health (indirect or longer term consequences) and environmental consequences.

An illustrative example is the explosion at Coalite's factory in Bolsover in which there were fatalities in the accident and dioxin pollution within the buildings. Workers subsequently developed chloracne and the entire site had to be demolished and buried. Many years later it is suspected that a local 'cancer cluster' is associated with dioxins leaching into the local environment.

Environmental risk from an approved (i.e. licenced) discharge arises from both forseen (eg. statistical risk in the population of tumours due to radiation release) or unforseen consequences which become apparent as knowledge is gained by monitoring and/or research. An occupational health parallel is in the setting of exposure (hygiene) standards which are based on current best knowledge. Thus, if, for example, workers' hearing deteriorates despite controls applied under the appropriate legislation (Control of Noise at Work Regulations 2000) there will be a need to improve controls which has cost implications and there may be civil claims made by affected persons. It is forseeable that there may be some hearing loss even if the UK action levels of 85dB(A) and 90dB(A) are adhered to because there is evidence that hearing damage may onset at lower levels and it has been suggested that the first action level should be 80dB(A). An environmental parallel could be the emissions from a brick works causing plant die-off and land contamination (due to sulphates and

fluorides) requiring tighter and more costly emission controls and compensation to landowners who have at least suffered from nuisance.

It is worthy of note that legal compliance alone is not an adequate risk assessment standard. Only an effective, proactive management system will control the risks.

Risk is generally assessed in terms of:

frequency (how often an incident occurs);
severity (cost implications);
numbers effected.

Timescale is also a factor.

As already mentioned, probabilistic methods can be used to determine a risk and these would be acceptable to insurers and regulators provided that sufficient study had been undertaken to get the input parameters accurately assessed.

But chapter 3 of the DEFRA guidance concerns itself with societal risk and risk communication. The point is made that even if the risk is accurately assessed (something which may be very difficult to achieve or prove) then various stakeholders may have different perceptions of that risk.

7.10.4 Stakeholders are individuals, pressure groups, companies, official bodies, the general public and so on. Relevant stakeholders should be identified and involved proactively in planning decisions which will impact upon them and their environment. Some stakeholders will be statutory consultees. In a society in which the media play an important investigative and communicative role, which is alas often biased towards a political perspective, stakeholder pressure can prevent a project from being realised. Misperceptions lead to anxieties which result in reduced tolerance to risk - so called 'fright' or 'outrage' factors.

Case Study 7.6 - A Tale of Two Incinerators

A municipal waste incinerator has been proposed at Belvedere, on the banks of the Thames in southeast London but local stakeholder groups have been very organised (using the acronym BADAIR) in opposition to the project. The LA (Bexley) has sided with the citizenry (who vote them in or out at election time!) and as a result, the proposed incinerator has become bogged down in its third public enquiry.(Finally constructed 2011) It was then heard that the citizens of Wandsworth have similarly objected to an incinerator so that an extra turn of the screw is the Nimby argument expressed as 'why should we have to burn their rubbish'. The fright and outrage factors centre on extra vehicle movements, asthma due to air pollution and the dread of dioxin. In fact, all 3 arguments are untenable because the vehicle movement is due to local dustcarts which still have to collect the MSW and take it for disposal; MSW incinerators do not emit anything that may exacerbate asthma; dioxin levels are falling due to improved incineration standards in comparison to old incinerators which have been decommissioned.

In the meantime, 80 000tpa of Bexley waste were incinerated in neighbouring Lewisham and its dustcarts travelled through their streets en route. The rest of Bexley waste went to landfill (an option which is increasingly unavailable).

Meanwhile, close by is Crossness sewage works which previously disposed of its sludge by dumping it at sea, an option prevented by international convention. A sewage sludge incinerator appeared on site without the local stakeholders appearing to notice and was recently hailed in the local press as a positive boon to the community. The point here centres on inevitability - becoming involved in protracted local discussion which may or may not become hostile would actually achieve nothing - the incinerator would still have been built.

Case study 7.7 - Hull sewage works

Complete renewal of the North Humberside sewerage system was urgently required to bring it to an acceptable standard. A number of alternative sites were under consideration with various LAs involved. Despite some initial acrimony, public discussion and involvement of stakeholders led to a consensus. Yorkshire Water went so far as to rent a shop in Hull city centre as a successful device for communication with the public. Whilst an EIA was required, there did not have to be a public enquiry.

Interestingly, and in complete contrast to Crossness, the sludge is digested and the spent product pelletised for use as land dressing. Crossness can no longer digest its sludge because the calorific value of spent sludge is too low to incinerate.

7.10.5 Danger is taken to be the realisation of the hazard, i.e. the actual harm caused to the environment. As an example, the hazard associated with operating the nuclear facility at Sellafield is that radiation may escape. A danger arising from this is of a leukaemia cluster appearing in the local population (there is one!).

7.11 Carrying out environmental risk assessment

The intention of an activity should be defined, i.e. what is its purpose and what will it produce. What benefits will accrue from it and what would be the consequences of not carrying out the intention. For example, if the intention is to grow genetically modified crops which have specific pesticide resistance, then the benefits can be defined in terms of improved farming methods, increased yields etc. An example of a particular benefit is claimed in a new rice strain which produces vitamin A thus improving the health of people who live on a rice diet which is otherwise deficient in Vitamin A.

The risks of the intention should not outweigh the benefits it may produce. Thus the risk assessment needs to fully identify the hazards and rank the risks in some way. A case study on experimental trials of genetically modified sugar beet is given in the DEFRA document. The risk rating system which is used is: high, medium, low, negligible (without actually defining what these terms mean). The conclusion drawn there is that all the risks are low or insignificant and that improved controls applied to those with a 'low' category reduces them to insignificance. Note that the risk criteria are not universally accepted and in particular Greenpeace went so far as to destroy such crops during field trials in protest. The societal issues had not been fully considered!

Uncertainty is a feature in environmental risk assessment because of it's complexity and the inherent difficulty of assessing effects, some of which may be in the longer term. Where uncertainty exists, it must be factored into the assessment process otherwise undue confidence may be given to the results leading to complacency.

Constructing a risk assessment grid.

Each hazard should identified and listed. The potential to enter each of the receiving media (air, water, land) and the likely consequences should then be assessed. It can be helpful at this stage to use the source - pathway - receiver model to help identify outcomes. The specific risks should then be stated.

For example: timber treatment with creosote (creosote may be considered to contain phenols and cresols). The main hazard is toxicity to both plant and animal species.

Activity spraying timber with creosote

air sprayed aerosol droplets drift, inhalation and skin absorption by workers, animals and on to plants.

Damage to painted surfaces

water spray drift settles, spillage, injurious to aquatic plants and animals.

drain off from timber groundwater contamination

land soil contamination phytotoxic. Penetrates plastic water pipes, polluting potable water supply

An assessment of the likelihood, severity and range of effects for each of these should be given an appropriate rating. All stages of the process should be considered and included in the grid. At the end of this process the worst risks should emerge and point towards appropriate levels of control.

The DEFRA document gives an example of environmental risk assessment applied to a garage dispensing petrol.

Lifecycle analysis

The risk assessment should take into account all stages in the activity. As a not necessarily trivial example, cleaning the spray equipment on completion of spraying. This is a different activity with different risks.

However, the lifecycle assessment should include commissioning, maintenance and decommissioning of the activity as well as normal operation. You have only to apply this to the nuclear industry to realise the enormous implications of such matters as decommissioning reactors and reprocessing of spent nuclear fuel.

Risk screening.

In assessing complex risks a preliminary screening exercise is useful in categorising and prioritising items for consideration. The intention is that resource should not be wasted by misdirection and take effort away from looking at the most important areas.

It will identify:

high risk which may need urgent action;
low risk which needs no more consideration (and the reasoning for that);
priorities for more detailed assessment.

Monitoring and review

Risk assessment is a reiterative process. Monitoring is a management activity and forms part of the management process, certainly of an EMS such as ISO 14001. It enables us to see how accurate our assessments have been. Monitoring includes sampling of the environment as well as considering process parameters (how well the process is operating). It will also indicate the state of legal compliance. It provides the information with which we can review our activity and continually improve.

Self Assessment Exercise

Carry out an environmental risk assessment on the use of depleted uranium as a material designed to increase the effectiveness of armour piercing shells.

The intention is a more effective battlefield weapon.

Depleted uranium (U238) is a waste product of the nuclear industry. It is radioactive - a low level alpha particle emitter with a half life of millions of years. Uranium is a toxic metal. Once inside the body it causes a slow death from cancers, irreversible kidney damage or wastage from immune deficiency disorders.

It has been used in Iraq, Bosnia and, presumably, in training exercises.

Efforts to decontaminate areas in Iraq use crumb tyres and bentonite as an absorbent.

Unit 8 - Energy Management

'C'mon Baby, light my fire'

Objectives

1 Know the main ways in which energy can be wasted and measures which can be taken to effect improvements.

2 Appreciate the need to prioritise energy conservation measures and the significance of purchasing policy.

3 Understand the issues which relate to transport and energy conservation.

As a nation, there is no doubt that we are very profligate with energy. It has been said that the UK can best work towards meeting its obligations for reduction of greenhouse gases, i.e. CO_2 emissions by energy efficiency measures rather than investment in new power stations. Our stock of premises are seriously under-insulated and energy wastefully used.

8.1.1 Energy Conservation Measures

In most workplaces it is possible to make immediate and considerable savings by making best use of what is existing, basically by a little staff training, coupled with improved facilities management. (Facilities Management seems to be some kind of new mystique. It isn't. It simply means looking after buildings and their maintenance and it is important nonetheless).

Perhaps as part of an environmental assessment (see Unit 7) a survey should be taken of the various working environments in order to find out people's views on their own workplace. This can be sensibly included in a general assessment of workplaces, required by the Workplace Regulations 1992, and work stations in the form of Display Screen Equipment risk assessments required by the DSE Regulations 1992. This would include lighting. The survey will hopefully reveal the real and perceived problems associated with temperature, ventilation and lighting, however, it should be remembered that such a survey should take account of conditions throughout the year.

8.1.2 Heating

Individual room thermostats for radiators are the ideal solution and will cater for persons with different comfort temperatures (for personal and/or job factors). Adjusting radiators with a key or flow control is a good alternative. Stuck valves should be reported for maintenance.

Windows and doors can be sealed against draughts. Simply ensuring that they are open or closed as necessary.

A person can be designated the task of looking after the environment in each office or workplace. This is not a major task and, for example, could easily be included with health & safety duties undertaken by workplace representatives. Any conflicts can be referred on to the office supervisor.

The workplace only needs to be maintained at working temperature while it is being used and there is always a time lag between turning on a heating system and the response. Optimising turn on and off times will ensure minimum fuel consumption and maximum comfort. In general, the temperature should not be too high. 170C is perfectly adequate for many purposes and persons can top up their personal insulation with an extra layer of clothing. Increasing the temperature by 10C increases fuel use by up to 10%.

Portable heaters are a potential source of energy wastage and even fire, easily left on overnight. The bringing in of heaters from home should be banned, they are usually electric radiant fires or fan heaters and may well be electrically unsafe. Unless such equipment is taken into the establishment's auditing system for portable electrical equipment, it does not conform to the Electricity at Work Regulations 1989. The largest single cause of fire, next to arson, is fire of electrical origin (Fire Protection Association statistics).

Case Study 8.1

A new 'front end' reception and security area was built on to college premises, it was also the main fire evacuation route. When winter came, the installed heating system was found to be inadequate and it became commonplace to see the uniformed security personnel huddled around a 3-bar electric fire. A constant stream of students opening the doors prevented any heat being retained inside despite a lobby style entrance (two sets of doors). The security staff had lodged a waste paper bin behind one of the doors to restrict the amount of opening, in gross contravention of the fire regulations. A smell of burning was reported by security which eventually turned out to be from the socket to which their own fire was plugged in.

The fire was banned, the heating system bled, giving some improvement and the wastepaper basket removed. A week later the ring main fused because the security personnel had now brought in two illegal electric fires and the wastepaper bin had returned. After 3 episodes of fuses blowing, the caretaker put in a larger fuse and the ring main burnt out, causing a fire evacuation of the premises, with most persons evacuating through the smouldering reception area.

The security firm was sacked and a large black panel radiant heater placed above the lobby doors to warm the new security personnel who had black uniforms, solving the problem.

8.1.3 Lighting

Switching off unwanted lights can be encouraged by publicity, notices etc. It should become habit for the last one out to switch off. Visitors to infrequently used areas may carelessly leave lights on for days on end. An office ablaze with lights at 2 o'clock in the morning has to be suspect! Movement sensitive switches, analogous to the PIR of a burglar alarm system can be used to automatically switch on lights and turn them off again a set time after all movement has ceased. The older type where a push switch then turns itself off after a set time is dangerous and should not be used. They are sometimes found used on stairways.

It is a myth, often quoted by those who do not turn lights off, that starting up fluorescent lights consumes as much power as running them for an hour and a half.

Maintenance of lights should be attended to promptly, flickering fluorescent tubes can be intensely annoying and it has been suggested that they may bring on epileptic fits in susceptible individuals. Old tubes may be running with reduced output. A maintenance policy should be established for tube replacement. It can be cost-effective to replace all the tubes and service all the fittings in a co-ordinated manner during closed periods, for example. All diffusers should be thoroughly cleaned because they become dusty and collect dead insects. They should be checked to ensure that they are of fire resistant material such as polycarbonate and not combustible polystyrene and replaced if necessary. Many fires occur due to flammable light fittings, the plastic melts, raining burning droplets on to surfaces below!

It may be cost-effective to have a scheduled replacement programme in which all the lights are replaced at once at a set interval of time. The advantage of this approach (which needs to be offset against its costs) is that:

the replacement works can be carried out at a quiet time, minimising disruption;
there will be minimal maintenance otherwise;
the environment will have lighting which functions fully at its designated levels;
waste tubes can be disposed of in bulk using a proper tube crusher which can be hired in for the purpose or else sent on to a specialist waste disposal contractor such as Grundon Waste.

A schedule for replacement with low energy light bulbs and tubes should be planned. Low energy lights are more expensive but last longer. A typical saving is from 60W reducing to 11W.

8.1.4 Water

Wasting water is bad practice and for metered commercial premises, is costly. Wasting hot water is vastly more so. It may be difficult to believe, but a college was found to have had the plumbing so badly modified that toilets in one block were being flushed with hot water!

Simple maintenance of existing facilities, ensuring that tap washers work and leaks are fixed, along with regular cleaning/inspection of welfare facilities will encourage the users to respect them. 'Prestex' type taps are particularly economical although they fail to maximum hot water waste. Low volume spray type taps using 'instant' hot water supply from a local gas or electric heater are a good option and overcome the losses associated with long pipe runs (which occur to some degree even if the pipes are efficiently lagged). Ensuring that hot water is hot will discourage people from running it to waste, instead to fill a handbasin, is more satisfactory, economical and better to use. This, at least is a theory but in any event it is not acceptable to provide water at such a temperature that there is a risk of scalding users! Hot water should, however, be hot enough to satisfy legionella control criteria.

Case Study 8.2

A company occupied a new industrial building which it rented from the Industrial Estate. It had furbished it as office accommodation on two floors and about 20 persons used the facilities. The shell was uninsulated, though it did have double glazing throughout. During the summer, the building sweltered, it suffered severely from heat gain. The occupants were reluctant to open windows because traffic noise and fumes on one side and dust nuisance from the neighbours on the other made this unpleasant. In winter it was invariably cold despite keeping the heating on at full blast all the time.

The management were contemplating either installing air conditioning at a cost of £1/4 million or moving elsewhere. A low cost alternative was found by using a combination of reflective film stuck to the windows and blinds which could be turned to block out sunlight in summer and reduce heat loss in winter. The improvement was enough that the company is now able to remain on the site without further problems.

8.1.5 Planned Maintenance

The existing state of the premises should be ascertained and a schedule for systems improvement drawn up. DEFRA issues a wealth of good practice under the Energy Efficiency Best Practice Programme which deals with straightforward energy conservation measures but also tackles common industrial and commercial processes. Very specialist guidance is also available (e.g. recovery of high temperature air in furnaces)

Consideration should be given to thermal insulation. Roof insulation should preferably be 150mm thick. Given that hot air rises, stopping losses at roof level is very cost effective. Other opportunities to improve insulation, e.g. cavity wall filling and underfloor should be taken.

Fitting draught excluders costs very little and can produce significant improvements.

Double or secondary glazing may take as much as 5 years to pay back the investment but in the meantime will give improved comfort and noise reduction.

The type of heating equipment should be ascertained and replacements specified which will give better efficiency. Condensing boilers make use of the considerable amount of energy in the form of *latent heat* which is lost with earlier designs. Gas heating is cleaner and produces less carbon dioxide than coal and to some extent oil. The option of using renewable energy from sunlight is also worth considering. Even in the UK, a significant proportion of domestic energy requirements can be provided using such a system.

The functioning of the system and the use to which the building is put should be evaluated. For example, a 14 storey tower block had to be heated for 3 evenings per week just to run a student bar because there were insufficient isolating valves.

8.1.6 Air Conditioning Systems

Properly operated, such systems should be capable of sophisticated energy management, neglected they can produce a very poor environment. The well known phenomenon of Sick Building Syndrome is invariably associated with modern, air conditioned buildings. SBS is typified by non-specific illness in the occupants, higher than usual numbers of colds and respiratory disorders, headaches, lassitude, dry and itching skin etc.

The causes are frequently due to poor ventilation, temperature and humidity control. The first port of call in investigating complaints about the environment of such a building is the air conditioning system itself. It needs to be properly set up, with air circulation, number of changes per hour, velocity and direction of airflow measured and adjusted. Filters should be regularly cleaned or changed. In one case, the filter unit in an air conditioning system had been located in the corner of a roof space so that it was physically impossible to service the equipment. The system had been in use for years.

People attempt to compensate for deficiencies of air conditioning by opening windows. The system then has to attempt to condition the entire atmosphere of the planet and is grossly thrown out of balance. One person enjoys what they perceive to be improvement (because they can exert some limited control over their own environment) to the detriment of everybody else. The answer is education, optimising the system so that there is no need to go to such measures and, as a resort, to fix the windows so that they cannot be opened.

8.2 Local Exhaust Ventilation

The purpose of such equipment is to remove airborne hazardous substances from the workplace. It typically comprises:

an extractor hood, either captor type (which draws air into itself) or a receptor type (which removes air contaminants produced within it);
a ducting system to conduct the air away;
a filter to remove any harmful substances;
an extractor fan and motor;
a discharge outlet to atmosphere.

Such a system will also have a cooling effect by removing warm air which will be replaced by make-up air. In some cases make-up air must be actively supplied but usually general ventilation suffices. Design is therefore important in terms of minimising waste heat.

Good design features are:

having a heat exchanger so that make-up air is warmed;
recirculating cleaned air;
using a high velocity/low volume system so that heat loss is minimal.

The system should be assessed in terms of its appropriateness for the job it is to perform.

Case study 8.3

A large user of isocyanates used a correspondingly large LEV system to withdraw fumes from its production area and discharge them to atmosphere. The air was not filtered because the level of dilution into the atmosphere was deemed to be sufficient and chimneys raised the discharge level some 5m above the roof. The occupational exposure standard (oes) for isocyanate was revised downwards from 1ppm to 0.02ppm, a 50 fold reduction because isocyanates had been found to be respiratory sensitisers. The output of the system was increased correspondingly by increasing the capacity of the LEV. Several more chimneys appeared on the roof. There were a number of unfortunate effects. The building became extremely draughty and doors would slam if they were let go. It was very cold in winter. And the system was very noisy, so that the whole area became a designated hearing protection zone and the workforce had to wear ear defenders. Despite all this, the oes was exceeded whenever the plant was operational so that the operatives were compelled to wear respirators.

An attempt was made to improve the efficiency of the system and comfort within the building by putting in blower fans to supply make-up air and a bank of heaters was placed in the path of the make-up. This succeeded in reducing the general draughtiness but it remained cold in winter, the heaters made little difference and were usually switched off so that there would a weekly works gain on the production costs because they had an allowance for using them.

An isocyanate monitoring programme discovered that the level outside the building and at the intake for the make-up air was 0.02ppm.

The whole system had to be scrapped and replaced by an enclosure around the plant with a small LEV and a filter system

8.3 Energy Efficiency Best Practice Programme

The Energy Efficiency office of DEFRA produces a series of guides to Best Practice which are aimed at industry, commerce and the public sector, also buildings and housing – e.g. SEDBUK They comprise:

energy consumption guides (Coloured blue) which enable users to gauge their performance against a benchmark;
good practice guides and case studies (coloured red) offering independent information on proven energy saving measures and techniques;
new practice projects (coloured green) independently monitoring the efficacy of new measures;
future practice R&D support (coloured purple) which help in developing good practice measures.

The office operates through regional offices and there is an Energy Efficiency Enquiries Bureau at the Energy Technology Support Unit, Harwell. The focus is on energy intensive processes. The Carbon Trust also supplies energy efficiency information and case studies.

8.4 Transport Management

The Institute of Environmental Management & Assessment has produced a special report entitled 'Transport and the Environment' (IEM Journal Vol5, Issue1,Dec97), sponsored by the DTI.

The (now defunct!) Royal Commission on Environmental Pollution has made recommendations on transport which has constrained the government to produce a consultation paper and a White Paper on an Integrated UK Transport Policy in 1998. A sense of urgency exists because transport issues are coming to the forefront of environmental concerns, particularly relevant to air pollution. Some facts which underline the concerns:

Congestion currently costs UK business £15 billion per annum (CBI estimate);
UK roads are the most congested in Europe. Traffic is set to double by 2025;
Transport accounts for 26% of UK emissions of CO_2 and 33% of energy consumption;
Transport is responsible for up to 80% of poor air quality;
Vehicle waste accounts for 10% of UK hazardous waste (by volume).

Transport management should be looked at from the perspective of short term optimisation of resources but also as a systemic issue - changing the infrastructure by longer term measures such as relocation, redesign of operations and change from road to rail. The introduction of congestion charging for London was designed to provide resource to fund improved public transport for the UK capital city. It has been seen to be successful, the congestion charge was raised from its initial £5 per day to £8 and the zone is to be extended to include the West End. It may well become a world model for other cities.

Otherwise, the Government seems to have done little to address the imperatives and gridlocks become ever more frequent as the overloaded network succumbs to accidents or roadworks while minor roads everywhere become witness to a bizarre elaborate dance as drivers rise and dip over endless speed humps.

8.4.1 Immediate cost savings in transportation and the operation of vehicles.

Attention to vehicle maintenance. Such matters as underinflated tyres reduce performance, fuel economy and tyre life and can be dangerous. Dragging brakes, poorly tuned engines, clogged air filters all reduce efficiency. In just one example a dirty air filter reduced the efficiency of a car from 45mpg to 32mpg. The exhaust emissions were not too pleasant either! - the RCEP estimates that 50% of vehicle pollution comes from an ill maintained 10% of vehicles. Vehicles should be serviced at the specified intervals and tyres checked weekly. Breakdowns will also be reduced.

Driving style. Defensive driving saves lives and reduces stress on both driver and vehicle (as well as that of other road users). Perhaps surprisingly, journey times are not significantly increased. Excessive speed increases fuel consumption and also noise to vehicle occupants and local residents. Even with the best aerodynamic designs, fuel usage increases dramatically with speed and incidentally the inverse is true for crash survivability. The Ashden Trust estimates that fuel consumption can be reduced by up to 20% by driver training. with concomitant reduction of pollution, wear and tear on vehicles, accident rates and lower insurance premiums

Travel management. Attention to routes with complex, multiple destinations planned using 'autoroute' type computer programs (CVR) will optimise journeys. Especially useful is sharing of

vehicles where possible. Better still, perhaps to eliminate the need for journeys by making optimum use of remote conferencing facilities, an area in which much development is currently taking place. Rescheduling and replanning work so that it can be done from home is an increasing trend which also has implications for quality of life.

Use of public transport. Where the option exists, staff should be encouraged to use other than roads. Rail warrants or some such system should be encouraged to decouple the direct costs from the person making the journey because it can be a real deterrent if the traveller has to pay fares and reclaim them retrospectively. Public transport is usually more reliable and work can be done while travelling. It is of direct benefit to the environment. This can be written into the environmental policy.

8.4.2 Purchasing Policy

Vehicles should be purchased with fuel economy and low maintenance cost in mind. The most obvious is to opt for diesel engines on the grounds that they are about 30% more fuel efficient and the power plant is more robustly constructed so that they tend to last longer. City diesel can now be purchased which is more refined and thus overcomes some of the objections to diesel as a fuel. Vehicles should be bought with purpose in mind, larger and heavier cars inevitably cost more to run than smaller ones (Greenpeace has demonstrated that 51% improvement in fuel efficiency can be achieved by design improvements to a standard car without loss of performance).

LPG is increasingly an option. It offers the advantage of cleaner emissions and is supplied as part of a dual-fuel system wherein petrol is used when LPG is unavailable. Only a relatively few filling stations currently offer LPG but this facility is steadily increasing and as the fuel costs only about half the price of petrol (a taxation incentive) there is significant incentive to use it. A disadvantage is reduced operating range as compared to petrol. Swindon council has purchased a fleet of dual fuel vehicles but found that because the range is reduced, frequent returns must be made to the fuelling depot which increases journey distances and wastes operative time – significant issues in an operational environment in which cost effectiveness is always under scrutiny as part of 'Best Value'.

The RCEP notes that company cars are associated with employee status. Senior executives have an expectation of a prestige car - fuel economy as a criterion is unlikely to feature very highly, thus changing attitudes is difficult, however, company cars account for 20% of all car mileage and purchasing policy has a disproportionate effect on pollution, proportionally linked to business costs.

8.4.3 Strategic Issues

Location and movement of goods should be considered in long term planning. The issues are invariably complex but should take account of journeys and also access to public transport, especially rail links. It is no accident that Bedford, the geographical centre of England, has more warehouses than most places.

Currently 85% of freight moves by road (RCEP). Journeys have doubled in distance over the last 35 years and current projections are between 54% - 110% in number of journeys by 2025.

Rail freight operators see the business opportunity and are increasing their infrastructure by providing more terminals and facilities for smaller unit loads, thus integrating with the containerised load carriage and attracting the smaller carrier.

The large distribution companies, Sainsburys, Tesco, Safeway etc. are looking at patterns of distribution and supply. By using round trips instead of individual supplier to warehouse delivery considerable savings are made. Tesco reports that this arrangement saved 3 million vehicle miles per year and improved vehicle loadings by 26%.

Visit the IEMA Website and access the special report on Transport. http://www.iema.org.uk (or by writing to the Institute) .

Other useful addresses are:

http://www.iem.org.uk/bestpr/bpr.html (IEMA members responses)

http://www.open.gov.uk/dot/dst/dst_home.htm (factual background to developing an Integrated Transport Policy)

http://www.open.gov.uk/dot/nrpd/heta2/nrtf97/index.htm (National Road Traffic Forecasts)

Contact the Energy efficiency Enquiries Bureau, ETSU, Harwell, Oxfordshire OX11 0RA Tel: 01235 436747, Fax: 01235 433066 and obtain a list of energy efficiency publications plus the address of your local area office.

A discussion document on the role of the company car is available from the Ashden Trust, 9 Red Lion Court, London EC4A 3EB (send 70p sae).

Unit 9 Managing the Working Environment

'select, record, examine, develop, install and maintain'

Objectives

1 Understand the process of management and how environmental management becomes part of the overall organisational structure.

2 Understand the relationship between environmental management, health & safety management and quality systems.

3 Know in outline what an environmental policy is and what is required in the implementation of it. Especially the importance of auditing.

4 Appreciate the similarity and difference between the environmental management systems ISO 14001 and Eco Management Audit System (EMAS).

9.1 Managing as a process, the Management Cycle

The process of management is basically the same whatever it is that must be managed. Most persons studying this course will have management experience, indeed, it is aimed at those who need to know how to introduce environmental management into the workplace or contribute to an existing Environmental Management System (EMS). But in all cases, environmental management must be grafted on to an existing management structure.

Before consideration is given to environmental management you should look at the management structures and styles within which it must be embedded. You need, therefore, to assess how effectively and efficiently the organisation is currently managed in a general sense. There are many factors which effect how it operates. Size of the establishment and its age are critical parameters in that:

a small organisation is more organic, flexible, is younger and has few formalised management systems. It usually has problems of financial and work control exacerbated by ill defined roles and overlapping perceived responsibilities. Perhaps surprisingly, there are often communications problems despite everybody knowing everybody else and what jobs each one does, or is supposed to do. Decision taking and change can be rapid but may be ill-considered. About 90% of UK business falls into this category, the so-called SMEs (Small to Medium Enterprises). The HSE perceives SMEs as being particularly difficult to reach;

a larger organisation becomes more mechanistic, it creates a bureaucracy and its functions become defined. Individuals acquire specified roles (e.g. Safety & Training Manager). Inertia increases and multi-site operations add to communication difficulties, diversification of work tends to occur. A later stage in the evolution of an organisation may involve mergers and acquisitions in which pre-existing management roles and functions must be integrated.

All organisations develop over time, either expanding because they are successful or contracting because they are perhaps less so and need to rejuvenate by downsizing.

It is against such a background that you must work.

9.2 Management of Quality Systems, Health & Safety and the Environment

Environmental Management tends to be seen in the same light as other 'non-productive' management systems and functions. It is therefore essential to look at these other, related and often overlapping disciplines.

Health and Safety management within an organisation tends to be led by the requirement to conform to legal obligations, i.e. it must evolve a strategy for compliance with the law. It is sadly too often the case that health & safety awareness raises its profile only after either an accident or a visit from the HSE, Local Authority Environmental Health Officer or Fire Officer. Other influences may come from the company's insurers who take a risk management approach and will raise premiums or even refuse cover if they assess that undue risks exist and that relevant risk control is inadequate. Increasingly, and especially to those tendering for work in the public sector, it becomes a requirement to demonstrate an adequate Health & Safety Policy - because they have legal duties to control the activities of, at least their contractors, ensuring that they work safely. A negative attitude, which the coercive 'stick' approach seeks to change is going to be a problem to anyone trying to introduce an environmental policy.

The HSE has taken a lead in recent time in persuading and advising enterprises of the values of a positive health and safety culture and seeks to move from 'stick' to 'carrot' by pointing up the benefits in terms of both financial gain and improved morale of the workforce. Basically these are that financial gains result from reduced accidents or ill-health. The HSE video 'The Secret Siphon' puts it the other way around by describing how a company collapsed following an accident due to the hidden costs - the 'tip of the iceberg' syndrome. Direct losses are maybe 10% of the total loss - indirect effects of civil litigation, accident investigation time, raised insurance premiums, tendering disadvantage etc. etc. account for the rest. And improved morale by having an employer who is seen to be caring, can't do anything but help productivity.

Proper management of health and safety means that risk assessments must be systematically carried out and recorded within a management system which is regularly reviewed. Specific assessments will be of benefit when it comes to installing EMSs:

COSHH (Control of Substances Harmful to Health) Regulations require chemical risk assessment and control systems to be in place;

Electricity at Work Regulations require an asset register of electrical equipment to be created;

Management of Health & Safety regulations 1999 require emergency planning and also comprehensive and systematic (suitable and sufficient) risk assessments.

The most familiar route to such integration is by using the HS(G)65 approach (Successful Health and Safety Management). Figure 9.1 is a flowchart, the elements of which can be applied easily to any management structure. Clearly, an EMS can be developed using this model, in parallel with OH&S. OHSAS18001 Occupational Health & Safety Management Systems is an auditable standard, currently being rolled out as ‘the way forward.’ And designed to integrate with ISO14001 EMS

Facilities, Fire and Security management are related matters which impinge also on environmental management in many diverse ways; from Legionella control, through emergency systems (e.g. firefighting runoff water) to the potential consequences of trespassing and vandalism. There is a good case for an integrated Health, Safety, Fire and Security management system. There is also a ‘new kid on the block’ as of 2004, DEMS (Disaster & Emergency Management Systems) which requires its own policy and system, now available which intermeshes with various elements of other management systems.

9.3 Safety, Health & Environmental Policies (SHE Policies)

Quality Assurance Systems such as ISO 9000/2000 series require documented systems to be in place and an audit trail, verified by an external assessor. Such a system should already embrace health and safety systems and is going to be of great value towards establishing an EMS, essentially it requires the same structures. Companies usually undertake quality assurance in order to gain tendering advantage, i.e. they are client led and this is now becoming all-pervasive.

Parallel to these management systems, BS EN ISO 14001 (the environmental standard) has been upgraded as of 2013 The requirement for continual improvement is rooted in the idea that environmental management (in common with the other systems) enables better use of resources year on year. Monitoring is set against significant Aspects (environmental issues) and Impacts (environmental outcomes), quantifiable in ISO14031, key performance indicators (KPIs), essentially benchmarks for performance against the Industry concerned.

As yet, there is not a legal requirement to have an Environmental Policy in the same way as a Health & Safety Policy is specified under the Health & Safety at Work etc. Act 1974, sadly a failure of legislation, (the Environment Act 1995 would have been the opportune moment). However, it will increasingly be the case that clients will call for evidence of environmental performance as a pre-tender requisite.

As it is a legal requirement to have a Health & Safety Policy, then it seems a logical management move to an integrated SHE policy, using the same structures. The worker/management interface of the Safety Representative and Safety Committee is readily extended to encompass environmental matters. The Trade Unions are beginning to awaken, the Transport and General Workers Union being particularly proactive to the environment. Your author claims to be the first (and probably still the only) Environmental Representative to be appointed by a NATFHE local branch, with a mandate parallel to that of the Health & Safety Representative.

9.4 Implementing a Policy

9.4.1 Establishing a baseline (initial assessment).

Unit 7 explains how you might go about an environmental assessment of a workplace, however, you will need to work to a structured proforma in order to ensure that you have been thorough and covered everything. A number of audit instruments have been developed, and these are essentially questionnaires broken up into sub headings. The NEBOSH Environmental Audit Proforma is an example of what is available and is more than adequate for the requirements of this course, however it is essentially a training tool and may not be sufficiently comprehensive or detailed for a proper audit. It may be prudent to buy a commercial product and it would be wise to get one which is available electronically. Developing an 'in house' audit instrument is likely to be an onerous task although the benefit would be that of ownership and the fact that it is 'tailor made' to an organisation's requirements. But, before investing in anything it is worth reading Philip Chambers' article in the 'Safety & Health Practitioner, March 1998' (available from IOSH) entitled 'The Use of a Database Structure to help Manage Safety & Environmental Actions' which shows what can be done with universally available software.

The initial assessment (Initial Status Review), if carried out thoroughly will provide a benchmark and a starting point for the audit process.

9.4.2 Writing a policy Statement (commitment)

Before contemplating an Environmental Policy statement it is essential to examine the Health & Safety Policy document. You should verify that the Policy Statement is personally signed by the

person at the top of the organisation. Too often (and this is especially true in the 'Public Sector' where Boards of Governors or trustees or whoever they may be) an unsigned general commitment 'on behalf of the Board' is found. This simply isn't good enough and ensures that, in fact, nobody makes that essential and personal commitment. It may also be illegal.

Here is a model environmental policy statement which meets the requirements of ISO14001

Solartherm Ltd Environmental Policy Statement

Date 01/01/2013

Next review date 01/01/2014

ENVIRONMENTAL POLICY

Solartherm Ltd commits to:

A policy of striving for environmental sustainability in all our business activities. We seek to achieve this by implementation of an environmental management system (EMS), using BS8555 (Project Acorn) as a phased approach towards ISO 14001 Certification. We will operate the EMS in tandem with our quality and health & safety policies.

We recognise the social and ethical importance of environmental best practice and will strive to achieve continual improvement in identifying our environmental aspects and minimising any adverse impacts which may arise from them.

Compliance with or exceeding legal requirements.

Review of purchasing practices and internal operations particularly including transport and energy to ensure best use of resources.

Reducing the creation of waste by the adoption of improved operating practices and by the recycling of materials whenever practical.

Ensuring all waste and effluent is stored, transported and disposed of in a safe and responsible manner.

Make this policy publicly available along with our achievements set against our objectives as defined in our EMS

The management of Solartherm Ltd. are totally committed to this policy and will provide all necessary resource, education and training for all concerned in the operation of its EMS.

Signed:_____

Toby Clark

Managing Director

Next is the structure - assess whether the organisation is in place (a management chart designating persons with responsibilities for OH&S) and whether the arrangements for carrying out the detail of the policy are realistic and in fact whether the functions are actually being carried through in practice. Note also that the Policy is a dynamic device and is the engine which drives the OH&S management system. It also requires that adequate resource is deployed in terms of:

purchasing OH&S equipment;

specialist consultancy;
training;
allocation of management time.

The next decision, which should only be taken after due consultation, is whether to write the Environmental Policy separately or as a SHE Policy. The latter is likely to prove the easiest and can fit almost seamlessly into the existing structure. Extra responsibilities within the line management must not be seen to simply fall as an additional burden on the shoulders of those currently dealing with OH&S matters. The extra time, physical resource and training must be written into the policy.

9.4.3 Systems for implementation (organisation)

An environmental manager should be appointed, with access to the top levels of the organisation in the same way that the OH&S manager should have. You should verify that the OH&S manager's position within the organisation structure is not in conflict with, say, the demands of production and that s/he can give professional advice directly to the company's executive. As small to medium sized companies (SMEs) now make up something like 90% of the UK workforce it is unlikely that a full time OH&S post will exist and it is frequently the case that environmental responsibilities will land on the same desk. The IOSH magazine 'Safety & Health Practitioner' carries increasing numbers of job advertisements for SHE Advisors. The Environmental Manager should have adequate professional training (as a minimum, IOSH 'Managing Environmental Responsibilities, IEMA Foundation, or equivalent).

Environmental functions and tasks should be identified and persons should be assigned to those tasks. The details should be written into the Policy.

Consultation structures which should exist already in the form of Safety Representatives and Safety committees should be extended to cover the environmental issues. Environment should become a standing agenda item for any Safety Committee, so that environmental issues enter the recording system and become actioned. A growing commitment and interest on the part of the Unions should be capitalised on.

9.4.4 Arrangements for carrying out the policy (training and resources).

The environmental manager will need professional training commensurate with the demands of the job. It is intended that this course will fulfil the training needs of a busy manager in an SME in order to cope with a new, part time responsibility, most probably grafted on to an existing OS&H role. Further professional development could be via the IEMA Certificate or beyond that as an element in a Degree or Post Graduate course, in any case, qualifying the holder to Associate Membership of IEMA.

It should be noted that IEMA membership is now about 10 000 by comparison to IOSH at 26 000, reflecting the professional status of these sister professional bodies (both now enjoying Chartered status (2005))

It is likely that the environmental manager will need to design and deliver basic training in house to raise the competency of both management and workforce to address the environmental issues at the practical level. The IEM Journal Vol3, Issue2, 1995 summarises the result of a series of workshops undertaken by its members and is worth studying by anyone about to embark on a training programme. Perhaps the most significant conclusion of the workshops was that formal classroom training was inappropriate in most circumstances but that an informal, participative approach worked better. Also that it was important to have an ongoing programme of training and action following on from it.

Resources will therefore be required for training, there will also be a need to purchase library material and systems to implement environmental management.

9.4.5 Monitoring and review (auditing)

The monitoring process is critical to any management system - if the Policy is the engine then monitoring is the transmission system. Monitoring:

gathers the required information;
builds a statistical base;
shows where you are;
shows up progress or its lack;
provides internal and maybe external verification of your performance.

We have distinguished between an Initial Status Review in which information is gathered in order to provide a starting point and a platform from which to launch the environmental Policy, and the Environmental Audit which is a continuous process – looking at all aspects of the EMS. Information gathered in the review, we note, helps to provide a benchmark for future audits.

Before developing an audit structure, careful planning should go into setting the parameters, there is a widely acknowledged danger that auditing for auditing's sake is likely to obscure the real value of the process and may distort the path of the EMS, the 'tail wagging the dog' effect (also a criticism of purchasing commercially available audit packages which are not 'tailor made').

The audit should be:

'a key part of the intelligent environmental management process - that is the process designed to deliver continual environmental improvement and benefit to the organisation'

see: IEM Journal Vol3, issue1, 1995 - the internal audit, making it work for your organisation'

9.5 Developing an Audit Structure

There should be a plan:

which details the individual audits;
schedules them;
establishes documentation (questionnaires, checklists);
sets up audit meetings;
circulates reports;
acts on non-conformances.

There should be a timetable:

which parts are to be audited when;
how frequently;
and by whom.

There should be procedures (which may link to other quality systems).
The audit cycle should be designed to focus on areas where problems are likely to be greatest using key performance indicators (KPIs):

non-conformances;
high environmental risks;
change.

9.6 Types of Audits

There are many different aspects of auditing. A representative sample of types follow:

Site audit - the buildings and activities on a given site. Buildings can be audited by Building Research Establishment Environmental Assessment Methods (BREEAMs), the intention being to optimise a given building's environmental performance. The audit includes options for development and change in use of the buildings. (Guidance notes are also available via the Royal Institution of Chartered Surveyors (RICS) which can help with many buildings' problems ranging over topics as diverse as timber treatment and asbestos). It is worth noting that Facilities Managers become critical participants (they also sometimes carry the 'environmental' tag for an establishment).

The overall aspects of site management will be found in the preliminary environmental review and have to be extended and tailored from there.

It is worth noting that the Eco Management Audit Scheme (EMAS) is site specific.

Compliance audit in which the environmental performance of the company is set against its legal duties. A good starting point here is its similar duties under Health & Safety legislation.

Pre-Acquisition audit - in which the pros and cons of a site are considered. The Environmental Auditors' Registration Association (EARA, now part of IEMA) developed to establish standards of competence for those carrying out environmental assessments.

Life Cycle audit - which considers a product lifecycle from the cradle to grave and assesses any significant environmental impacts at any stage. In applying for an Eco-Label, a manufacturer must show environmental best practice at all stages of product life. Life Cycle analysis is probably the most important long term technique currently being developed in which true environmental costs and benefits are assessed. It is dependant on the creation of a database of environmental effects.

Local Authority audit - the 1992 Rio Conference on Environment & Development under its Agenda 21 required signatory governments to produce local Agenda 21s and this has been implemented in the UK by requiring State of the Environment Reports and Local Authority Policy Statements.

9.7 Continual improvement.

Once an EMS exists and is being monitored, there should be a steady improvement in environmental performance, maybe following an initial larger gain as the 'quick fixes' are made. . If improvement is not being made, then the reasons should be sought with the intent to improve the scope and systems in place. It may be that resourcing is inadequate or focused wrongly. All EMSs, in principle, require measurable improvement year on year. Here we see the closing of the Management Cycle, the essential feedback of performance indicators to refinement of the system.

9.8 Environmental Management systems

Any organisation can devise an EMS and it will contain the essential steps of:

Initial Review
Environmental Policy
Implementation (resources, training))
Creation of Management system
Monitoring and Review

However, currently available are just two internationally recognised standards:

ISO 14001 (revised 2012) is a world-wide standard;
EMAS which is a European standard.

Similarities are:

there must be an Environmental Policy and a review of significant environmental effects;
there must be an effective EMS;
the EMS is robust to external auditing;
corrective action can be successfully applied where necessary.

Differences are:

EMAS is restricted to specific industries or sectors, ISO 14001 is unrestricted in any way, not by sector or size of organisation;
EMAS is site specific, ISO 14001 can be applied across a whole organisation and may be applied only to a particular function or sector of its operation.

also

EMAS requires a preliminary review
register of environmental effects
strict controls on contractors and suppliers.
an Environmental Statement which is:
a Specific Statement for each site;
validated by an external verifier;
addressing key environmental issues;
setting objectives and timescales for improvement;
containing factual information about performance;
made publicly accessible and written in simple language.

Verification of whichever EMS is used should be by a UK Accreditation Service (UKAS) accredited verifier.

The picture seems to be that of evolution. ISO14001 can be used to support EMAS Registration, however, it is rather different in itself. ISO14001 is seen as a management system intended to bring about business improvement. Environmental performance improves as a result. EMAS, on the other hand, focuses on quantified environmental improvement and the onus of proof to the (European!) world at large that this is so. Both systems facilitate international business enhancement.

9.9 Project Acorn – a Phased Approach to ISO14001 Certification.

Designed to be used friendly for SMEs and managed by IEMA as the Competent Body enables companies to progress towards ISO14001 at a pace they can comfortably manage. IEMA have a downloadable introductory guide (Acorn Performance Leaflet).

Phase 1: Commitment and establishing the baseline.

Write Environmental Policy Statement and have it signed off by the CEO, determine compliance by using a NETREGs questionnaire, carry out an Initial Status Review and from this draw up an Aspect Register.

Phase 2: Identifying and ensuring compliance with legal and other requirements.

Further compliance checks, obtain copies of permits etc, use the aspects to make a list of significant impacts. Get a site drainage plan!

Phase 3: Developing objectives, targets and programmes.

Make calculations of the impacts and use to set objectives and then (SMART) targets.

Phase 4: Implementation and operation of the environmental management system.

Develop operational roles and responsibilities, committee (can be part of a Safety Committee), assess training needs. Set up procedures, including emergency procedures.

Phase 5 : Checking, audit and review.

Impact assessment is an iterative process, hence should be included in the system audit.

Phase 6: Environmental Management System acknowledgement.

ISO14001 accreditation.

In July 2009, there were 272 participating companies, most had registered at Phase 3 – by which time most of the initial work had been done, some registered at Phase 1- as a means of showing that they were 'working towards ISO14001' and thus being able to give an acceptable response in tender documents, almost none at stage 2 or 4. None registered at Phase 6 because it is simpler to go directly to ISO14001.

The direct cost is approx. 1 day's consultancy per Phase. It is, of course, possible to follow the phases without external certification!

9.10 Case Study 1 – the foundry.

The foundry made aluminium and ferrous castings, operating from a mature site which had expanded somewhat haphazardly up to its physical limits. The Safety Advisor was interested in promoting an EMS and called in a consultant to assist with an initial status review. The consultant helped to set up the Environmental Policy, a compliance assessment and the development of an aspect register. He was concerned at the large amount of materials, especially liquid chemicals stored on site and suggested a review – and that a drains plan be obtained.

One week later, a tanker driver arrived to deliver a consignment of flammable resin used in the sand casting process. He was told to deliver into one of two tanks and due to lack of supervision began to discharge into the wrong one which, alas was not bunded. Shortly after pumping began, the tank overflowed and then failed catastrophically, dumping 20 000 litres into the yard.

The Safety Advisor instructed the maintenance team to shovel casting sand into the drains and organised the tanker driver to begin recovery using a low-level strainer. Due to fire risk, the Fire Brigade were asked to attend, they followed procedure and called in the local Environment Agency officer. On attendance, his first act was to ask for a site drainage plan (which had been obtained only two days before!). As a result the foundry management were commended for their prompt and efficient emergency response! During the incident, the local newspaper phoned in and the Safety Advisor was able to tell them that, yes, they had an environmental emergency but that the EA had commended them for the effective operation of their emergency plan!

The 20 000 litre tank was written off but in the meantime production resumed from two IBCs, a tenfold reduction of inventory and this arrangement became permanent.

The Safety Advisor was promoted!

9.9 Environmental Statements

You can obtain copies of Environmental Statements on request from the larger Corporations. BT, the Water Companies, the Power Industry, especially British Nuclear Fuels Ltd., and the Retail Conglomerates. They can usually be accessed on the internet.

Two examples are given here, illustrating opposite ends of a spectrum.

Bryant & May, match manufacturers produced an A5 illustrative booklet (from 2 x A4 folded sheets) called 'A Match For The Environment', claiming to use a 'Green Check' standard against which to consider the environmental impact of its products. It considered only the matches and the boxes into which they are put. However it is informative and well written, though it does not quantify its statements.

BT's Environmental Performance 1995/6 is a 44 page A4 booklet with an A3 fold-out inside the front cover which summarises the Company's environmental effects. It is very detailed and comprehensive and its content has been independently verified by external auditors. There is insufficient space here to do more than point to it and you are strongly advised to apply for a copy for yourself to:

BT Environmental Issues Unit
Room 103
Proctor House
100 - 110 High Holborn
London WC1V 6LD
or on the internet at: http://www.bt.com/home/corpinfo/enviro/

There is, sadly, a ‘feeling’ that BT has ‘done’ the environment and moved on. Its environmental reports around 2002/4 were exemplars of good practice.

UNIT 10 INDUSTRY SPECIFIC ISSUES

10.1 Construction.

The Construction Industry probably has it all from the perspective of environmental problems. It is useful to consider that the same could be said for health & safety issues and that the industry had imposed upon it the Construction (Design & Management) Regulations (CDM) in order to try to improve its notoriously poor performance record. The basic thrust of CDM is to try to improve performance by raising the profile of health & safety matters, and it also encompasses environmental issues which is our particular interest.

CDM requires that:

health & safety and environment are considered at the design stage of any significant project, including such matters as choice of materials;

it is allowed for in the planning process - there must be a pre-tender plan, a construction plan and finally a safety file to be handed on to the client which will permit 'she' issues to be managed from the 'cradle to the grave' of the project. Demolition needs to be included!

Relevant also will be the need for an environmental impact assessment for any large or environmentally sensitive project such as a town-centre redevelopment or bypass road.

Construction meets environmental issues as it proceeds through its various stages. As it starts on the ground, usually, then the question of the status of the land is immediately relevant. It is frequently the case that land contamination will either be known to exist or be found on opening up the site in accordance with govt. policy to develop ‘brownfield’ where possible. Problems really become difficult if remediation has not been allowed for in tendering. Contaminated land presents many problems including;

disposal of contaminated soil;

toxic problems arising when it is disturbed - presenting environmental risk of leachate, dust or other nuisances and also health & safety risks to the workforce and possible local residents;

measures to encapsulate or confine contamination

gas emissions (methane is a common example, typically arising when construction occurs on or near old landfill sites).

asbestos which often is found buried and creates major management problems if it then has to be disturbed or, worse, is found as a result of groundworks. Digging up unexploded bombs is comic relief by comparison.

Thus, proper management of contaminated land can have a major influence on the success of the works. An environmental assessment should be carried out if problems are likely. Also, construction works themselves may cause land contamination. For example, at the Bluewater Park site in Kent, the site is an old chalk quarry and the chalk ground beneath it the catchment for a Grade 1 aquifer, i.e. it is abstracted for potable purposes. Such a sensitive (and extensive) site receives close attention from the Environment Agency and is subject to strict local controls, especially over spillages. Control of chemicals and fuels, bunding of all quantities, no matter how small and minimisation of inventories are all essential control measures. Non-conformances on a high-profile site such as this are difficult to get away with and could attract serious penalties from the enforcing authority - including remediation costs!.

Where there are special environmental risks there must be adequate emergency plans to deal with them. The most obvious are those arising from spillage of chemicals or oils (the dumper fallen into the river syndrome) and firefighting runoff water. Occasionally construction operations require the use of pesticides (treatment of dry rot for example) and these require special handling under the COSHH Regulations anyway, but specifically under the Pesticides Regulations (controlling use and types permitted) and subject to an emergency plan for spillage and safe disposal of waste pesticides. It is worth noting that site inductions which normally cover health & safety matters can be extended to basic environmental issues and hope to prevent, by education, such practices as discarding paint residues to ground or the sewage system (or worse, to storm drain).

Vehicles move large amounts of materials to and from sites and these will range from visitors' cars to all kinds of heavy vehicles and plant. Wheel washing is likely to be specified by the local authority in order to protect the public highway - a wheel wash plant usually comprises a ramp and washing system, either sprays or more simply by driving the vehicle through a pond. The wheel wash plant must be cleared of soil periodically and this is either redistributed on site or sent to landfill. If it is used as a contaminated land control measure then further treatment will be needed and maybe the residue removed as special waste. Water is usually settled and recycled or run to foul sewer.

There should be robust security - if a site is left unattended then it must be securely fenced (2.4m high). Solid boarding is adequate for most purposes and has several other advantages in containing noise and dust and generally reducing the profile of the works. Wire mesh in prefabricated sections, such as Heras fence is increasingly used in mobile situations like roadworks and should fulfil legal requirements to secure a site, so far as is reasonably practicable. Trespassers on site may create vandalism and create environmental contamination. Storage tanks should be secured, usually by locking off outlet valves. IBCs (Intermediate Bulk containers are an industry standard. Plastic containers of one m3 capacity (i.e. one tonne at nominal density of 1, same as water) are especially vulnerable to tampering and vandalism and can cause serious pollution if damaged.

Heavy vehicle movements cause noise, dust and fumes. Depending on the sensitivity of the neighbourhood, restrictions in the form of an injunction can be placed by the local authority to limit the hours for delivery and also for working on site. Under the Waste Management Duty of Care, site waste must be secured so as to prevent it escaping and this usually means sheeting or debris netting covers. Where practicable waste should be segregated into hard-core, active and special and skips need to be clearly delineated as to purpose. They will also need to be covered and the use of a properly managed chute system can do much to limit dust. Wetting down may be needed, especially during demolition works. Figure 10.1 illustrates a typical waste disposal system. Special arrangements will be required if asbestos is involved.

Fire in construction materials is currently an issue and the Fire Protection Association has recently issued advice on firesafety in construction. It contains the usual sound advice on escape routes, extinguishers and housekeeping. Fire is of obvious environmental significance and siting of materials safe from vandalism is part of a security management system. Burning of rubbish is to be discouraged and is only justified in destroying infected demolition timber - it should only be done if safe and under direct, competent supervision and then taking note of possible nuisance considerations. Plastic and other noxious waste should never be burned, it causes severe air pollution and may burn so fiercely it gets out of control.

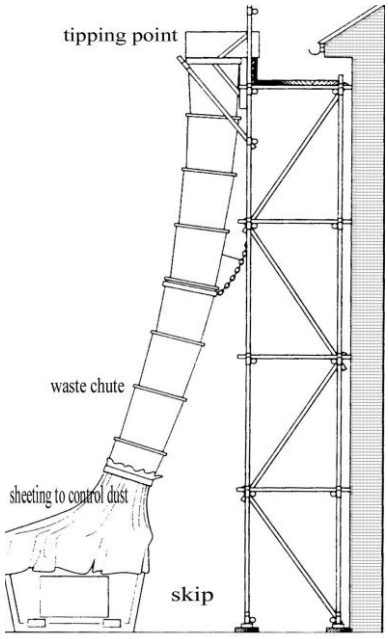
Environmental noise is a complex matter, requiring both specialist equipment and specialist training to be able even to monitor accurately. Good, common sense controls can go far to minimise noise. Construction equipment such as ground breakers can be purchased with mufflers (affording benefit to the noise-exposed workforce also). Noisy woodworking machines can be located sensitively to the site boundaries and the rest

of the works. Sometimes working methods can be changed or materials purchased requiring less cutting operations (using angle grinders to cut curbstones might be a case in point where more careful purchase of sizes could reduce the need). Prefabricated sections can sometimes be bought in complete. In some cases, unusual solutions may be imposed, for example, sheet piling at Mogden sewage works had to be done quietly with special equipment which slowly pushed them in rather than by the usual piledriver.

Worker noise, especially portable radios, should be controlled - it is not automatically obvious to operatives that they are audible to the public on the other side of the fence.

And plant should not be left on needlessly at night. The droning of fans, whirring of pumps and even the glare of site lights can be disturbing long after the works have shut down. Also, alarms from vehicles and unattended buildings are subject specifically to restrictions under the Noise Act 1996.

Construction noise is regulated under the Control of Pollution Act (COPA) 1974 and codes of practice established thereunder, usually known as 'section 60' under which a notice imposing controls may be served by the local authority (who is deemed to be the best judge of what is required). Except that works done by statutory undertakers is generally deemed to be of an emergency nature and is exempted.



Disposal of construction waste

Site Waste Management Plans

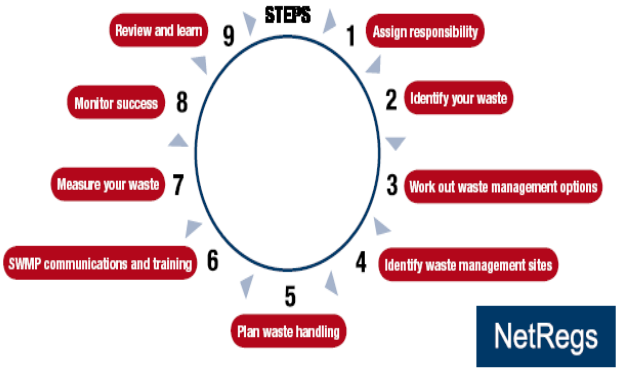
The Site Waste Management Plans Regs. 2008 require that for any project costing over £300 000, a plan is mandatory. Construction is the biggest consumer of material resources: 420 million tonnes/year *As of Jan 2013 the UK Government may scrap them but SWMPs are a good practice anyway and a reputable company should always have one in place*

Produces about 150 Mta waste:

ca90 Mta construction and demolition waste
ca2m Mta production and packaging waste
ca59 Mta quarry waste
10% wastage rates - unused building materials
26% of waste is packaging
Void space is 40% of skips

Cost of a skip has been variously estimated between about £1300 - £2000 – breaking down into Skip Hire, landfill tax, labour to fill it and wasted materials put into it

The duty falls on the Principal Contractor and the plan must be in place before the project starts.



10.2 Agriculture

Agriculture should be considered as land-based production industry. It uses large amounts of materials over large areas and long time spans and has the potential for both acute pollution episodes and long term environmental degradation if it is improperly managed.

As treatment is applied to the land, its consequences inevitably and often rapidly impact on the water system and it has been the NRA and MAFF (Now within the EA and DEFRA) together who have traditionally controlled farming practices. Advisory leaflets are available, including management of pesticides, fertilisers, silage, slurry and how to establish a farm management plan.

Fertilisers are of two main types, inorganic in the form of nitrates and phosphates and organic in the form of manures. All fertilisers will encourage algal growth and cause eutrophication of surface waters, manures have a BOD, thus will deplete oxygen in watercourses as well as encouraging algae and may also increase turbidity. Nitrates in groundwater may be a particular problem, they are toxic, persistent and difficult to remove. There are no benefits from over-nitrating of soil, though spreading of organic manures improves soil texture and cannot really be overdone as long as runoff is considered. The limit to application rates in sewage farming is imposed by toxic metal build-up in the soil. Good husbandry, avoiding over-application and overspray at the edges of fields, noting weather conditions and the likelihood of flooding (which will mobilise the fertilisers to unwanted places) requires skill and empathy with the land.

Herbicides and pesticides should be used to a minimum and under strict controls. The usual and obvious criteria of knowledge, training, and careful application are of paramount importance in their use. The use of crop rotation, mixed rather than monoculture and such methods as control by predator species should be used in a holistic land management programme. The approach should be when using pesticides to only spray when needed (not as a routine precaution) and then early in an outbreak when less need be used to gain control. Less environmentally harmful agents should be used where this is practicable and only approved pesticides should be used. Pesticide residues, contaminated materials and old stock should be properly and safely disposed of. A BBC report (Sept 2005) claimed that 2% of 2500 randomly chosen fruit & vegetable products contained residues greater than the legal limits.

Silage is chopped grass and molasses mixture which is fermented into cattle feed. It may be prepared and stored in dedicated silos but it is commonly seen under large plastic sheets, held down by old tyres. Silage produces a dark liquor with an enormous BOD, it is many times worse than sewage and leachate must not be permitted to overflow on to the land. The silage heap should be set on a concrete apron with adequate drainage control. Properly managed, it doesn't have to create widespread and offensive odour.

Slurry is created by cattle. A typical milking shed may handle 150 cows, twice daily and produce a layer of thick slurry over the whole floor area. This is often scraped into deep slurry pits and allowed to ferment until it is relatively innocuous when it can be spread on the land. This process is the same as sewage sludge digestion and the methane so produced is sufficient in quantity be used to run the farm's heating and electrical requirements.

Fuel oil is supplied as low cost 'Agricultural diesel'. It should be stored in a secure and fully bunded tank.

Housekeeping. Like any other industry, the general state of the workplace is a good indicator of its management style. Old and decaying farm machinery becomes dangerous and a source of contamination as its operating fluids seep out. Rotting waste may contain weeds and pathogens

which will spread across the land. Blocked gullies and ditches encourage stagnant water which rapidly becomes anaerobic and putrid. Farmyards that are deep in septic manure are unhealthy for animals, man and the environment alike. Piles of rubbish are unsightly, they are often 'mini-landfills' and have all the environmental problems associated with them. Decaying and unsafe outbuildings should either be secured or demolished. Old bales of hay, grain, sacks of fertiliser etc. which tend to accumulate in such places are liable to spontaneous combustion and should be cleared out.

Agricultural practice is inevitably linked to the requirements and aspirations of society. We seem to have passed through a stage where farming was simply food production and resulted in inhumane intensive methods, exemplified by the battery chicken (Debeaked to stop it pecking itself to bits, laying an egg a day for 300 days, by then up to 15% of them lying dead in the cages). Concerns are being expressed over the routine use of antibiotics to increase yields and protect animals from the greater risks of infection brought about by intensive breeding. It is known that overuse of antibiotics breeds resistant bacteria and creates 'superbugs' a worrying example of this being tuberculosis - some strains are only controllable by one known antibiotic and we have no backup if that fails.

The wholesale grubbing out of hedgerows to facilitate huge acreages of monoculture has had disastrous consequences in loss of species and their habitats, soil by wind and water erosion and has completely changed the character of the countryside. The forestry commission practice of using powerful tractors to plough straight furrows across peatlands, turning it on to itself to create drainage ditches and planting conifers on top of the rows has also had serious environmental consequences. A man described what was done to an SSSI near to his home in rural Wales.

'The trees are grown closely together so that they bolt for the light and are fit only for fence posts and paper pulp for tabloid newspapers. The land is physically impossible to cross and the plantations are at serious risk from fire in summer. Water retention by the peat layer is disrupted so badly that rivers which used to take a day's heavy rain to respond to, rise dramatically in two hours and soil erosion is accelerated. The plantation drains on to arguably the best waterfall scenery in the UK. Now as you walk along the gorge in wet weather you can see the regular spouts cascading over. It will ruin it eventually.'

An extreme view, perhaps but illustrates the point that the land should be seen as a resource for all stakeholders and managed in the same sort of way as water catchments are. It is encouraging to see that efforts are now being made, perhaps in response to such criticisms, to make the forests of the future more varied. The Kielder forest is a good example (the Pennine Way passes through it). Informative notices explain about the plantations, why sections are cut down, the age and type of trees being planted and so on. Various deciduous trees are being planted, open spaces are being created and varied habitiats encouraged including ponds. Public access is encouraged and nature trails exist.

Organic farming methods are increasingly being used and a somewhat different approach to farming is required. It is very much going back to pre-industrial methods in which crop rotation and natural controls are used. Animals are used to provide manure so it tends to be mixed farming. Pesticides and inorganic fertilisers are not permitted - indeed the land must be declared free from such for two years before produce can be sold as 'organic'. It is a premium product, requiring more labour intensive production and yielding generally lower crop yields and thus is more expensive to buy but it is perceived by many as being the way forward, in harmony with the environment.

Food Security.

Defra has published a UK Food Security Assessment which is available as a pdf download. It concludes that:

"*The Strategy Unit report, Food Matters, concludes that "The principal food security challenge for the UK is a global one", and it warns against taking an isolationist approach. Defras July 2008 paper Ensuring Food Security, echoes this: "Global food security is important for the UK because, ultimately, global stability depends on there being enough food in the world to feed everyone and for it to be distributed in a way that is fair to all." Sufficient global food production is a precondition for global food security.*

There is also a website (http://www.foodsecurity.ac.uk) which states:

'The UK's main public funders of food-related research and training are working together through Global Food Security to meet the challenge of providing the world's growing population with a sustainable, secure supply of good quality food from less land and with lower inputs'. Without actually stating who they are!

10.3 Healthcare Sector (National Health Service)

At first glance the National Heath Service (NHS) may seem to have very little or negligible environmental impacts. However

If it is considered that:

the UK NHS is a £20 billion per year business;
a typical hospital has all the services of a small town, including bus, road and possibly rail links;
It can have 5000 (or more) staff working or visiting a single site;
It can have as many as 10,000 visitors, day patients, emergency cases via ambulance and reporting to Accident & Emergency, suppliers, contractors, deliveries and collections;
Substances that cross the boundary of a hospital can be very toxic, infectious or even radioactive.

So it can be seen that hospitals have the ability to make significant environmental impacts on the local environment and surrounding communities.

There are few details currently available in relation to the environmental performance (or lack of it!) in the NHS. One of healthcares' major objectives is the improvement of the health of the population, so with this in mind it is a complete contradiction for hospitals to pollute the environment leading to a deterioration in public health or the unnecessary waste of resources.

Hospitals can affect the environment through various media and some are outlined below.

Emissions to Air - Typically arising from boilers (smoke stacks) for heating and in some hospitals incinerators for clinical waste disposal. Many of these facilities may have suffered from a lack of investment over a long period of time and, as a result, may not be able to meet emission standards.

With ever more stringent emission standards coming from Europe there is pressure through out the NHS to upgrade to modern Combined Heat and power (CHP) - technologies that are environmentally friendly and cost effective.

Vehicle/Transport issues will be dealt with in more depth later. Suffice to say that moving services within a region will increase exhaust emissions by causing more travel between sites for the staff, public and others.

Discharges to Drain - The average Hospital uses vast quantities of water daily. Washing/bathing of patients, flushing of toilets and use of bedpan washers (which pulp waste), cleaning of the wards etc, heating often steam and water. Water is also used in laboratories, the mortuary and in various

processes such as washing surgical equipment from theatres. The list is almost endless. In addition some hospitals still have their own laundry facilities and all this water goes down the drain often with no thought of reducing its usage!

Water saving projects like the 'HIPPO' (or brick!) in the toilet cistern, decreasing flow rates at all taps etc. can help reduce water usage. Thought should be given to the volume of cleaning fluids tipped down the drain and the use of bio-degradable detergents considered. Often chemicals are discharged directly to foul drain. This is particularly so of chemicals used in, for example, the processing of x-rays. Prior to discharge the silver content (from the film development phase) must be removed from the solution and recycled.

Hospital laundries have their own problems, not only in the use water but the discharge of chemicals to drain. The major chemicals used in a laundry are chlorine (from bleach) perchloroethylene, hydrogen peroxide and possibly 1,1,1trichloroethane (a COSHH Assessment will also need to be carried out as they all have Occupational Exposure Limits which can be found in HSE guidance Note EH 40)

Checking the particulars of the 'Consent to Discharge' with the local water company is of vital importance. Some of the processes mentioned may not pose a threat to the environment due to the small amounts in solution after dilution, but it is better to check.

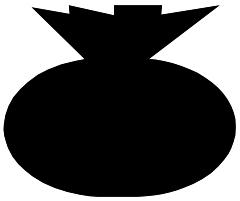
Wastes -There are various waste streams in a hospital. Figure 1 illustrates them. It is imperative that waste is sorted into the correct 'stream' at the point of creation.

Clinical Waste is very expensive to dispose of, so putting non-clinical waste items in yellow bags just doesn't make ecological or economical sense as it increases the volume for incineration, hence cost. Refer to unit 4 section 4.3.2 for further details. A low-cost method of disposal is to microwave heat clinical waste to pasteurise it so that it then can be disposed of as ordinary black bag controlled waste.

Black Bag waste goes straight to landfill via the local council collection service. For the recycling of paper and cardboard, using a compactor reduces volume in storage, and hence costs on collection (frequency). Also the re-use of packaging for out goings will help, duties imposed by the packaging regulations have made some in-roads in this area.

Hazardous Wastes arise out of the disposal of Cytotoxic/out of date drugs. Good stock control will help reduce this problem. However it will not stop patients handing in partly used drugs for disposal by the hospital. The disposal of Mercury (from broken equipment e.g. old Sphygmomanometers) is another special waste area. Procurement polices to phase out mercury by purchasing only non-mercury products/equipment is one obvious way of eliminating this problem (e.g. digital thermometers are available as an alternative to the traditional mercury-in-glass thermometers and have the additional advantage that they are robust and will not produce dangerously sharp fragments if they are broken).

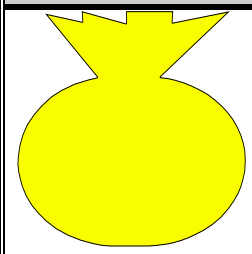
BLACK PLASTIC BAG



NON-CLINICAL WASTE

Paper, hand towels, boxes, flowers, office waste and waste from catering departments.

YELLOW PLASTIC BAG



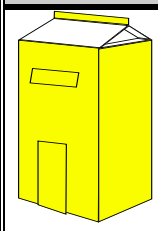
CLINICAL and THEATRE WASTE - NO SHARPS

Foul waste, nappies, dressings, drainage bags, laboratory waste (after autoclaving).

Clinical waste bags must be tied using numbered security seals to allow identification of source.

NOTE: All ties for bags will be coded for audit and tracing purposes

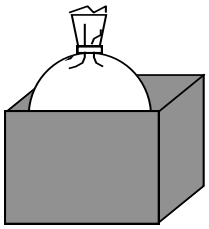
DESIGNATED SHARPS BOX



SHARPS DISPOSAL- with Clinical Waste

Needles, blades, glass ampoules.

ANY CARDBOARD BOX LINED WITH CLEAR PLASTIC BAG



*Tins, aerosols, glass

*Tins can be compacted and recycled

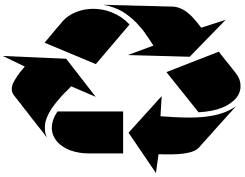
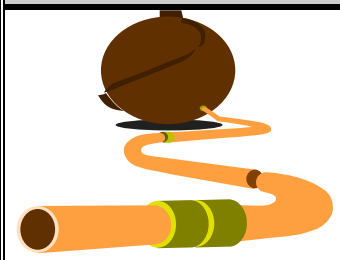
CARDBOARD BOXES, PACKAGING (FOR COMPACTOR) AND PAPER	
	All cardboard and packaging, paper
SPECIAL WASTES	
	Cytotoxic / out of date drugs, Mercury, Batteries etc Mineral/other oils and waste chemicals, asbestos from works and other departments

Figure 10.4 ; Typical Waste Streams in a Hospital

Lighting - The fitting of low energy bulbs/tubes on a renewal basis is one very cost effective option, as are regular campaigns to 'switch off' unnecessary lighting or have timed lighting systems on stairs and proximity lighting in outside areas.

Electricity - Lighting has already been mentioned and switching off unused electrical equipment and awareness campaigns can help reduce usage during and outside office hours.

Heating - This is very much linked to the choice/source of the heating system. Converting boiler systems to be 'duel fuelled' e.g. gas and/or oil, will allow savings to be made by choosing the cheapest fuel option available. Bulk oil deliveries and tank storage should be looked at in detail and appropriate bunding , safe systems and maintenance of existing storage tanks should be taken into account.

Transport - Hospitals, like other business sectors are in the process of merging, often encompassing very large geographical areas. These increased catchment areas and the moving of essential services within them will have the knock-on effect of more travel by the public, staff, and others. Local councils and their Agenda 21 issues will need to be addressed and the strain and possibly costs on parking in hospitals will increase especially if parking space taxes are brought in by government.

Land Management/Contaminated land - Hospitals are constantly refurbishing, upgrading or expanding their facilities. With a large proportion of hospitals built around the fifties and sixties, or even earlier, asbestos and the associated problems/costs of removal/disposal are pertinent. Hospitals are required to keep an up to date 'Asbestos Register' of known sites with asbestos in them thus ensuring employees and contractors are warned when carrying out works.

Systems and procedures to check for contamination of land in any proposed expansion or acquisition should be in place, and of course should land be sold off to raise capital - given that the polluter pays for any contamination!

Procurement - This is an area often ignored, but making it policy that you select your suppliers and contractors for their environmental credentials will help drive environmentally friendly/ethical processes down the supply chain. An example is Quality ISO 14001 - only doing business with those who are conforming to a known environmental standard.

Management Systems - The NHS is beginning to wake up to the benefits of managing its environmental impacts by the launch of 2 documents:

'*Strategic Guide to Environmental Management for chief Executives and General Managers' demonstrating that environmental management within the health service is government policy*

'*GREENCODE' is an environmental management system developed by the NHS in Scotland and Northern Ireland. Greencode systems are compatible with ISO14001 and are seen as a step on the road to its implementation. Greencode concentrates on developing and commonising the process of initial review for the hospital sector where it is seen that much management time will be required. By producing a computerised system, the review can be carried out easily in a structured way, at a fraction of the effort required if a hospital management starts from scratch and it will create an audit structure within which the EMS can be developed*.