The Earth in our hands

- how geoscientists serve and protect the public

Photo: Jeremy Joseph

9 LANDFILL & WASTE

About these briefings

The Earth is a dynamic planet. It is active and productive, offering humanity enormous opportunities. However, living on it also presents us with many dangers; some of our own making.

In our interaction with the Earth, geoscientists are in the front line. They seek and find the raw materials we use for agriculture, roads, buildings, energy, water supply and all the industries that provide wealth and health.

Geoscientists help society understand natural hazards and mitigate their effects. Such dangers include floods, landslips, volcanic eruptions and earthquakes.

Geoscientists also help to minimise hazards we have created (or made worse) by our activities. These include subsidence, and the disposal of waste.

With their unique understanding of the immensely long time spans over which Earth processes operate, geoscientists help communities world-wide to learn how to use the planet's resources safely, wisely, and sustainably.

This series of information sheets is dedicated to bringing this role to public attention.

Further information

Web sites

http://www.iwm.co.uk The Institute of Waste Management is the professional body for the wastes management industry.

http://www.environment-agency.gov.uk The Environment Agency for information on national and local issues regarding landfills and pollution.

http://www.envirolink.org A US-based site with useful links to environmental groups worldwide, news items and bulletin boards.

http://www.nrf.org.uk National Recycling Forum for information on recycled products.

http://wastewatch.org.uk The national charity promoting waste reduction and recycling. Provides information and free books along with information sheets for adults and senior school students, and activity packs for teachers and primary school children in English and Welsh tel 020 7253 6266.

Publications

Reuse, Repair, Recycle by Jan McHarry (Gaia Books Ltd.) A practical book with ideas and action on what you can do at home, school or work.

Making Waste Pay - A Landfill Case Study. Earth Science in Everyday Life. A/AS Geology, Geography, Environmental Sciences; Key Stage 4 Science. Joint Earth Science Teachers' Association (ESTA) and Geological Society leaflet written by Peter Kennett. Available from the Geological Society **http://www.geolsoc.org.uk**

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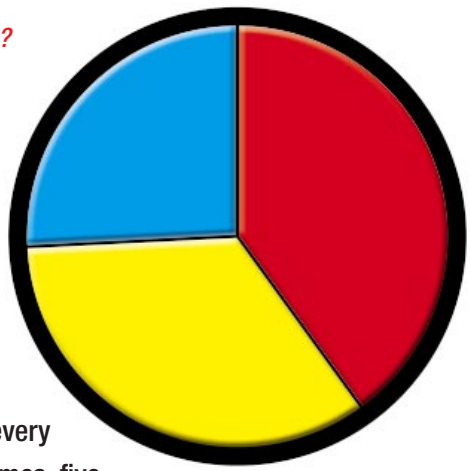
Introduction

Human society, like everything else in nature, has always generated wastes and will continue to do so. Every process, domestic, industrial, extractive or agricultural, generates waste in one form or another.

Fig. 1 - Where does waste come from?

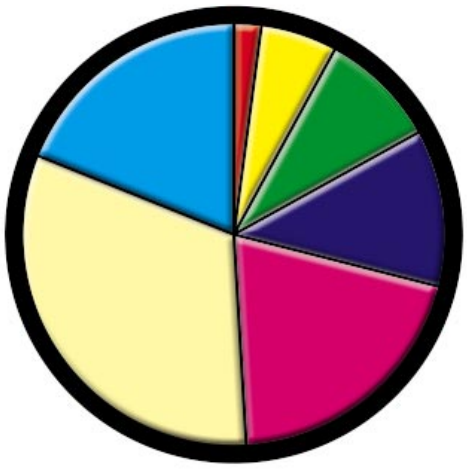
- 40% construction wastes
- 34 % industrial wastes
- 26 % household wastes



The UK produces 27 million tonnes of household wastes each year. For every tonne of waste we produce in our homes, five tonnes have already been created at the manufacturing stage and 26 tonnes at the point where the raw material was extracted.

Fig. 2 - Contents of the average dustbin, by weight.

- 2% textiles
- 6% metal (cans etc.)
- 9% glass (bottles etc.)
- 11% plastic
- 20 % organic wastes (waste food, garden rubbish etc.)
- 33 % paper and card
- 19% miscellaneous waste (rubble, cinders etc.)



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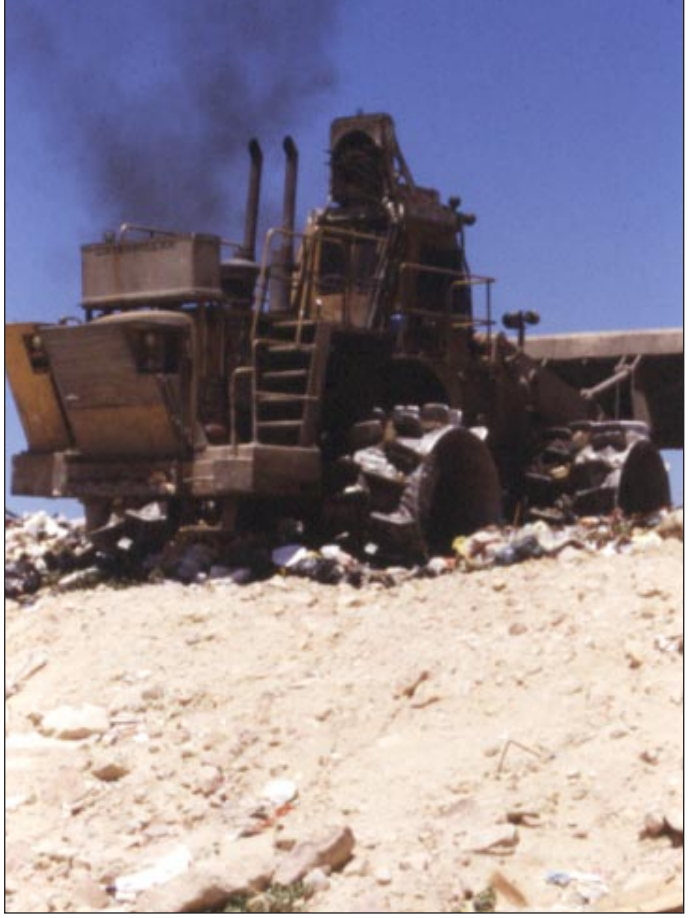


Waste disposal

Groundwater, rivers, lakes and seas are the ultimate disposal sites for much of our wastes, as is the atmosphere. Wastes must be managed if we are to avoid unsightly, odorous and potentially dangerous accumulations that would be harmful to us and to the environment.

Only 9% of domestic wastes in the UK is recycled. The rest is buried (shallow disposal) as landfill (in engineered landfill sites, e.g., in natural hollows and features in the landscape, or disused quarries), or in some cases, burned (incinerated or pyrolysed).

If buried, domestic wastes degrade to produce liquids and gases; if burned, they produce ash and gases. All of these have some potential to pollute the air and water. What is left - the inert solid residues - may be toxic.

In order to manage wastes we need to understand the environmental hazards they pose during collection, storage, transport, treatment and disposal, and to be aware of the options available for their minimisation, recovery, re-use etc.

Although a variety of adverse health outcomes have been allegedly linked to landfill disposal operations in the media, no causal relationship has been identified. Landfill remains an internationally recognised and established method for the disposal of wastes and a useful tool in their management. It is very important, however, that landfill sites are designed, managed and operated in such a way as to minimise their potential effects on health and the environment.

'The UK produces 27 million tonnes of household wastes each year. For every tonne of waste we produce in our homes, five tonnes of wastes have already been created at the manufacturing stage and 26 tonnes at the point where the raw material was extracted.'

The role of the geoscientist

Elements of geology and hydrogeology are essential to the development, management and regulation of landfill operations, especially in deciding on where they are built and how (location and construction).

Location

To identify a location, geoscientists must understand the local rock and soil types, and their disposition and structure. Porosity and permeability of the local rock is clearly a vital factor in a site's suitability. The ideal result is to keep any pollution and contamination to a minimum for as long as the waste presents a hazard - which, even for normal wastes, may be hundreds of years.

Where possible, sites will close to where the waste originates and inexpensive to engineer, such as:

- abandoned quarries, disused brick pits and gravel pits
- low value land

However, the tendency in recent years has been for a smaller number of larger capacity sites to be built - some many miles away from the waste source - involving a lot of waste transport. Low value land is becoming more difficult to acquire.

Construction

Once an appropriate site has been found for landfill, the engineering construction of the site can begin.

Geotechnical engineers and hydrogeologists will advise on:

- landfill settlement
- site geometry (shape and drainage)
- the effects of rainfall and evaporation
- potential gas generation and emission
- leachate management (extraction/circulation)

An appreciation of the hydrologic (water) cycle and of groundwater flow patterns in rock formations are also relevant.

The geological environment strongly affects choice of design and decisions regarding the best construction options for the landfill - for example:

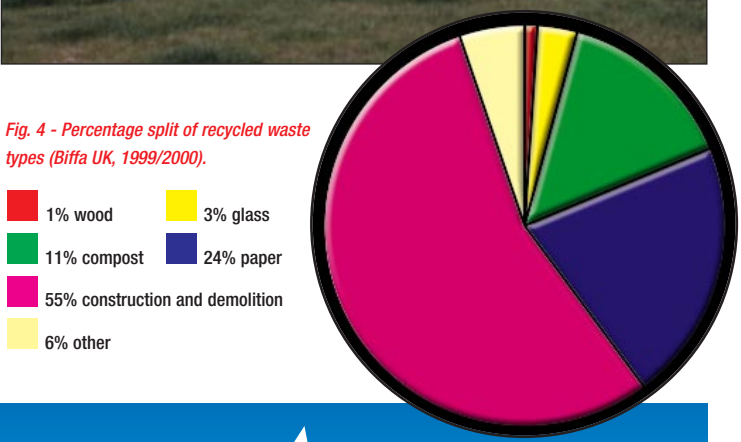
- whether there are suitable materials within the site that can be used in the construction (e.g., clays for liners or gravels for drainage)
- how best to use containment structures such as mineral lining (e.g., layers of compacted clays)
- which artificial barrier systems to use (such as welded, thick polymeric geomembranes).

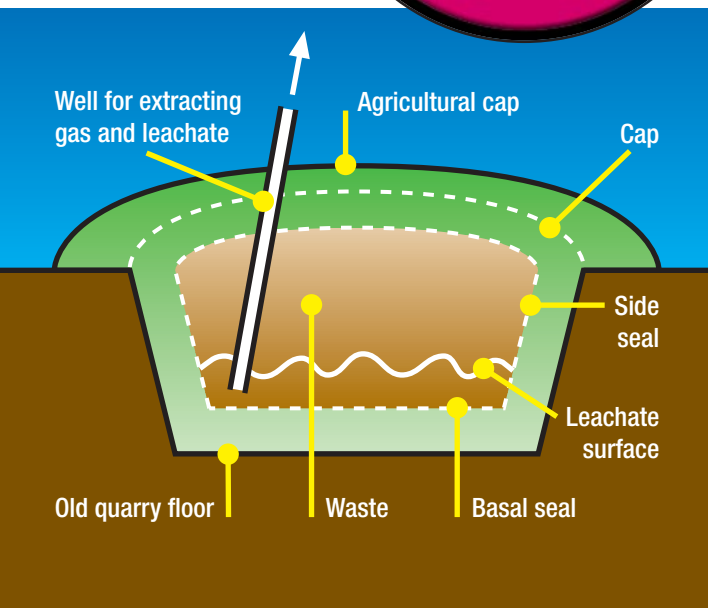
Liners and containment layers are used to prevent leakage. They must provide a high level of containment, be strong and flexible enough to resist damage during construction and operation, and should last for as long as there is a pollution risk. They should combine durability, relative impermeability, flexibility and strength.

Fig. 3 - An idealised cross-section of a landfill site. As wastes in a landfill decompose, contaminated leachates are generated as rainfall percolates through the site. These are collected by a drainage blanket above the landfill liner system, from where they can be pumped for treatment and disposal, or recirculation, during which biological degradation of the leachate takes place.

Restoration of landfill sites to farmland (below), woodland or recreational use also benefits the environment, and is, in essence, the recycling of land. Photos: Jeremy Joseph.

Fig. 4 - Percentage split of recycled waste types (Biffa UK, 1999/2000).





The future

The Government has a formal regional framework for the management of wastes, with implications for planning, regulation and resourcing.

Minimisation, reduction, recycling

One of the keys to a healthier, cleaner and more sustainable environment is to minimise and recycle wastes wherever possible, i.e., to make use of any potential that they have as a *resource*. Although waste minimisation and recycling are beneficial to the environment, there will always be waste that cannot be recycled.

Techniques now exist to separate, crush, distil, burn and biodegrade waste in order to re-use it or reduce its mass. Although it leaves the amount of waste unchanged, *waste reduction* reduces its volume: e.g., by using shredding, granulating, compacting and crushing machines for tyres, paper, cardboard, plastic, wood, builders' rubble etc. *See Fig. 4 - Percentage split of recycled waste types (Biffa UK, 1999/2000).*

Recovering energy

The number of new landfill sites is strictly controlled. Waste disposal in landfill sites, even though indispensable, is increasingly perceived as environmentally detrimental, and will be affected by the European Landfill Directive, which will require pre-treatment of wastes prior to landfilling. Some facilities will burn waste to produce energy.

Picture, left: Methane and other gases formed by the decomposition of wastes in landfill sites is now generally collected and re-used to generate electricity.

Environmental impact

Geologists are involved in assessing the environmental impact of landfill sites and waste disposal, both short and long-term. Environmental monitoring (including monitoring the rate of decomposition) is essential to minimise and manage any potential environmental impact.

The long time scales that geologists deal with - often millions of years - enable them to advise on rates of geological processes that may affect the environment in and around landfill and disposal sites, to achieve the best practical environmental option - even over much shorter, human, time scales.

The migration of leachates (the liquids produced in landfills as a result of the decomposition of wastes) and the emission of landfill gases (including methane) are the principal environmental concerns.

Leachate and pollution

The management of leachate (see above) is a key element of good environmental practice. Leachate can be treated (for example using extraction and recirculation systems) before being discharged into a foul sewer. Otherwise, toxicity levels can sometimes be reduced sufficiently to allow their safe discharge into the environment (streams, rivers or the sea).

Methane and global warming

Methane, a greenhouse gas, is the main gas formed from decomposing wastes at landfill sites (unless they have been burned beforehand). Capping and restoring of landfill sites does reduce methane emission rates and improves the efficiency of collection for the generation of electricity (see above).

However much we achieve in the way of recycling and minimization, we will always need landfill for residues from other waste processes. There will therefore be a role for geoscientists and engineers in selecting sites that are geologically suitable, and for designing and managing them to minimise the possible impacts on the environment.