The Earth in our hands

- how geoscientists serve and protect the public

Photo: John Simmons, OnTV

8 CONTAMINATED LAND

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.defra.gov.uk The web site for the Department for Environment, Food and Rural Affairs has links to the Environment Agency and other government agencies.

http://www.environment-agency.gov.uk has information on land contamination, local contact addresses and updates on legislation.

http://www.clarrc.ed.ac.uk the Contaminated Land Assessment and Remediation Research Centre (CLARRC) has a selection of the best web sites for contaminated land research and associated topics.

http://www.claire.co.uk Contaminated Land: Applications in Real Environments. A public/private partnership involving government policy makers, regulators, industry, research organisations and technology developers.

http://envirolink.org the "Enviro" Web has useful links to environmental websites and a search facility.

http://www.eea.dk The European Environmental Agency

http://www.foe.co.uk Friends of the Earth

http://www.greenpeace.org Greenpeace

http://www.contaminatedland.co.uk a university site with clear information on land contamination (parental guidance advised!).

http://www.environment.dtlr.gov.uk/waste/strategy/index.htm Tel. 0870 1226 236 for free leaflets such as *Waste strategy 2000 for England and Wales*.

http://www.bura.org.uk The British Urban Regeneration Association have produced a booklet *Breaking old ground - BURA guide to contaminated land assessment and development* Tel. 0800 0181 260 (freephone)

The Earth in our hands

Published by:
The Geological Society of London
Burlington House
Piccadilly
LONDON W1J 0BG
Tel: +44 (0)20 7434 9944
Fax: +44 (0)20 7439 8975
Email: enquiries@geolsoc.org.uk
Web site: www.geolsoc.org.uk

Further copies are available on request (preferably by email). Individual copies are free, and will be posted anywhere without charge. Multiple copies attract both charge and postage. Please contact the Society if you wish to order more than one copy. All leaflets in this series can now be downloaded free as colour PDFs from www.geolsoc.org.uk

Series Editor: Ted Nield
Written by: Cally Oldershaw

The Geological Society gratefully acknowledges the assistance of its External Relations Committee (Chair, Dr Hazel Rymer) and the following scientists, who (in a personal capacity) read and commented on earlier drafts of this briefing.

Prof. Jeremy Joseph
Richard Owen
Dr Barry Rawlins
Jonathan Steed
Dr Eva Valsami-Jones

September 2001

The Geological Society of London is a Registered Charity, No. 210161

The Geological Society

The Earth in our hands

- how geoscientists serve and protect the public

Photo: John Simmons, OnTV

8 CONTAMINATED LAND

What is contaminated land?

Contaminated land is defined as land "where there is a serious threat or risk to health, flora and/or fauna", and is generally reserved for areas where the pollutant or harmful substance is man-made or is put there by humans. Even small amounts of heavy metals, organic compounds (such as herbicides, pesticides, dyes, solvents and paints) or petroleum products (oils and tars), can be classified as contamination - which may be on or beneath the surface.

Why is it a problem?

By definition, contaminated land poses a potential hazard to human health, threatens the environment (natural and built), is a risk to investment and regeneration and limits land development - particularly in urban areas.

Environmental pollution (contamination) is often linked to past urban and industrial expansion and is often being contained or dealt with. However, untreated industrial and domestic discharges may pollute, either directly or indirectly, any or all of the land, streams and rivers and eventually the sea - causing damage to sensitive ecosystems, reduction in biodiversity, and ultimately, economic damage to important activities like fishing and tourism.

With growing awareness of environmental issues and increased pressure to re-develop brownfield sites (below), there is a general need to know whether a site is contaminated.

- "Brownfield" sites are land or premises that have previously been used or developed. They may also be vacant, derelict or contaminated. Brownfield land is not necessarily contaminated. So-called "greenfield" sites, on the other hand, have only previously been developed - if at all - for agriculture.

Where land is contaminated, the potential impact on health, the environment and development will depend on:

- the contaminating substance(s)
- their ability to migrate (dependent partly on local geology and hydrogeology), and
- the potential land use, or the nature and design of a development.

Humans can be at risk through direct contact with soil, water or gases containing hazardous substances and/or eating plants or animals that have been in contact with them. Lives may also be put at risk occasionally as a result of explosions and fires caused by combustible material underground or the release of toxic, inflammable or explosive gases from the soil. (See *Radioactive waste disposal* in this series).

The real and perceived hazards of contaminated land often make house-buyers wary of new developments because of concerns about their health and potential liabilities, and the influence on the value of the property.

Legislation and regulations, such as the *Contaminated Land (England) Regulations (2000)*, place the responsibility for assessing the extent of contaminated land with local authorities. Historically the UK has approached site reclamation from the viewpoint of 'fitness for purpose'. Increasingly, landowners, developers, builders and property-related professionals will be involved in remediation (clean-up) of contaminated land, regardless of whether the contamination was caused by a previous owner and/or user, and whether or not the intention is to re-develop.

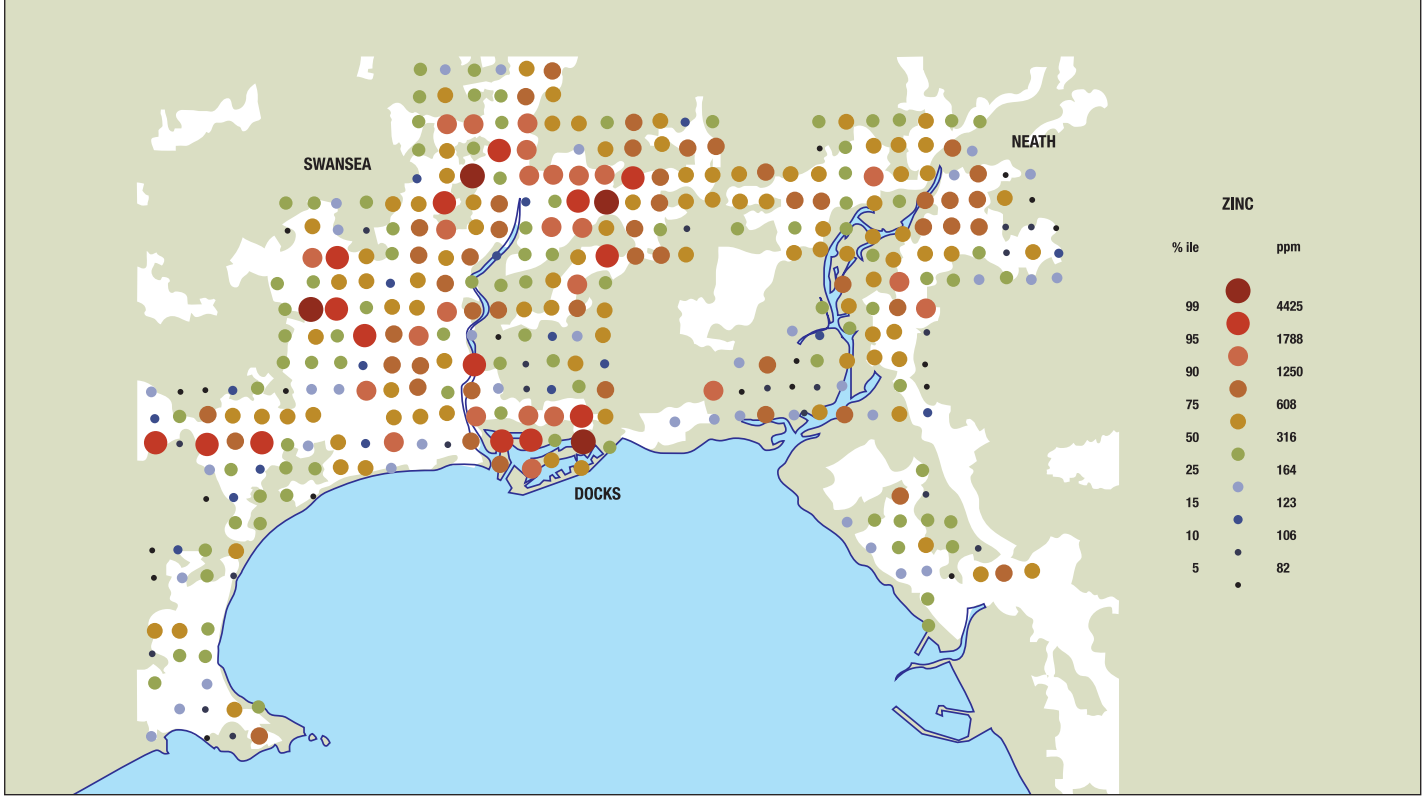
Landowners and developers, local authorities, consulting engineers and environmental consultants, contractors and house builders need to know the risks they are exposed to in dealing with land that may be contaminated. They need to identify ways in which technical and financial risks can be assessed and managed so that effective remedial treatment can be designed (according to future plans for land-use and the nature and size of the risk). Planning controls may be used to regulate remediation of brownfield land.

Photo: John Simmons, OnTV

Photo: John Simmons, OnTV

Photo: John Simmons, OnTV

The Geological Society



Contaminated land in the UK

The number of potential sources of contamination and the complexity of contaminants have increased in line with technological advance; however, most contamination in the UK is historical.

Contamination is generally due to industrial activity, inappropriate or inadequate management of waste disposal, or spillage of raw material or sewage into or onto land and drainage systems - either deliberately or accidentally.

Industrial activities that have caused contamination include:

- chemical production
- gasworks
- sewage treatment
- printing
- fulling and dyeing of cloth
- paper making
- armament manufacture
- placing of colliery and mining spoil heaps
- dockside industries (unloading/loading, storage, cleaning/painting ships, bulk storage of fuels, processing of landed raw materials etc.)
- steelworks
- petrol stations.

Publications, e.g., from the Environment Agency, provide lists of contaminants including:

- heavy metals (zinc, copper, lead and cadmium)
- cyanides
- tars
- oil products
- arsenic
- organophosphates.

Cadmium, for example, is used in making metal products and in metal-plating, as well as being a constituent in paints and plastics. Before the introduction of North Sea gas, "town-gas" (or "producer gas") was used in homes. It was produced from coal or oil in a process that generated cyanide compounds as a by-product, causing contamination at or near the now-derelict gasworks.

Fig. 1 Proportional symbol plot of zinc in the surface soils of Swansea, South Wales. Note the elevated levels in the dock areas and around the historic industrial smelting centre of the Lower Swansea Valley, formerly the largest area of industrial dereliction in Europe. Redrawn from an original in Earthwise 17, p19 IPR/22-16C British Geological Survey. NERC All rights reserved.

Such contamination is often localised, staying close to the initial site; but it can also migrate and become widespread.

Several different contaminants may need to be identified and dealt with separately at any one site. For example a gasworks, dye-works and an armaments factory all contributed to contamination of one major London site. Geoscientists and geotechnical engineers were involved in the remediation and reclamation necessary to transform this area into what is now the Thames Barrier Park. In the same way, part of the Greenwich peninsula, owned by British Gas, had to be remediated before construction of the Millennium Dome could begin.

The geology (rock formations) in an area (which controls the soil type) can interact with contaminants to increase - or reduce - risk. For example, cadmium is more mobile in acidic grounds, but under alkaline conditions can become practically immobile. The cadmium is not inert, however. Whether it still presents a hazard will depend on its bioavailability (whether it can be taken up by living things). Groundwater may also be vulnerable, and this depends on the hydraulic and chemical properties (such as permeability) of the underlying rock and soil.

In addition to the insecticides and pesticides used in agricultural processes, the poorly managed application of sewage sludge and slurry effluent can pollute the rural environment. The UK Dept. for Environment, Food and Rural Affairs (DEFRA) is working with farmers to prevent this type of pollution. Prevention is better than cleaning up - both environmentally and financially.

Most problems are due to a historic lack of care over industrial and waste management. Many are the result of inadequate planning or failure to recognise that land might have to be reused in the future.

Where inadequate records of contaminants have been kept, land may be re-used without appropriate remediation. The contamination may not become apparent until much later. In one case it was not apparent that a new housing estate had been built on land containing hazardous waste until landfill gas (largely methane) began to seep into basements.

Geoscientific evaluation & risk assessment

Contamination evaluation requires multidisciplinary surveys by a number of experts including geoscientists. Assessing the risk associated with a potentially contaminated site can be complex. The risk depends on interaction between various contaminants and the geology of a site.

The first step in a site evaluation is to find out whether the land is contaminated and identify contaminants. These may have been newly deposited on the site or have migrated from an old area of contamination. Although this is uncommon in the UK, contaminants can be remobilised by disturbance (major storms, dredging, etc.).

In order to assess risk, site inspections are made and data collected. The British Geological Survey is one of the organisations that provides site investigators with information; e.g., background concentrations of inorganic contaminants such as arsenic, lead and cadmium (from BGS regional and urban geochemical data, collected under the Geochemical Baseline Survey of the Environment (G-BASE) programme). In addition, a full investigation involving drilling and sampling is often needed.

Geoscientific involvement in a contaminated land investigation includes:

1. A desk search for information involves, amongst other things, studies of:
   - BGS maps and information about the geology of the area
   - Ordnance Survey maps (oldest to newest, for historic land use)
   - Local authority and planning records etc., for pollution incidents
   - Environment Agency records, for information on landfills, water abstraction, pollution incidents
   - Any industrial/commercial records

2. A visit to the site and surrounding areas to obtain information and to verify:
   - Site access and boundaries
   - Evidence of previous/current use including:
     - *buildings and structures*
     - *waste storage areas*
     - *radioactive use/storage*
     - *abandoned mine shafts, etc.*
   - Evidence of contamination from:
     - *asbestos*
     - *methane or other gas*
     - *odours*
     - *vegetation/animal growth abnormalities*
     - *soil discolouration*
     - *organic/inorganic waste material*
   - The underlying geology including:
     - *topography and landscape (geomorphology)*
     - *rock type (petrology)*
     - *soil type (pedology)*
   - hydrogeological/ hydrological information such as:
     - *licensed and private water abstractions*
     - *aquifers and aquifer recharge zones*
     - *historical borehole information*
     - *groundwater levels*
     - *location and condition of ditches, streams, etc.*

Chemical testing of soil and groundwater samples is carried out. As an initial screening tool, chemical results are compared with an "action level" specific to each contaminant and the intended (or likely) use of the land. If contamination levels are above this level, the risk is considered unacceptably high and some form of remediation becomes necessary. A more detailed assessment will then be carried out before remediation begins.

Action levels can vary from place to place and always depend on intended use, and differ if, for example, the land is to be used for car parking, a school playing field or a vegetable garden.

Remediation/reclamation methods

Making land suitable for use helps to reduce pressure on "green field" sites and thus to conserve agricultural land and natural habitats. Various methods can be used, depending on the contaminant and the site's intended use.

a) soil covering

"Capping" (covering the contaminated soil with cement or other hard surface) is common. Although this may be adequate in an area to be used as a car park, in some circumstances it may not be appropriate (e.g., where it is intended to develop a housing estate with domestic gardens).

b) soil removal

Soil is dug up and taken away. The remaining land is then hard covered (with cement or tarmac) or infilled with loose aggregate. This method, often used on brownfield sites, can result in the hole being reinstated with "non-engineered" fill.

c) soil remediation by chemical treatments. Methods include:

- Transformation by chemical treatment (by the addition of chemicals either *in situ* or at chemical plants)
- Solidification and stabilisation (adding minerals to the soil to 'fix' contaminants, as recommended by environmental mineralogists).

d) soil treatment by biological methods including:

- Transformation or removal of contaminants by biological treatment on site, for example by planting particular species (phytoremediation), or off site (removing soil and treating it elsewhere). Although infrequently used and of limited technical application, some plants are able to take up contaminating metals from the soil and concentrate them in their leaves and stems.
- Transformation using microorganisms (bioremediation). Such microbes could include bacteria and yeasts, and are part of the natural cycle of the decomposition in the environment. Some contaminants are useful sources of nutrients to certain microorganisms. With sufficient time, they can attack, digest and ultimately remove some highly toxic man-made contaminants, mostly organic, from the environment.

The future - reducing contamination

Geoscientists play a vital role in helping make land safe when it has been contaminated. The rehabilitation of contaminated land includes geoscientific problems that need to involve hydrologists, hydrogeologists and geochemical engineers, as well as chemists and biologists.

Whether a site is going to be redeveloped and contaminated land remediation is carried out, or whether such works are financially and environmentally worthwhile, will depend partly on the regulators and partly on the planned end-use of the land. Remediation can be necessary, quite independent of any redevelopment, to protect other parts of the environment.

Photo: John Simmons, OnTV