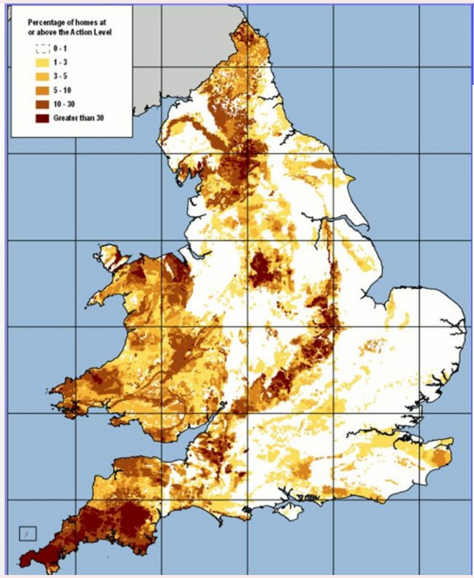
Nuclear Waste Disposal and Environmental Geochemistry

Radon gas pollution

One of the **decay products of Uranium or Thorium is radon**, a **gas** at room temperature. This gas itself is r**adioactive** and is **found to seep up from soils** leaking out of **igneous intrusions** such as **granite batholiths** and collecting at the surface to dangerous levels.

UK geochemical surveys ensure that **radon gas flux** in residential areas are **below acceptable risk limits.** They highlight which areas of the British Isles are at most risk from Radon pollution.

They include **granites** of southwest England, Scotland, Northern Ireland; **phosphate** rocks in Northamptonshire; **black shales** in Wales; and **limestones** in Derbyshire and Northern Ireland.



Radon Gas Levels in England and Wales

100,000 people have higher than average concentrations of radon in their homes

Cornwall, Derbyshire and Northamptonshire are the three counties in England with the highest concentrations

Parts of Devon and Somerset also have significantly higher levels of radon than average

Radon is **colourless, odourless, tasteless** and non-reactive (a noble gas) **but is radioactive**. Radon emits **alpha radiation**. It is the **heaviest known gas** at room temperature and is 9 times denser than air. **Radon**-222 (most common in natural environment) is a member of the radioactive decay chain **of uranium**-238. **Radon-**220 is formed in the decay chain of **thorium**-232. Radon is **soluble** in both water and organic solvents.

Sites situated near **granite, black shales, phosphate rocks** and **some limestones** are most at risk.

18

2	He	Helium 4.002602
10	Ne	Neon 20.1797
18	Ar	Argon 39.948
36	Kr	Krypton 83.798
54	Xe	Xenon 131.293
86	Rn	Radon (222.0176)
118	Uuo	Ununoctium (294)

Radon from igneous rocks:

Felsic rocks such as granite, microgranite and rhyolite

Regional metamorphic rocks Schist and Gneiss

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Radon from igneous rocks:

Dark, organic-rich shales
Rocks that contain phosphate such as limestones and iron rich sandstones

The main source of radon entering houses is **from groundwater** and the **soil beneath cracks, fonts, and gaps in the foundations** of service utilities.

The Becquerel is the SI-derived unit of radioactivity measured in Bq per m^3 of air. One Becquerel is defined as the activity of a quantity of radioactive material in which one nucleus decays per second.

- Average UK concentrations in homes: 20 Bq per m^3 of air .
- The maximum recommended level in the UK is 200 Bq per m^3

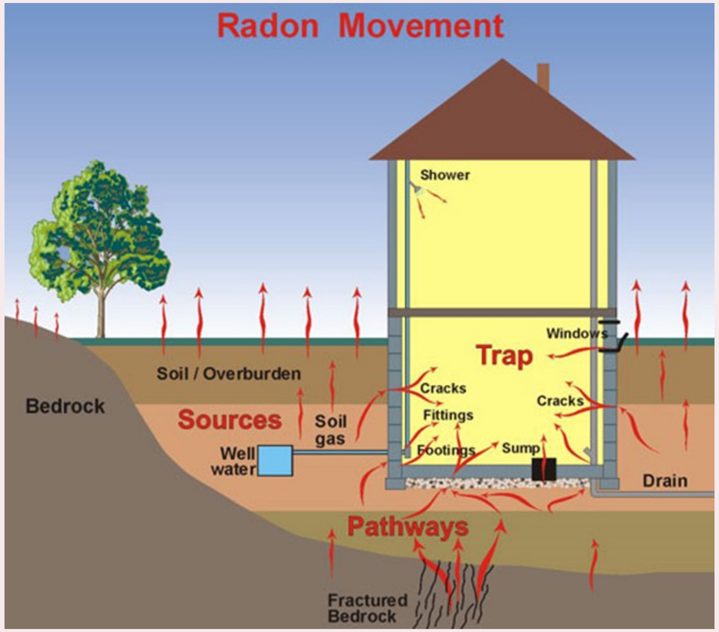
At the moment, government policy in England consists of **targeting areas of a country where 5% or more homes are above the natural action level.**

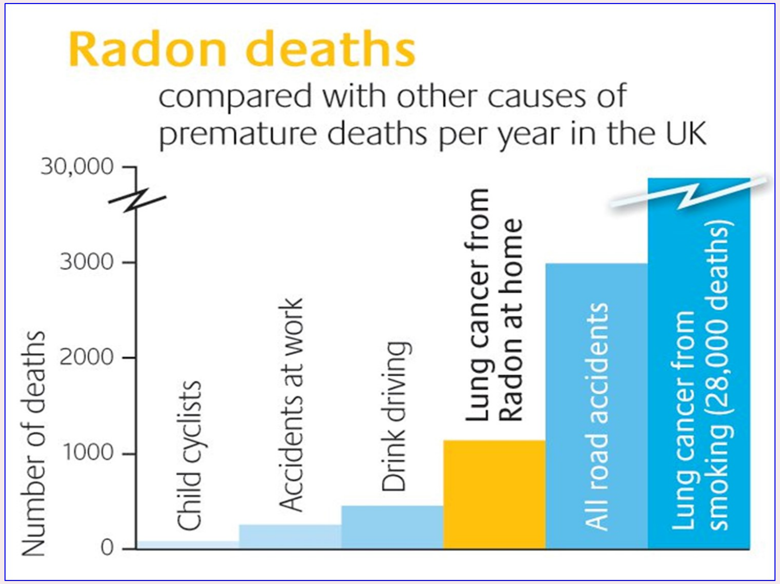
Solutions involve **opening windows**, **installing air bricks and installing air pumps**. **Cracks can be sealed** (grouted), gaps around **service utilities** are sealed and pressurising building by blowing in air to exclude soil air.

When radon in air decays, it forms a number of short-lived radioactive decay products (called **Radon Progeny**), which include **lead**-214, **bismuth**-214, **polonium**-214 and polonium-218. All are **radioactive isotopes of heavy metal elements** and all have half-lives that are much less than that of radon.

These are **solids and stick to surfaces like dust particles** in the air. If such contaminated dust is **inhaled,** these particles **stick to the airways of the lung** and **alpha particles bombard and damage cells** causing increased risk of cancer.

Radon causes over 21 000 deaths from lung cancer each year. Half of these deaths occur among the quarter of the population who are current smokers.





A smoker who is also exposed to radon has a much higher risk of lung cancer.

Radon gas can **seep from rocks and soils** and build up to dangerous levels in homes that aren't well **ventilated.** Radon radiation may be **released from water such as in wells**.

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Radiation disposal

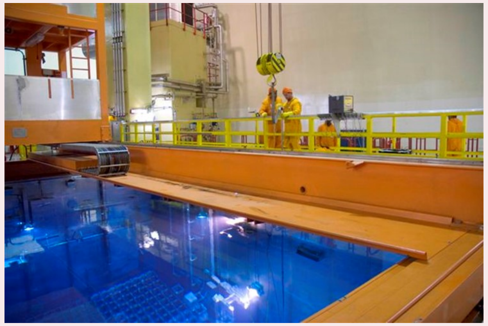
Nuclear waste disposal is a serious problem since in many case the waste needs to e isolated for millions of years before radiation n levels are at background safe levels. The toxic legacy of nuclear waste mean's the waste needs to be stored safely into the future.

Nuclear waste is classified as low, intermediate, high and transuranic—with increasing degrees of hazard associated with disposal and isolation.

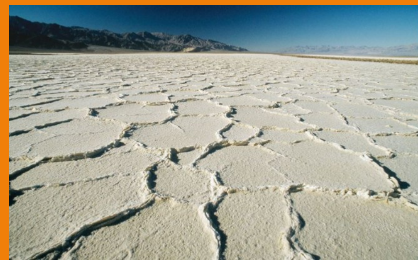
- **Low level waste** is usually disposed of in secure landfill sites.
- **High and transuranic waste** emit heat as they decay (over an extremely long half life) as well as emitting high doses of radiation. This type of waste is stored in isolated pools for 50 years in the UK to allow it to cool prior to solidification and disposal.

Safe disposal criteria	
1	Isolation for at least 25, 000 years
2	Secure from accidental or deliberate entry
3	Safe from natural disasters
4	No chance of leakage to the surrounding environment
Potential sites **may** meet these requirements	
a	Launching into space (1,2)
b	Burying on the sea floor near a subduction zone (1, possible 2)
c	Placing the secure containers in the ice sheets on Greenland or Antarctica (Possibly 2,3)
d	**Burying in an underground geological repository (1,2,3, possibly 4)**

All of these methods have merits and draw-backs. Burying in an underground geological repository Is probably the best solution.



Evaporite rocks have been suggested as a good potential location for a geological repository. Unfortunately, many salt minerals are **hydrated** so contain **water of crystallisation** in their lattice. When heated, they may release this to form **pools of saline water** that can **corrode storage containers**—leaking radioactive waste.



This needs to be...

- **In a tectonically stable area**
- **Within dry, impermeable rocks with a low water table**
- **Free form the effects of potential natural hazards**

Volcanic or intrusive rocks are also another good suggestion.
Dry competent rocks like granite or basalt/rhyolite/andesite etc.

Granite contains naturally high levels of radioactive elements making them less attractive to dig through.

The best option is **crystalline basement rocks below younger sedimentary cover rocks.** This option has been chosen for the burial of radioactive waste in Sellafield, Cumbria.

The Sellafield nuclear dump.

This involves sinking two 5m diameter shafts down into 1020m of the **Borrowdale Volcanics Group**. Then, opening up caverns laterally for an underground repository.

NIREX is the UK government's nuclear waste body. Sellafield poses a good site as the waste will be stored deep underground; reducing risk of accidental or deliberate entry, the radiation will be absorbed by a vast thickness of volcanic rock so will not affect organisms on the surface, the area is quite remote; away from urban areas (tunnelling, basements, homes), the rock is impermeable and strong / competent; the waste is not in the vicinity of any porous permeable rock where aquifers are. The region is not near a plate boundary ; no strong seismic activity.

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Environmental geochemistry

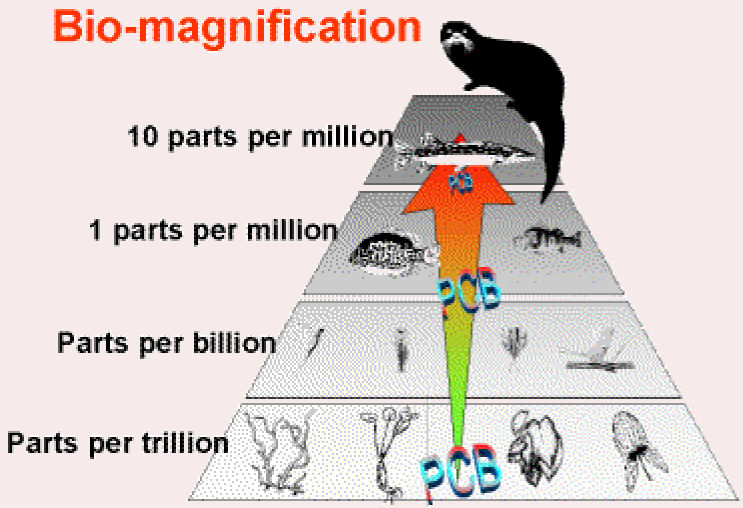
#EG Identifies and monitors the movement of natural and man-made toxins in the environment and studies their interactions between rocks, soils, water, the atmosphere and organisms. This field pays particular regard to biochemical cycling.

Heavy metal contamination of soils

Toxic heavy metals such as **lead, arsenic, cadmium** and **mercury** can accumulate naturally in soils and as a result of human activities such **as mining and smelting.**

- Contamination of **surface water** or **groundwater supplies.**
- Toxic heavy metals in **soils and groundwater** are taken up through the **roots of plants**
- **Ingestion** of such impurities in **plants and soil by animals during grazing** or **drinking** of surface water.
- Humans then consume agricultural produce and heavy metals **bio accumulate** in the body. This means their **concentration** in the body **increases over time** since they are not **easily excreted or broken down**.

1. Groundwater
2. Soils > vegetation > livestock > humans



Bio magnification

Moreover, the **concentration of the toxic heavy metals in organisms increases up the food chain.** This is because organisms higher up in the food chain are consuming many prey individuals `infected' by heavy metals**.** This means they build up to toxic levels and have a dramatic effect on higher members of the food chain, humans.

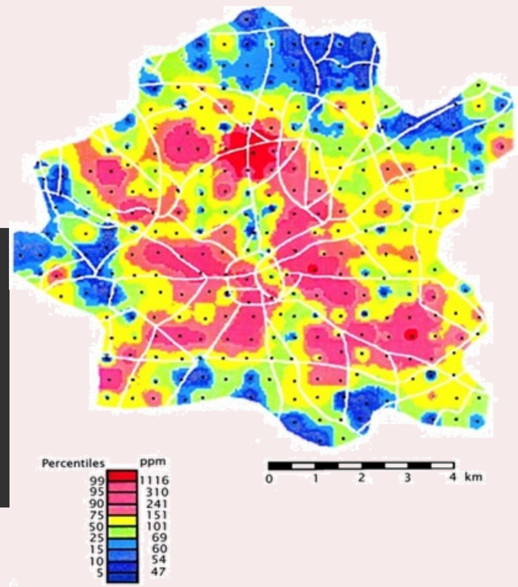
The British Geological Survey has been carrying out regional geochemical surveys both in the British Isles and abroad for over 40 years. The BGS aims to:

Identify areas of **contaminated land**

Improve our understanding of the **links between Geology and Health**

Study **geochemical** factors that **affect habitats and biodiversity**

Allow for **sustainable development** of **natural resources and management of waste disposal**



How is geochemical research done?

In the UK, **stream samples are taken every** 1 to 2km^2, supplemented by **soil samples from urban areas.** They are analysed for 48 elements and the data is used to compile a series of **geochemical atlases**.