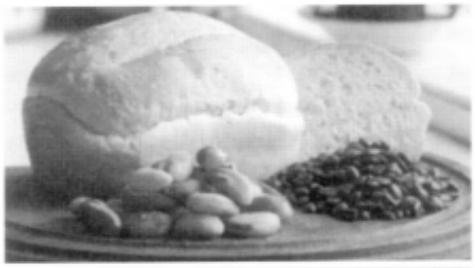
No. 6 in a series of essays on Radioactivity produced by the Royal Society of Chemistry, Radiochemical Methods Group

Radioactivity in the Environment

Every person, animal and object present on our planet Earth is subjected to radiation and may indeed contain it. We cannot see it, smell it or feel it, but it is with us at all times. What is this radiation? Where does it come from? What sort of radiation is it?



Typical radioactivity levels in Bq per Kg are:-

Soil (Berkshire)	1,000
Human Body	4,000
Coffee	1,000
Brazil Nuts	460
Tea (Indian)	630
Fertiliser	2,200
Grass (Dried)	600
Coal (UK)	300

1 Bq is one disintegration per second.

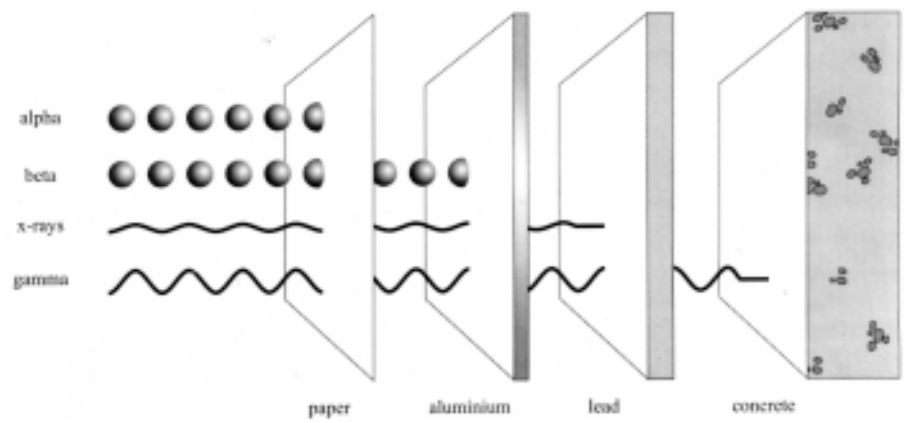
Radiation

Radiation is measured in terms of its effects on people and materials. Radiations such as ultra violet, infra-red, microwaves etc. are not considered here but only those emitted by radioactive materials. These are known as ionising radiations. For man the unit used to measure ionising radiation dose is the millisievert (mSv). Radiation from radioactive materials can be in the form of three main types namely:-

1) Alpha particles which are positively charged helium nuclei, which are of very low penetration and hence do not give rise to a measurable external radiation dose but can give higher doses when incorporated into the body by inhalation or ingestion.

2) Beta particles which are equivalent to electrons. These can give an external dose, particularly those of high energy which will penetrate through two cm of aluminium.

3) Gamma-rays. These are very penetrating passing through up to 6m of concrete. X-rays are equivalent to low energy gamma-rays.



Penetration characteristics of various ionising radiations

Let us consider the source of this radiation and its variation within the United Kingdom.

Radiation Sources

Cosmic radiation

This is gamma radiation which has emanated from the sun and other terrestrial bodies and travelled to our planet. On its journey it has not had to pass through any substantial matter only space. Hence it can travel large distances without being absorbed. Once the radiation reaches our atmosphere it begins to be absorbed by the air, thus reducing the radiation level on the ground. The radiation dose will be higher if you live or work at any altitude and will be highest for people in aircraft or spaceship.

Ground

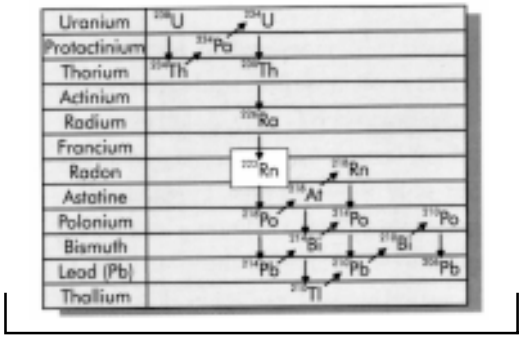
Rocks and soil contain uranium, thorium and potassium. The former two are part of an elaborate decay scheme producing a range of radioactive elements which emit alpha, beta and gamma radiation. Potassium has a naturally occurring isotope, potassium-40 which emits beta and gamma radiation. All of these give rise to background radiation which will vary from 0.0lmSv to 0.03mSv per annum depending on where you live in the UK. The highest radiation areas are those in which the underlying rocks are granite such as Devon & Cornwall and parts of Scotland.

Buildings

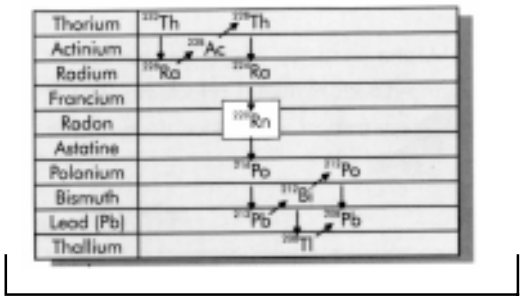
The buildings in which we work, study, play and live have all been constructed of materials which contain radioactivity that is uranium, thorium and potassium. In addition wood and any other material which at one time was living will contain carbon-14. This is a very weak beta emitter and does not give a measurable dose. We will return to this radionuclide when considering the dating of ancient objects.

Air

The air which we breath also contains radioactive material which will give both an external dose to our bodies as a whole and an internal dose to our lungs. The major radionuclides are of radon gas; radon-222 which is produced from the decay of uranium and radon-220 from the decay of thorium.



Uranium Decay Series



Thorium Decay Series

↗ Beta (β) Particle emitted

↓ Alpha (α) Particle emitted

We have already seen that both uranium and thorium are present in rocks, soil and building materials. The level of these radon isotopes in the air will depend on the quantity of uranium and thorium in the ground and the degree to which they can escape from the ground. Both gases also emanate from building materials. Hence levels inside buildings can be higher particularly if there is poor ventilation and the gases are trapped. This radiation dose can vary from 0.9mSv to 6.6mSv in normal air. Within buildings and other confined spaces where the gases cannot disperse the levels may be even higher.

The carbon dioxide in the air we breath contains carbon-14 a weak beta-emitter. Carbon-14 is produced in the upper atmosphere by the interaction of cosmic rays with nitrogen-14. The radioactive isotope carbon-14 hence enters every carbon cycle involving living organisms. It is subsequently trapped when organisms die and it is a measure of its decay which allows us to perform carbon dating.

Food

Any radioactivity present in air or more importantly the ground and soil may transfer into food grown on it. Some of the food producing the highest concentrations of radioactivity are tea, coffee and Brazil nuts. The dose to man will vary depending on the quantities consumed and the rate at which the body excretes the radioactivity.

Medical

The X-ray equipment used by hospitals and dentists is the best known source of medical radiation. Nowadays hospitals use a wide range of radioactive materials for diagnostic as well as therapeutic purposes. Examples of radioactive nuclides used are Iodine-131, Iodine-129 and Technetium-99. Besides giving a dose when administered, the hospital, like all other establishments handling radioactive material, has an authorisation to discharge small quantities to the local environment. This will add to background radiation. Medical sources of radiation account for approximately 95% of the average dose to the public from artificial (man-made) radiation.

Fallout

As a result of nuclear weapon testing in the past our atmosphere contains radioactive material primarily Caesium-137 and Strontium-90 which can be detected in current rainfall and is present in sea-water and soils. The initial explosions transferred radioactive

debris to the upper stratosphere from where it will take decades to return to earth. This is the reason why radioactivity from weapon testing is still measurable in rainfall. Levels were substantially increased as a result of the Chernobyl accident, but these have now mainly been deposited on the ground and form part of the ground source as these discharges were confined to low altitude.

Discharges

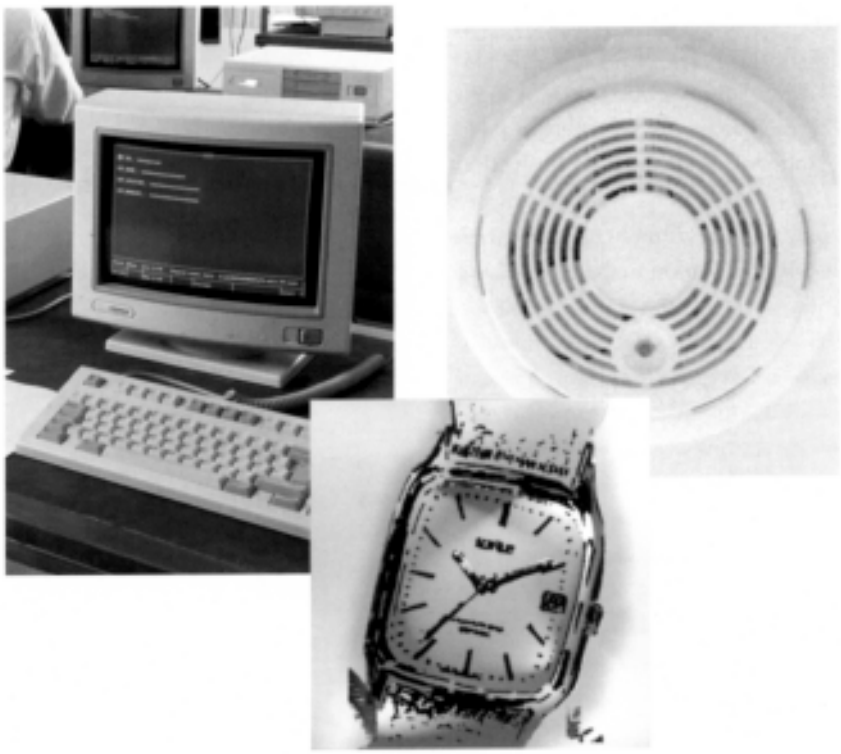
As indicated earlier many hospitals and industries are permitted to discharge radioactive material to the environment in a controlled and monitored manner. These include the discharges from the nuclear power industry. Coal-fired stations also emit natural radioactivity released through the burning of coal, which are not routinely monitored, but can be estimated from known concentrations in the coal. This latter source produces 25% of the total dose from all UK discharges.

Occupational Exposure

Nowadays many people are exposed to radiation as a result of their work not just in the nuclear power industry but in hospitals, industry, universities, armed services, civil aviation and mining.

Products

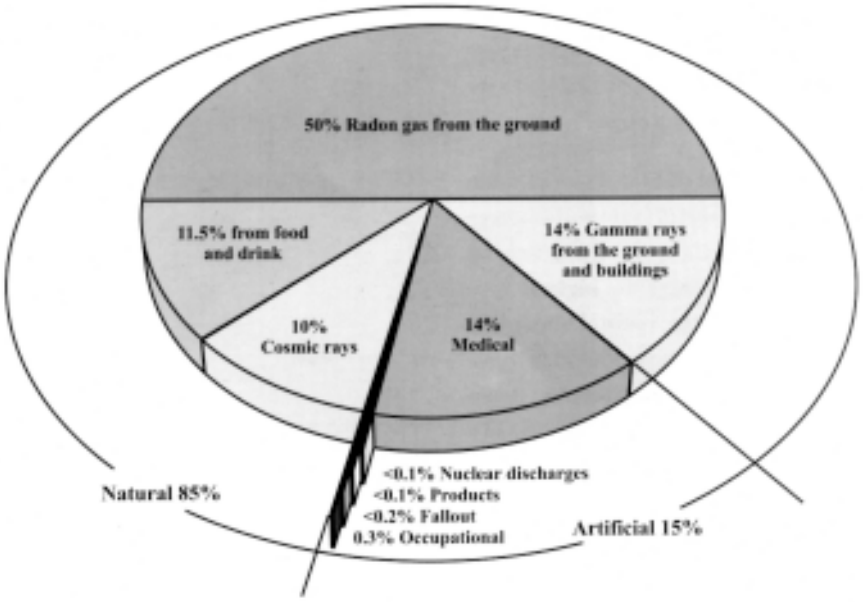
Finally there are consumer products which contain radioactive material. Luminous watches and clocks originally contained radium-226 but are now more likely to contain tritium (which is hydrogen-3) a very weak beta-emitter. Smoke detectors contain americium-241. Gas mantles contain thorium oxide. You may like to think of other examples. Be careful though as we may have included some common items in the sections on buildings and food above.



Radioactive sources found in common use

Radiation Dose

The average annual dose to each person in the UK is 2.6mSv of which 2.2mSv (85%) arises from the natural background. The remaining 0.4mSv (15%) comes from artificial radioactivity and 0.37mSv (14%) of this is from medical applications. Note that these are average figures and will vary from person to person.



Percentage contributions to the average annual dose in the UK of 2.6mSv

The background radiation from the ground can vary by a factor of three and that from air by a factor of six. Information on radiation doses from all the above sources can be obtained from the National Radiological Protection Board (NRPB) which was specifically set up by the Government to advise it on the levels of radiation in the UK and the potential effect on man. For example the NRPB has a continuing programme to measure radon gases in houses.You can participate in this programme for relatively little cost. Affected areas where more than I % of homes have indoor radon concentrations above 200Bq per cubic metre are shown in the illustration. The NRPB recommend that annual exposure to radon gas should not exceed l0mSv in existing buildings. This is based on their concepts of safe levels of radiation and you will note that this is a lot higher than the average background radiation and therefore considerably greater than artificial radiation discharged as a result of industrial applications and power production in this country.

Summary

By now you should be able to answer all the questions posed in the introduction and you have obtained some information of all kinds of radioactivity in our normal surroundings.

Radiation is a fact of life. The radiation given off by artificial radioactive materials is no different from natural radiation. On average the highest dose to man results from natural radiation. Radiological protection methods have over the years developed to keep doses to man "as low as reasonably practicable". This has allowed us to reap some of the benefits from both natural and artificially produced radioactive material.

Radon Areas. Affected areas where more than I% of homes have indoor radon concentrations above 200Bq per cubic metre.

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