Radioactive pollution

Radiation is energy travelling through space. Energy can be transported either in form of electromagnetic waves (radiations) or a stream of energetic particles. These radiations are of two types:

1) Non-ionizing radiations are the electromagnetic waves of longer wavelength from near ultraviolet rays to radiowaves. These waves have energies enough to excite the atoms and molecules of the medium through which they are moving, causing them to vibrate faster.

2) Ionizing radiations are the electromagnetic radiations having high energy, such as short wavelength ultra violet radiations, *x*-rays and gamma rays. The energetic rays like (α, β and γ etc.) produced in radiocative decay can cause ionization of atoms and molecules of the medium through which they pass and convert them into charged ions.

Alpha (α), beta (β) and gamma (γ) radiations are produced by the process called **radioactive decay.** The unstable nuclei decay spontaneously and emit these radiations. These rays (radiations) can affect some other non-radioactive atoms to become radioactive (unstable) and give out radioactive radiations.

Radioactive pollution and their sources

Living organisms are continuously exposed to a variety of radiations called background radiations. If the level of the radioactive radiations increases above a certain limit it causes harmful effects to living beings. This harmful level of radiations emitted by radioactive elements is called *radioactive pollution*. There are two sources of radiation pollution:

1. Natural Sources of Radiation

(i) Atomic radioactive minerals are one of natural sources of radioactive pollution. During mining of uranium, radon gas is constantly released into the air. The parent of radon-222 ($t_{1/2}$ = 3.82 days) is radium 226 which has a half-life of 1602 years. Radium-226 is widely distributed in rocks, sediments and soils along with isotopes of uranium.

Radioactive radiations from these natural sources are known as natural or background radiation.

(ii) Cosmic rays are high energy ionizing electromagnetic radiation. The cosmic rays originate from the stars in our galaxy by virtue of nuclear reactions primarily in their cores. The cosmic rays are constantly reaching the earth from outer space.

(iii) Naturally occurring radioisotopes such as radon-222 found in soil in small quantity is another source of radioactive radiations.

(iv) Radioactive elements which like uranium, thorium, radium, isotopes of potassium (K-40) and carbon (C-40) occur in the lithosphere.

Anthropogenic sources

The following human activites add to the source of radioactive pollution:

(i) **Diagnostic medical applications:** Radiations are employed for diagnostic and therapeutic applications. *X*-rays are used in general radiology and CT scan. Gamma rays are used in treatment of cancer.

(ii) **Nuclear Tests:** Nuclear explosion tests especially when carried out in the atmosphere are a major cause of radiation pollution.

(iii) **Nuclear Reactors:** Radiations may leak from nuclear reactors and other nuclear facilities even when they are operating normally. It is often feared that even with the best design, proper handling and techniques, some radioactivity is routinely released into the air and water.

(v) **Nuclear Wastes:** When uranium-235 nuclei split in a nuclear reactor, they break into fission products

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n + \text{Energy}$$

which are also highly radioactive. Since one uranium atom splits into two radioactive products, there is a doubling of the number of radioactive atoms on the earth. Furthermore. uranium-235 has a half-life of more than 700 million years.

There is no method by which we can increase or decrease the rate of decay of these products. The wastes of nuclear reactor emit dangerous radiations for thousands and thousands of years. **Plutonium** does not occur naturally on earth. This element is produced either in nuclear reactors or in nuclear weapons programme. **Radon** can diffuse through rocks and soils into the atmosphere. Once the radon reaches the atmosphere it can be breathed in. The transformation into lead is very significant because the solid radioactive particles are trapped in the lungs and are acutely harmful.

Units: More traditional unit of absorbed doses is *radiation absorbed dose* (rad). Biological damage caused by a particle depends not only on the total energy deposited but also on the rate of energy loss per unit distance traversed by the particle. For example, alpha particles do much more damage per unit energy deposited than do electron (β-particles). This effect is represented by the quality factor Q taken 0 for electron and 20 for alpha particle.

The biological impact is specified by the human equivalent dose H, which is the product of the absorbed dose D and the quality factor Q: H=QxD. The unit of the human equivalent dose is called the sievert, Sv.

Biological Effects of ionizing radiation on the human body

Exposure to any type of ionizing radiation (α and β particles, γ-rays and X-rays) can prove harmful and even lethal. The two types of effects are: (i) **genetic** and (ii) **nongenetic** or **body damage.**

In **genetic damage,** genes and chromosomes get altered. Its effect may become visible as deformations in the offsprings. Alterations or breaks in the genetic material, that is DNA (deoxyribonucleic acid).

In **nongenetic effects**, the harm is visible immediately in the form of birth defects, burns, some type of leukemia, miscarriages, tumors, cancer of one or more organs.

Radiation doses and radiation effects

The biological damage caused by the radiation depends upon the following factors:

i) the time of exposure ii) the intensity of radiation
iii) the type of ionizing radiation (i.e. its penetration power)
iv) whether the radiation is emanating from outside or inside the human body.

Preventive measures from nuclear radiation

To reduce the effects due to both natural and artificial radiations:

(i) Atomic explosions should not be carried out in the atmosphere.

(ii) In nuclear reactors, closed cycle coolant system may be employed, so that no radiation leakage through coolant can take place.

(iii) Radioactive wastes generated by nuclear reactors or from nuclear weapons programme must be disposed in a manner that they will do the least harm. First, the wastes may be stored at some place temporarily to allow for the initial, very intense, radioactivity to die down by natural decay. Nuclear wastes should always be sealed in double-walled tanks so that no leaks may take place. In the second stage, some useful isotopes generated during fission in the reactors may be recycled in reprocessing plants. Finally, a permanent storage space for the wastes in geologically stable underground deep mines should be established.

(iv) Production and use of radioisotopes should be minimum and only for very essential use because radioisotopes once produced cannot be destroyed by any means except by the passage of time.

(v) The number of nuclear installations should be minimised so as to limit the emission of radio-pollutants.

(vi) Fission reactions should be minimized.

(vii) In nuclear mines, wet drilling may be used and tailings properly sealed and protected for radiation leakage.

(viii) Industrial wastes contaminated with radionuclides be disposed off carefully in specially built tanks.

(ix) Working places where radioactive emissions are possible should have high chimneys and good ventillation system.