Dumping / Disposal of Radioactive waste

Characteristics of radioactive waste
1. Release of radiations by radioactive materials in waste for a longer duration.
2. Decay of radioactivity with time.

The primary objective of radioactive waste management is protection of
- Human health,
- Environment and
- Future generation.

Nuclear waste comprises a variety of materials requiring different types of management to protect people and the environment. One of the factors in managing nuclear wastes is the time that they are likely to remain hazardous. This depends on the kinds of radioactive isotopes in them, and particularly the half-life characteristic of each of those isotopes. The half-life is the time it takes for a given radioactive isotope to lose half of its radioactivity. After four half-lives the level of radioactivity is 1/16th of the original and after eight half-lives 1/256th.

The various radioactive isotopes have half-lives ranging from fractions of a second to minutes, hours or days, through to billions of years. Radioactivity decreases with time as these isotopes decay into stable, non-radioactive ones.

The rate of decay of an isotope is inversely proportional to its half-life; a short half-life means that it decays rapidly. Hence, for each kind of radiation, the higher the intensity of radioactivity in a given amount of material, the shorter the half-lives involved.

The nuclear wastes produced are classified into three categories (i.e. gas, liquid and solid wastes). The disposal of nuclear wastes is based on the principle of recycling and minimize the release quantities as far as possible. The management of the nuclear wastes must comply with the requirements of the national safety regulations. The release of the nuclear waste is

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strictly monitored and controlled by the national authority and the actual release is far below the prescribed permissible quantities.

Three general principles / techniques are employed in the management of radioactive wastes:

- **Delay-and-decay**

  ‘Delay and decay’ involves holding the waste in storage until the desired reduction in activity has occurred through radioactive decay of the radionuclides contained in the waste. If the concentrations of radioactive elements are largely short-lived, then ‘delay and decay’ approach is preferred; that is, to hold on to such a waste for a sufficiently long time that the radioactivity will die in the meanwhile.

- **Concentrate-and-contain**

  ‘Concentrate and contain’ means reduction of volume and confinement of the radionuclide contents by means of a conditioning process to prevent dispersion in the environment. This technique of radioactive waste disposal is sometimes used for radioactive materials with very high activity levels and for those with long half-lives. Their disposal by delay and decay method is impractical because of longer storage period, particularly if space availability is limited. Radioactive waste is collected in suitably designed and labeled containers and then buried in exclusive burial sites approved by the competent authority.

- **Dilute-and-disperse**

  ‘Dilute and disperse’ means discharging waste to the environment in such a way that environmental conditions and processes ensure that the concentrations of the radionuclides are reduced to such levels that the radiological impact of the released material is acceptable. In establishing policies in this area, consideration has to be given to the radiological impacts of the different management options. From a radiological protection perspective, a balance has to be struck between the present exposures resulting from the dispersal of radionuclides in the environment and potential future exposures which could result as a consequence of radioactive waste disposal.

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The first two approaches (‘delay and decay’, ‘concentrate and contain’) require that radioactive waste be held in storage for varying lengths of time or placed in a disposal facility with a view to preventing its release to the environment. Radioactive waste must therefore be processed, as necessary, in such a way that it can be safely placed and held in a storage or disposal facility.

The third approach (‘dilute and disperse’) is a legitimate practice in the management of radioactive waste and has to be carried out within authorized limits established by the regulatory body.

**Disposal methods for different types of radioactive wastes**

**High level waste disposal**

Most of the radioisotopes in high level waste emit large amounts of radiation and have extremely long half-lives (some longer than 100,000 years) requiring long time periods before the waste will settle to safe levels of radioactivity. While only 3% of the volume of all radioactive waste, it holds 95% of the radioactivity. It contains the highly radioactive fission products and some heavy elements with long-lived radioactivity. It generates a considerable amount of heat and requires cooling, as well as special shielding during handling and transport.
The HLW contains highly-radioactive fission products and radionuclides with long-lived radioactivity. The spent fuels would be stored and cooled in the "spent fuel pool" inside the Fuel Building for about 10 years to allow for the radioactive decay of its nuclides and removal of the residual heat. The spent fuels would then be arranged for either reprocessing or direct deep underground burial in repository for HLW.

Disposal in deep, stable geological formations usually several hundred meters or more below the surface is the generally recognized option for disposal of HLW.

**Intermediate level waste (ILW) disposal**

This is waste that, because of its radioactivity content, particularly of long-lived radionuclides, requires a greater degree of containment and isolation than that provided by near surface disposal. However, ILW needs no provision, or only limited provision, for heat dissipation during its storage and disposal. ILW may contain long-lived radionuclides that will not decay to a level of activity concentration acceptable for near surface disposal during the time for which institutional controls can be relied upon. Therefore, waste in this class requires disposal at greater depths, of the order of tens of meters to a few hundred meters. The composition of ILW is broad, but unlike LLW it requires shielding due to radioactivity levels.
ILW is solidified by mixing it with sand/cement and then poured into concrete drums. The ILW would be transported to the repository for burial eventually after temporary storage at the nuclear power station.

*Low level waste disposal*

Low-level waste is comparatively easy to dispose of. The level of radioactivity and the half-life of the radioactive isotopes in low-level waste are relatively small. Storing the waste for a period of 10 to 50 years will allow *most of the* radioactive isotopes in low-level waste to decay, at which point the waste can be disposed of as normal refuse. It is not dangerous to handle, but must be disposed of more carefully than normal garbage.

Low-level nuclear waste is usually buried in shallow landfill sites. To reduce its volume, it is often compacted (in a closed container) before disposal. Worldwide it comprises about 97% of the volume but only 5% of the radioactivity of all nuclear waste.

![Low-Level Radioactive Waste Disposal](image)

LLW is compressed into steel drums, sealed and stored temporarily at the nuclear power station and eventually be transported to the repository for disposal.
**Very Low Level Waste (VLLW)**

This waste usually has higher radioactivity content than EW but may, nonetheless, not need a high level of containment and isolation. It is suitable for disposal in near-surface landfill type facilities with limited regulatory control. Therefore, VLLW can be safely disposed of in municipal, county or commercial landfills.

**Very Short Lived Waste**

This is waste that can be stored for a limited period of up to a few years to allow its radioactivity content to reduce by radioactive decay. It can subsequently be cleared from regulatory control according to arrangements approved by the regulatory authority for disposal as ordinary waste, for use or for controlled discharge.

**Exempt waste (EW)**

This is waste with such a low radioactivity content, which no longer requires controlling by the regulatory authority. Once the material is cleared by the regulatory authority it is no longer considered as radioactive waste.

**The Pangea proposal**

A major research program in the 1990s (by Pangea Resources Australian Pvt. ltd.) has identified Australia, southern Africa, Argentina and western China as having the appropriate geological credentials for a deep geologic repository, with Australia being favoured on economic and political grounds. It would be located where the geology has been stable for several hundred million years, so that there need not be total reliance on a robust engineered barrier system to keep the waste securely isolated for thousands of years.
It would be a commercial undertaking and would have a dedicated port and rail infrastructure. It would take spent fuel and other wastes from commercial reactors, and possibly also material from weapons disposal programs. The proposal was highly controversial, and elicited opposition from Australian state and federal parliaments. Pangea ultimately abandoned its advocacy.

**Practice Questions**

Q1. Consider the following statements

1. Beta particles are charged particles
2. Gamma radiations are composed of charged particles
3. Both alpha and beta particles have an electric charge and mass

Which are correct?

(a) 1 only  (b) 1 & 2 only  (c) 1 & 3 only  (d) 1, 2 & 3

Ans. (c)

Q2. Consider the following statements about the spent fuel

1. It consists of long-lived radionuclides only
2. Significant amount of heat is generated by this waste material
3. Spent fuel can’t be reprocessed as it is a radioactive waste

Which of the above statements is/ are correct?

a) 1 only  b) 2 only  c) 1, 2 & 3  d) 2 & 3 only

Ans. (b)
Q3. (ESE 2018)

Consider the following characteristics with respect to Alpha particles:

1. They have large specific ionization value
2. They dissipate their energy rather slowly
3. They can penetrate the outer layer of human skin
4. Their emitters are heavy elements

Which are correct?

(a) 1&4  (b) 1&3  (c) 2&4  (d) 2&3

Ans. (a)