Energy and Environment Engineering

Dr K D Yadav
Associate Professor
Environmental Section
Department of Civil Engineering
S. V. National Institute of Technology, Surat
Mobile: +91-9428398266
E mail: kdy@ced.svnit.ac.in

Energy and Environmental Engineering CEME106

ENVIRONMENT AND ECOSYSTEMS

Introduction: Concept of an ecosystem- structure and functions of ecosystem. Components of ecosystem - producers, consumers, decomposers, Food chains, food webs, ecological pyramids, Energy flow in ecosystem. Bio-geo- chemical cycles, Hydrologic cycle Components of Environment and their relationship, Impact of technology on environment, Environmental degradation. Environmental planning of urban network services such as water supply, sewerage, solid waste management.

ENVIRONMENTAL POLLUTION

Water, air, soil, noise, thermal and radioactive, marine pollution: sources, effects and engineering control strategies. Drinking water quality and standards, Ambient air and noise quality standards

GLOBAL ENVIRONMENTAL ISSUES AND ITS MANAGEMENT

Engineering aspects of climate change. Acid rain, depletion of ozone layer. Concept of carbon credit. Concepts of Environmental impact assessment and Environmental audit. Environmental life cycle assessment

Radioactive Pollution

Introduction

Radioactive pollution can be defined as the release of radioactive substances or high-energy particles into the air, water, or earth as a result of human activity, either by accident or by design.

Radioactive contamination, also called radiological contamination, is the deposition of, or presence of radioactive substances on surfaces or within solids, liquids or gases, where their presence is unintended or undesirable.

Radioactive pollution occurs when there is presence or depositions of radioactive materials in the atmosphere or environment, especially where their presence is accidental and when it presents an environmental threat due to radioactive decay. The destruction caused by the radioactive materials is because of the emissions of hazardous ionizing radiation (radioactive decay) like beta or alpha particles, gamma rays or neurons in the environment where they exist.

Radioactive waste

Radioactive waste is usually the product of a nuclear process such as nuclear fission, which is extensively used in nuclear reactors, nuclear weapons and other nuclear fuel-cycles. Radioactive pollution. Radioactive waste is spread through the earth's atmosphere is called "Fallout".

Radioactive decay

Radioactive decay occurs because unstable isotopes tend to transform into a more stable state. Radioactivity is measured in terms of disintegrations, or decays, per unit time.

Surface **contamination** is usually expressed in **units** of **radioactivity** per **unit** of area for alpha or beta emitters. For SI, this is becquerels per square meter (or Bq/m^2). Other **units** such as picoCuries per 100 cm^2 or disintegrations per minute per square centimeter (1 dpm/cm^2 = 167 Bq/m^2) may be used.

Sources of radioactive pollution

The natural sources of radiation may be:

1. Radioactive Minerals:

The minerals containing Uranium- 235 , Uranium-238 , Thorium-232 , Plutonium- 239 etc. are capable of emitting energetic radiations causing pollution.

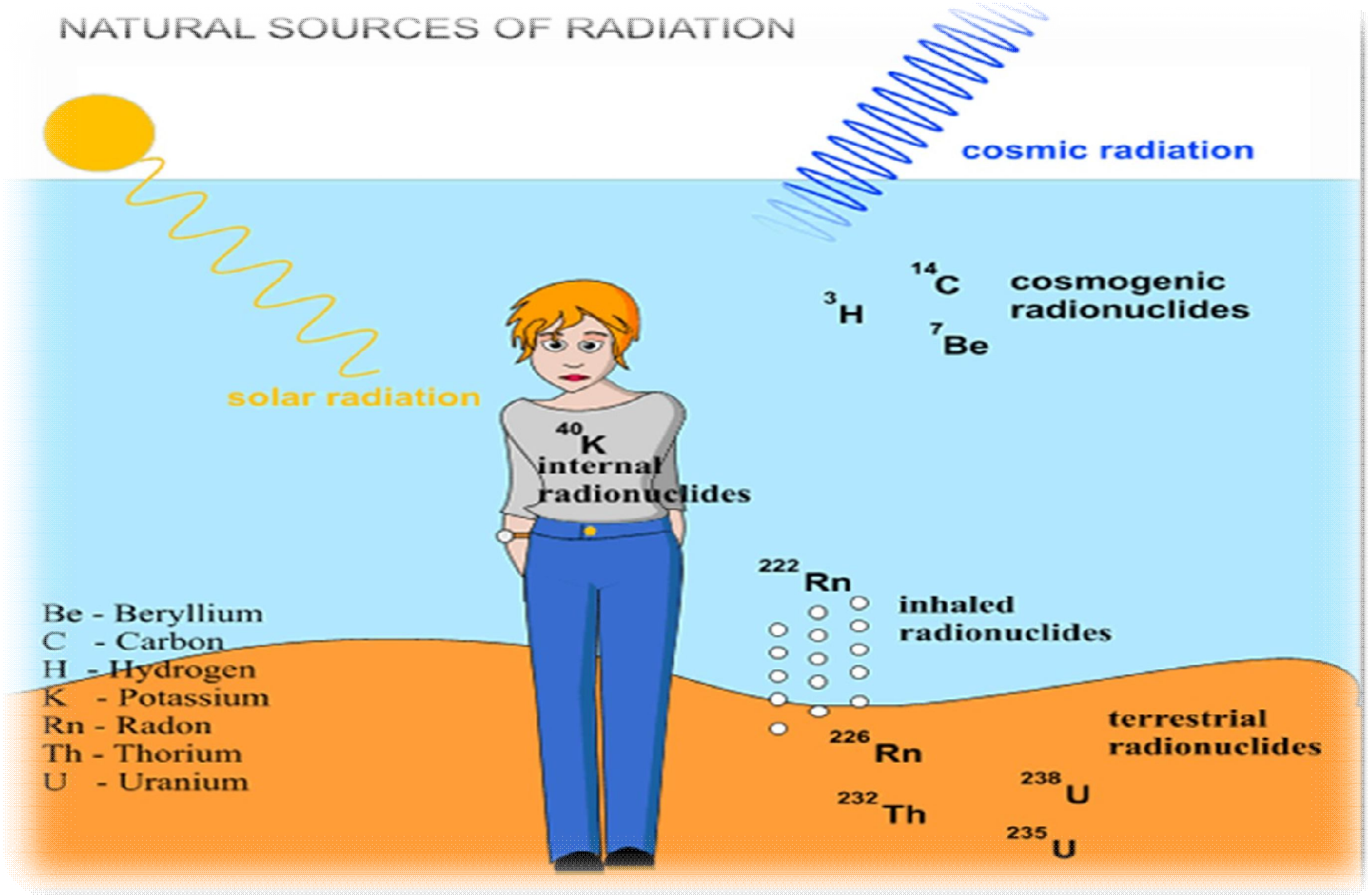
2. Cosmic Rays:

The cosmic rays containing highly energetic particles reach the surface of the earth causing pollution. The intensity of cosmic rays depends on latitudes and altitude of the place. The intensity is maximum at the poles and minimum at the equator.

3. Radio nuclides:

The unstable radio-nuclides in the atmosphere can split-up into smaller parts emitting energetic radiation. The smaller radio-nuclides enter into the body of organism along with air during respiration.

A variety of radionuclides occur naturally in the environment. Elements like uranium and thorium, and their decay products, are present in rock and soil. Potassium-40, a primordial nuclide, makes up a small percentage of all potassium and is present in the human body. Other nuclides, like carbon-14, which is present in all living organisms, are continuously created by cosmic rays.



NATURAL SOURCES OF RADIATION
cosmic radiation
solar radiation
^{14}C ^{3}H ^{7}Be
cosmogenic radionuclides
^{40}K
internal radionuclides
^{222}Rn
inhaled radionuclides
terrestrial radionuclides
^{226}Rn
^{232}Th
^{238}U
^{235}U
Be - Beryllium
C - Carbon
H - Hydrogen
K - Potassium
Rn - Radon
Th - Thorium
U - Uranium

Sources of radioactive pollution cont.

The various sources of manmade radiation pollutions may be:

1. **Nuclear Power Plants:** Nuclear power plants emit radiation to a very smaller extent except accidental leaks (Chernobyl accident of undivided USSR).

2. **Radio-active Wastes**: The nuclear power plants produce a lot of nuclear radio-active wastes. The disposal of these wastes has become a global problem. Some countries producing large quantity of nuclear wastes dump them in ocean near other countries.

3. **Nuclear Explosion**: During nuclear explosion, a large number of radio-nuclides are generated in the atmosphere. The radio nuclides settle down with rain contaminating the soil and water bodies. Finally, these enter into food chain causing serious problem to the living organisms.

4. **Radio-isotopes:** Radio-isotopes are also prepared artificially either by nuclear fusion or by nuclear fission. If these radio- isotopes are not properly handled, these emit radiations causing pollution.

5. **Television Set**: Television sets produce radiations which can also cause cancer.

Types of Pollutions

1. Continuous Pollution:

This type of condition exists in uranium mines, nuclear reactors, test labs etc. where the humans are under continuous exposure to radioactive contaminants and protective clothing is required to avoid radiation exposure.

2. Accidental Pollution:

This type of condition exists during accidental exposure to radiations by virtue of equipment failure, radiation leak, faulty protective equipment etc.

3. Occasional Pollution:

This condition exists during isolated experiment or test of nuclear substance.

Effects of Radioactive Pollution

1. Genetic mutations

It leads to damage of DNA strands leading to genetic break up in the course of time. The degree of genetic mutation leading to changes in DNA composition vary due to the level of radiation one has been exposed to and the kind of exposure.

2. Diseases

Cancer is the most dominant radiation related disease. Others include leukaemia, anaemia, haemorrhage, a reduction in the life span leading to premature aging and premature deaths as well as others such as cardiovascular complications. Leukaemia, for instance, is caused by radiation in the bone marrow.

3. Soil infertility

Radioactive substances in the soil react together with the various nutrients leading to destruction of those nutrients, thus rendering the soil infertile and highly toxic. Such soil leads to the harvest of crops that are riddled with radiation and thus, unfit for consumption by both humans and animals.

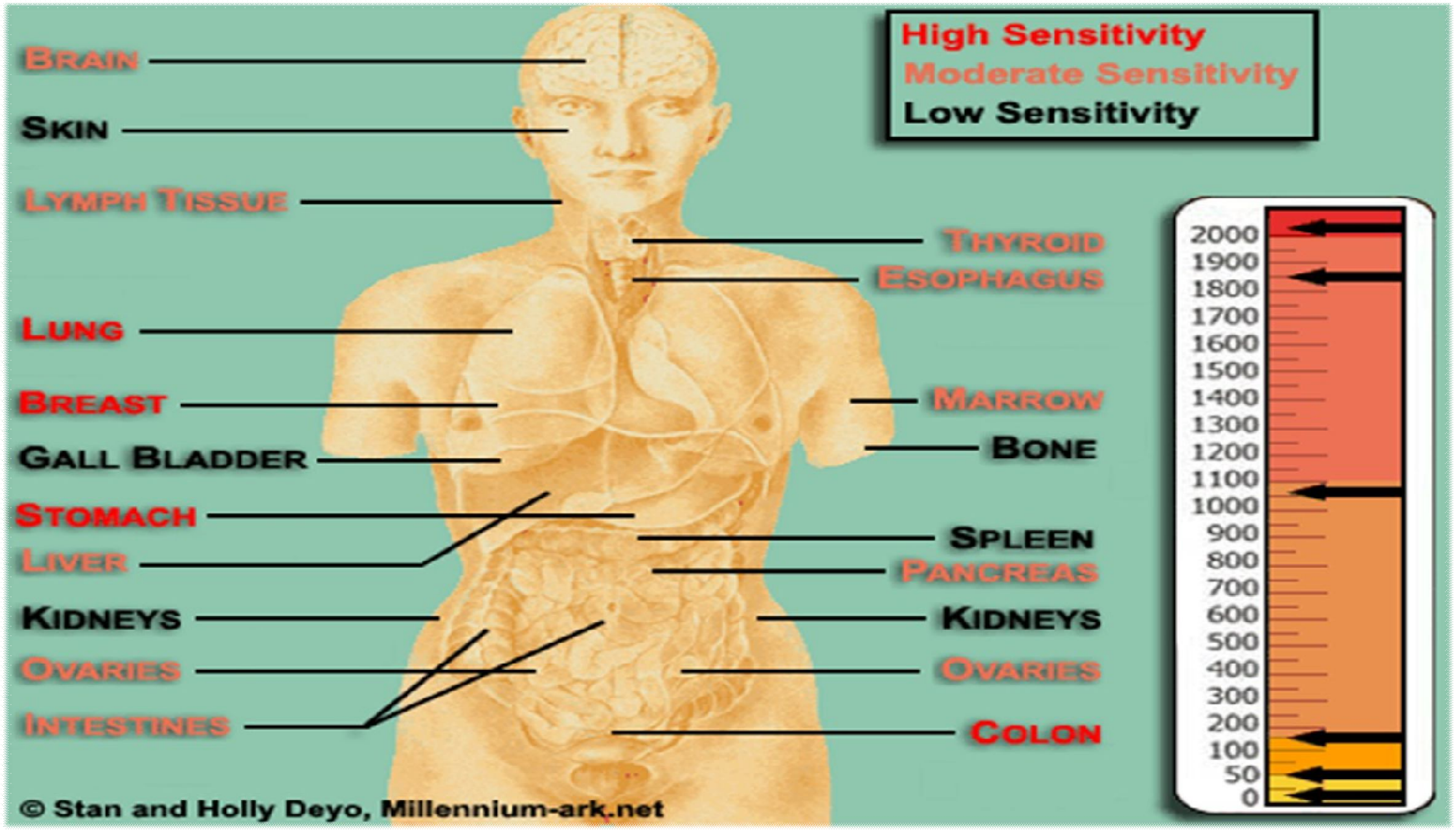
4. Cell destruction

Radioactive pollution has diverse effects such as the alteration of cells. Radiation distorts the cells present leading to permanent damage of the various organs and organ systems. In the face of too much radiation, permanent illnesses and death are inevitable.

5. Burns

The immediate presence of burns, red lesions and sores is evidence. To make it worse, this can lead to skin cancer.

Effect of Radiation



Control of Radioactive pollution

1. Proper method of disposing radioactive waste

Radioactive waste cannot be disposed in the same way as normal waste. It cannot be incinerated or buried. Since there is likelihood of seepage, this waste should be stored in heavy and thick concrete containers. Another option is to dilute the radiation since storage may not be possible

2. Proper labelling

It is necessary for any material with radioactive content to be labelled and the necessary precautions advised on the content of the label. The reason for this is because radiation can enter the body by a mere touch of radioactive material.

3. Banning of nuclear tests

It has already been proven that nuclear power has a lot of latent power that is very destructive. Nevertheless, the tests done to perfect the energy contribute greatly to the overall presence of radioactive substances.

Control of Radioactive pollution cont.

4. Alternative energy sources

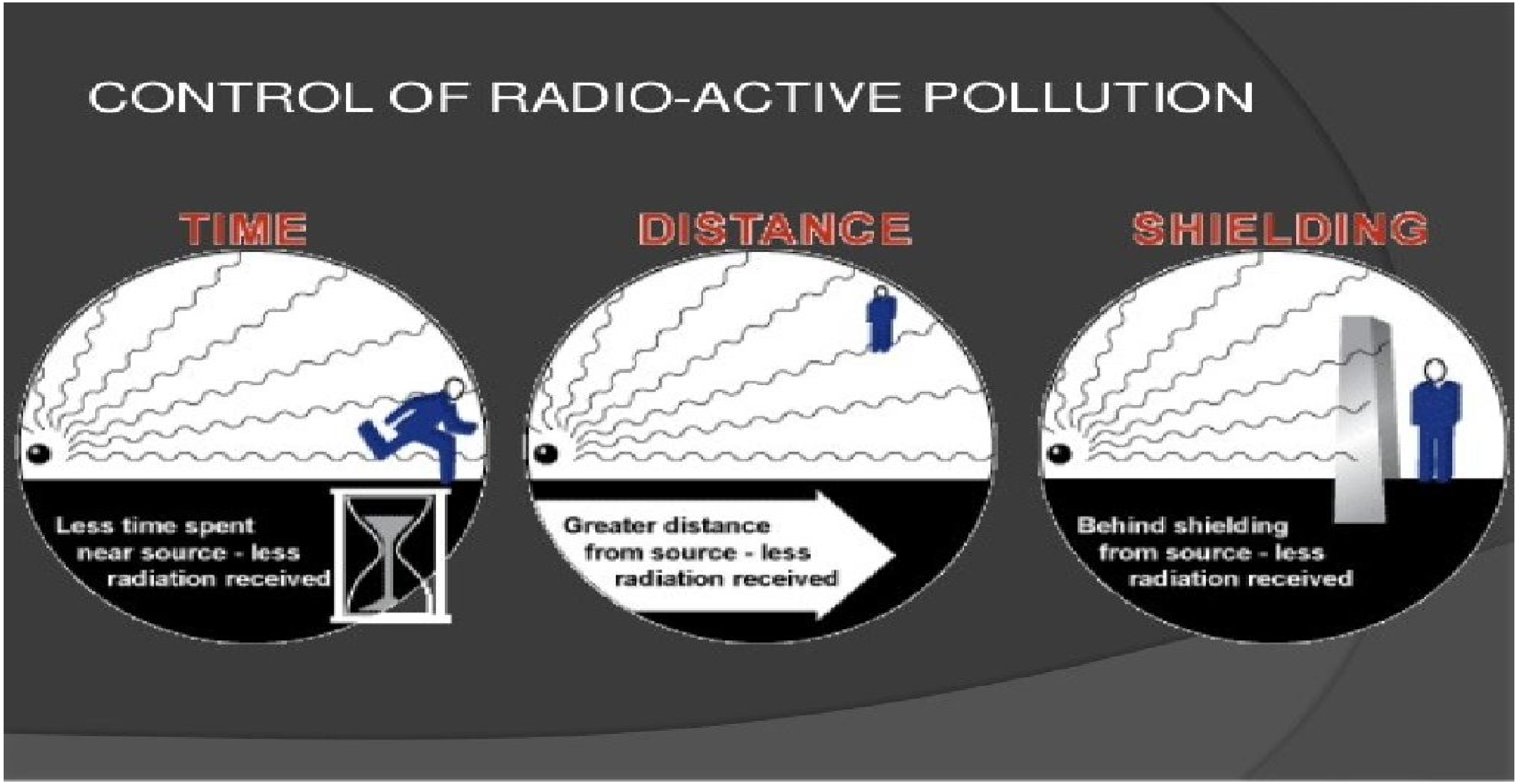
It is high time for its use to be discontinued and for the world to perhaps focus on alternative and environmentally friendly energy sources – like renewable sources of energy namely Solar, hydro-electric and wind power. The use of radioactivity to generate energy in nuclear power plants, for example, leads to the production of more radiation to the atmosphere considering the waste released from the various processes and combustion.

5. Proper storage

It is mandatory for containers carrying radioactive material to be stored properly. For starters, such substances should be stored in radiation proof containers to ensure no seeping or leakage during handling. Proper storage means no harm and can minimize cases of accidental leakage.

6. Reusing

Since it is not easy to store or dispose the waste, it can be recycled and used for other purposes like in another reactor as fuel thereby protecting the environment.


CONTROL OF RADIO-ACTIVE POLLUTION
TIME
DISTANCE
SHIELDING
Less time spent near source - less radiation received
Greater distance from source - less radiation received
Behind shielding from source - less radiation received

Storage and Disposal of Radioactive Waste

- Radioactive wastes are stored so as to avoid any chance of radiation exposure to people, or any pollution.

- The radioactivity of the wastes decays with time, providing a strong incentive to store high-level waste for about 50 years before disposal.

- Disposal of low-level waste is straightforward and can be undertaken safely almost anywhere.

- Storage of used fuel is normally under water for at least five years and then often in dry storage.

- Deep geological disposal is widely agreed to be the best solution for final disposal of the most radioactive waste produced.

Category of waste for disposal

Low-level radioactive waste (LLW): it is typically sent to land-based disposal immediately following its packaging for long-term management.

High-level radioactive waste (HLW): It is stored to allow decay of radioactivity and heat, making handling much safer. Storage of used fuel may be in ponds or dry casks, either at reactor sites or centrally. Used fuel that is not intended for direct disposal may instead be reprocessed in order to recycle the uranium and plutonium it contains.

Intermediate-level radioactive waste (ILW): that contains long-lived radioisotopes is also stored pending disposal in a geological repository.

Commonly-accepted disposal options

Sr. No.	Option	Suitable waste types
1	Near-surface disposal at ground level, or in caverns below ground level (at depths of tens of metres)	LLW and short-lived ILW
2	Deep geological disposal (at depths between 250m and 1000m for mined repositories, or 2000m to 5000m for boreholes)	Long-lived ILW and HLW (including used fuel)

Radioactive Waste Disposal Method

Near surface disposal: These facilities are on or below the surface where the protective covering is of the order of a few metres thick. Waste containers are placed in constructed vaults and when full the vaults are backfilled. Eventually they will be covered and capped with an impermeable membrane and topsoil. These facilities may incorporate some form of drainage and possibly a gas venting system.

Disposal of low level radioactive waste

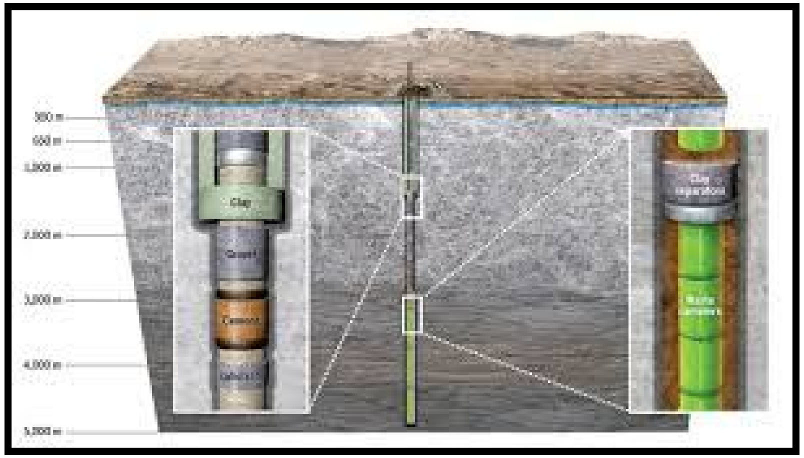
- Disposal facility for low level radioactive waste (LLW).
- **Near surface disposal:** disposal in a facility consisting of engineered channels or vaults constructed on the ground surface or up to a few tens of meters below ground level.

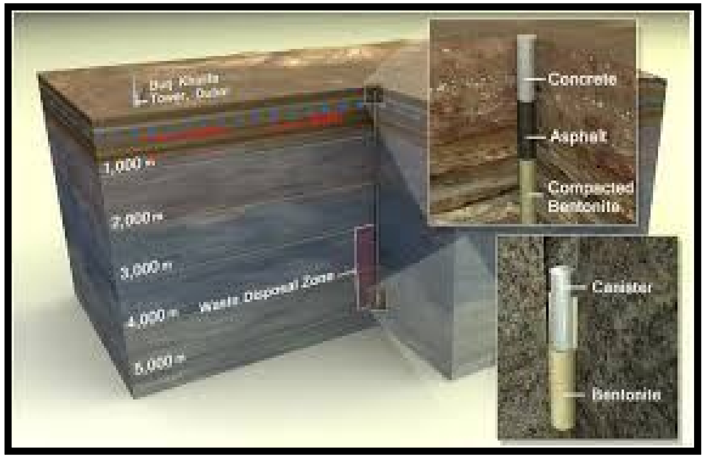
Hanford (Nuclear News, November 2004)

Deep geological disposal: The long timescales over which some waste remains radioactive has led to the idea of deep disposal in underground repositories in stable geological formations. Isolation is provided by a combination of engineered and natural barriers (rock, salt, clay) and no obligation to actively maintain the facility is passed on to future generations. This is often termed a 'multi-barrier' concept, with the waste packaging, the engineered repository, and the geology all providing barriers to prevent the radionuclides from reaching humans and the environment. In addition, deep groundwater is generally devoid of oxygen, minimising the possibility of chemical mobilisation of waste.

Mined repositories: The most widely proposed deep geological disposal concept is for a mined repository comprising tunnels or caverns into which packaged waste would be placed. In some cases (*e.g.* wet rock) the waste containers are then surrounded by a material such as cement or clay (usually bentonite) to provide another barrier (called buffer and/or backfill). The choice of waste container materials and design, as well as the buffer/backfill material varies depending on the type of waste to be contained and the nature of the host rock-type available.

Deep boreholes: The concept consists of drilling a borehole into basement rock to a depth of up to about 5000 metres, emplacing waste canisters containing used nuclear fuel or vitrified radioactive waste from reprocessing in the lower 2000 metres of the borehole, and sealing the upper 3000 metres of the borehole with materials such as bentonite, asphalt or concrete. The disposal zone of a single borehole could thus contain 400 steel canisters each 5 metres long and one-third to half a metre in diameter. The waste containers would be separated from each other by a layer of bentonite or cement.





Interim waste storage and transport

Specially designed interim surface or sub-surface storage waste facilities are currently used in many countries to ensure the safe storage of hazardous radioactive waste pending the availability of a long-term disposal option.

Storage ponds: Storage ponds at reactors, which are 7-12 metres deep to allow the racked fuel assemblies to be covered by several metres of water. These pools are robust constructions made of thick reinforced concrete with steel liners. Ponds at reactors may be designed to hold all the used fuel for the life of the reactor, but usually the design assumes some removal of cooled fuel for reprocessing or to dry storage.

Dry storage: Some storage of fuel assemblies which have been cooling in ponds for at least five years is in dry casks or vaults, typically with air circulation inside concrete shielding. Dry storage has been used at US nuclear power plants since 1986, and at least one-third of the total US used fuel is now in dry storage casks.

Multi-purpose canisters: Sealed multi-purpose canisters (MPCs), also called dual-purpose canisters (DPCs), each holding up to 89 fuel assemblies with inert gas, are commonly used for transporting, storing

Other disposal method in practise.

Ideas	**Examples**
Long-term above ground storage	❖ Investigated in France, Netherlands, Switzerland, UK, and USA. ❖ Not currently planned to be implemented anywhere.
Disposal in outer space (proposed for wastes that are highly concentrated)	❖ Investigated by USA.
Rock-melting (proposed for wastes that are heat-generating)	❖ Investigated by Russia, UK, and USA. ❖ Not implemented anywhere.
Disposal at subduction zones	❖ Investigated by USA. ❖ Not permitted by international agreements.
Sea disposal	❖ Implemented by Belgium, France, Germany, Italy, Japan, Netherlands, Russia, South Korea, Switzerland, UK, and USA.
Sub seabed disposal	❖ Investigated by Sweden and UK (and organisations such as the OECD Nuclear Energy Agency).
Disposal in ice sheets (proposed for wastes that are heat-generating)	❖ Investigated by USA
Deep well injection (for liquid wastes)	❖ Implemented in Russia for many years for LLW and ILW.

Laws regulating radiological accidents in India

- Atomic Energy Act, 1962
- Radiation protection rules, 1971
- Atomic energy (safe disposal of radioactive waste) rules, 1987
- Environmental protection Act,1986

Conclusion

- Radioactive waste disposal practices have changed substantially over the last twenty years. Evolving environmental protection considerations have provided the impetus to improve disposal technologies, and, in some cases, clean up facilities that are no longer in use.
- Designs for new disposal facilities and disposal methods must meet environmental protection and pollution prevention standards that are stricter than were foreseen at the beginning of the atomic age.
- Disposal of radioactive waste is a complex issue, not only because of the nature of the waste, but also because of the stringent regulatory structure for dealing with radioactive waste.
- India has achieved self-reliance in the management of all type of radioactive waste. Decades of safe and successful operation of our waste management facility stand testimony to international standards. An ongoing effort to upgrade technology to minimize radioactive discharge is also on.

Thank you