

NUCLEAR HAZARDS:

Nuclear hazards are threat posed by the invisible and odourless contamination of the environment by the presence of radioactive materials such as radio-nuclides in air water or soil. These radio-nuclides emit high energy particles (alpha and beta rays) and electromagnetic radiations (gamma rays). Radio nuclides are elements, such as uranium 235, uranium 283, thorium 232, potassium 40, radium 226, carbon 14 etc., with unstable atomic nuclei and release ionizing radiations in the form of alpha, beta and gamma rays. The spontaneous emission of particles and rays by an unstable nucleus is called Radioactivity and contamination of environment with these radiations is called as Radioactive or Nuclear pollution.

Thus, Radioactive or Nuclear pollution can be defined as the release of radioactive substances or high-energy particles into the air water, or earth mostly as a result of human activity, either by accident or by design. Sometimes natural sources of radioactivity, such as radon gas emitted from beneath the ground, are considered pollutants when they become a threat to human health.

Radio-nuclides occur naturally in our environment. They are even found in human bodies and every day we ingest or inhale these radio-nuclides through air, water or food. Out of the known 450 radioisotopes only some are of environmental concern like strontium 90, tritium, plutonium 239, argon 41, cobalt 60, cesium 137, iodine 131, krypton 85 etc. These can be both beneficial and harmful, depending on the way in which they are used.

Sources of Nuclear Pollution / Hazards/ Radioactive Pollution: The sources of nuclear pollution include both natural and manmade sources.. The human environment has always been radioactive and accounts for up to 85% of the annual human radiation dose. Radiation arising from human activities typically accounts for up to 15% of the public's exposure every year.

1. Natural Sources: Most radiation exposure is from natural sources. These include: radioactivity in rocks and soil of the Earth's crust; radon, a radioactive gas given out by many volcanic rocks and uranium ore, cosmic radiations etc.

- a. Cosmic rays from outer space. The quantity depends on altitude and latitude; it is more at higher latitudes and high altitudes.
- b. Emissions from radioactive materials in the Earth Crust i.e. Rocks, Marine sediments etc.

1. Man-Made Sources: These sources involve any process that emanates radiation in the environment. While there are many causes of radiation pollution such as including research and medical procedures and wastes, nuclear power plants etc.

a. Nuclear waste handling and disposal: It may generate low to medium radiation over long period of times. The radioactivity may contaminate and propagate through air, water, and soil as well. Thus, their effects may not be easily distinguishable and are hard to predict. The main issue with the radiation waste is the fact that it cannot be degraded or treated chemically or biologically. Thus, the only options are to contain the waste by storing it in tightly closed containers shielded with radiation-protective materials (such as Pb) or, if containing is not possible, to dilute it. The waste may also be contained by storage in remote areas with little or no life (such as remote caves or abandoned salt mines). However, in time, the shields (natural or artificial) may be damaged. Additionally, the past waste disposal practices may not have used appropriate measures to isolate the radiation. Thus, such areas need to be carefully identified and access restrictions promptly imposed.

b. Use of radioactive materials in Defense weapon production: Nuclear weapon production may also release radiations from the handled radioactive materials (usually of high health risks).

However, unless accident occurs, the current standards will not allow the release of any significant amount of radiation.

- c. **Nuclear explosions and detonations of nuclear weapons:** The highest amounts of human-induced radiation pollution have been generated probably in the mid twenty century through various experimental or combat nuclear detonations, that ended the Second World War.
- d. **Mining and processing of radioactive ores:** It involve the crushing and processing of radioactive ores and generate radioactive by-products. Mining of other ores may also generate radioactive wastes (such as mining of phosphate ores).
- e. **Nuclear accidents:** explosion at Three Mile Island 1979 and Chernobyl 1986 nuclear-power plant accidents are the classic examples of radiation pollution from this type of source. Even accidents from handling medical nuclear materials/wastes could have radiation health effects on workers.
- f. **Use of radioactive isotopes in medical, industrial and research applications:** The greatest exposure to human beings comes from the diagnostic use of X-rays, radioactive isotopes used as tracers and treatment of cancer and other ailments.

Human Risks

Effects of Nuclear Pollution / Hazards/ Radioactive Pollution: Radioactive substances when released into the environment are either dispersed or become concentrated in living organisms through the food chain. Other than naturally occurring radioisotopes, significant amounts are generated by human activity, including the operation of nuclear power plants, the manufacture of nuclear weapons, and atomic bomb testing. Typically these effects can be of two types:

1. **Somatic effects:** Somatic affects the function of cells and organs of the individual exposed. It causes damages to cell membranes, mitochondria and cell nuclei resulting in abnormal cell functions, cell division, growth and death.

2. **Genetic effects:** Radiations can cause mutations, which are changes in genetic makeup of cells and effects the future generations also. These effects are mainly due to the damages to DNA molecules. People suffer from blood cancer and bone cancer if exposed to higher doses around 100 to 1000 roentgens.

Nuclear hazard effects can be either initial or residual.

Initial effects occur in the immediate area of explosion and are hazardous immediately after the explosion. The principal initial effects are **blast and radiation**. Blast causes damage to lungs, ruptures eardrums, collapses structures and causes immediate death or injury. Thermal Radiation is the heat and light radiation, which a nuclear explosion's fireball emits producing extensive fires, skin burns, and flash blindness. Nuclear radiation consists of intense gamma rays and neutrons produced during the first minute after the explosion. This radiation causes extensive damage to cells throughout the body. Radiation damage may cause headaches, nausea, vomiting, diarrhoea, and even death, depending on the radiation dose received. Whereas **the residual effects** can last for days or years and may lead to death.

All organisms are affected from radiation pollution, and the **effects can vary from mild to extremely dangerous depending upon the various factors such as dose, duration and type of radiation**. Some of the possible human health effects are listed as under:

- a. **Effects on DNA and Mutations :** Radiations may break chemical bonds, such as DNA in cells and cause mutations. This affects the genetic make-up and control mechanisms. The effects can be instantaneous, prolonged or delayed types. Even it could be carried to future generations.

- b. **General Physiological Effects:** Exposure at low doses of radiations (100-250 rads), men do not die but begin to suffer from fatigue, nausea, vomiting and loss of hair. But recovery is possible.
- c. **Effects on Immunity:** Exposure at higher doses (400-500 rads), the bone marrow is affected, blood cells are reduced, natural resistance and fighting capacity against germs is reduced, blood fails to clot, and the irradiated person soon dies of infection and bleeding.
- d. **Effects on Tissues of Vital Organs:** Higher radiation doses (10,000 rads) kill the organisms by damaging the tissues of heart, brain, etc. **Hypothyroidism** may also be a radiation cause due to the destruction of thyroid gland by radioactive accumulated iodine.
- e. **Occupational Diseases:** Few occupations that involve radioactive exposures are uranium miners, radium watch dial painters, technical staff at nuclear power plants, etc. Exposure to radioactive and nuclear hazards has been clinically proven to cause cancer, mutations and **teratogenesis** (Teratogenesis is a prenatal toxicity characterized by structural or functional defects in the developing embryo or foetus).
- f. **Effects through biomagnifications:** Through food chain also, radioactivity effects are experienced by man. E.g. Strontium 90 behaves like calcium and is easily deposited and replaces calcium in the bone tissues. It could be passed to human beings through ingestion of strontium-contaminated milk.
- g. **Cancers:** Cancer generation is the most typical **health effect of radiation exposure**, especially when high or moderate amounts of radiation are involved (in general regardless of the exposure period). **Lung cancer** is a typical example of the effect of exposure to radon, which is the second leading cause of lung cancer in the U.S.
Many years of monitoring of radiation effects from detonation of nuclear bombs in Japan in 1940's, showed that cancers may develop immediately following the exposure to radiation or after shorter or longer periods (up to 30 years from the exposure) of time since the exposure occurred.

Control of nuclear hazards:

Peaceful uses of radioactive materials are so wide and effective that we cannot go without them but also there is no cure for radiation damage. Thus the only option against nuclear hazards is to check and prevent radioactive pollution. Following are the ways to prevent or control these hazards:

- a. Leakages from nuclear reactors, careless handling, transport and use of radioactive fuels, fission products and radioactive isotopes have to be totally stopped.
- b. Safety measures should be enforced strictly and strengthened against nuclear accidents.
- c. There should be regular monitoring and quantitative analysis through frequent sampling in the risk areas.
- d. Preventive measures should be followed so that background radiation levels do not exceed the permissible limits.
- e. Appropriate steps should be taken against occupational exposure.
- f. Waste disposal must be careful, efficient and effective.

Disposal of nuclear wastes

Since nuclear waste can be extremely dangerous and, therefore, the way in which they are to be disposed of is strictly controlled by international agreement. Since 1983, by international agreement, the disposal in the Atlantic Ocean and into the atmosphere has been banned.

After processing, to recover usable material and reducing the radioactivity of the waste, disposal is made in solid form where possible. The nuclear wastes are usually classified into three categories:

1) High Level Wastes (HLW): High level wastes have a very high-radioactivity per unit volume. E.g. Spent nuclear fuel. HLWs have to be cooled and are, therefore, stored for several decades by its producer before disposal. Since these wastes are too dangerous to be released anywhere in the biosphere, therefore, they must be contained either by converting them into inert solids (ceramics) and then buried deep into earth or are stored in deep salt mines.

2) Medium level wastes (MLW): Medium level wastes (e.g., filters, reactor components, etc.,) are solidified and are mixed with concrete in steel drums before being buried in deep mines or below the sea bed in concrete chambers.

3) Low liquid wastes (LLW): Low liquid wastes (e.g., solids or liquids contaminated with traces of radioactivity) are disposed of in steel drums in concrete-lined trenches in designated sites.

In India, a Waste Immobilization Plant (WIP) was commissioned in 1985 at Tarapore. It verifies HLWs.

Precautions after the disposal of nuclear waste:

The careful, efficient and effective treatment/disposal of radioactive waste, just do not complete the task. A regular supervision of the disposal sites is must. The essential precautions, at the disposal sites, that have to be taken include:

- 1) Monitoring radioactivity around the disposal sites.
- 2) Prevention of erosion of radioactive waste disposal sites.
- 3) Prevention of any drilling activity in and around the waste disposal site.
- 4) Periodic and long-term monitoring of such disposal sites and areas of naturally occurring uranium rich rocks.