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Radiation Pollution: The Most Dangerous Form of Pollution

Dr. Sayantan Mondal

Assistant Professor, Department of Chemistry, Bankura Zilla Saradamani Mahila Mahavidyapith, Bankura University

ABSTRACT

The release of radioactive substances into the air, water, or earth as a result of human activity, either by accident or by designbecome a threat to the mankind. Through appropriate safeguards and control measures we can prevent or at least mitigate these adverse environmental impacts.

Keywords: Radiation, Pollution, Nuclear, Hazardous, Cancer.

I. 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. The natural radiations are also known as the background radiations. In this the cosmic rays are involved and reach the surface of earth from space. It includes the radioactive elements like radium, uranium, thorium, radon, potassium and carbon. These occur in the rock, soil and water. The man made radiations include the mining and refining of plutonium and thorium. This production and explosion of nuclear weapons include the nuclear fuels, power plants and radioactive isotopes.

The first atom bomb was exploded in the Japan in the year 1945. It affected the Hiroshima and Nagasaki cities. It adversely affected the flora, fauna and humans of that area. In spite of these destructions the nuclear race is still going on between different nations. The nuclear arms are tested with the production of nuclear weapons.

II. SOURCE OF RADIOACTIVE POLLUTION

A Radioactive pollution is increasing because of the increased use of radioactivity. It occurs mostly from the waste products that are left behind after the use of radioactive substances. 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 wastes are disposed of without any precautionary measures to isolate the emissions which then contaminate the air, soil and water. Large amount of radioactive waste is generated from nuclear reactors used in nuclear power plants and for many other purposes. It occurs during extraction and refining of the radioactive material. Nuclear accidents and nuclear explosions are the two worst man-made sources of radioactive pollution.

Radioactive pollution is not a constant or regular phenomenon and hence the duration and frequency of pollution will vary with time and conditions. The three major types of conditions exist.

i. **Continuous pollution:** This type of condition exists in Uranium mines, nuclear reactors and laboratories where the humans are under continuous exposure to radioactive contaminants.
ii. **Accidental pollution:** This type of condition exists during accidental exposure to radiations by virtue of equipment failure, radiation leak, faulty protective equipment etc; and
iii. **Occasional pollution:** This condition exists during isolated experiment or test of nuclear substance.

Ever since the earth came into existence, all life forms have been exposed to some degree of low-level radiation (natural background radiation). Scientists consider that this exposure has played a key role in the evolution of life. However, in the present scientific and industrial world, the sources of radiation have increased due to multiple human activities.

Thus the sources of radiation can be broadly classified into two major groups:

(A) **Natural sources:** Our surrounding environment, such as the air, the rocks and soil, our house, even the food we eat and the water we drink are all sources of radiation. Some amount of radiation is also present within the human body; for example, polonium and radium are present in the bones while radioactive carbon and potassium are found in the muscles.

The natural sources can be further categorized into the following:

(a) **Solar radiation:** The radiation from the sun comprises both ultraviolet and infrared radiations.

(b) **Cosmic radiation:** Cosmic rays constantly rain down in the Earth's atmosphere from outer space. These primarily contain protons, few electrons, helium ions, etc. which continuously interact with the Earth's atmosphere.

(c) **Terrestrial radiation:** Terrestrial sources are the most important natural source to which the Earth's organisms are exposed. It results from the cumulative effect from a number of materials around us, such as water, air, rock, soil, food, etc. The sources of terrestrial radiation are the radioactive minerals that are present in the Earth's crust.

(B) **Man-made sources:** Due to the advancements in science and technology, humans have been using radiation technology for energy requirements and for health benefits.The major sources where radioactive wastes are generated and are responsible for radioactive

Pollution are as follows:

(i) Uranium mining; (ii) Production of nuclear fuel; (iii)Nuclear power reactors; (iv) Use of radionuclides in industries for various application; (v) Nuclear tests carried out by the Defense Personnel; and (vi) Disposal of nuclear waste.

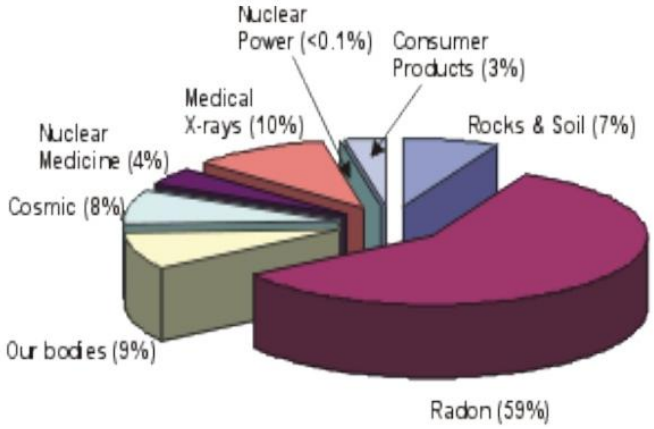

Fig. 1: Source of radiations

These radiations are of two types:

(1) **Non-ionizing radiations:** They are the electromagnetic waves of longer wavelength from near ultraviolet rays to radio waves. These waves have energies enough to excite the atoms and molecules of the medium through which they are moving, causing them to vibrate faster. These do not have enough energy to ionize them.

(2) **Ionizing radiations:** These 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 radioactive decay can cause ionization of atoms and molecules ofthe medium through which they pass and convert them into charged ions.

III. ATMOSPHERIC POLLUTION: FALLOUT

Radioactive pollution that is spread through the Earth's atmosphere is termed fallout. Such pollution was most common in the two decades following World War II, when the United States, the Soviet Union, and Great Britain conducted hundreds of nuclear weapons tests in the atmosphere. France and China did not begin testing nuclear weapons until the 1960s and continued atmospheric testing even after other nations had agreed to move their tests underground.

Three types of fallout result from nuclear detonations: local, tropospheric, and stratospheric. Local fallout is quite intense but short-lived. Tropospheric fallout (in the lower atmosphere) is deposited at a later time and covers a larger area, depending on meteorological conditions. Stratospheric fallout, which releases extremely fine particles into the upper atmosphere, may continue for years after an explosion and attain a worldwide distribution.

IV. LAND AND WATER POLLUTION

The major sources of radioactive pollution on land and water include: (1) the nuclear fuel cycle--the extraction, separation and refinement of materials for use in nuclear weapons and nuclear power and (2) the day-to-day operations of nuclear power plants.

At every stage in the production of nuclear fuels, contaminants are left behind. The mining of uranium, for example, produces highly radioactive tailings which can be blown into the air, contaminate soil, or leach into bodies of water. The magnitude of radioactive pollution caused by the nuclear fuel cycle, especially in the United States, Great Britain, and the Soviet Union, has only recently been revealed. Through the years of the cold war, the extent of accidental discharges and intentional dumping carried out by government plants like Britain's Wind scale and the United States' Hanford Nuclear Reservation remained largely unknown. Not until the late 1980s, for instance, was the legacy of pollution at Hanford exposed to public scrutiny. This legacy included the release of half a million curies of radioactive iodine into the air from 1944 to 1955, and the release of millions of curies of radioactive material into the Columbia River, Washington from 1944 through at least the 1960s. In 1956, 450,000 gallons (1.7 million l) of high-level waste were accidentally spilled on the Hanford grounds. Through the 1950s, additional millions of gallons of waste were dumped into the ground. Residents in the area and along the river were never notified about any of the radioactive discharges that took place at Hanford.

In 1988, the U.S. Department of Energy (DOE) reported that radioactive wastes from Hanford were contaminating some underground water supplies; Hanford was shut down a year later. For many years, some 177 deteriorating steel tanks held approximately 56 million gallons (over 210 million l) of radioactive waste combined with toxic chemicals. In late 2010, workers at the Hanford site were continuing the remediation process of transferring this toxic brew to new, double-lined steel tanks. In September 2009, the U.S. Government Accountability Office (GAO) forecast that the clean-up at Hanford, which had previously been estimated at 57 billion dollars, might ultimately exceed 100 billion dollars. The DOE is in charge of the clean-up effort at Hartford; as of 2010, DOE's deadline for completion of the massive clean-up effort at Hanford had slipped from the year 2028, to the new deadline of 2047.

Nuclear power plants also contribute to radioactive pollution. Spent nuclear fuel from these plants, a high-level waste, must be kept from human contact for hundreds or thousands of years, yet no completely reliable disposal method exists. At present, most high-level waste has simply been left in pools at power plant sites while the government seeks a central location for permanent disposal. In the 2000s, the George W. Bush administration intended to begin depositing high-level nuclear waste within the Yucca Mountain complex in Nevada. In 2009, the decision to utilize YuccaMountain as the nation's main depository for high-level nuclear waste was rescinded.

V. HARMFUL EFFECTS

The effects of radiation were first noted in 1909 when it was found that uranium miners suffer from skin burn and cancer due to radiations from the radio-active mineral. Different organisms show different sensitivity to ionising radiations. For example, tests have shown that pine trees are killed by radiations in which oak trees continue to thrive comfortably.

It has also been reported that high altitude plants have developed polyploidy as a protective mechanism against radiations. Parts of coastal areas in South India have a high degree of background radiation which was formerly considered to be quite harmful to human beings.

The cells which actively grow and divide are quickly damaged. This category includes the cells of skin, intestinal lining, bone marrow, gonads and embryo. Radiations have both immediate or short-range and delayed or long-ranged effects.

A. Short Range (Immediate) Effects

They appear within days or a few weeks after exposure. The effects included loss of hair, nails, subcutaneous bleeding, change in number and proportion of blood cells, changed metabolism, and proportion of blood cells, etc. In the last few decades, number of people being exposed to ionizing radiation has increasedtremendously, especially people involved in the mining of uranium ores, patients treatedwith γ-radiations and technical people using X-rays and other radioactive isotopes. Beforethe dangers of radiation on human body were known, workers dealing with radioactivematerials were careless and suffered from various types of cancer. Early workers whoused phosphorescent radium paint on the dials of watches suffered from bone tumours in1920s.

B. Long Range (Delayed) Effects

They appear several months or even years after the exposure. The effects are caused by development of genetic changes, mutations, shortening of life span, formation of tumour, cancers, etc. The effect of mutations can persist in the human race.

All organisms are affected by radiation pollution. Some organisms preferentially accumulate specific radioactive materials. For example, oysters accumulate ^{65}Zn, fish accumulate ^{55}Fe, and marine animals accumulate ^{90}Sr.

Exposure to any type of ionizing radiation (α and β particles, γ-rays and X-rays) can proveharmful and even lethal.

The two types of effects are:

(i) Genetic and
(ii) Non-genetic or body damage.

In genetic damage, genes and chromosomes get altered. Its effect may become visibleas deformations in the off springs (children or grandchildren). Alterations or breaks in thegenetic material, that is DNA (deoxyribonucleic acid) - the molecule containing geneticinformation, is called mutation. In non-genetic effects, the harm is visible immediately inthe form of birth defects, burns, some type of leukemia, miscarriages, tumours, cancer ofone or more organs and fertility problems.

Table I: Effects of Radioactive Radiation on Living Beings

Type of radiation	Effect on the body
α–particles	Generally they cannot penetrate the skin. But if their sources is inside the body, they can cause damage to bones or lungs.
β-particles	Can penetrate the skin but cannot damage the tissues. They can cause damage to skin and eyes (cataract).
γ-radiation	Can easily penetrate the body and pass through it. They cause damage to cell structure.
X-rays	Can travel very far and pass through the body tissues except bones. They can cause damage to the cells.

VI. CONTROL OF RADIOACTIVE POLLUTION

Since radioactive pollution is highly hazardous to human health therefore prevention and control of radioactive pollution is inevitable. The radioactive pollution can be controlled by number of ways which are as follows:

- Leakage from the radioactive materials including the nuclear reactors, industries and Laboratories need to be checked.
- The disposal of radioactive material must be safe and secure.
- Radioactive materials must be stored in safe places and must be changed into harmless form.
- The radioactive wastes with a very low radiation must be put into the sewage.
- The nuclear power plants must follow all the safety instructions.
- The protective garments must be worn by the workers who work in the nuclear plants.
- The natural radiation must be at the permissible limits.
- Nuclear devices should be exploded under ground.
- Contaminants may be employed to decrease the radioactive emissions.
- Production of radio isotopes needs to be minimized.
- Extreme precautions should be taken during the disposal of industrial wastes containingradionuclides.
- High chimney and ventilations should be used at working places where radioactive contamination is high.
- In nuclear reactors, closed cycle coolant system with gaseous coolants of very high purity may be used to prevent extraneous activation products.
- Fission reactions need to be minimized.
- In nuclear mines, wet drilling may be employed along with underground drainage.
- Nuclear medicines and radiation therapy should only be applied when absolutely necessary.

CONCLUSION

Radioactive pollution adversely affects the human health often leading to death, hence it is the most dangerous form of pollution among all pollution types. Since the radiation targets the genetic material therefore the defects caused are transmitted from parents to offspring. Hence prevention and control of radioactive pollution is inevitable to avoid its harmful effects on the human health.

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