Low Level Radioactive Contamination in the Environment

Eurami Group

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Radiation is defined as the release of energy from an atom in the form of electromagnetic radiation or as radioactivity. As such, the energy is released as either a wave or a particle. When energy is released as a waveform, electromagnetic radiation results. Visible light, heat, ultraviolet radiation, radio waves, infrared waves, X rays, cosmic rays and gamma rays generate electromagnetic radiation. When energy is released as particulate matter, radioactivity exists. Radioactivity is generated when an atomic nucleus experiences decay and takes on the form of alpha and beta particles. However, this type of atomic decay may also cause waves of energy to be released as gamma rays

While some forms of radiation are necessary and naturally occurring in life, others are artificially generated from various sources

Electromagnetic radiation that occurs naturally with heat, visible light and ultraviolet light is not typically known to cause danger or death to living tissue. Most harmful radiation results from radioactivity or electromagnetic radiation with frequencies in excess of those in visible light, such as with X-rays or gamma rays. This type of harmful electromagnetic radiation is known as ionizing radiation. With ionizing radiation, atoms are stripped of some electrons leaving free radicals, which are highly reactive ions that may damage living tissue and other genetic material

Since radiation cannot be detected by any of the human senses, several devices have been developed to detect radiation. One of the most widely used detection devices is the Geiger counter, also known as the Geiger-Muller counter. This device has been configured using a number of design variations, but the overall purpose is to identify types of radiation and characteristics of particulates that are introduced to the counter. While just about all Geiger counters detect the presence of gamma and x-rays, specialized counters must be acquired to detect alpha and beta particles. Other devices that are used by individuals who are at risk of exposure to radioactive materials are the electrometer dosimeter or film badges. Unlike Geiger counters, these devices are used to measure a cumulative exposure to radiation over time. Dosimeters or film bags are designed to signal the user before exposure reaches unsafe levels. However, since film badges require the development of film for detection, they are best suited to measure long-term exposure under conditions where brief catastrophic exposure is not expected

Radioactive contamination is considered to be the uncontrolled emission of radioactive material. Natural sources of radiation include naturally occurring emissions from the human body, underground gas emissions, cosmic rays from space and radioactive particulate matter that is emitted from soil and rocks. Radon, a radioactive gas, is thought by many scientists to be responsible for most naturally occurring doses of radiation absorbed by humans. Radon is released as the uranium in earth decays. Radon enters buildings and structures through cracks in basement floors and walls, around piping and through the pores of block walls. The EPA estimates that dangerous levels of radon contaminate tens of millions of U.S. homes and radon may contribute to more than 20,000 cases of lung cancer death. While Geiger counters have shown to provide accuracy in radiation detection, they are not able to detect radon. A specialized device, known as a radon detector, must be acquired. Radon detectors may be purchased at most hardware and department stores

Radioactive contamination is usually the result of emissions of radioactive material from artificial sources, which are not contained

Containment involves the storage of radioactive materials in designated and sealed containers. A radioactive monitor is usually used to determine if content is properly contained. These artificial sources of radiation include emissions from medical x-rays, nuclear medicine, consumer products, the production and testing of nuclear weapons and the manufacture of nuclear fuels. Variations of Geiger counters are used to measure and monitor radiation from these sources

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Artificial sources of radioactive contamination include the earliest use of nuclear warfare during the bombings of Hiroshima and Nagasaki, Japan by U.S. forces in 1945. In the bombing of Hiroshima, an atomic bomb known as the "Little Boy" bomb was used. Three days later, the bombing of Nagasaki also involved an atomic bomb known as the "Fat Man" bomb. The "Fat man" bomb was a plutonium-based bomb, which was less radioactive (outside of the moment of critical mass) than the uranium-based "Little Boy" bomb. Artificial sources of radioactive contamination raise two primary concerns. Firstly, such contamination is avoidable and secondly, geographic and occupation nuances pose higher levels of exposure for certain segments of the population. During the 1950s and 1960s more than 600 nuclear tests were conducted at a Nevada testing site. The overall increase in radiation dosage for residents downwind to the site was as much as 7%. After the testing was moved underground, radiation detectors indicate that the overall increase in dosage dropped to less than 1%. Radioactive fallout is also a source of artificial contamination. Radioactive fallout is contamination from nuclear activities in the atmosphere. During the 1950s and 1960s nuclear bombs were detonated in the upper atmosphere as weapons testing was performed in the U.S., the Soviet Union, Britain, China and France. Radioactive dust and debris were transported by wind and then settled to contaminate water, land and food supplies around the globe. Radiation monitoring indicated that while lighter particles tended to remain in the atmosphere for years beyond the testing, heavier particles tended to settle downwind of the explosions. Radioactive fallout has been detected at the Windscale plutonium processing plant in Britain, Three Mile Island in Pennsylvania and the Chernobyl Nuclear Reactor facility in Moscow

During the cold war era, fallout shelters were established in many U.S. urban communities to provide shelter, minimize risk to either accidental or deliberate radioactive fallout and provide treatment for contamination

Dirty bombs, more formally known as Radiological Dispersal Devices (RDD) are weapons developed during the 1950s and 1960s that include a combination of radioactive materials and conventional explosives. These weapons were designed to disperse radioactive material over large areas without causing severe illness or death. The design provided for the conventional explosive components to have the most lethal and immediate effect. The radioactive component was designed to incite psychological damage, such as panic and fear, rather then physical damage. Geneva Protocol prohibits the use of any weapon designed to induce biological damage. Subsequent tests and analysis of detected radiation levels indicates that radiation exposure was high in individuals if they remained in the affected area for a period of one year. Further analysis of the effects of radiation detected after the Chernobyl fallout indicates that effects after five or more years are minimal

Other sources of low level radiation as indicated by the EPA include the following:

Consumer products	Smoke detectors Older model watches and clocks that glow in the dark Ceramics Antique greenish or yellowish glassware Commercial fertilizers Camping lantern mantels Salt substitutes Naturally occurring sources in food Food glazes and food containers Cell Phones Microwaves Television Sun lamps and tanning devices
Food irradiation	Electron beam technology and some powerful x-ray devices
Mail irradiation	Concrete, granite bricks, cinder blocks
Construction materials	Cigarettes
Tobacco smoke	X rays and mammograms
Medical Procedures	30 states identified as having known releases or threatened releases of hazardous radioactive substances from: Accidental spills Violations of regulations

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	Poor waste management and storage practices
Contaminated Land Sites	Metal containers and specialized industrial containers with sealed radioactive content used in: Manufacturing Chemical processing Construction Radiography Coastal engineering Oil refinery Energy production Agriculture Dust and static control
Sealed Radioactive Sources	
TENORM - Technologically-Enhanced, Naturally-Occurring Radioactive Materials	Extraction and processing of naturally occurring radioactive materials in soil, rock and water bodies that expose or concentrate radioactive material for the purpose of: Mining Waste treatment Water treatment Energy production

Amounts of Low Level Radioactive Contamination

Contamination may exist on surfaces or in volumes of material or air. Radiation that contaminates living tissue is usually measured as volume contamination. Radiation monitors and radiation meters are used to determine the amount or volume of contamination.

Volume Contamination

The energy released during radiation is measured in rads. A rad is a measure of the absorbed radiation dose deposited in tissue. One rad is quivalent to an absorbed dose of 0.01 joules of energy per kilogram of tissue. Aother measure of absorbed radiation dose is a gray. One gray is equivalent to a joule of energy per kilogram of tissue. As such, one gray is equal to 100 ad.

A measure used to assess damage to living tissue by a prticular type or energy of radiation is known as the relative biological effectiveness (RBE). Measures of the RBE of radiation are also known as quality factors or potency factors and it is denoted as Q. This factor is used determining the risk of radiation. Such risk is measured in rem, which is short for Roentgen. A rem is equivalent to one rad times the RBE of radiation. Another measure of risk is sieverts (Sv), which is equivalent to one gray times the RBE of radiation. As such, one Sv is equal to 100 rem.

1 rad	=	0.01 joules of energy per kg of tissue
1 gray	=	1 joule of energy per kg of tissue
1 gray	=	100 rad
1 rem	=	1 rad * Q
1 Sv	=	1 gray * Q
1 Sv	=	100 rem

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Measures of Sv are used to differentiate the biological effects of radioactivity from the physical aspects measured in gray and described in terms of absorbed dosages. Some established Q values are as follows:

Material	**Energy**	**Q**
Alpha particles		20
Beta particles		1
Photons	All energies	1
Electrons and muons	All energies	1
Protons	Energy > 2MeV	5
Neutron radiation	Energy < 10 keV	5
	10 keV < energy < 100 keV	10
	100 keV < energy < 2 MeV	20
	2 MeV < energy < 20 MeV	10
	Energy > 20 MeV	5
Other atomic nuclei		20
X rays		1
Gamma rays		1

It should be noted that alpha and beta particles are limited in their potential to penetrate the human body. X rays and gamma rays, on the other hand, are more potent and will penetrate the body. While most Geiger counters will detect radioactivity, only some specially designed Geiger counters provide the capability to differentiate gamma and x-rays from alpha and beta radiation.

Surface Contamination

Surface contamination is measured as becquerel (Bq) per square meter. This unit of radioactivity per unit area may apply to either fixed or removable surface contamination. Fixed contamination implies that the radioactive material cannot be spread, but is measurable by a radioactivity meter. Removable surface contamination may spread. A properly calibrated radiation detection unit will detect uncontained contaminants at points beyond the surface. Another measure of surface contamination is disintegrations per minute (dpm) per square centimeter.

The Effects of Low level Radioactivity on the Human Body

The effects radioactivity on the human body depends on the type and dose of radiation as well as the part of the body affected. Radiation sickness, also known as radiation poisoning and more formally known as acute radiation syndrome, typically indicates acute medical problems resulting from large dosage exposure to ionizing radiation over a short period of time from either natural or artificial radiation sources.

Ionizing radiation has the effect of disturbing and interfering with cell division so that in the same manner that radiation may cause cancer; it is also used in the treatment of cancer. Cancer cells are fast-dividing cells that are killed by doses of radiation that normal cells are able to sustain. Research has shown that low levels of ionizing radiation are responsible to lower the risk of cancer. This represents a form of hormesis, which is phenomenon where low doses of a toxin have the opposite effect than high doses on a biological system and the effect is beneficial at low doses and harmful at high doses. However, it should be noted that the scientific community is not in complete agreement on this phenomenon as it relates to radioactivity.

Low-level radiation is low risk radiation that measures less than 200 rems (2 Sv). For the average American citizen, eighty-two percent of the exposure to radiation is from natural sources. In a lifetime, an individual can expect to receive between 7 and 14 rems of radiation from natural sources. The other 18 percent of exposure is from artificial sources. The amount of radiation acquired from artificial sources is dependent upon a number of factors that are responsible to put an individual at risk of exposure. Some human symptoms from various low-levels of radiation are as follows.

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Rems	Sv	Symptoms	Effects
5 – 20	0.05[1]- 0.2	None	Potential for cancer and mutation of genetic material.[2]
20 – 50	0.2 - 0.5	None	Temporary decrease in red blood cell count.
5 – 100	0.5 – 1	Mild radiation sickness accompanied by headaches and an increased risk of infection.	Possible male sterility
100 - 200	1 - 2	Light radiation poisoning accompanied by fatigue, vomiting and loss of appetite, with a 10% chance of fatality after 30 days.	Depressed immune system, extended convalescence, increased risk of infection, possible male sterility and spontaneous abortion or stillbirth.

Radiation contamination is most harmful to bone marrow, embryonic tissue and lymphoid tissue cells, testes and ovaries. Lymphatic tissue is responsible to produce white blood cells (WBCs). The onset of radiation sickness is almost always accompanied by a reduction in WBC production within 72 hours, while recovery is first indicated by an increase in WBC production.

Any exposure to radiation increases the risk of cancer, birth defects and genetic damage. Some of the other common and more chronic conditions that result from radiation contamination include hypertension, stroke, diabetes, heart disease and renal disease.

[1] An Sv of 0.05 is the federal limit established for radiation workers in the U.S. Many U.S. companies establish stricter limits to ensure that they do not violate the federal limit.
[2] This is disputed in the scientific community under the hormesis phenomena.

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