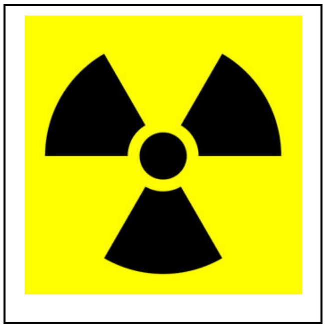
ASSEMBLY OF FIRST NATIONS

Nuclear Waste Technical Backgrounder Series

Part One: Radiation and Health

Introduction:



We are exposed to radiation every day of our lives, from many different sources both natural and man-made. In fact, natural sources of radiation make up most of our entire annual dose. These sources include the ground, certain types of rocks, outer space, and even the foods we eat. Man-made sources of radiation can include medical and dental equipment (ie. X-Rays, radiation therapy for cancer patients), building materials, cigarettes, and nuclear power plants. Although man-made sources of radiation cause the greatest concern among the public, it makes up less than 20% of our annual dosage according to many estimates.

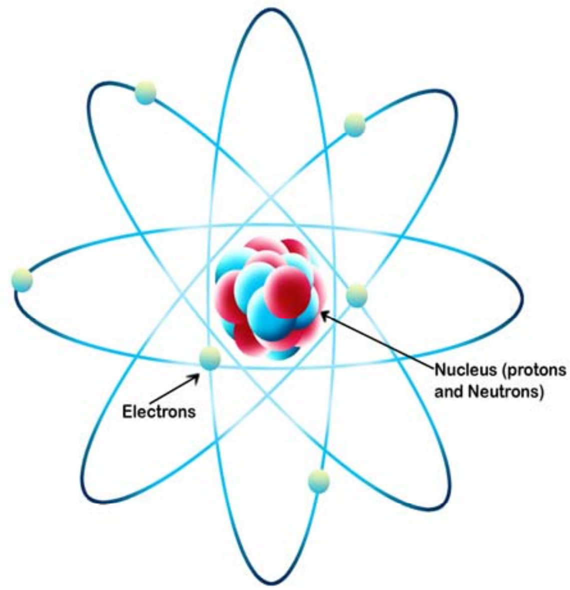
This backgrounder will provide an overview of the science and facts behind radiation, its sources, and its effects on humans. This includes information on what radiation is, what different types of radiation there are, how radiation can affect our bodies, and descriptions of commonly used terms such as radionuclides and half-lives. It is the purpose of this backgrounder to provide you with a broad understanding of radiation and its effects on human health, and to provide context for discussions regarding nuclear energy and waste.

I. Radiation

What Is Radiation?

Radiation is energy passing through space. It comes in many different forms, such as visible light, ultraviolet light, radio waves, microwaves, x-rays, and more. It is and always has been everywhere in our environment, meaning animals, human beings, and other life on earth has evolved in its presence.

Radiation is typically described in terms of the effects it has on things. There are two types of radiation: ionizing and non-ionizing. To ionize means to change the electric charge of an atom, making it positively charged or negatively charged. Non-ionizing radiation does not carry enough energy to ionize atoms, and makes up most of the radiation we are most familiar with (radio waves, microwaves, infrared, visible light). It is a relatively safe form of radiation that has minor health risks for living things.



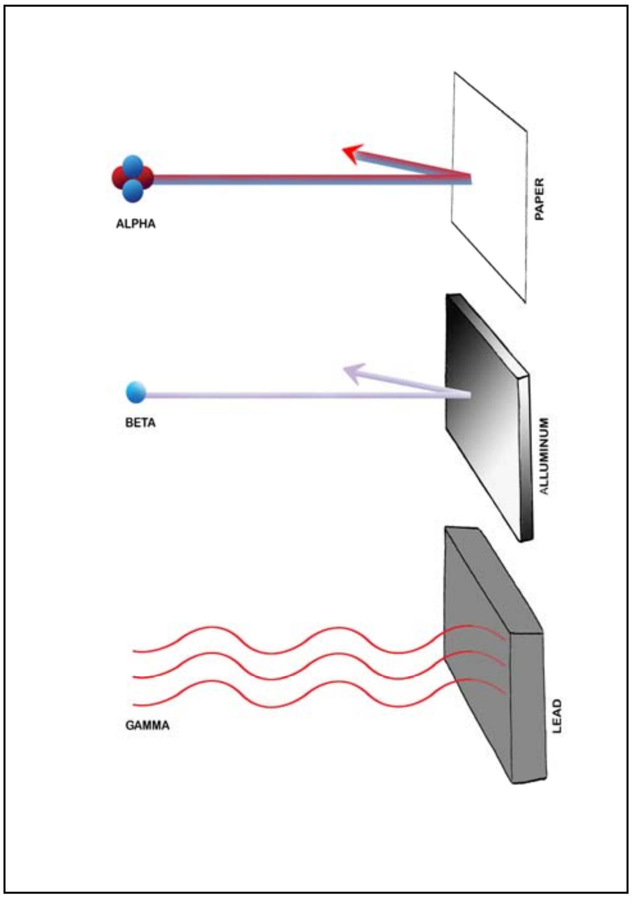
This image gives us an idea of what atoms look like and what they are composed of. The nucleus is made up of positively charged protons and neutrons, which have no electric charge. Negatively charged electrons orbit around the nucleus.

Ionizing radiation, on the other hand, is a much more hazardous form of radiation because it has enough energy to change the electric charge of atoms, changing their normal state. Ionizing radiation can be produced by unstable atoms (atoms which have excess mass and/or energy), or by high-voltage electric devices (x-ray machines, for instance). Used nuclear fuel contains atoms that emit ionizing radiation in the form of alpha and beta particles, and gamma rays.

Alpha particles consist of two protons and two neutrons, and are the largest and heaviest of the radiation particles. Because of their size and weight, they do not travel very far and have very poor penetrating power. They can barely penetrate any layers of skin and can be stopped by a sheet of paper.

Beta particles consist of fast moving electrons ejected from their orbit around an unstable atom. They are about 7000 times smaller than alpha particles and can therefore move faster and farther. They can penetrate further than alpha particles but can be stopped by a small amount of shielding such as a sheet of aluminum or plastic. Beta particles can penetrate some layers of skin, down to the germinal layer where new skin cells are produced.

When an alpha or beta particle is ejected from an unstable atom, it is usually accompanied by gamma rays. Gamma rays are made up of electromagnetic waves instead of subatomic particles, and has no mass (like light waves), and can travel faster and further than alpha or beta particles. These waves are highly penetrating, capable of passing through the human body. Only dense materials such as lead plates or thick concrete blocks can absorb gamma radiation.



Radionuclides, Isotopes and Half-Lives

In discussions regarding radiation and used nuclear fuel, reference is often made to isotopes, radionuclides, and half-lives. It is difficult to follow discussions on these topics without understanding what these terms mean.

Isotopes have been the topic of extensive media coverage in the past few years, ever since the Chalk River Laboratories, located near Chalk River, Ontario, was forced to shut down its reactor for repairs. This resulted in a worldwide shortage of medical isotopes, which Chalk River Laboratories produce, used for medical imaging. Simply put, an isotope is a different type of atom of the same chemical element, having a different number of neutrons in its nucleus.

Isotopes are often identified by the name or symbol of the element, followed by its mass number. The mass number is the sum of the protons and neutrons in the nucleus, with the number of protons always staying the same for that element. For example, carbon has three naturally occurring isotopes, carbon-12, carbon-13, and carbon-14, with the latter two having one more neutron than the last. Some isotopes have an unstable nucleus, causing it to emit ionizing radiation. For instance, while carbon-12 and carbon-13 are stable, carbon-14 is unstable and is radioactive.

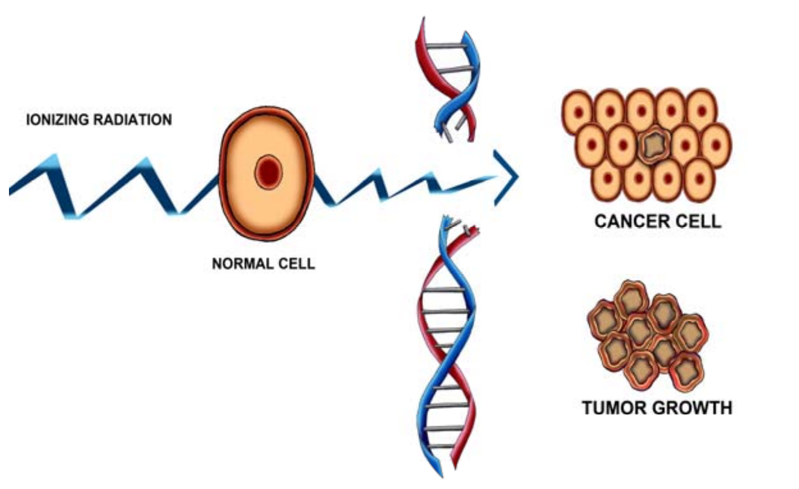
A commonly used term for a radioactive isotope is a radionuclide (sometimes also called a radioisotope). Used nuclear fuel is primarily made up of uranium, but also contains several other types of radionuclides. While radionuclides emit ionizing radiation, they undergo radioactive decay, which brings us to the topic of half-lives.

A half-life refers to the amount of time it takes for half of the atoms in a radioactive material to decay into a "daughter" atom. An atom decays by releasing energy in the form of ionizing radiation, as well as particles such as alpha and beta. This daughter atom can be either stable or radioactive. Although the radioactivity in used nuclear fuel reduces with time, it will remain hazardous essentially indefinitely. That is why safe, permanent storage is required.

II. Radiation & Health

Radiation Exposure: We are exposed to radiation from many sources every day of our lives. Approximately 75-85% of this radiation comes from our natural environment. Radiation from the earth, including radon, accounts for about 50% of our total annual average radiation exposure, while cosmic rays from outer space and the Sun account for about 15%, and internal radiation from our own bodies makes up about 15%. Man-made radiation exposure mostly comes from medical procedures such as X-rays, diagnostic imaging, and radiation therapy, and this constitutes about 20% of our total annual average radiation exposure. Radiation from nuclear power plants and uranium production accounts for about 0.1-1% of our total exposure, but it causes us the greatest amount of concern.

There are two main ways to become exposed to ionizing radiation: through external irradiation or through contamination. External irradiation occurs when all or part of the body is exposed to penetrating radiation from an external source, such as an x-ray machine. During exposure this radiation can be absorbed by the body or it can pass completely through. Following external exposure, an individual is not radioactive and can be treated like any other patient.



This image illustrates one of the effects ionizing radiation has on cells. The radiation passes through the cell and damages its DNA. If the cell cannot repair the damage, and if it doesn't die, it can replicate and create more disfunctioning cells with altered DNA, leading to tumour or cancer growth.

Radioactive contamination can occur when radioactive materials in the form of gases, liquids, or solids are released into the environment and come into contact with people externally, internally, or both. An external surface of the body, such as the skin, can become contaminated, and if radioactive materials get inside the body through the lungs, gut, or wounds, the contaminant can become deposited internally.

The type and amount of ionizing radiation will determine how much damage is caused to living tissue exposed to it. Used nuclear fuel emits high-energy ionizing radiation that is extremely harmful to living things. When ionizing radiation passes through the cells of living creatures, it damages DNA which leads to mutations when new cells are created. These mutated cells can form cancer, and can also lead to mutations in developing babies. It is also possible that cells can either repair the DNA damage or self-destruct (die), avoiding the replication of mutated cells. The amount and type of damage done depends on the amount of exposure, much like the severity of a sunburn depends on the amount of exposure to sunlight.

Symptoms of Radiation Exposure

Symptoms associated with exposure to small amounts of ionizing radiation usually include headache, fatigue, and weakness. Nausea and vomiting usually occur within 24-48 hours of exposure, after which time the symptoms usually subside.

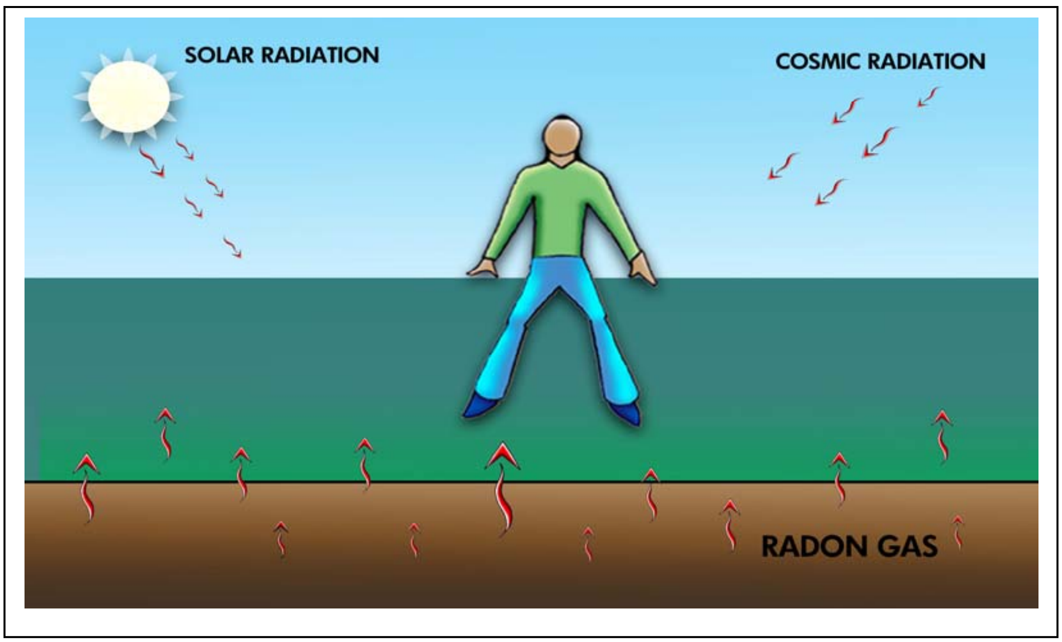
As the dosage of radiation increases, so does the severity of the symptoms. Nausea and vomiting occurs a bit sooner with moderate exposure, but the longer-term symptoms can include fever, hair loss, infections, bloody vomit and stool, as well as poor blood clotting. The most serious symptoms occur with severe exposure, with nausea and vomiting occurring within an hour as well as more aggressive symptoms of lower levels of exposure.

The effects of severe exposure may be familiar to those who have experienced radiation as used in cancer treatments. An example of lower levels of exposure may be experienced in the use of X-Rays for dental treatments. All of these uses are governed by strict regulations to protect workers and the public. Long-term exposure to radiation that may not produce immediate symptoms can damage DNA in cells, causing mutations when new cells are formed, which leads to cancers.

The severity of exposure to ionizing radiation depends on a number of factors. These include the type of radiation (beta or alpha particles, gamma rays, x-rays, etc), the type of exposure (external, or internal if it is ingested), the proximity to the radiation source, the length of time exposed, as well as the presence of any barriers between the individual and the radiation source.

Natural Radiation:

There is still no definite answer as to whether exposure to natural background radiation carries a health risk, even though it has been demonstrated for exposure at a level a few times higher. Life on earth has evolved and grown in the presence of natural background radiation and it is generally considered safe. However, there are always exceptions, and how much radiation we are exposed to depends on factors such as proximity to the source and amount of time exposed.



Cosmic/Solar Radiation

As mentioned, ionizing radiation from outer space and our Sun is natural, and therefore is generally not a significant health risk. However, the Sun emits a significant amount of ultraviolet (UV) rays, which can be both beneficial and damaging to our health. UV ray exposure causes our skin to produce vitamin D, which has many health benefits. Overexposure to UV rays, however, can lead to sunburn, DNA damage, and skin cancer. The amount of UV rays that reaches us depends on the time of year, weather conditions, location, and other factors. Public health authorities encourage people to wear sunscreen when exposed to intense sunlight for extended periods of time, and weather forecasts regularly indicate the “UV Index” on any given day, which indicates the intensity of UV rays outside.

Radiation from Earth

Naturally occurring gamma rays from the earth also do not pose a significant health risk. These rays come from very low concentrations of uranium, potassium, and thorium radionuclides in the soil and rocks all over the Earth’s crust. The amount of radiation given off depends upon location and geography. In areas where uranium concentrations are higher it can be mined and turned into nuclear fuel. However, the low concentrations of these radionuclides in the ground make this source of ionizing radiation fairly harmless.

Because there are radionuclides in the soil and rocks, they are also present in our water and food, albeit in very low concentrations. Radionuclides of potassium, for instance, are found in relatively high concentrations in bananas. This has always been the case, and one could eat high volumes of bananas over long periods of time without getting a significant dose of radiation. The risk of radiation poisoning from food and water in the natural environment is virtually non-existent.

Radon gas, on the other hand, is a significant source of natural radiation exposure. Radon gas is formed by the decay of uranium in the ground, and when it is released into the outdoor environment it immediately disperses and is not a concern. However, in closed spaces such as basements, it can accumulate because it becomes trapped by the closed space. This leads to increased concentrations and, if inhaled, increases the risk of lung cancer. In fact, radon gas inhalation is the second-leading cause of lung cancer in Canada, after smoking. Health Canada has a National Radon Program that educates people about these risks and provides methods of testing for levels of radon gas in homes.

Man-made Radiation:

Exposure to man-made sources of ionizing radiation mostly comes from medical procedures and from certain occupations that entail exposure to small amounts of radiation (such as nuclear power plant technician or hospital nurse). On average, medical procedures account for most of our exposure to man-made ionizing radiation.

Medical x-ray image of a hand. X-ray machines use ionizing radiation to produce images of our bones.

Radiation in Medicine

In medicine, radiation has two distinct uses: diagnosis and therapy. Most people have had x-rays used on them to help the doctor examine the body. Another common procedure involves injecting radionuclides into the patient to help instruments outside the body detect what is happening inside. Gamma ray emitting devices are also used to treat diseases such as cancer (called radiation therapy), and uses significant amounts of radiation which is designed to target the disease itself, hopefully destroying or weakening it, and affect the rest of the body as little as possible.

While receiving medical x-rays and ingested radionuclides for diagnosis is not considered a significant health risk and is fairly routine, radiation therapy does, depending on the specific treatment, pose a significant health risk as it may possibly cause cancer or other delayed health effects. These treatments and equipment are regulated by the Canadian Nuclear Safety Commission (CNSC) and are employed according to very high standards. Radiation from medical procedures is carefully contained to ensure almost all the radiation exposure is to the patient, while protecting other patients, the public, and medical staff.

Food Irradiation

It is a common practice in developed countries to expose certain foods to ionizing radiation (called irradiation) to destroy microorganisms, bacteria, viruses, or insects, among some other applications such as delaying ripening. This usually prolongs the shelf life of foods and sometimes avoids the use of powerful insecticides. Irradiated food never contacts any radiation sources, so it never has the opportunity to become radioactive. The food passes through a radiation field where a radiation source emits gamma rays or x-rays. These rays pass through the food and damage the DNA of the target organism while minimally affecting the nutritional value of the food.

According to health Canada, the following products have been approved for irradiation in Canada: potatoes, onions, wheat, flour, whole wheat flour, whole and ground spices, and dehydrated seasoning preparations. The World Health Organization and the Food and Agriculture Organization, both United Nations bodies, recognize the irradiation process as one safe way of reducing levels of organisms that cause food borne illness and disease in food products.

Nuclear Power Generation

Nuclear power plants use uranium to drive a chain reaction that produces steam, which in turn drives turbines to produce electricity. As part of their normal activities, NPPs release regulated levels of radioactive material which can expose people to low doses of radiation. Given that there are some 440 nuclear reactors worldwide you'd expect the risk of radiation to be high. However, the only major accident that saw radiation escape over large areas has to date been the explosion at the nuclear power plant in Chernobyl, Ukraine, in 1986. Two Chernobyl plant workers died on the night of the accident, and a further 28 people died within a few weeks as a result of acute radiation poisoning. There are various estimates of how many people will be affected over the long term. The Chernobyl accident was the result of a poor reactor design that was operated with inadequately trained personnel, who were conducting an unusual and unsafe test at the time.

Canadian nuclear power plants emit low levels of both airborne and waterborne radiation to the environment, typically through normal operational leakage or through less frequent cooling water spills within the containment building. Public radiation exposure as a result of nuclear power activities is limited through regulations to about one-third the total radiation dose that Canadians receive annually, on average, from natural sources. Nuclear power generators typically set their own targets at about 1% of the regulatory limit**,** taking into account a hypothetical "most-exposed individual", who spends 100% of his/her time at the boundary of the plant, eating only locally-derived produce, meat, fish, water, and milk.

A major concern among First Nations people, and the public in general, are the large amounts of used nuclear fuel that nuclear power plants produce. This waste remains highly radioactive for thousands of years and currently there is no permanent storage facility for it. For more information on this, see the *Used Nuclear Fuel & Long Term Storage* backgrounder.

The amount of radiation that the public is exposed to from nuclear plants is a matter of public record. Past and present information can be obtained through the Canadian Nuclear Safety Commission website, or from the power utility companies themselves.

Radiation Protection and Safety:

Although exposure to radiation on a daily basis is inevitable, it is good practice to keep this exposure As Low As Reasonably Achievable (ALARA, an acronym commonly used in the nuclear industry). This is accomplished through time, distance, and shielding.
The shorter the time in a radiation field, the less the radiation exposure you will receive.
The farther a person is from a source of radiation, the lower the radiation dose. Radiation levels decrease exponentially as distance from the source increases. Do not touch radioactive materials, or contamination will occur. Finally, the presence of appropriate barriers between the radiation source and the individual will shield some or all of the radiation. Shielding could include walls, containers, radiation blocking compounds (i.e. sunscreen), clothing, gloves, etc.

The Canadian *Radiation Protection Regulations* set limits on the amount of radiation the public and nuclear energy workers may receive. In Canada, the effective dose limit for the public through industrial activities regulated by the Canadian Nuclear Safety Commission is 1 millisievert (mSv) in one calendar year. A sievert is a unit of measurement used to measure the amount of biological damage caused by various types of ionizing radiation. Regular reporting and monitoring shows that the average annual dose to the public from nuclear power generation in Canada ranges from 0.001 to 0.1 mSv per year. As a comparison, our radiation exposure, on average, due to all natural sources amounts to about 2.4 mSv a year - though this figure can vary according to location, health, etc. One chest X-ray will give about 0.2 mSv of radiation dose.

If it is necessary for an individual to be close to a radiation source, safety from radiation poisoning and/or contamination can be maximized by following a few simple precautions:

1. Use time, distance, and shielding to reduce exposure.
2. Wear radiation-detecting badges, if issued.
3. Avoid contact with the contamination.
4. Wear protective clothing that, if contaminated, can be removed.
5. Wash with nonabrasive soap and water any part of the body that may have come in contact with the contamination.