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EFFECTS OF IONIZING RADIATIONS ON ENVIRONMENT

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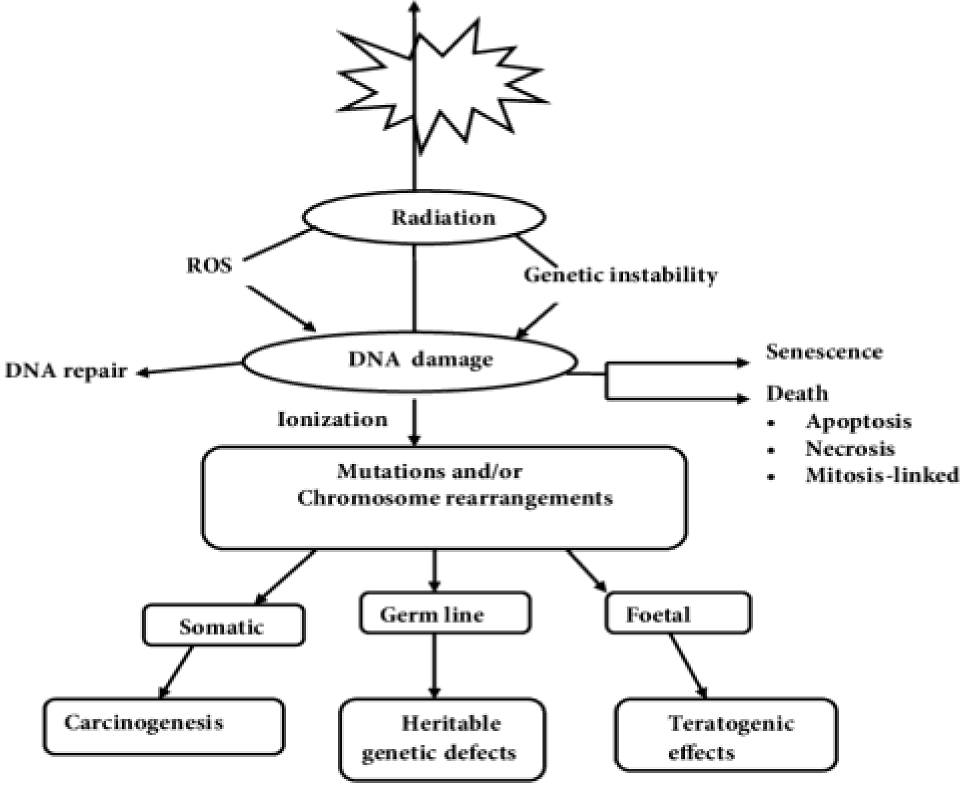
ABSTRACT

Ionizing radiation is a type of energy released by atoms that travels in the form of electromagnetic waves (gamma or X-rays) or particles (neutrons, beta or alpha). The spontaneous disintegration of atoms is called radioactivity, and the excess energy emitted is a form of ionizing radiation. Unstable elements which disintegrate and emit ionizing radiation are called radionuclides.All radionuclides are uniquely identified by the type of radiation they emit, the energy of the radiation, and their half-life.The activity — used as a measure of the amount of a radionuclide present — is expressed in a unit called the becquerel (Bq): one becquerel is one disintegration per second. The half-life is the time required for the activity of a radionuclide to decrease by decay to half of its initial value. The half-life of a radioactive element is the time that it takes for one half of its atoms to disintegrate.

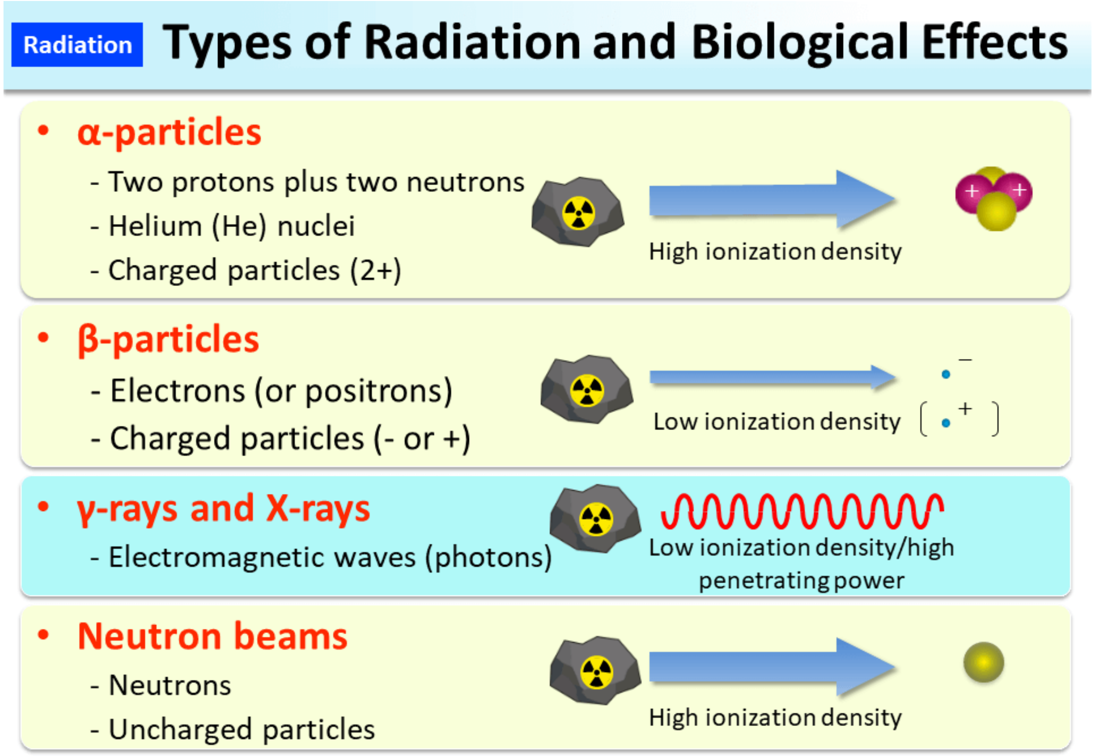
KEYWORDS: ***radiations, ionizing, effects, environment, radioactive, electromagnetic***

INTRODUCTION

DNA is the primary target for the induction of biological effects from radiation in all living organisms.



There are broad similarities in radiation responses from different organisms, and yet wide differences in radiation sensitivity. The range in lethality from acute exposure to radiation various by three to four orders of magnitude among organisms, with mammals being among the most sensitive and viruses being among the most radioresistant. Free radicals are not unique to radiation, but are produced in response to many stressors: smoking, air pollution, exposure to solar UV radiation, tissue inflammation, and metabolism---all produce damaging free radicals. Such free radical production results in humans experiencing approximately 104 to 105 endogenous oxidative damages per cell per day among the 3 x 109 bases in the genome . Damage caused from the free radicals is so abundant that very efficient repair mechanisms have evolved within all biological species, from yeast to humans, to counter their effects.



Radiation Types of Radiation and Biological Effects

- **α-particles**
  - Two protons plus two neutrons
  - Helium (He) nuclei
  - Charged particles (2+)

  High ionization density

- **β-particles**
  - Electrons (or positrons)
  - Charged particles (- or +)

  Low ionization density

- **γ-rays and X-rays**
  - Electromagnetic waves (photons)

  Low ionization density/high penetrating power

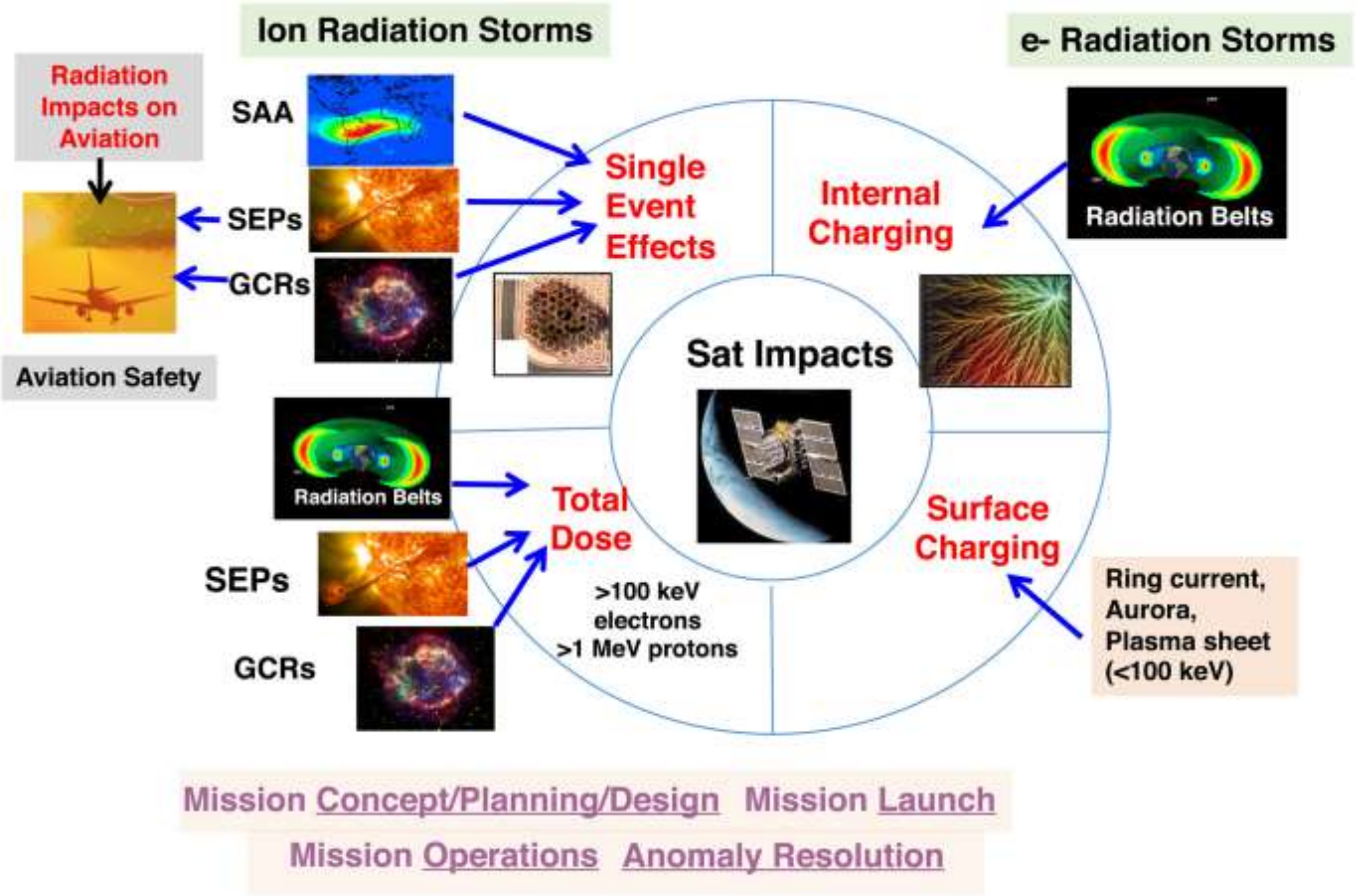
- **Neutron beams**
  - Neutrons
  - Uncharged particles

  High ionization density

When the ionization number is the same, the higher the ionization density is, the larger the biological effects are.

Radiation and the free radicals produced can damage DNA by causing several different types of lesions (e.g. single strand breaks, double strand breaks, base changes, interstrand crosslinks). The number of DNA lesions caused by a dose of 1 to 2 Gy is some 1000 base damages, 1000 single strand breaks (SSBs), and some 40 double strand breaks . DSBs are central to radiation-induced damage and their numbers correlate with radiosensitivity and the probability of cell survival. There are efficient DNA repair processes specific to each type of lesion. For DSBs the two primary repair pathways are non-homologous-end-joining (NHEJ) and homologous recombination (HR). The mechanisms of the two repair pathways are such that NHEJ is much more prone to errors during the repair process . Errors in repair can result in cell death through apoptosis, chromosome aberrations or mutations. The fate of mutations and their impacts within a population are dependent on the type of cell in which they occur. Two general types of cells are germ and somatic. [1]

Germ cells refer to the primordial cells from which eggs or sperm are derived. All other tissues (bone, muscle, blood, etc.) are derived from somatic cells. A mutation within a somatic cell can lead to cell death, or if the DNA damaged cell has undergone mis-repair such that the cell is still viable, then the mutation in the somatic cell can lead to cancer. Mutations in reproductive germ cells can decrease the number of gametes, increase embryo lethality, or be inherited by the offspring, resulting in their alteration. For humans, the risk of hereditary effects in offspring of exposed individuals is about 10% of the cancer risk to the exposed parents. The risk of non-fatal cancer for humans has been estimated at 1 x 10^{-5} per mSv. For non-human biota the risk of hereditary effects is unknown. Most mutations are deleterious, offer no advantage to the individual that possesses it, and are subsequently removed from the population. Some mutations are neutral, have no apparent effect on the individuals that possess it, and can persist over many generations within a population. Rarely, a mutation might offer a selective advantage (e.g. increase the efficiency of water absorption in the roots of a plant that contains the mutation). Such selective advantages would spread in a population[2]

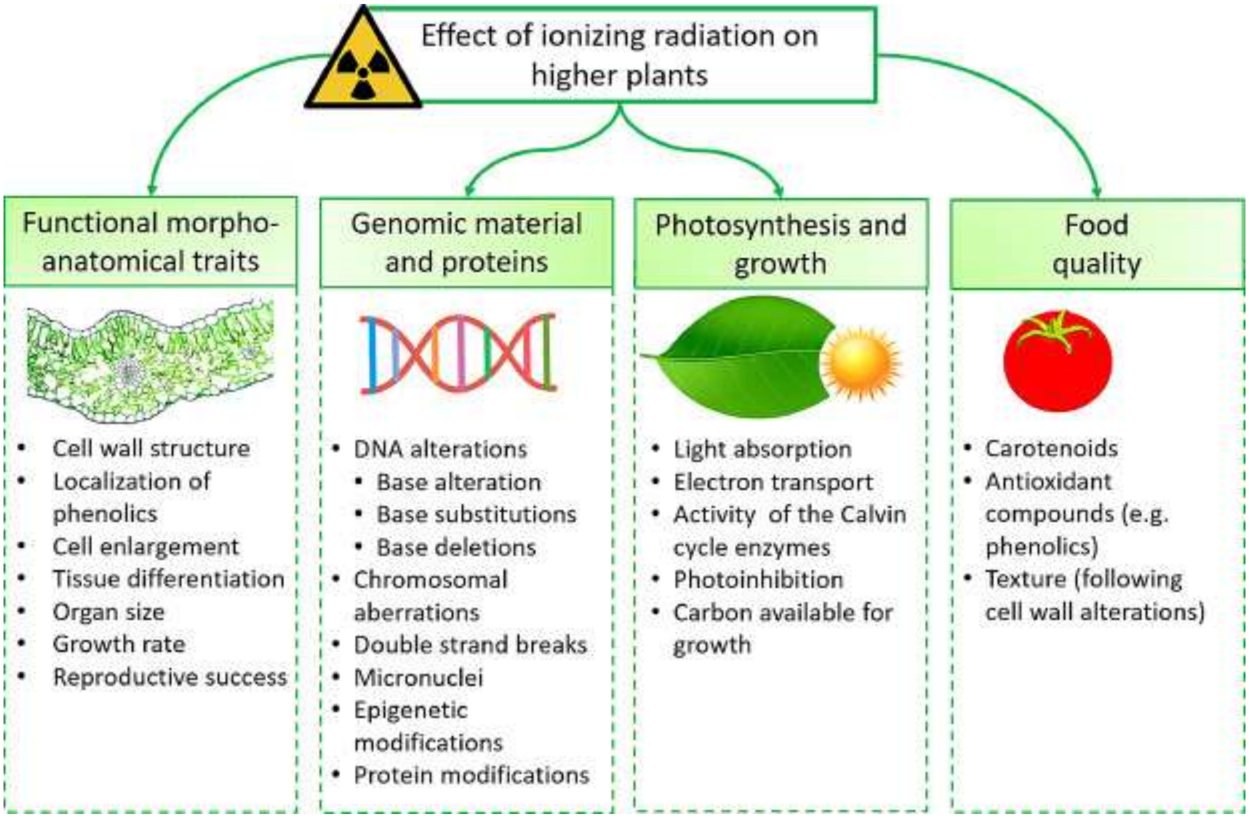


DISCUSSION

Ionizing radiation has many industrial, military, and medical uses. Its usefulness must be balanced with its hazards, a compromise that has shifted over time. For example, at one time, assistants in shoe shops used X-rays to check a child's shoe size, but this practice was halted when the risks of ionizing radiation were better understood.

Neutron radiation is essential to the working of nuclear reactors and nuclear weapons. The penetrating power of x-ray, gamma, beta, and positron radiation is used for medical imaging, nondestructive testing, and a variety of industrial gauges. Radioactive tracers are used in medical and industrial applications, as well as biological and radiation chemistry. Alpha radiation is used in static eliminators and smoke detectors. The sterilizing effects of ionizing radiation are useful for cleaning medical instruments, food irradiation, and the sterile insect technique. Measurements of carbon-14, can be used to date the remains of long-dead organisms (such as wood that is thousands of years old).

Occupationally exposed individuals are controlled within the regulatory framework of the country they work in, and in accordance with any local nuclear licence constraints. These are usually based on the recommendations of the International Commission on Radiological Protection. The ICRP recommends limiting artificial irradiation. For occupational exposure, the limit is 50 mSv in a single year with a maximum of 100 mSv in a consecutive five-year period.[3]



The radiation exposure of these individuals is carefully monitored with the use of dosimeters and other radiological protection instruments which will measure radioactive particulate concentrations, area gamma dose readings and radioactive contamination. A legal record of dose is kept.Examples of activities where occupational exposure is a concern include:

- Airline crew (the most exposed population)
- Industrial radiography
- Medical radiology and nuclear medicine
- Uranium mining
- Nuclear power plant and nuclear fuel reprocessing plant workers
- Research laboratories (government, university and private)

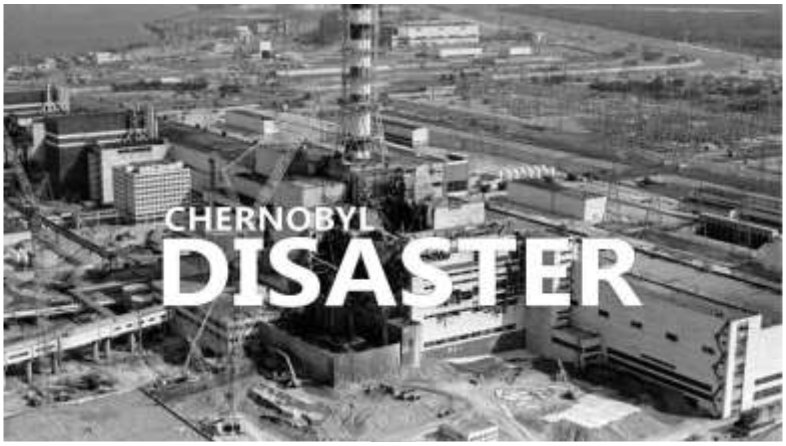
Some human-made radiation sources affect the body through direct radiation, known as effective dose (radiation) while others take the form of radioactive contamination and irradiate the body from within. The latter is known as committed dose.Medical procedures, such as diagnostic X-rays, nuclear medicine, and radiation therapy are by far the most significant source of human-made radiation exposure to the general public. Some of the major radionuclides used are I-131, Tc-99m, Co-60, Ir-192, and Cs-137. The public also is exposed to radiation from consumer products, such as tobacco (polonium-210), combustible fuels (gas, coal, etc.), televisions, luminous watches and dials (tritium), airport X-ray systems, smoke detectors (americium), electron tubes, and gas lantern mantles (thorium).Of lesser magnitude, members of the public are exposed to radiation from the nuclear fuel cycle, which includes the entire sequence from processing uranium to the disposal of the spent fuel. The effects of such exposure have not been reliably measured due to the extremely low doses involved. Opponents use a cancer per dose model to assert that such activities cause several hundred cases of cancer per year, an application of the widely accepted Linear no-threshold model (LNT).[4]

Implications

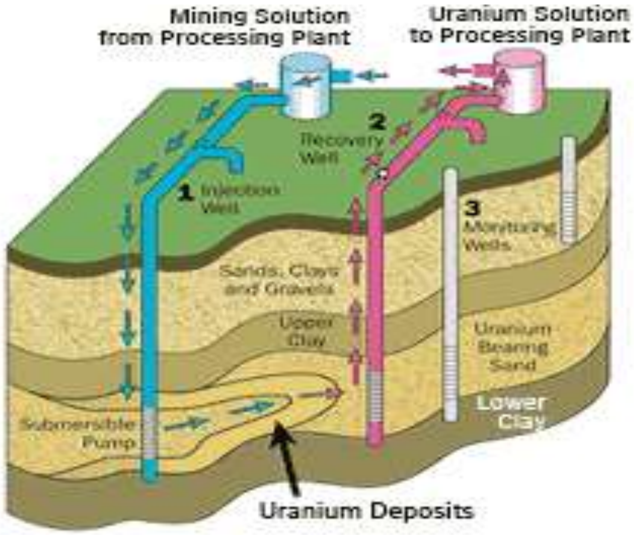
Massive particles are a concern for astronauts outside the earth's magnetic field who would receive solar particles from solar proton events (SPE) and galactic cosmic rays from cosmic sources. These high-energy charged nuclei are blocked by Earth's magnetic field but pose a major health concern for astronauts traveling to the moon and to any distant location beyond the earth orbit. Highly charged HZE ions in particular are known to be extremely damaging, although protons make up the vast majority of galactic cosmic rays. Evidence indicates past SPE radiation levels that would have been lethal for unprotected astronauts.

Air travel exposes people on aircraft to increased radiation from space as compared to sea level, including cosmic rays and from solar flare events. Software programs such as Epcard, CARI, SIEVERT, PCAIRE are attempts to simulate exposure by aircrews and passengers. An example of a measured dose (not simulated dose) is 6 μSv per hour from London Heathrow to Tokyo Narita on a high-latitude polar route. However, dosages can vary, such as during periods of high solar activity. The United States FAA requires airlines to provide flight crew with information about cosmic radiation, and an International Commission on Radiological Protection recommendation for the general public is no more than 1 mSv per year. In addition, many airlines do not allow pregnant flightcrew members, to comply with a European Directive. The FAA has a recommended limit of 1 mSv total for a pregnancy, and no more than 0.5 mSv per month. Information originally based on Fundamentals of Aerospace Medicine published in 2008.[5]

RESULTS



Nuclear radiation can impact the environment in three primary ways: improper disposal of nuclear waste, direct exposure via disasters and through the mining process of uranium.While nuclear power plants do not emit very much pollution, they do produce radioactive waste as a byproduct. Some plants dispose of nuclear waste – particularly waste with lower levels of radiation than is harmful to human health – using landfills or by releasing it into lakes and rivers. Unknown leaks of nuclear wastes can also find their way into the environment, as can damage to permanent underground housing facilities for nuclear waste.Disasters provide a similar danger to the environment and surrounding ecosystems, simply on a larger and more destructive scale. Accidents can happen, and the impact of an accident and a nuclear power plant can catastrophic consequences to human health and the environment. Disasters can directly expose those in the vicinity to high levels of radiation; wind and water can carry radiation long distances, and radiation can remain in the soil for many years.



Nuclear power requires the use of uranium, which companies must mine from the ground to obtain. Uranium mining provides its own slew of environmental impacts. Some facilities dispose of the byproducts of uranium mining, known as *tailings*, in the surrounding area of the mine. These not only expose the area to radiation, which can spread through the air or leach into the water, but also pose the risk of heavy metal contamination as well.The disaster at Chernobyl provided researchers with an example of how nuclear radiation affects the environment after a large-scale meltdown. Plants and animals within the affected area take up radioactive particles, and these move through the ecosystem through bioaccumulation.[6]

Radiation pollution within waterways also accumulates within fish and other aquatic organisms, and runoff from radiation within the soil provides additional contamination. Even today, over 35 years later, some waterways outside of the exclusion zone remain "closed" to fishing due to radiation exposure.Plants and animals within approximately 20 miles of the nuclear power plant at Chernobyl received high levels of radiation. Wildlife within this region saw an increase in overall mortality as well as a decrease in reproductive success. Genetic anomalies and deformities also occurred due to the DNA damage associated with exposure to radiation.Interestingly enough, in recent years the exclusion zone in the 20-mile radius surrounding the disaster site has become quite biodiverse with plant and animal life. As the mortality and reproductive impacts of the radiation have declined, the lack of human activity has allowed the ecosystem to thrive in the absence of urbanization and agriculture.

Of course, the major concern about nuclear reactors is the possibility of a catastrophic failure. In 1986, the operators of the Chernobyl nuclear reactor near Pripyat, Ukraine, initiated a safety test under dangerous conditions, and the procedure overheated the reactor and caused an enormous steam explosion and fire, killing many of the first-responders sent to deal with the disaster. The catastrophe also released a significant amount of radiation into the surrounding town, and it remains uninhabitable more than two decades later. In 2011, a tsunami and earthquake in Japan damaged the Fukushima nuclear plant, causing a partial meltdown that required the evacuation of the nearby area and released contaminated water into the nearby ocean.

All of these concerns are exacerbated by the fact that most nuclear plants in operation today are decades old, and some are operating well beyond their expected lifespan. The reason for this is largely due to public opposition to nuclear energy, making it difficult for companies to construct new plants. Unfortunately, this resistance is somewhat counterproductive because modern reactor designs feature better safety systems and produce significantly less waste than older reactors. In fact, modern thorium reactors can actually use spent fuel from older reactor designs, consuming this problematic toxic waste to produce energy.

CONCLUSIONS

When an atomic or nuclear bomb detonates, the 1 megaton blast kills or poisons everything within a two-mile radius. The accident at the Chernobyl power plant in 1986 and the bombs dropped on Hiroshima and Nagasaki in 1945 provide insight into the short and long-term effects of radiation and thermonuclear detonation on the environment. If enough nuclear weapons were exploded in a large-scale nuclear war, vast areas of the earth would become uninhabitable When an atomic or nuclear bomb detonates, the 1 megaton blast kills or poisons everything within a two-mile radius. The accident at the Chernobyl power plant in 1986 and the bombs dropped on Hiroshima and Nagasaki in 1945 provide insight into the short and long-term effects of radiation and thermonuclear detonation on the environment. Radioactive particles can travel from the site of an atomic bomb explosion and contaminate the land and water for miles. Genetic mutations and disease in the generations of plants, animals and humans following contamination also occurs. Contamination remains for decades.

The detonation of an atomic bomb creates radioactive dust that falls out of the sky into the area around the site of the explosion. Wind and water currents carry the dust across a much larger radius than the initial explosion, where it contaminates the ground, water supply and the food chain. Initially, little was known about radioactive fallout. Radioactive particles from nuclear fallout also can contaminate both wild and domesticated animals, as well as agricultural plants.[7]

The release of radiation from the Chernobyl power plant gives scientists an idea of what the effects would be on the environment in a small nuclear war. The amount of radiation released at Chernobyl is equivalent to the detonation of about a dozen atomic bombs at an altitude that would cause maximum blast damage. At Chernobyl, large amounts of radioactive particles called iodine-131 and cesium 137 were released into the environment during a fire that burned for 10 days. These isotopes are particularly dangerous to living organisms.

Radioactive particles can travel from the site of an atomic bomb explosion and contaminate bodies of water, including aquatic life like fish. In addition, the fallout from the detonation of numerous atomic bombs would result in the contamination of berries and other plant life found in the surrounding areas and forests. Genetic mutations and disease in the generations of animals and humans following contamination would also occur. Animals in Chernobyl's forests, for example, have high levels of radioactive cesium. Scientists expect the contamination to remain that way for decades.[8]

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