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Nuclear Energy and Radiation Impact Management

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Abstract*: Nuclear energy is a potential solution to electricity demand but also entails risks. Policy debates on nuclear accidents have focused primarily on negative impacts on humans. Although such impacts are important, we argue that policy debates must also consider the consequences for biodiversity and ecosystem services. We reviewed 521 studies conducted after the Chernobyl accident, the most severe nuclear accident in history. Elevated radiation levels have been recorded among a diversity of species, even up to thousands of kilometers away from the meltdown site, and after more than two decades following the accident. Close to the reactor, physiological and morphological changes have occurred. Negative effects on ecosystem services have been observed, including the contamination of water, soils, and wild food supplies. Informed policy decisions on nuclear energy require a greater understanding of the consequences of accidents, including effects on biodiversity and ecosystem services. Based on our review, we recommend to (1) fully incorporate risks for biodiversity and ecosystem services into policy debates; (2) develop a coherent information chain regarding such risks; (3) use proactive planning strategies to be prepared for potential accidents; and (4) develop a coherent research agenda on the consequences of nuclear accidents for biodiversity and ecosystem services*

Keywords: Biodiversity, morphological, chernobly

I. INTRODUCTION

In the 21st centurie there are several modes of energy generation like ,thermal,wind,hydro energy, etc. The NUCLEAR Energy is one of the widely use due to its high energy generation capabilities. Generally this belows elements are widely use for Nuclear energy like in power plant, atomic missiles,etc.

Uranium-235 (U-235) - This isotope of uranium is widely used in nuclear reactors and atomic bombs. It readily undergoes fission when struck by a neutron, releasing more neutrons that can continue the chain reaction.

Plutonium-239 (Pu-239) - Plutonium-239 is another key material for nuclear reactors and weapons. It also undergoes fission and can sustain a chain reaction.

Uranium-233 (U-233) - Produced from thorium-232 in a process called breeding, Uranium-233 can also sustain a chain reaction.

Neptunium-239 (Np-239) - This isotope is less commonly used but can contribute to a chain reaction through its decay into plutonium-239.

Thorium-232 (Th-232) - While not directly fissionable by thermal neutrons, thorium-232 can be converted into Uranium-233, which can then sustain a chain reaction.

Nuclear radiation comes in several forms:

1. Alpha Particles: These are heavy, positively charged particles consisting of two protons and two neutrons. They have low penetration power and can be stopped by a sheet of paper or human skin. However, alpha emitters can be very dangerous if ingested or inhaled.
2. Beta Particles: These are high-energy, high-speed electrons or positrons. They have greater penetration power than alpha particles but can be stopped by materials like plastic or glass. Beta radiation can pose a risk to living tissues.
3. Gamma Rays: These are highly energetic electromagnetic waves with high penetration power. Gamma rays require dense materials like lead or several centimeters of concrete to block them. They are often associated with nuclear reactions and radioactive decay.

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4. Neutron: Neutron radiation consists of free neutrons, which have no electric charge but can penetrate most materials. Neutron radiation is particularly prevalent in nuclear reactors and can activate materials, making them radioactive.

Learning Objectives

To know the different kinds of radioactive decay.

To balance a nuclear reaction.

The two general kinds of nuclear reactions are nuclear decay reactions and nuclear transmutation reactions**.** In a **nuclear decay reaction**, also called radioactive decay, an unstable nucleus emits radiation and is transformed into the nucleus of one or more other elements. The resulting daughter nuclei have a lower mass and are lower in energy (more stable) than the parent nucleus that decayed. In contrast, in a **nuclear transmutation reaction**, a nucleus reacts with a subatomic particle or another nucleus to form a product nucleus that is *more massive* than the starting material. As we shall see, nuclear decay reactions occur spontaneously under all conditions, but nuclear transmutation reactions occur only under very special conditions, such as the collision of a beam of highly energetic particles with a target nucleus or in the interior of stars. We begin this section by considering the different classes of radioactive nuclei, along with their characteristic nuclear decay reactions and the radiation they emit.

Classes of Radioactive Nuclei

The three general classes of radioactive nuclei are characterized by a different decay process or set of processes:

Neutron-rich nuclei. The nuclei on the upper left side of the band of stable nuclei have a neutron-to-proton ratio that is too high to give a stable nucleus. These nuclei decay by a process that *converts a neutron to a proton*, thereby *decreasing* the neutron-to-proton ratio.

Neutron-poor nuclei. Nuclei on the lower right side of the band of stable nuclei have a neutron-to-proton ratio that is too low to give a stable nucleus. These nuclei decay by processes that have the net effect of *converting a proton to a neutron*, thereby *increasing* the neutron-to-proton ratio.3

Heavy nuclei. With very few exceptions, heavy nuclei (those with $A \geq 200$) are intrinsically unstable regardless of the neutron-to-proton ratio, and all nuclei with $Z > 83$ are unstable. This is presumably due to the cumulative effects of electrostatic repulsions between the large number of positively charged protons, which cannot be totally overcome by the strong nuclear force, regardless of the number of neutrons present. Such nuclei tend to decay by emitting an α particle (a helium nucleus, 42He24He, which decreases the number of protons and neutrons in the original nucleus by 2. Because the neutron-to-proton ratio in an α particle is 1, the net result of alpha emission is an increase in the neutron-to-proton ratio.

Nuclear Decay Reactions

Just as we use the number and type of atoms present to balance a chemical equation, we can use the number and type of nucleons present to write a balanced nuclear equation for a nuclear decay reaction. This procedure also allows us to predict the identity of either the parent or the daughter nucleus if the identity of only one is known. Regardless of the mode of decay, the total number of nucleons is conserved in all nuclear reactions.

To describe nuclear decay reactions, chemists have extended the AZXZAX notation for nuclides to include radioactive emissions. Table 24.3.124.3.1 lists the name and symbol for each type of emitted radiation. The most notable addition is the **positron**, a particle that has the same mass as an electron but a positive charge rather than a negative charge.

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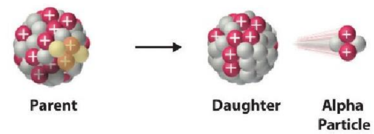
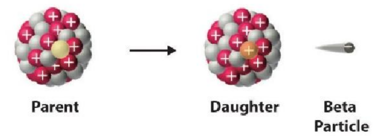
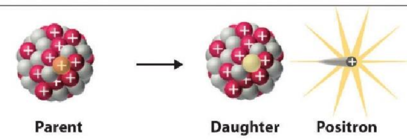
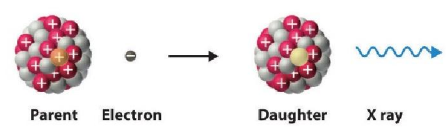
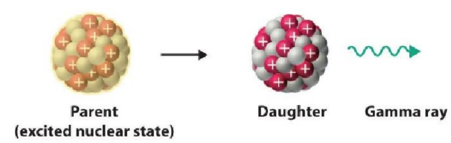
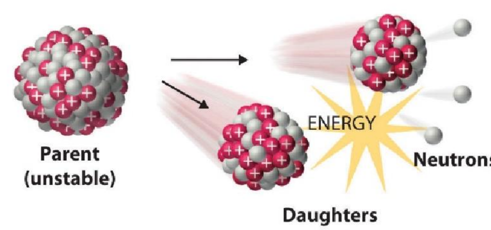
Decay Type	Radiation Emitted	Generic Equation	Model
Alpha decay	${}^{4}_{2}\alpha$	${}^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}X' + {}^{4}_{2}\alpha$	
Beta decay	${}^{0}_{-1}\beta$	${}^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}X' + {}^{0}_{-1}\beta$	
Positron emission	${}^{0}_{+1}\beta$	${}^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}X' + {}^{0}_{+1}\beta$	
Electron capture	X rays	${}^{A}_{Z}X + {}^{0}_{-1}e \longrightarrow {}^{A}_{Z-1}X' + \text{X ray}$	
Gamma emission	${}^{0}_{0}\gamma$	${}^{A}_{Z}X^{*} \xrightarrow{\text{Relaxation}} {}^{A}_{Z}X' + {}^{0}_{0}\gamma$	
Spontaneous fission	Neutrons	${}^{A+B+C}_{Z+Y}X \longrightarrow {}^{A}_{Z}X' + {}^{B}_{Y}X' + C\,{}^{1}_{0}n$	

Fig.1

Alpha Decay

Many nuclei with mass numbers greater than 200 undergo **alpha (α) decay**, which results in the emission of a helium-4 nucleus as an **alpha (α) particle**, 42α24α. The general reaction is as follows:

AZXparent→A−4Z−2X′daughter+42αalphaparticle

Beta Decay

Nuclei that contain too many neutrons often undergo **beta (β) decay**, in which a neutron is converted to a proton and a high-energy electron that is ejected from the nucleus as a β particle:

10nunstableneutron innucleus→11pprotonretainedby nucleus+0−1βbeta particleemitted bynucleus

Gamma Emission

Many nuclear decay reactions produce daughter nuclei that are in a nuclear excited state, which is similar to an atom in which an electron has been excited to a higher-energy orbital to give an electronic excited state. Just as an electron in an electronic excited state emits energy in the form of a photon when it returns to the ground state, a nucleus in an excited state releases energy in the form of a photon when it returns to the ground state. These high-energy photons are γ

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rays. **Gamma** (γγ) **emission** can occur virtually instantaneously, as it does in the alpha decay of uranium-238 to thorium-234, where the asterisk denotes an excited state:

23892U→23490Th*excitednuclearstate+42α−→−−−−−relaxation23490Th+00γ

Example:-

Predict the kind of nuclear change each unstable nuclide undergoes when it decays.

4522Ti2245Ti

24294Pu94242Pu

125B512B

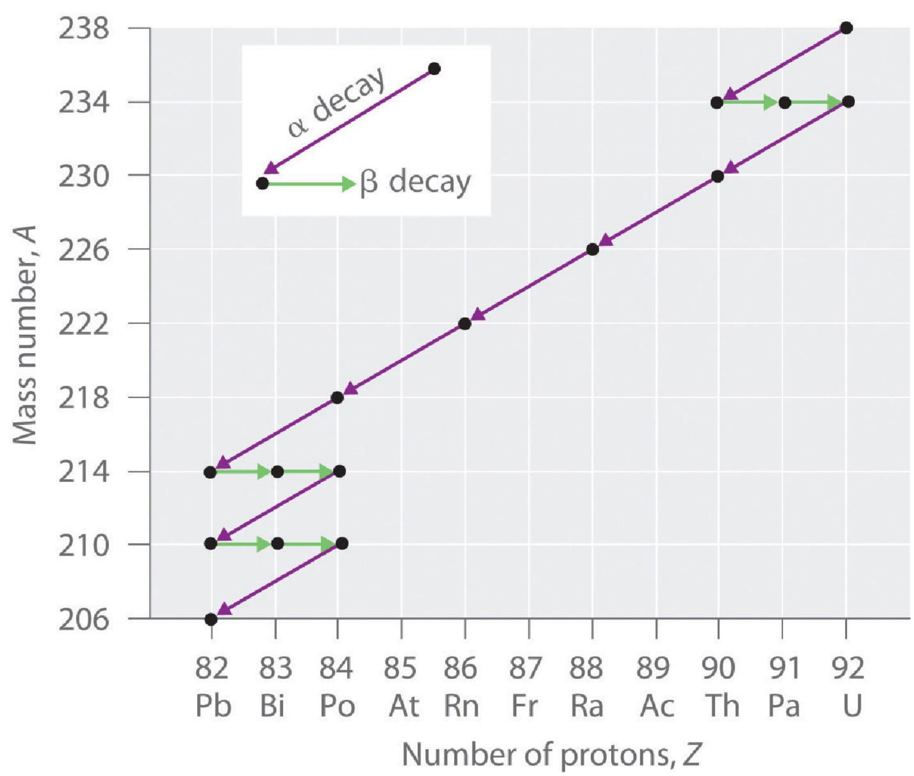
256100Fm100256Fm

Given: nuclide

Asked for: type of nuclear decay

Radioactive Decay Series

The nuclei of all elements with atomic numbers greater than 83 are unstable. Thus all isotopes of all elements beyond bismuth in the periodic table are radioactive. Because alpha decay decreases *Z* by only 2, and positron emission or electron capture decreases *Z* by only 1, it is impossible for any nuclide with $Z > 85$ to decay to a stable daughter nuclide in a single step, except via nuclear fission. Consequently, radioactive isotopes with $Z > 85$ usually decay to a daughter nucleus that is radiaoctive, which in turn decays to a second radioactive daughter nucleus, and so forth, until a stable nucleus finally results. This series of sequential alpha- and beta-decay reactions is called a **radioactive decay series**. The most common is the uranium-238 decay series, which produces lead-206 in a series of 14 sequential alpha- and beta-decay reactions (Figure 24.3.224.3.2). Although a radioactive decay series can be written for almost any isotope with $Z > 85$, only two others occur naturally: the decay of uranium-235 to lead-207 (in 11 steps) and thorium-232 to lead-208 (in 10 steps). A fourth series, the decay of neptunium-237 to bismuth-209 in 11 steps, is known to have occurred on the primitive Earth. With a half-life of “only” 2.14



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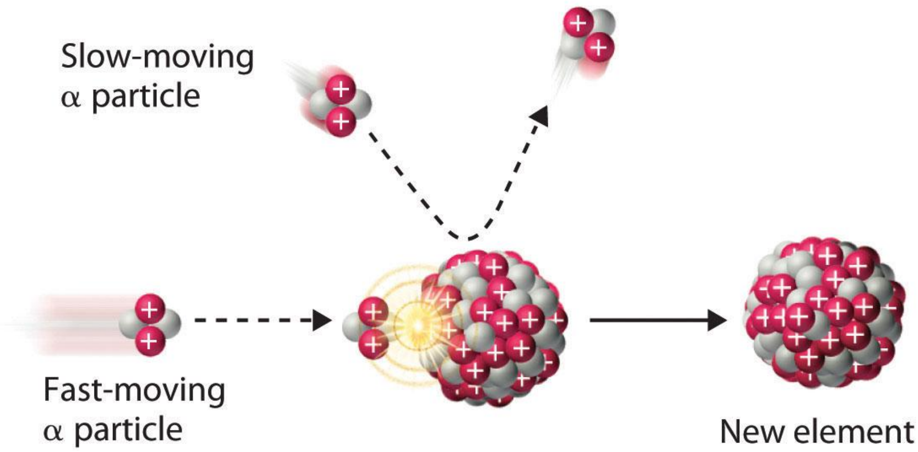
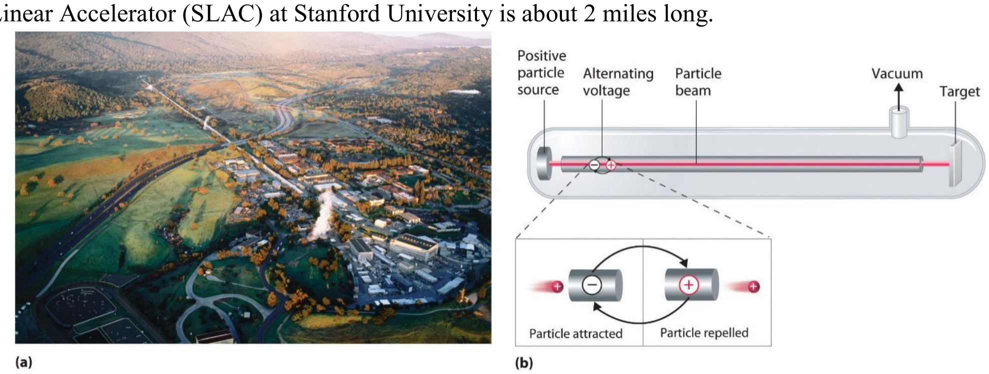
Induced Nuclear Reactions

The discovery of radioactivity in the late 19th century showed that some nuclei spontaneously transform into nuclei with a different number of protons, thereby producing a different element. When scientists realized that these naturally occurring radioactive isotopes decayed by emitting subatomic particles, they realized that—in principle—it should be possible to carry out the reverse reaction, converting a stable nucleus to another more massive nucleus by bombarding it with subatomic particles in a nuclear transmutation reaction.



A device called a particle accelerator is used to accelerate positively charged particles to the speeds needed to overcome the electrostatic repulsions between them and the target nuclei by using electrical and magnetic fields. Operationally, the simplest particle accelerator is the linear accelerator (Figure 24.3.624.3.6), in which a beam of particles is injected at one end of a long evacuated tube. Rapid alternation of the polarity of the electrodes along the tube causes the particles to be alternately accelerated toward a region of opposite charge and repelled by a region with the same charge, resulting in a tremendous acceleration as the particle travels down the tube. A modern linear accelerator such as the Stanford Linear Accelerator (SLAC) at Stanford University is about 2 miles long.



Uses Of Nuclear Energy :-

The main use of nuclear energy is the generation of electrical energy.

However, there are many other applications in which nuclear technology is used directly or indirectly.

By working with different isotopes of the same element, nuclear technology can be used for other applications in various fields.

The main uses of nuclear energy are the following:

1. **Electricity generation**

The most important and well-known use of nuclear energy is the generation of electricity in nuclear power plants.

After World War II, nuclear reactors were given a new use: generating electricity from the nuclear fission of uranium atoms.

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A nuclear power plant is a facility capable of converting the atomic energy contained in uranium atoms to generate electricity. The process to obtain this conversion is the result of a thermodynamic and mechanical process. Uranium is one of the most unstable elements on the periodic table of elements, making it ideal for this purpose.

At first, the nuclear reactor generates fission reactions of the uranium atomic nuclei, emitting a large amount of thermal energy. With all this heat energy, high-pressure steam is obtained to drive the steam turbines of the plant. In this way, mechanical energy is obtained to power the electrical generator and convert the kinetic energy of the shaft into electrical energy.

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2. Industrial processes

Nuclear technology acquires great importance in the industrial sector. In particular, it is used in:

Development and improvement of processes.

Measurements.

Automation.

QA.

It is used as a prerequisite for the complete automation of high-speed production lines. This technology is applied to process research, mixing, maintenance and the study of wear and corrosion of facilities and machinery.

Nuclear technology is also used in the manufacturing of plastics and in the sterilization of single-use products.

3. Military weapons and development of atomic bombs

A weapon is an instrument used to attack or defend oneself. Nuclear weapons are those weapons that use nuclear technology.

The origin of the development of nuclear energy occurred during World War II with war objectives. After a warning from Albert Einstein, the president of the United States began what would be called the Manhattan Project. The goal of the project was to develop the atomic bomb.

4. Nuclear medicine

One of the most important applications of nuclear energy after electricity generation is its use to treat and diagnose diseases: nuclear medicine.

Ionizing radiation allows images of the interior of patients to be obtained, helping to diagnose diseases. These radiations are also used to treat diseases such as cancer since they have the ability to destroy tumor cells.

One in three patients who attend a hospital in an industrialized country receives the benefits of some type of nuclear medicine procedure.

Some examples of the use of nuclear medicine are:
Use of radiopharmaceuticals
Techniques such as radiotherapy for the treatment of malignant tumors
Use of teletherapy for cancer treatment
Radiological biology that allows medical products to be sterilized.

Agriculture and pest control

The application of isotopes to agriculture has made it possible to increase agricultural production in less developed countries.

Nuclear technology is very useful in:
Insect pest control
Maximum use of water resources
Improvement of crop varieties
Establishment of the necessary conditions to optimize the effectiveness of fertilizers and water.

Echo Friendly Nature Of Nuclear Energy :-

The environmental impacts of nuclear energy
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Nuclear energy is a (mostly) clean, (sort of) renewable source of electricity

Although nuclear is technically not renewable (due to the finite amount of uranium available on Earth), it's still widely available. And although generating electricity with nuclear energy is a carbon-free process, constructing new nuclear energy plants and mining the uranium fuel has its own environmental impact.

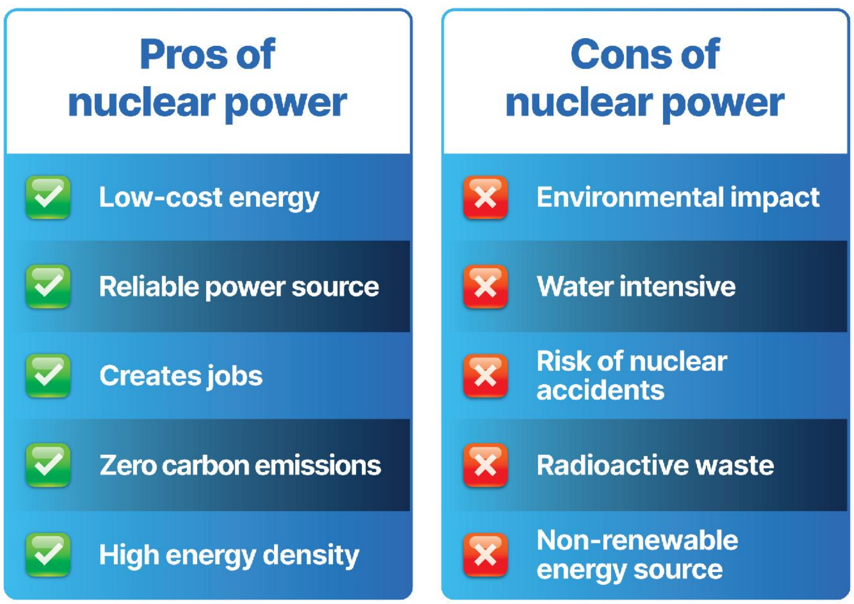
Nuclear power plant emissions compared to fossil fuels

One way to compare the environmental impact of various electrical generation technologies is to analyze their life-cycle greenhouse gas emissions, which is the total amount of greenhouse gas output (measured in grams carbon dioxide equivalent, or gCO2eq) that can be expected from deploying a generator. Life-cycle analyses take into account the full life of the system, from obtaining materials through the construction process to operation to end-of-life waste management.

Nuclear emissions compared to other clean sources

What's more, nuclear energy stands up very well to other clean energy sources, not just traditional fossil fuels. Nuclear energy is just about on par with the median lifecycle emissions from wind power, the lowest-emissions energy source noted in the same IPCC report:

Technology	Lifecycle Emissions (g CO2eq/k Wh)
Wind	11
Hydropower	24*
Concentrated solar	27
Nuclear	12
Geothermal	38
Solar PV	48

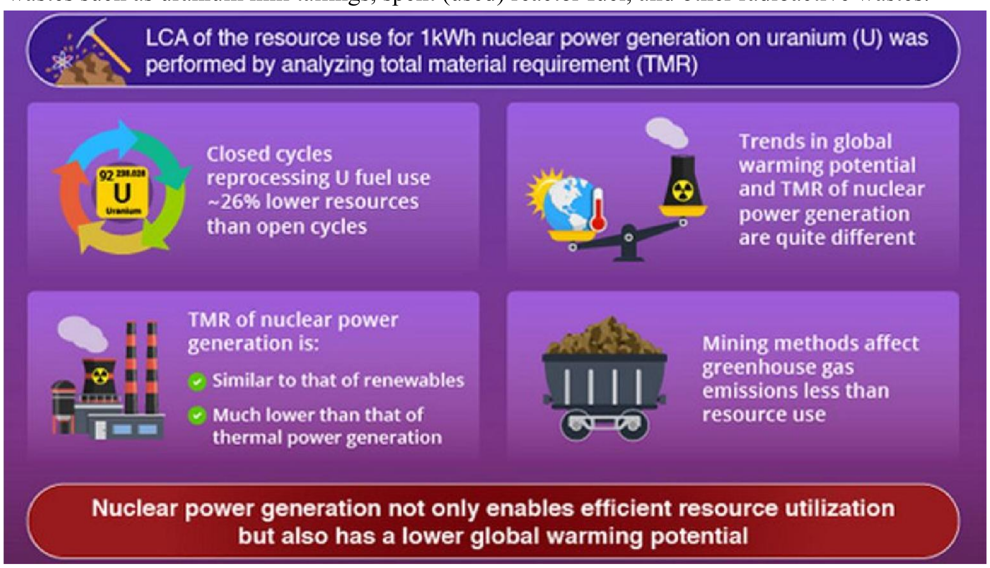


Impact on wild an articles:-

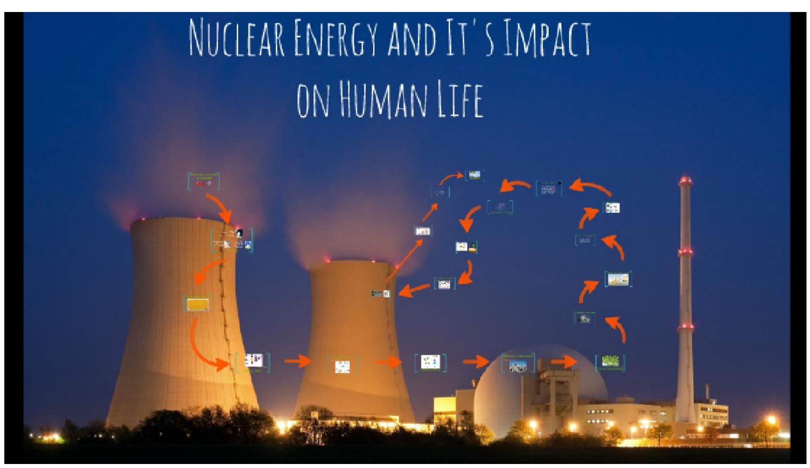
Nuclear disasters can cause widespread death and sickness among wildlife, just like humans. But after the initial radiation leaks subside, research has shown that wildlife communities can recover to levels sometimes higher than they were before the catastrophes

Impact on Nature:-

Nuclear energy produces radioactive wasteA major environmental concern related to nuclear power is the creation of radioactive wastes such as uranium mill tailings, spent (used) reactor fuel, and other radioactive wastes.



Impact on human:-



Physical injury, illness and cancer are effects that may arise from inadvertent exposure to chemicals and materials used in fuel cycle activities. Uranium-238, for example, which is ubiquitous in the fuel cycle, is toxic and has been shown to impair kidney function in humans when ingested.

Management of the Impact of Radiation

Managing the impact of radiation involves several key strategies to protect human health and the environment:

1. Radiation Protection Principles:
   - Time: Minimize the time spent near a radiation source. The less time you are exposed, the lower your dose.
   - Distance: Increase the distance between yourself and the radiation source. Radiation intensity decreases with distance.
   - Shielding: Use appropriate materials to shield against radiation. For alpha particles, paper or clothing is sufficient; for beta particles, plastic or glass; and for gamma rays, dense materials like lead or concrete.
2. Monitoring and Measurement:
   - Radiation Detectors: Use devices like Geiger counters, scintillation detectors, and dosimeters to measure radiation levels and doses.
   - Regular Monitoring: Conduct routine monitoring of radiation levels in areas where radioactive materials are used or stored.
3. Safety Protocols:
   - Training: Ensure that individuals working with or around radiation sources are properly trained in radiation safety and emergency procedures.
   - Protective Gear: Provide appropriate personal protective equipment (PPE) such as lead aprons or shields for those handling radioactive materials.

4. Waste Management:
   - Storage: Store radioactive waste in secure, specially designed containers to prevent leaks and environmental contamination.
   - Disposal: Follow regulations and best practices for the disposal of radioactive waste, including the use of licensed facilities for long-term storage or disposal.

5. Emergency Preparedness
   - Plans: Develop and implement emergency response plans for radiation incidents, including procedures for evacuation, decontamination, and medical treatment.
   - Communication: Ensure effective communication with the public and stakeholders in case of a radiation emergency to provide timely information and instructions.
6. Regulation and Compliance:
   - Standards: Adhere to national and international safety standards and regulations governing the use and management of radioactive materials.
   - Inspection: Regularly inspect facilities and practices to ensure compliance with safety regulations and standards.

Advantages Of Nuclear Energy:-

Nuclear protect our air
Restricted fuel supply
Radioactive waste
Zero emission
Affordable

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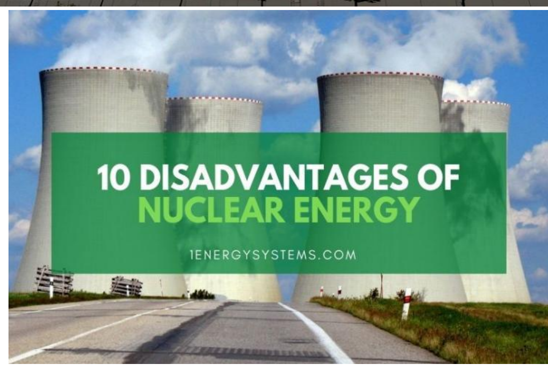
Disadvantage Of Nuclear Energy:-



II. CONCLUSION

Nuclear power plants are also capable of producing huge quantities of electricity, further reducing the need for additional coal or gas power plants. Since nuclear plants can produce so much energy, far fewer are needed in order to meet demands than are coal or gas plants.

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