PLUTUS IAS

CURRENT AFFAIRS

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MANAGEMENT OF NUCLEAR WASTE

THIS ARTICLE COVERS 'DAILY CURRENT AFFAIRS' AND THE TOPIC DETAILS OF "MANAGEMENT OF NUCLEAR WASTE". THIS TOPIC IS RELEVANT IN THE "SCIENCE AND TECHNOLOGY" SECTION OF THE UPSC CSE EXAM.

WHY IN THE NEWS?

India has reached a noteworthy achievement in its nuclear endeavours by successfully loading the core of the Prototype Fast Breeder Reactor (PFBR). Despite this advancement towards energy autonomy, India encounters the intricate task of effectively handling nuclear waste as it moves forward.

ABOUT NUCLEAR WASTE

- In a nuclear fission reactor, **atoms** of specific elements are **bombarded by neutrons. When a nucleus absorbs a neutron**, it **becomes unstable and splits**, releasing energy and forming nuclei of different elements. **For instance**, a uranium-235 (U-235) nucleus, upon absorbing a neutron, can split into barium-144, krypton-89, and three neutrons. If the resulting elements (barium-144 and krypton-89) cannot undergo further fission, they become classified as nuclear waste.
- The fuel utilised in a nuclear reactor becomes irradiated during operation and eventually needs to be replaced, at which stage it is termed **spent fuel**. **Nuclear waste is highly radioactive and necessitates storage in specialised facilities designed to prevent leakage** and contamination of the surrounding environment.

MANAGEMENT OF NUCLEAR WASTE

COOLING DOWN

Freshly removed spent fuel is highly radioactive and generates significant heat. To address these concerns, it's initially placed in underwater pools located at the nuclear power plant itself. The water serves a dual purpose: shielding the environment from radiation and acting as a coolant for the spent fuel. After a period of several years, the radioactivity and heat levels decrease sufficiently, allowing for the next step.

REPROCESSING: EXTRACTING USABLE FUEL

Some countries choose to reprocess spent fuel. This process involves chemically separating out usable fissile materials like plutonium and uranium from the waste. These recovered materials can then be used to create new fuel for reactors, maximising resource utilisation. However, it's important to note that reprocessing generates additional radioactive waste streams that also require management.

TREATMENT AND PACKAGING

Whether reprocessed or not, spent fuel undergoes treatment and conditioning to ensure safe storage and disposal. Liquid waste streams are treated to remove radioactive contaminants, while solid waste might be compacted, solidified, or encased in robust containers for long-term management.

SECURE STORAGE

Nuclear waste necessitates secure storage facilities that prevent any possibility of leaks, environmental contamination, or unauthorised access. There are different storage options available:
On-site storage: Used fuel can be stored within the confines of the nuclear power plant itself, typically in specially designed concrete casks.
Interim storage facilities: These centralised facilities provide temporary storage for spent fuel from multiple reactors before final disposal.
Long-term repositories: The ultimate goal is to dispose of nuclear waste in deep geological repositories. These repositories are carefully selected underground geological formations, chosen for their stability and isolation from the environment, ensuring the safe containment of radioactive waste for thousands of years.

DISPOSAL

Deep geological disposal serves as the final resting place for nuclear waste. Here, the waste is carefully placed deep underground in a meticulously chosen geological formation. This isolation from the environment minimises the risk of human exposure or environmental contamination for millennia.

CHALLENGES AND CONCERNS IN HANDLING THE NUCLEAR WASTE

Technical Hurdles: Effectively managing radioactive waste presents a complex set of technical hurdles. Ensuring secure containment at every stage, from storage facilities to transportation, is paramount. Long-term monitoring of these sites is also crucial to detect any potential issues.

Balancing Safety and Security: Nuclear waste facilities operate under a tightrope walk, balancing safety and security concerns. Stringent regulations are in place to prevent accidents, leaks, or unauthorised access to this hazardous material.

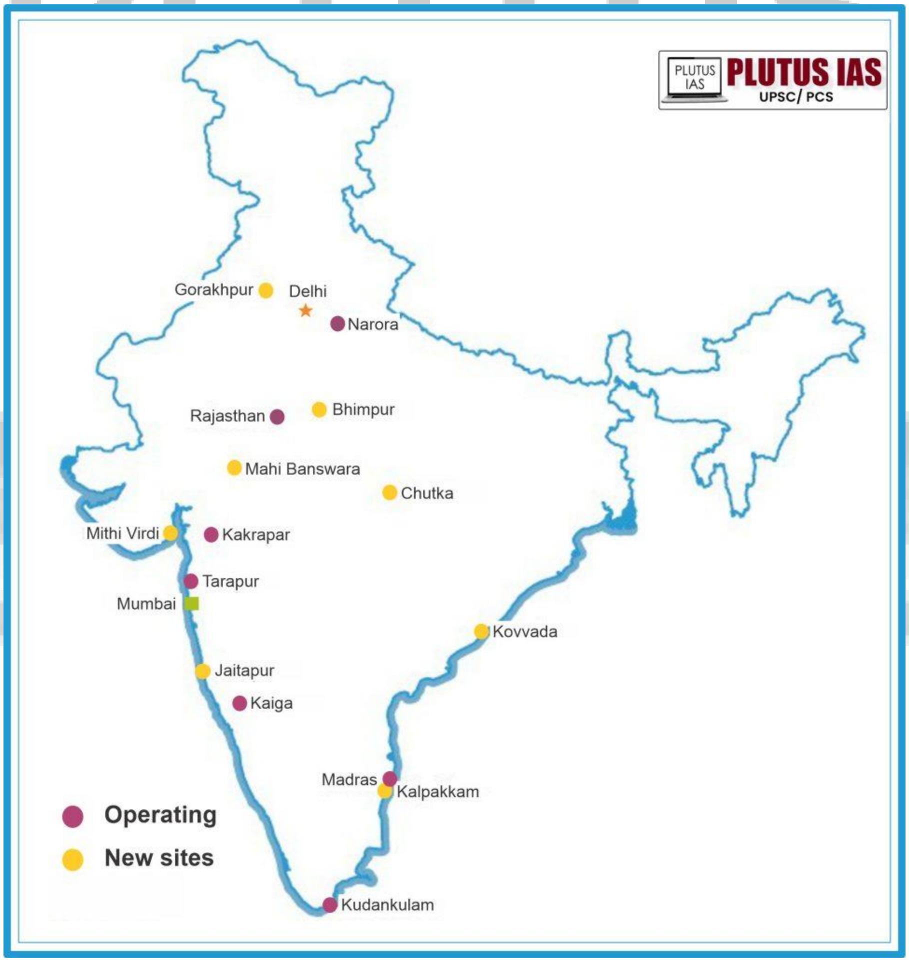
Impact on Environment: Improper disposal or mismanagement of nuclear waste poses a significant threat to the environment. Contamination of land, water, and air can have devastating consequences for ecosystems and human health, making responsible waste management an absolute necessity.

Public Perception: The concept of nuclear waste disposal often faces public resistance. Concerns about safety, potential environmental damage, and the ethical implications of storing radioactive material for millennia contribute to this public apprehension.

Financial Burden: Handling nuclear waste is an expensive undertaking. The financial responsibility for this process falls on governments, utility companies, and, ultimately, taxpayers. Additionally, the long-term liability associated with managing and disposing of this waste raises further economic concerns.

INDIA'S APPROACH TO NUCLEAR WASTE MANAGEMENT INVOLVES SEVERAL STRATEGIES AND FACILITIES

- According to a **2015 report by the International Panel on Fissile Materials (IPFM),** India operates reprocessing plants located in **Trombay, Tarapur, and Kalpakkam**. The **Trombay** facility primarily **focuses on reprocessing spent fuel** from research reactors, while the **Tarapur and Kalpakkam facilities handle spent fuel from pressurised heavy water reactors (PHWRs).**
- Furthermore, India manages **on-site waste generated** during the operation of nuclear power stations, including low and intermediate-level radioactive waste.
- However, operational challenges have been noted. The **IPFM report highlights delays in the implementation of stage II of India's nuclear program**, attributing these delays to subpar performance at the reprocessing facilities in Tarapur and Kalpakkam.
- Moreover, the **upcoming operation of the Prototype Fast Breeder Reactor (Stage II of India's nuclear program)** presents new challenges. This reactor's functioning will introduce complexities in the distribution of fission products and transuranic elements compared to conventional reactors.



PRELIMS PRACTISE QUESTIONS

Q1. In India, why are some nuclear reactors kept under "IAEA safeguards" while others are not?

(a) Some use uranium, and others use thorium

(b) Some use imported uranium, and others use domestic supplies
(c) Some are operated by foreign enterprises, and others are operated by domestic enterprises
(d) Some are State-owned, and others are privately owned

Answer: B

Q2. Consider the following statements:

1. Aluminium is used to shield containers of nuclear waste.
2. Boron is commonly used in nuclear reactors to absorb excess neutrons.

Which of the above statements is/are correct?

1. 1 only
2. 2 only
3. Both 1 and 2
4. Neither 1 nor 2

Answer: B

MAIN PRACTISE QUESTION

Q1. Evaluate the ethical implications of relying on nuclear deterrence as a strategy for national security. Consider the risks of accidental or intentional nuclear escalation and the potential humanitarian consequences.

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