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Nuclear Waste Management

Published On: 16-03-2024

Why is in news? How is nuclear waste generated?

Recently, India loaded the core of its long-delayed Prototype Fast Breeder Reactor (PFBR) vessel, bringing the country to the cusp of stage II — powered by uranium and plutonium — of its three-stage nuclear programme.

By stage III, India hopes to be able to use its vast reserves of thorium to produce nuclear power and gain some energy independence.

But the large-scale use of nuclear power is accompanied by a difficult problem: **waste management**.

Nuclear waste:

Nuclear waste is **highly radioactive** and needs to be **stored in facilities** reinforced to prevent leakage and/or contamination of the local environment.

In a **fission reactor**, neutrons bombard the nuclei of atoms of certain elements.

When one such nucleus absorbs a neutron, it destabilises and breaks up, yielding some energy and the nuclei of different elements.

For example, when the uranium-235 (U-235) nucleus absorbs a neutron, it can fission to barium-144, krypton-89, and three neutrons.

If the ‘debris’ (**barium-144 and krypton-89**) constitute elements that **can’t undergo fission, they become nuclear waste.**

Nuclear Waste Management Conventions:

Bamako Convention: This treaty was framed by African nations to prohibit the import of hazardous waste(radioactive)into Africa.

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management: It is an international treaty of the International Atomic Energy Agency (IAEA). It is an initial treaty on the international level to address the management of radioactive waste.

Convention on Nuclear Safety (CNS): It ensures that all nations with nuclear power plants prioritise safetyCNS makes fundamental safety principles that all states are to follow. The convention aims to increase safety levels through regular meetings.

Handling of nuclear waste:

Handling the spent fuel is the main challenge — it is hot and radioactive, and **needs to be kept underwater** for up to a few decades.

Spent fuel storage: Once spent fuel has been cooled in the spent-fuel pool for at least a year, it can be **moved to dry-cask storage**. It is placed inside large steel cylinders and surrounded by an inert gas. The cylinders are sealed shut and placed **inside larger steel or concrete chambers**.

All countries with long-standing nuclear power programmes have accumulated a considerable inventory of spent fuel. For example, the **U.S.** had 69,682 tonnes (as of 2015), **Canada** 54,000 tonnes (2016), and **Russia** 21,362 tonnes (2014).

Liquid waste treatment: Nuclear power plants also have **liquid waste treatment facilities**.

Japan is currently discharging, after treatment, such water from the Fukushima nuclear power plant into the Pacific Ocean.

Vitrification: Liquid high-level waste contains “almost all of the fission products produced in the fuel”. It is vitrified to form a storable glass.

Reprocessing: It separates fissile from non-fissile material in spent fuel**. T**he material is chemically treated to separate fissile material left behind from the non-fissile material.

Because spent fuel is so hazardous, reprocessing facilities need specialised protections and personnel of their own. Such facilities present the **advantage of higher fuel efficiency but are also expensive**.

Only uranium and plutonium can be used as fuel. Because **India reprocesses its spent fuel**, these fission products will have to be stored, at least for a while, in the form of liquid waste, which poses accident hazards.

Geological disposal: Some experts have also rooted for geological disposal: the waste is **sealed in special containers and buried underground** in granite or clay.

Issues associated with nuclear waste:

Environmental Risks: Improper waste management can lead to contamination of water resources and surrounding areas.

For instance: The Asse II salt mine in Germany faced contamination concerns due to nuclear waste storage.

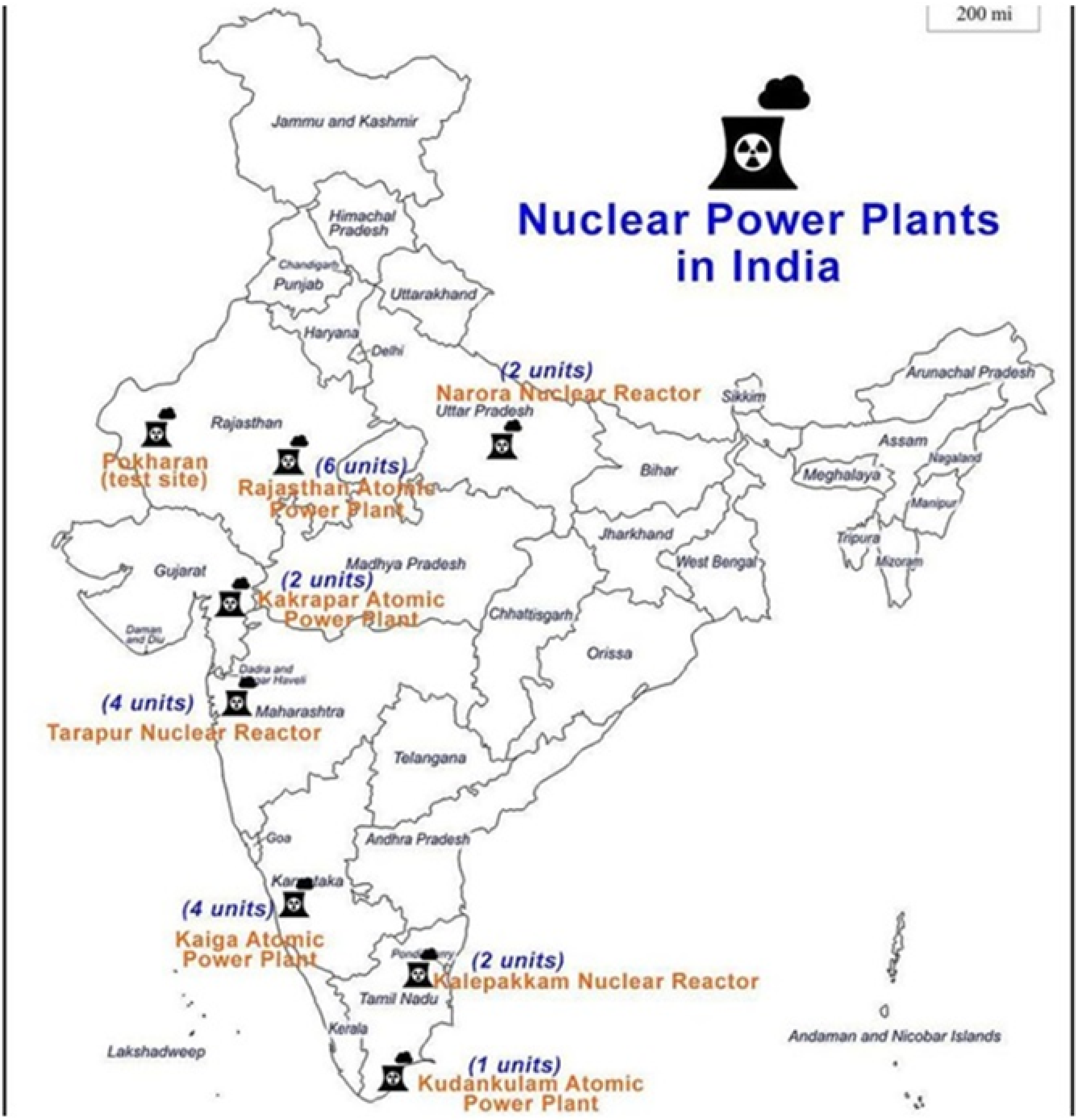
Safety Concerns: Accidents at nuclear waste storage sites highlight the need for stringent safety measures.

Ex.: The Waste Isolation Pilot Plant (WIPP) in the U.S. experienced an accident in 2014, releasing radioactive materials.

Cost Implications: Waste management accounts for a significant portion of the overall cost of nuclear energy production. Cost Estimate: Waste management imposes a cost of $1.6-7.1 per MWh of nuclear energy.

India's Nuclear Waste Management:

According to a 2015 report of the **International Panel on Fissile Materials** (IPFM), India has **reprocessing plants** in Trombay, Tarapur, and Kalpakkam.



The wastes generated at the nuclear power stations during the operation are of low and intermediate activity level and are **managed at the site itself**.

They are **treated and stored in on-site facilities**, that such facilities are located at all nuclear power stations and that the surrounding area is monitored for radioactivity.

India **adheres to International Atomic Energy Agency (IAEA) safeguards**, ensuring the safe and secure handling of nuclear materials and waste.

The **delayed commissioning of the PFBR** suggests potential complications in managing spent fuel with different compositions.

Way Forward:

Continued **investment in research and development** of advanced waste treatment technologies can enhance efficiency and safety in nuclear waste management.

Collaborating with international organizations and sharing best practices can provide valuable insights and expertise in addressing nuclear waste challenges.

Engaging with stakeholders and the public to raise awareness about nuclear waste management and address concerns regarding safety and environmental impact is crucial.

Strengthening regulatory frameworks and implementing robust safety standards can ensure compliance with international guidelines and safeguard against potential hazards.