Challenges of Nuclear Waste

Why in news?

Recently India reached stage II of nuclear program, but large scale use of nuclear power highlights the significant challenge associated with nuclear waste.

What is nuclear waste?

- It's the by-product of *fission reactors* where elements like uranium-235 break down into *non-fissile elements*, which are then considered as nuclear waste.
- When atoms undergo fission, they break apart, releasing energy and producing various *radioactive isotopes.* These isotopes, along with unburned fuel, constitute nuclear waste.
- This waste is hazardous due to its radioactivity and must be managed carefully to prevent harm to the environment and human health.

As per International Atomic Energy Agency report, many countries are taking major steps to dispose of all types of nuclear and radioactive waste, with more than 80% of all solid radioactive waste volume now in disposal.

How the nuclear waste is handled?

Stages of handling nuclear waste	Issues
• **Storage**- Spent fuel is both hot and radioactive, requiring it to be stored underwater for cooling, sometimes for decades, before being moved to dry casks for long-term storage. • The fuel loaded into a nuclear reactor eventually becomes irradiated and must be unloaded. At this stage, it is referred to as spent fuel.	Countries with long-term nuclear programs have *significant amounts of spent fuel*, with the U.S., Canada, and Russia having tens of thousands of tonnes each.
• **Reprocessing-** It involves chemically separating reusable fissile material from non-fissile waste components in spent fuel. • Uranium and plutonium are extracted from spent nuclear fuel and other materials including fission products are kept for storage and disposal.	While reprocessing increases fuel efficiency, it also generates additional waste and poses proliferation risks due to the p*roduction of weapons-usable plutonium* which needs proper regulation.

• **Treatment-** Liquid waste from nuclear plants undergoes treatment to reduce its volume and radioactivity before disposal. • **Low level waste**- It is released into the environment, like Japan's discharge from Fukushima into the Pacific Ocean. • **High level waste-** Liquid waste is turned into a solid glass form, through verification process which facilitates long term storage.	The challenge lies in ensuring proper treatment and storage of liquid waste which can pose *accident hazards* if mishandled.
• **Disposal-** The ultimate goal is to dispose of nuclear waste safely and permanently. • **Geological disposal**- The waste is sealed in containers and buried deep underground in stable geological formation.	Geological disposal minimizes human exposure but there are concerns about *potential exposure* if the containers are disturbed during activities like digging.

What are the challenges associated with nuclear waste management in India?

- **Groundwater contamination**- Decontamination project has been launched in *Asse II salt mine region in US* to address mounting public concerns over contamination of water with nuclear waste as thousands of drums filled with nuclear waste has been kept for 3 decades.
- **Environmental injustice**- Exporting nuclear waste and hazardous materials disproportionately affects certain regions, the cost of waste management is beared by countries which don't benefit from nuclear power.
- **Emission of CO_2**- Mining uranium and establishing nuclear plants contribute to carbon emissions, further radioactive waste left over from nuclear energy generation continues to emit carbon dioxide during transportation.
- **Impact on environment**- The environmental effects of mining and the production of Uranium lead to the destruction and pollution of the ecosystem, the water coolants used to cool rods are disposed of into water bodies which disrupts aquatic ecosystems.
- **Mishandling waste management**- The *Waste Isolation Pilot Plant* in US has been hailed as a model for radioactive waste management, but it faced a serious setback in 2014 when an accident led to the release of small quantities of radioactive materials into the environment.
- **High cost**- The nuclear waste management imposes significant financial burden on the overall cost of nuclear energy production which includes the management of depleted uranium, decommissioning of nuclear plant cost, operational cost related to storage and disposal etc.,
- **Health concern** Direct or indirect contact with radioactive waste can lead to genetic mutations, skin cancer, other forms of cancer, cataracts, and tissue and organ damage.
- **Nuclear weapon proliferation**- The process involving uranium pellets and other radioactive elements could potentially be misused to create nuclear weapons.
- **Nuclear accident**- *Chernobyl disaster in 1986* and the *Fukushima Daiichi disaster in 2011* led to the death and displacement of many individuals and properties.
- **Regulatory challenges**- Disputes over site selection for disposal facilities and concerns about transportation of radioactive materials often arise.
- **Long term management**- Nuclear waste remains hazardous for thousands of years, necessitating robust long term management strategies that span generations.

India’s nuclear waste management
• **Reprocessing plants**- As per 2015 report of the International Panel on Fissile Materials (IPFM), India has reprocessing plants in Trombay, Tarapur, and Kalpakkam. • **Trombay**- It focuses on reprocessing spent fuel from research reactors. • **PHWRs**- Tarapur and Kalpakkam facilities handle spent fuel from pressurized heavy water reactors (PHWRs). • **On-site waste management-** The wastes generated during the operation of nuclear power stations, such as low and intermediate-level radioactive waste, are managed on-site. • **Operational challenges**- The IPFM report suggest that delay in stage II of India’s nuclear program is due to poor operation of reprocessing facilities at Tarapur and Kalpakkam • **New challenges**- If the ***Prototype Fast Breeder Reactor*** (Stage-II of India’s nuclear program) starts functioning, it will introduce new complexities in the distribution of fission products and transuranic elements compared to conventional reactors.

References

1. The Hindu- What are the challenges of nuclear waste
2. IAEA- Global overview of radioactive waste

