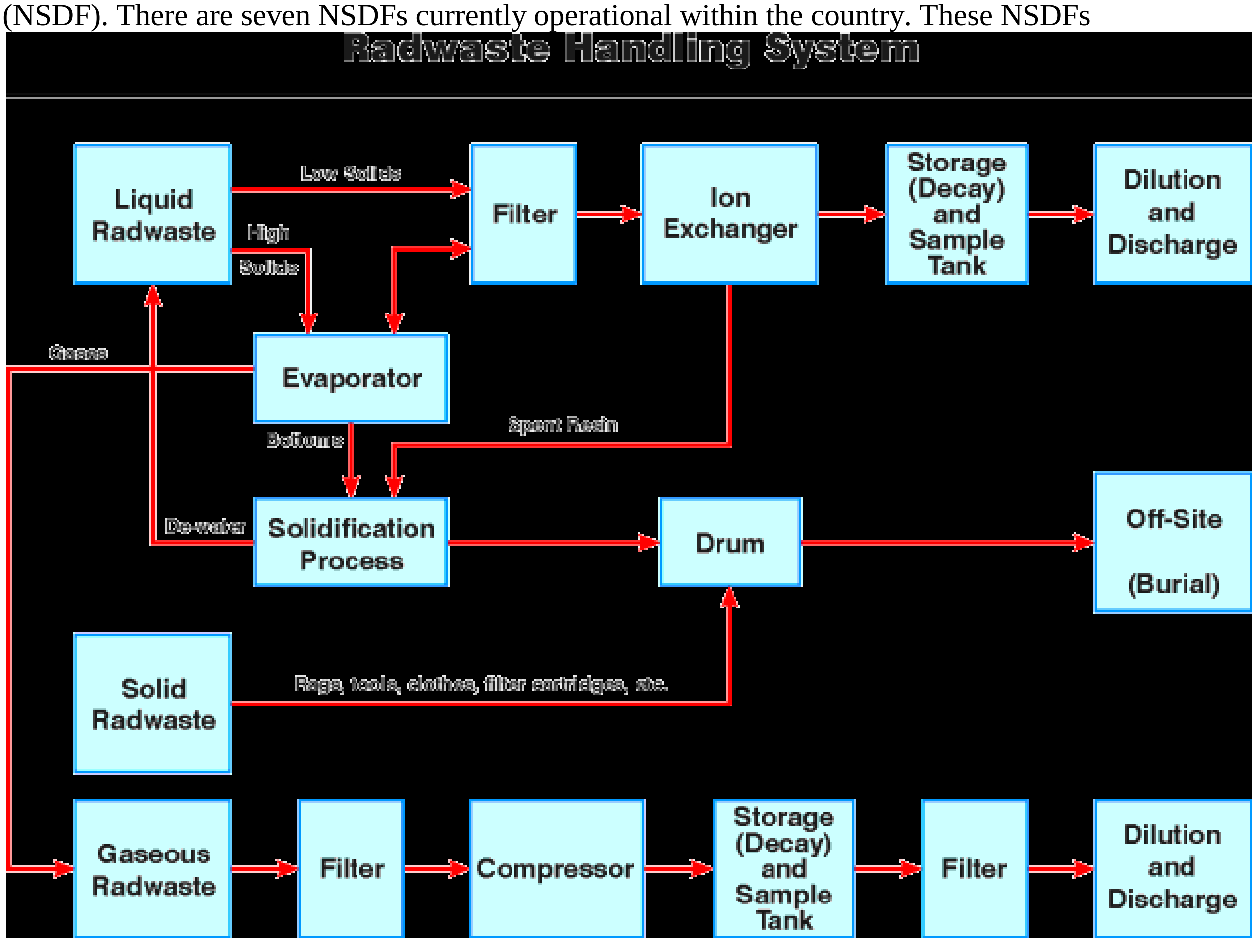
DISPOSAL OF RADIOACTIVE WASTES

Disposal as a final step in the management of radioactive waste involves confinement or isolation of these wastes from biosphere in the repositories. Based on the longevity and concentration of the radionuclide present in the waste, the repository could be either near-surface or in deep geological formation. India has extensive & varied experience in the operation of near surface disposal facilities (NSDFs) in widely different geohydrological and climatological conditions. Over the years, considerable expertise has gone in refining and improving the design and construction of these NSDFs. A system of multiple barriers employed in these NSDFs ensures isolation and release of radionuclides below permissible limits to the environment. This is ensured by regular monitoring and periodic performance assessment of these NSDFs. Disposal of long-lived and high level waste in deep underground geological formation is one option which has received world-wide attention. In India, the most promising formation is granitic rocks. In this context, our programme of site selection and host rock characterization for an Underground Research Laboratory is under evaluation.

1 NEAR SURFACE DISPOSAL

As a national policy, each nuclear facility in India has its own Near Surface Disposal Facility (NSDF). There are seven NSDFs currently operational within the country. These NSDFs

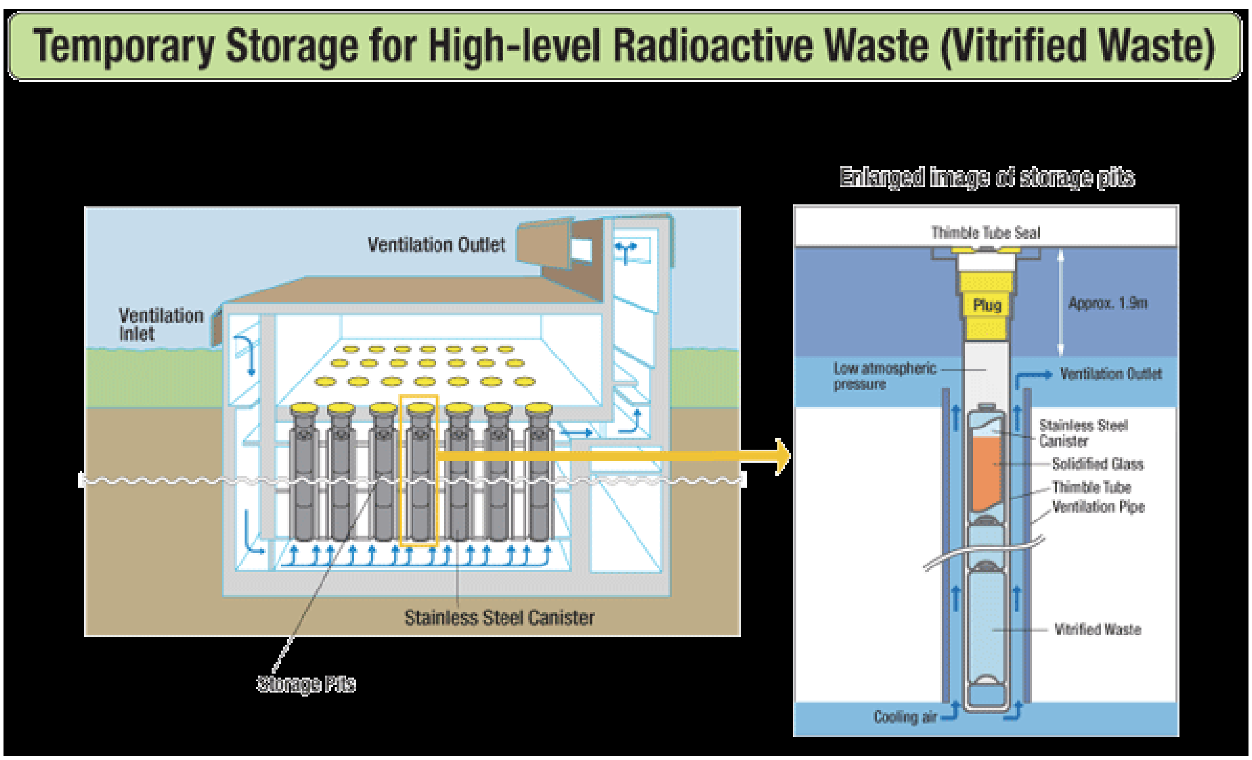


in India have to address widely varied geological and climatological conditions. The performance of these NSDFs is continuously evaluated to enhance the understanding of migration, if any and to adopt measures for upgrading the predictability over a long period of time.

2 DEEP GEOLOGICAL REPOSITORY

A programme for development of a geological repository for vitrified high level long lived wastes is being pursued actively, involving Insitu experiments, site selection, characterization and laboratory investigations. A. Insitu underground experiments For assessment of the rock mass response to thermal load from disposed waste overpack, an experiment of 8-years duration was carried out at a depth of 1000 m in an abandoned section of Kolar Gold mine. The thermal processes were also modeled by developing suitable codes. Good agreement between predicted and measured parameters was obtained.

B. Site selection and characterization Geologically, India is endowed with a number of suitable rocks to serve as host rocks for geological repository viz. granites, basalts, shales etc. The current investigations focus on granites due to availability of vast regions occupied by these massive granitic rock with very good mechanical, geochemical and geohydrological properties. A few promising areas lying in NW and Central India, occupied by good quality granites were systematically investigated using satellite data, geological and structural mapping on different scales, geophysical surveys viz. electromagnetic, resistivity and magnetic to generate three dimensional structural and lithological models. These models were validated and refined with shallow and deep drilling amounting to about 5000 m in 25 boreholes.



3 BACKFILLS AND BUFFERS FOR GEOLOGICAL DISPOSAL Backfills and buffers constitute the most important components of multibarrier scheme adopted in a geological disposal system in hard rocks. These layers are placed between the waste overpack and the host rock mainly to restrict the groundwater flow towards the waste form and to retard the migration

of radionuclides in the event of their release from the overpack. Swelling bentonitic clays predominantly composed of smectite mineral have emerged as preferable choice for such use due to their very low hydraulic conductivity and high retardation for radionuclides. Besides, their swelling property adds in sealing the fractures in the host rock. Indian swelling clay deposits are being evaluated for their suitability. Studies are underway to characterize their mineralogical compositions, geochemical characteristics viz. pore water compositions, hydration, cation effect, diffusion and adsorption for various radionuclides, engineering properties viz. Atterberg limit, plasticity index, swelling potential etc both under normal and elevated temperatures. Suitable admixtures of these clays with sand and crushed rocks are also being optimized for future testing insitu environment.

Shut down scenario of nuclear plant

- Utilities warn public to cut energy use 20% immediately!
  - Public ignores warning; consumes as usual
- Nuclear generators are taken off the Grid by law on stop date
- Immediate Grid overload occurs (~20% of energy missing)
- Electricity outages occur simultaneously across the entire country, not just as in the past Northeast states disruptions
- Electric lighting, communication, refrigeration, trains, elevators, traffic lights, gas pumps, oxygen generators, etc. fail to operate
- Back-up diesel generators use up reserve fuel in days
- Civilization as we know it drops back to the 1700s, but without the appropriate conveniences they were using back then
- As widespread hunger spreads, pillaging mobs kill for food (and TVs), while soldiers shoot looters by thousands

Future trends of nuclear plant

- Standardized plant designs speed construction and increase safety; use additional reactor units as needed
- Nuclear energy will increase in the less-developed countries in order to have long-term energy
  - Some countries may desire to create nuclear weapons at the same time; e.g., North Korea, Iran?

Fusion reactors may become useful in the future but years of research have only yielded less energy than was put in to the process

  - ITER (Latin for "The Way", I T E Reactor)
    - Produce 0.5 GW for 400 seconds!
    - Fuse deuterium and tritium to make H_2 and emit a neutron
  - Seven countries researching fusion energy
  - Tokamak accelerator
  - Goal is >10 units of energy out for each unit in
  - Perhaps demo ready between 2030 to 2035
- Nuclear plants provide a significant 20% of US energy
- Some antinuclear organizations want all plants closed right now and vocally oppose them
- Nuclear energy provides too much energy to readily close them without a substitute (~1600 MW/plant)
- Nuclear energy may be a transitional approach from fission plants to fusion plants some far away day
- Nuclear plants likely will be built again since population growth demands more energy, natural gas prices will be higher in the future, and fossil fuel plants pollute
  - Wind energy is the closest renewable, since major hydro is difficult (see China's Three Gorges Dam)