Radioactive Waste - Myths and Realities

(Updated February 2020)

- **There are a number of pervasive myths regarding both radiation and radioactive waste.**
- **Some lead to regulation and actions which are counterproductive to human health and safety.**

Over the years, many views and concerns have been expressed in the media, by the public and other interested groups in relation to the nuclear industry and in particular its waste. Questions have been raised about whether nuclear power should continue when the issue of how to deal with its waste has apparently not yet been satisfactorily resolved.

Some of the more commonly expressed views and concerns include:

- 1. The nuclear industry still has no solution to the 'waste problem'.
- 2. The transport of this waste poses an unacceptable risk to people and the environment.
- 3. Plutonium is the most dangerous material in the world.
- 4. Nuclear waste is hazardous for tens of thousands of years. This clearly is unprecedented and poses a huge threat to our future generations.
- 5. Even if put into a geological repository, the waste might emerge and threaten future generations.
- 6. Nobody knows the true costs of waste management. The costs are so high that nuclear power can never be economic.
- 7. The waste should be disposed of into space.
- 8. Nuclear waste should be transmuted into harmless materials.
- 9. There is a potential terrorist threat to the large volumes of radioactive waste currently being stored and the risk that this waste could leak or be dispersed as a result of terrorist action.
- 10. Man-made radiation differs from natural radiation.

1. The nuclear industry still has no solution to the 'waste problem'

Like all industries, the thermal generation of electricity produces waste. Whatever fuel is used, this waste must be managed in ways which safeguard human health and minimise their impact on the environment.

The nuclear industry has developed – and implemented – most of the necessary technologies required for the final disposal of all of the waste it produces. The remaining issue is one of public acceptance, and not of technological feasibility.

The amount of waste produced by the nuclear power industry is small relative to other industrial activities. 97% of the waste produced is classified as low- or intermediate-level waste (LLW or ILW). Such waste has been widely disposed of in near-surface repositories for many years. In France, where fuel is reprocessed, just 0.2% of all radioactive waste by volume is classified as high-level waste (HLW).[a]

The amount of HLW produced (including used fuel when this is considered as waste) during nuclear production is small; a typical large reactor (1 GWe) produces about 25-30 tonnes of used fuel per year. To the end of 2013, a total of about 370,000 tonnes of used fuel had been discharged from reactors worldwide, with about one-third of this (120,000 t) having been reprocessed.[b]

Unlike other industrial toxic wastes, the principal hazard associated with HLW – radioactivity – diminishes with time. At present, interim storage facilities provide an appropriate environment to contain and manage existing waste, and the decay of heat and radioactivity over time provides a strong incentive to store HLW for a period before its final disposal. In fact, after 40 years, the radioactivity of used fuel has decreased to about one-thousandth of the level at the point when it was unloaded. Interim storage facilities also allow a country to store its spent fuel until a time when it has generated sufficient quantities to make a repository development economic.

In the long-term, however, appropriate disposal arrangements are required for HLW due to its prolonged radioactivity. The safe, environmentally-sound disposal of HLW is technologically proven, with international scientific consensus on deep geological repositories. Such projects are well advanced in some countries, such as Finland, Sweden, France, and the USA. In fact, in the USA a deep geological waste repository (the Waste Isolation Pilot Plant) is already in operation for the disposal of transuranic waste (long-lived ILW contaminated with military materials such as plutonium). Countries where plans for deep geological repositories have been advanced demonstrate that efforts to resolve political and public acceptance issues at a community and national level can be successful.

Progress is being made to achieve public acceptance, but it is important that governments follow the lead of countries more advanced in the process of long-term disposal of HLW.

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Radioactive Waste Management
Storage and Disposal of Radioactive Wastes
Treatment and Conditioning of Nuclear Wastes

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2. The transport of this waste poses an unacceptable risk to people and the environment

Hazardous waste is produced by most major industrial processes. Of all hazardous material shipped each year in the USA, radioactive waste accounts for just 5% of the total; and of that 5%, less than 10% relates to nuclear power production.[c]

At least 25,000 shipments of HLW have been made worldwide, covering many millions of kilometres on land and sea. There has been no instance of radioactive release causing harm to people, property or the environment in many millions of transport miles.[d]

The primary assurance of safety in the transport of nuclear materials is the way in which they are packaged. Packages that store waste during transport are designed to ensure shielding from radiation and containment of waste, even under the most extreme accident conditions. Different packaging standards have been developed by the International Atomic Energy Agency (IAEA) according to the characteristics and potential hazard posed by the different types of nuclear material. HLW shipments are made in robust 125-tonne 'Type B' casks. There has never been an accident in which a Type B transport cask containing radioactive materials has been breached or has leaked. A significant accident in the USA in 1971 demonstrated the integrity of a Type B cask, which was later returned to service.

The safety features built into Type B casks are very significant. For the radioactive material in a large Type B package in sea transit to become exposed, the ship's hold (inside double hulls) would need to rupture, the 25cm thick steel cask would need to rupture, and the stainless steel flask or the fuel rods would need to be broken open. Either borosilicate glass (for reprocessed wastes) or ceramic fuel material would then be exposed, but in either case these materials are very insoluble.

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Transport of Radioactive Materials

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3. Plutonium is the most dangerous material in the world

Plutonium has been stated to be 'the most toxic substance on earth' and so hazardous that 'a speck can kill'.

Comparisons between toxic substances are not straightforward. The effect of plutonium inhalation would be to increase the probability of a cancer developing in several years time, whilst most other strong toxins lead to more immediate death. Best comparisons indicate that, gram for gram, toxins such as ricin, some snake venoms, cyanide, and even caffeine are significantly more toxic than plutonium.

Nevertheless, plutonium is toxic and therefore must be handled in a responsible manner. Its hazard is principally associated with the ionising radiation it emits. However, it is primarily hazardous if inhaled in small particles.

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Plutonium

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4. Nuclear waste is hazardous for tens of thousands of years. This clearly is unprecedented and poses a huge threat to our future generations

Many industries produce hazardous and toxic waste. All toxic waste need to be dealt with safely, not just radioactive waste.

The radioactivity of nuclear waste naturally decays, and has a finite radiotoxic lifetime. Within a period of 1,000-10,000 years, the radioactivity of HLW decays to that of the originally mined ore. Its hazard then depends on how concentrated it is. By comparison, other industrial wastes (*e.g.* heavy metals, such as cadmium and mercury) remain hazardous indefinitely.

Most nuclear waste produced is hazardous, due to its radioactivity, for only a few tens of years and is routinely disposed of in near-surface disposal facilities (see above). Only a small volume of nuclear waste (~3% of the total volume) is long-lived and highly radioactive and requires isolation from the environment for many thousands of years.

International conventions define what is hazardous in terms of radiation dose, and national regulations limit allowable doses accordingly. Well-developed industry technology ensures that these regulations are met so that any hazardous waste is handled in a way it poses no risk to human health or the environment. Waste is converted into a stable form that is suitable for disposal. In the case of HLW, a multi-barrier approach, combining containment and geological disposal, ensures isolation of the waste from people and the environment for thousands of years.

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Radioactive Waste Management

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5. Even if put into a geological repository, the waste might emerge and threaten future generations

Radiation scientists, geologists and engineers have produced detailed plans for safe underground storage of nuclear waste, and some are now operating. Geological repositories for HLW are designed to ensure that harmful radiation would not reach the surface even in the event of severe earthquakes or through the passage of time.

The designs for long-term disposal incorporate multiple layers of protection. Waste is encapsulated in highly engineered casks in stable, vitrified form, and is emplaced at depths well below the biosphere. Such long-term geological storage solutions are designed to prevent any movement of radioactivity for thousands of years.

Whilst the timeframes in question preclude full testing, nature has provided analogous examples of the successful storage of radioactive waste in stable geological formations. About two billion years ago, in what is now Gabon in Africa, a rich natural uranium deposit produced spontaneous, large nuclear reactions which ran for many years. Since then, despite thousands of centuries of tropical rain and subsurface water, the long-lived radioactive 'waste' from those 'reactors' has migrated less than 10 metres.[e]

Further information

Storage and Disposal of Radioactive Waste

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6. Nobody knows the true costs of waste management. The costs are so high that nuclear power can never be economic

Because it is widely accepted that producers of radioactive waste should bear the costs of disposal, most countries with nuclear power programmes make estimates of the costs of disposal and update these periodically. International organisations such as the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD) have also coordinated exercises to compare these estimates with one another. For LLW the costs are well-known because numerous facilities have been built and have operated for many years around the world. For HLW, cost estimates are becoming increasingly reliable as projects get closer to implementation.

Based on the estimated total costs of managing nuclear waste, many countries require that the operators of nuclear power plants set aside funding to cover all costs. Different mechanisms exist in different countries. Although the sum already deposited in dedicated funds is high, the costs of waste management do not drastically increase the price of electricity. Typically the spent fuel management and disposal costs represent about 10% of the total costs involved in producing electricity from a nuclear power plant. Thus, although the absolute costs of waste management are high, they do not render the nuclear fuel cycle uneconomic, because of the high ratio of revenue earned to waste volumes produced.

Further information

Radioactive Waste National Policies and Funding

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7. The waste should be disposed of into space

The option of disposal of waste into space has been examined repeatedly since the 1970s. This option has not been implemented and further studies have not been performed because of the high cost and the safety aspects associated with the risk of launch failure.

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8. Nuclear waste should be transmuted into harmless materials

Transmutation is the process of transforming one radionuclide into another via neutron bombardment in a nuclear reactor or accelerator-driven device. The objective is to change long-lived actinides and fission products into significantly shorter-lived nuclides. The goal is to have waste that becomes radiologically harmless in only a few hundred years.

Transmutation is not feasible for all of the waste produced in the past or to be produced. Transmutation may be able to reduce waste quantities, but it will do so only to a certain extent and therefore not eliminate the need for some means of ultimate disposal.

Research on transmutation is, however, ongoing. One of the technical issues is to isolate each nuclide (partition) so that it can then be irradiated, otherwise the process is likely to create as much waste as it destroys. Cost aside, it is likely that the benefits of transmutation will not compensate the burden of additional required operations for separating and transmuting only part of the nuclides.

Further information

Nuclear Energy Agency's webpage on Partitioning and Transmutation of Minor Actinides and Fission Products

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9. There is a potential terrorist threat to the large volumes of radioactive waste currently being stored and the risk that this waste could leak or be dispersed as a result of terrorist action

HLW is kept in secure nuclear facilities with appropriate protection measures. Most HLW produced is held as stable ceramic solids or in vitrified (glass) form, designed to ensure that radioactive isotopes resulting from the nuclear reaction are retained securely in the glass or ceramic. Their structure is such that they would be very difficult to disperse by terrorist action, so that the threat from so-called 'dirty bombs' is not high.

The US Nuclear Regulatory Commission (NRC) has responded to suggestions that spent fuel is vulnerable to terrorist actions and should be put into dry storage casks after five years: "Nuclear power reactor spent fuel pools are neither easily reached nor easily breached. Instead, they are strong structures constructed of very thick steel-reinforced concrete walls with stainless steel liners. In addition, other design characteristics of these pools ... can make them highly resistant to damage and can ease the ability to cope with any damage. Such characteristics can include having the fuel in the pool partially or completely below grade and having the pool shielded by other plant structures."[f]

A report released on 25 June 2002 by the National Academy of Sciences concludes that if a dirty bomb attack were to occur, "the casualty rate would likely be low, and contamination could be detected and removed from the environment, although such cleanup would probably be expensive and time consuming." The disruption caused by such an attack would result from public fear of anything 'nuclear', and thus "the ease of recovery...would depend to a great extent on how the attack was handled by first responders, political leaders, and the news media, all of which would help to shape public opinion and reactions."[g]

The International Atomic Agency (IAEA) has identified medical and industrial radioactive sources as posing considerable concern in terms of potential terrorist threats from their use in dirty bombs. The need for stronger controls to prevent the theft or loss of control of powerful radiological sources and hence ensure their safety and security has been highlighted as of paramount importance.

Further information

Making the Nation Safer: The Role of Science and Technology in Countering Terrorism, Committee on Science and Technology for Countering Terrorism, National Research Council of the National Academies, The National Academies Press (ISBN: 9780309084819)
IAEA webpage on Security of Radioactive Sources
NRC webpage on Nuclear Security and Safeguards

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10.Man-made radiation differs from natural radiation

Radiation emitted from man-made radionuclides is exactly the same form as radiation emitted from naturally-occurring radioactive materials (namely alpha, beta, or gamma radiation). As such, the radiation emitted by naturally-occurring materials cannot be distinguished from radiation produced by materials in the nuclear fuel cycle.

Most elements have a radioactive form (radioisotope) and many of these occur naturally. We live our lives surrounded by naturally-radioactive materials, and are constantly bathed in radiation originating from rocks and soil, building materials, the sky (space), food, and one another. A typical background level of exposure is 2-3 millisieverts per year. Regulations limit extra exposure from man-made radiation due to human activities (other than medicine) to 1 mSv/yr for members of the public and an average 20 mSv/yr for occupational exposure. These levels are very seldom exceeded, though no harm has been shown for levels up to 50 mSv/yr. Some people are exposed to lifelong natural background levels which are higher than this.

Further information

Naturally-Occurring Radioactive Materials (NORM)

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References

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c. Freight Facts and Figures, US Department of Transportation (2015). [Back]

d. A Historical Review of the Safe Transport of Spent Nuclear Fuel, US Department of Energy (2016). [Back]

e. Oklo Fossil Fission Reactors, American Nuclear Society. [Back]

f. NRC Review of Paper on Reducing Hazards From Stored Spent Nuclear Fuel, US NRC Fact Sheet (2003). The Fact Sheet was published in response to the paper Reducing the Hazards from Stored Spent Power-Reactor Fuel. [Back]

g. Making the Nation Safer: The Role of Science and Technology in Countering Terrorism, The National Academies Press (ISBN: 9780309084819). [Back]