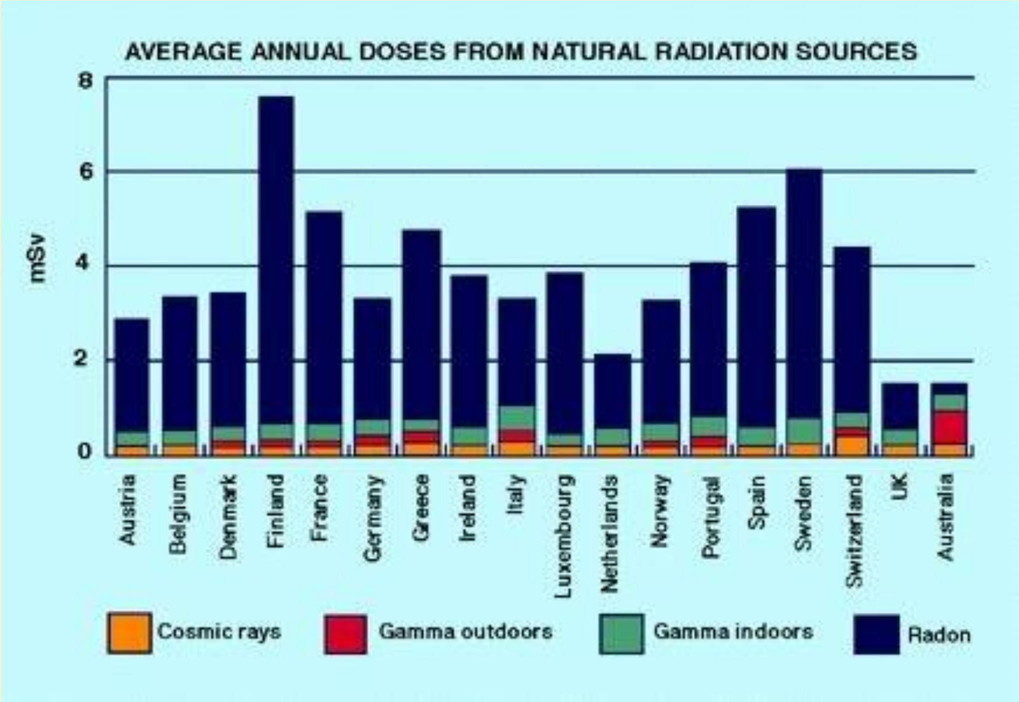
Disposal & Storage of Radioactive Waste

Science for the Future!

What is Radioactive Waste?

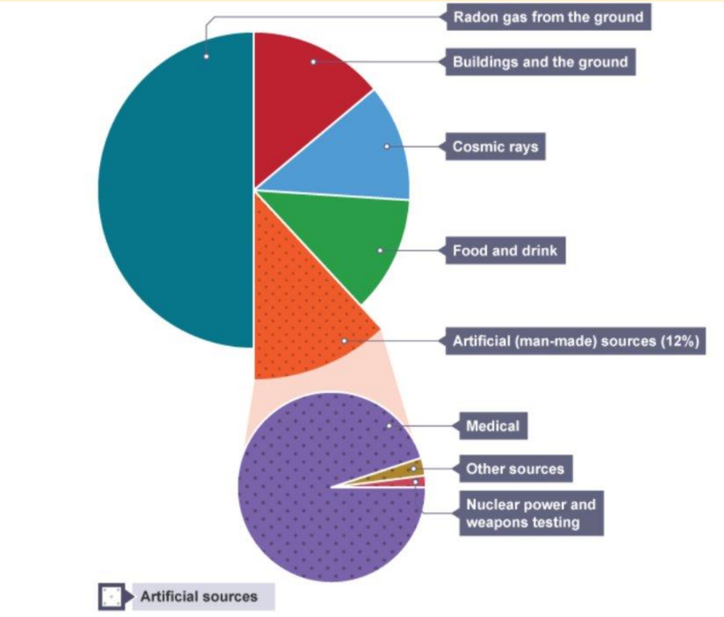
Radioactive waste is any material that contains radioactive substances and is no longer useful. Due to it emitting radiation, it must be carefully stored and managed to prevent harm to people and the environment. It can contaminate a large area for thousands of years, so it must be kept in storage which is also difficult to do. However, there are also positives to it as it is also used as a cure for cancer, it can be used in nuclear power plants for efficient low carbon emission made energy, and in general it can be used for scientific research to broaden our understanding on what else it can be used for.

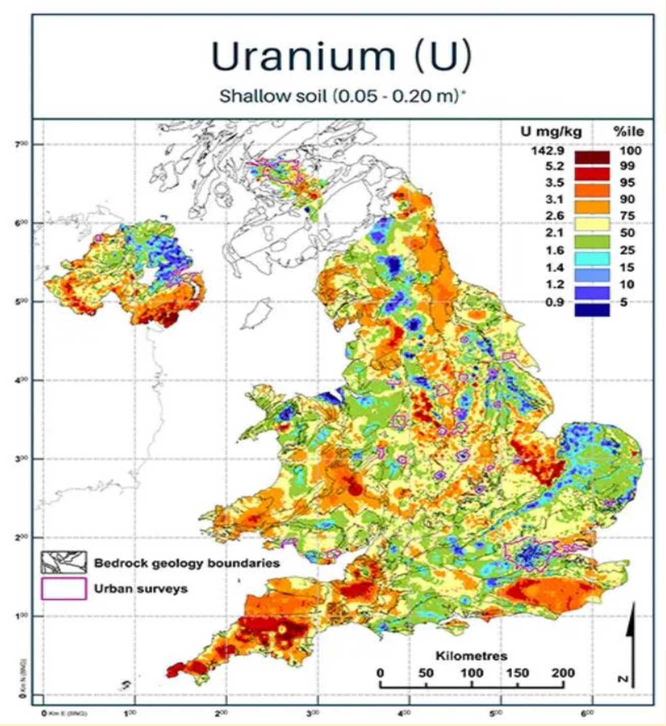
Here's a bar chart showing the frequency of radioactivity of different radioactive emitting rays in a few different countries.



What background radiation are we all exposed to?

Radiation is a part of our normal life and always has been. Natural radiation exists in our Earth's crust, our homes, floors, walls, office buildings, schools as well as our food, drinks, air and even some medicine as seen by the graph below.





The UK average dose of radiation per annum is around 2.3 mSv. However, in places such as Cornwall, the rocks in the ground contain more radioactive substances, mostly uranium. Per year, the average dose of radiation in Cornwall is 7.8 mSv, more than 3 times the UK average.

Eating a banana that contains radioactive potassium	0.000000098 Sv	0.000098 mSv
Exposure for cabin crew on airliners (per year)	0.0016 Sv	1.6 mSv
6 months on the International Space station	0.08 Sv	80 mSv
Highest dose to a worker during Fukushima disaster	0.67 Sv	670 mSv
Typical fatal dose	10 Sv	10,000 mSv

The effects of Cosmic Radiation when flying

Aviation Staff:

- *Estimates say pilots and flight attendants are subject to 0.2-5 millisieverts per year, depending on flight time and altitude. This also means passengers flying above 8000 metres are subject to small amounts of radiation. Fortunately, however, this is less radiation than you would gain from a chest x-ray.*
- *Cosmic Radiation is very high energy particles produced in space; for example from the sun. Charged particles react with the earth's atmosphere to produce secondary radiation which reaches the earth.*
- *Cosmic Radiation is extremely dangerous as they can reverse digital bits and create incorrect signals which operate the aircraft.*

X-Rays

- - High-energy electromagnetic waves, discovered by Wilhelm Roentgen in 1895.
- - Used in medicine, security, industry, and scientific research.

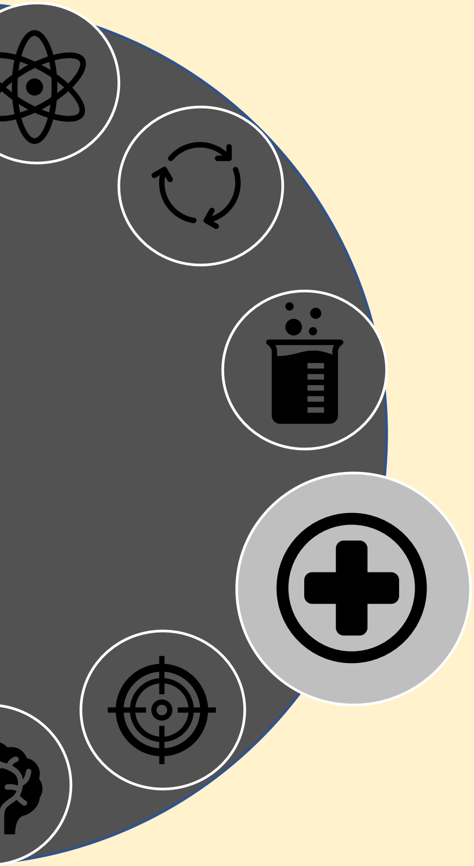
- **How Do X-Rays Work?**
- - X-rays pass through the body and create images.
- - Dense materials (like bones) absorb more X-rays and appear white.
- - Softer tissues absorb less, appearing in shades of gray.

- **Uses of X-Rays:**
- 1. Medical Field: Identifying fractures, infections, tumors, and dental issues.
- 2. Security Screening: Airport baggage and cargo scanning.
- 3. Industrial Uses: Detecting cracks in materials and quality control.
- 4. Scientific Research: Studying atomic structures, DNA analysis, and crystallography.

- **Health Risks & Damages:**
- - Cell Damage: X-rays are ionizing radiation and can harm DNA.
- - Cancer Risk: High exposure increases the risk of mutations and cancer.
- - Acute Radiation Syndrome: Severe exposure can cause burns, nausea, and organ damage.
- - Pregnancy Risks: Can affect fetal development, leading to birth defects.

- **How to Minimize Harm:**
- - Lead Shields: Protective aprons block radiation exposure.
- - Low-Dose Imaging: Modern X-ray machines use the lowest necessary dose.
- - Limiting Exposure: X-rays are only used when medically or scientifically essential.
  - Worker Protection: Technicians use lead barriers and follow safety regulations.
- **Conclusion:**
- - X-rays are crucial in various fields, but excessive exposure can be harmful.
- - Advances in technology continue to make X-rays safer and more efficient.

So how is Radioactive waste actually formed?



~ Radioactive waste is formed as a by-product of activities involving radioactive materials, primarily from nuclear power generation, medical treatments, industrial applications and military operations. It consists of materials that emit radiation and require careful handling and disposal to avoid environmental contamination and health hazards

When is it formed?

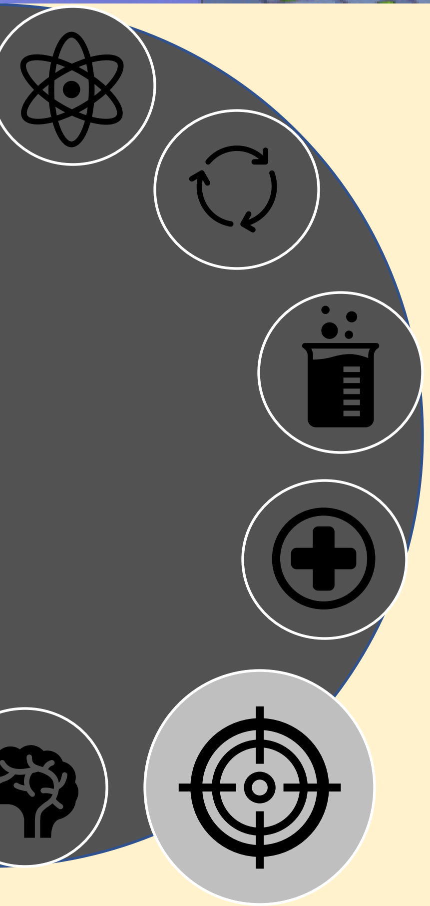
1. *Nuclear Power Plants: The most significant source of radioactive waste comes from nuclear reactors, where uranium or plutonium undergoes nuclear fission to generate energy. During this process, spent nuclear fuel, contaminated equipment, and cooling water become radioactive and require disposal.*

2. *Medical and Industrial Uses: Hospitals and research facilities use radioactive isotopes in cancer treatment (radiotherapy), diagnostic imaging (X-rays, CT scans, and PEcans), and sterilisation. Once these materials decay beyond usefulness, they turn into radioactive waste.*

Most Radioactive Waste by Volume & Mass:

80 – 90% of Low-Level Waste (LLW) (Tools, Clothes, medical waste etc.)
7- 15% Intermediate-Level Waste (ILW) (Reactor Components, Resins, Filters etc.)
<3% High-Level Waste (HLW) (Spent Nuclear Fuel, Weapons Waste etc.)

Transmutation of Radioactive Waste



Transmutation of radioactive waste refers to a process where radioactive isotopes in nuclear waste are transformed into other, often less harmful, elements or isotopes through nuclear reactions. The goal is to reduce the long-term hazards of nuclear waste by turning dangerous isotopes into those that decay more quickly or are less harmful to the environment.

Advantages

- *Reduced Long-Term Hazard: Transmutation can turn long-lived radioactive isotopes into ones with shorter half-lives, reducing the risk over time.*
- *Volume Reduction: It can reduce the overall volume of high-level radioactive waste.*
- *Energy Production: Some transmutation methods can generate additional energy, possibly reducing the need for new uranium mining.*
- *Easier Storage/Disposal: Shorter-lived isotopes are safer to store and dispose of compared to long lived ones.*

Disadvantages

- High Costs: The technology is expensive, both in terms of infrastructure and operation.
- Technological Challenges: It's still in development and not yet commercially viable on a large scale.
- Safety Risks: Handling the technology (like reactors or accelerators) can pose safety risks.
- New Radioactive Isotopes: Some processes might create new radioactive elements that still require careful disposal.
- Limited Impact on Some Waste: Not all nuclear waste types are easily transmuted or improved through this process.
- Uncertain Environmental Impact: The long-term environmental effects of transmutation are not fully understood.

How can we store radioactive waste?

•In the UK, most of the low-level radioactive waste is stored at the low-level waste repository (LLWR) in Cumbria since 1959.

•Waste was initially placed into landfill style trenches but is now grouted in metal containers before being stacked in concrete lined, highly engineered vaults.

•Between 1948 and 1982, the British government consigned almost 70,000 tonnes of nuclear waste to the ocean's depths, typically in deep-sea trenches or abyssal plains. The idea is that the vast depth, high pressure, and isolation of these areas would contain the waste and prevent it from affecting humans or the environment. Other countries such as USA and Japan have also used the ocean to dispose of radioactive waste but in much smaller quantities.

•Long-term above ground storage of radioactive waste involves specially constructed facilities at the Earth's surface that would neither be backfilled nor permanently sealed.

•Currently, the preferred way of storing high level waste is through geological disposal which consists of placing packaged radioactive waste in an underground facility or 'repository' typically hundreds of meters to kilometres below the Earth's surface. The geology provides a barrier against the escape of radioactivity.

What materials can be used to store Radioactive Waste?

1. Plastic

- **HDPE (High-Density Polyethylene):** Used for garbage bins, trash bags, and containers due to its durability and resistance to chemicals.
- **LDPE (Low-Density Polyethylene):** Used for lightweight trash bags and liners.
- **Polypropylene (PP):** Used for medical waste bins and biohazard containers.

2. Metal

- **Stainless Steel:** Used in medical and hazardous waste storage due to its corrosion resistance.
- **Aluminum:** Used for recycling bins and some industrial waste containers.
- **Galvanized Steel:** Commonly used for outdoor trash bins and dumpsters.

3. Glass

- Used in specialized waste storage, such as chemical or pharmaceutical waste that requires non-reactive containment.

4. Concrete

- Used for large-scale waste storage, such as landfills, nuclear waste containment, and underground storage.

5. Fabric

- **Geotextiles:** Used for landfill liners and covering hazardous waste to prevent leaks.
- **Reusable Waste Bags:** Used in industrial settings to store large amounts of debris.

6. Paper & Cardboard

- Used for compostable waste storage and temporary containment of recyclables.

7. Rubber

- Used in some industrial and hazardous waste containment systems, such as spill containment barriers.

8. Composite Materials

- **Plastic-lined cardboard:** Used for medical and hazardous waste.
- **Multi-layered containment drums:** Used for nuclear and toxic waste storage.

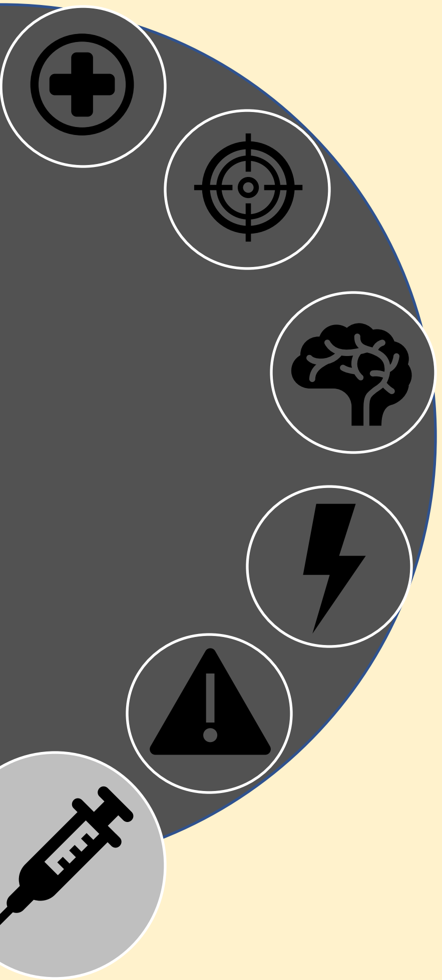
Other ways to dispose of Radioactive Waste

~ *Firing radioactive waste into the Sun is a specific variation of the idea of disposing of nuclear waste in space. The concept involves launching the waste on a spacecraft that would travel toward the Sun, where the extreme heat and pressure would destroy the waste even before it reached the sun.*

So why don't we do this?

The cost of sending nuclear waste to the sun would be very expensive, also when launching spacecrafts into space there are still many instances when they fail and come crashing back to earth. This would have catastrophic consequences if the spacecraft contained radioactive waste.

What are the severe consequences of improper storage?

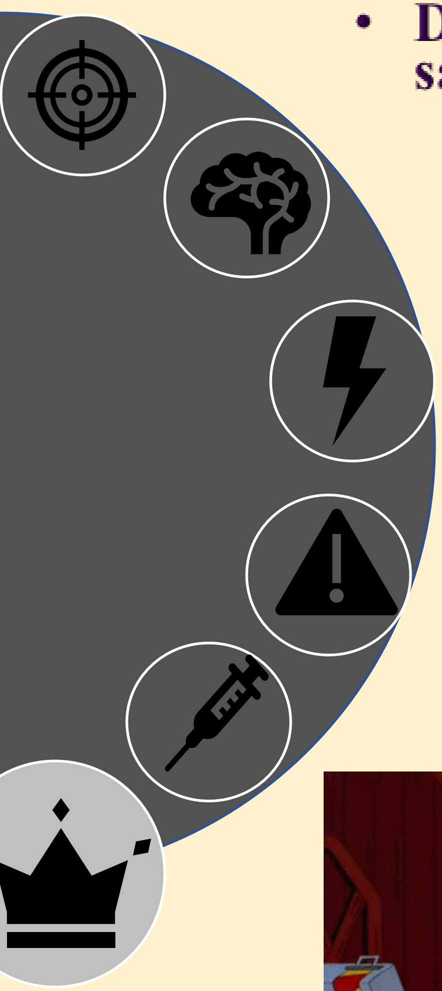


Effects and Impacts of Radioactive Waste

1. Environmental Impact: If improperly stored, radioactive waste can contaminate soil, water, and air, leading to long-term ecological damage. Leakage from storage facilities or accidents can render large areas uninhabitable for centuries.
2. Health Risks: Exposure to radioactive waste can cause radiation sickness, genetic mutations, and increased cancer risks, especially for workers handling nuclear material. Contaminated water sources can spread radiation to populations far from disposal sites.

Risk assessment

- Keep a safe distance from the radioactive materials
- Wear goggles
- Don’t stand in front of radioactive samples



Hypothesis

We hypothesise that the denser the material the harder it'll be for the radiation to penetrate the material.

IV: -Radioactive source
- Protective material
DV: -Count rate
CV: -Thickness of the material
-Distance between the radioactive material and the Geiger muller tube

	Average density G/cm3	Radon count rate	Americium count rate
Lead	11.34	66	10
Aluminium	2.7	79	11
Plastic	2	178	1018
Paper	1.2	340	16
wood	1.2	199	38

Our Conclusion

So, we hypothesised that the denser the material the harder it'll be for the radioactive waste to penetrate.

Our Conclusion

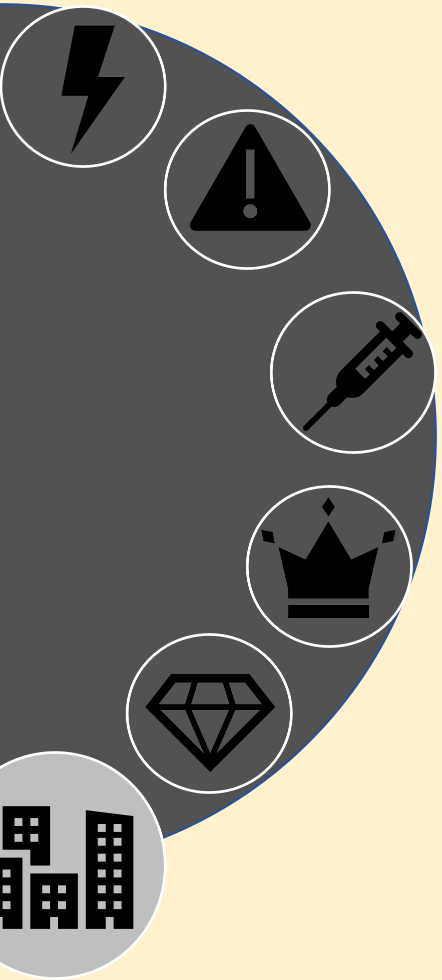
You can see from our results; denser materials have a lower count rate for both radioactive sources, showing less radiation penetrates denser materials, although there is an anomalous result for plastic using the Americium source. As you can see our most dense material tested, lead, allowed the least amount of radiation through. We believe that lead would be the most suitable material for storing radioactive waste.

Our Conclusion

Although lead would be the most efficient material at preventing radiation from contaminating the surrounding environment, lead is toxic to humans with no safe levels. Lead leaching occurs through corrosion of lead containing materials leading to contamination of drinking water systems and natural water courses.

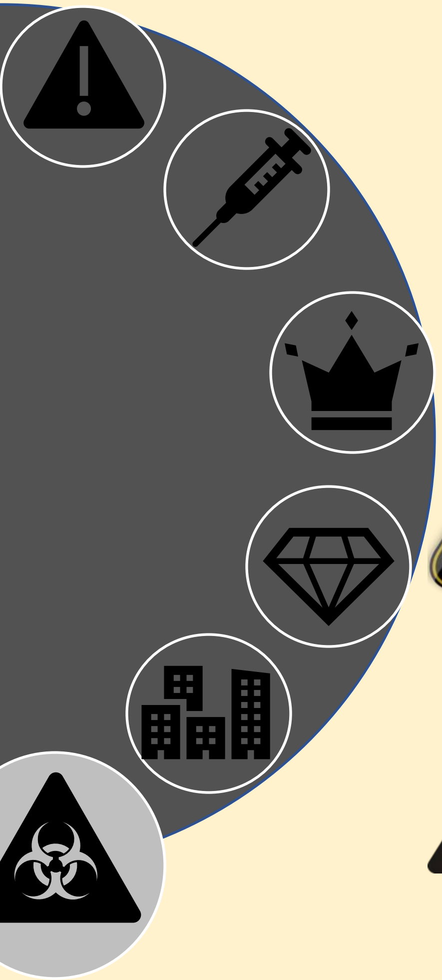

WOO!
YAY!
WOO!

How can we protect future generations from Radioactive waste in a 1000 years time?



- Long Term Storage: Store waste deep underground in stable geological formations with multiple physical barriers to isolate it from the environment.
- Durable Warning Systems: Use long-lasting markers like stone monuments, symbols to indicate danger, designed to be understood by future cultures even if languages change.
- Cultural Memory: Embed warnings in myths, stories, or traditions that future societies may retain, ensuring the danger is culturally recognised.
- Archiving Information: Store detailed records in durable forms such as metal plates or synthetic materials and ensure access to digital information, using methods that can withstand time.
- International Cooperation: Create global agreements and ongoing monitoring to safeguard radioactive sites and ensure that they remain secure across borders and generations.
- Technology for Monitoring: Invest in technologies, like remote sensing or drones, that can help monitor waste sites over long periods, provided that future societies can maintain the necessary technology.
- Ethical Responsibility: Ensure legal frameworks address the ethical obligation to protect future generations from radioactive waste risks.

Evolution of the Radioactive Symbol Why did it change?



1. *Signs are vital tools for communication that enhance understanding, provide clarity, and ensure safety in a complex world. As communication methods change and evolve, the role of signs will likely remain essential, adapting as needed to maintain their relevance and effectiveness.*
2. *The previous sign for radioactive waste was simple and vibrant but lacked detail, leading to confusion about its dangers. As a result, it became clear that a more informative sign was necessary to effectively communicate the associated risks.*
3. *The new sign is much clearer, symbolising danger and the risk of death with a bold red colour that signifies immediate threat. This improvement effectively communicates the need to stay away, enhancing personal safety both now and in the future.*

Our Final Thoughts on the Disposal and Storage of Radioactive Waste!

~ The disposal and storage of radioactive waste remains a critical scientific and ethical challenge. On one hand, deep geological storage offers a long-term solution supported by research and technology, ensuring public safety.

~ On the other hand, concerns about environmental justice, long-term ecological risks, and the burden placed on future generations raise important ethical questions. While no method is perfect, continued innovation and transparent international cooperation are essential to balancing progress with responsibility.

CREDITS!

Special thanks to these individuals for providing information to put in the powerpoint:

- Murshed Haque
- Daria Marinescu
- Leo Wong
- Dillon Kearney
- Jatin Chawla
- Safa Islam Wafia
- Raziana Ahmed
- Mekaeel Siddiqi
- Yusuf Saed
- Melos Esmeni
- Nushrat Chowdhury
- Zunaira Zahur

Special thanks to these individuals for helping to refine the powerpoint:

- Rahul Singh
- Ruhma Rashid
- Adetokunbo Joseph
- Abigael Fageyimbo

Many Thanks to Mr. Peer for giving us this awesome opportunity!

Thank You for listening to our Presentation!

From Eastbury Community School