

Nuclear Pollution



Types of radioactive waste

- Mill tailings
- Low-level nuclear waste
- Intermediate-level nuclear waste
- Transuranic waste
- High-level nuclear waste



Mill tailings

- Mill tailings are usually waste by-products of the processing of uranium-bearing ore. They often consist of thorium, uranium and radium.
- Although they are not highly radioactive, mill tailings have long half-lives and therefore it takes quite a long time for them to entirely decay.



Low-level nuclear waste

- Low-level nuclear waste includes clothing, filters, paper and other materials which exhibit small amounts of radioactivity.
- Low-level radioactive waste is usually a by-product of hospitals or industrial processes.
- Materials which got in touch with low-level nuclear risk areas are precautionary designated as low-level waste (LLW), however, they do not pose a risk to human health in most cases.
- Although some of the LLWs require shielding for handling and transportation purposes, most of the LLWs are suitable for shallow land burial.



Intermediate-level nuclear waste

- Since intermediate-level nuclear waste exhibits higher levels of radioactivity, it requires shielding. However, there is no need for cooling in most cases.
- Intermediate-level waste includes, among others, materials from reactor decommissioning as well as chemical sludge.
- Long-lived intermediate-level waste is usually disposed in geological repositories, while short-lived intermediate waste may be buried in shallow repositories.



Transuranic waste

- Transuranic waste is defined as nuclear waste contaminated with alpha-emitting transuranic radionuclides with concentrations greater than 100 nCi/g and half-lives greater than 20 years, but which are also not classified as high-level nuclear waste.
- Due to its longer half-life, transuranic waste is disposed with more caution than low or intermediate level waste.
- Transuranic waste usually is the by-product from the manufacturing process of nuclear weapons.
- Transuranic nuclear waste is currently mainly disposed in deep salt formations.



High-level nuclear waste

- High-level radioactive waste are usually by-products in the generation of electricity in nuclear power plants.
- The disposal process for high level nuclear waste is subject to discussion by leading scientists.
- Many of them advocate a solution in which the high-level nuclear waste is buried in either deep boreholes or in mines.



Nuclear waste disposal



- Depending on the category and the classification of nuclear waste, it can be disposed in several different ways.
- As mentioned above, most disposal tactics include the burial or storage in mines.
- Since the classification also varies by countries, different countries may also treat the disposal process differently.
- This can lead to great problems since if radioactive waste is not disposed appropriately, due to their long half-lives, the contaminated areas could be lost for other purposes for a quite long time.

Causes

- Nuclear fuel cycle
- Weapon decommissioning
- Medical purposes
- Legacy waste
- Industrial waste
- Wars
- Natural nuclear waste sources



Nuclear fuel cycle

- Radioactive waste is produced during the nuclear fuel chain.
- The nuclear fuel chain describes the process of how radioactive fuel is extracted, processed, used and disposed.
- If the disposal process is not set up properly, large amounts of nuclear waste may be produced.
- However, even if there is an effective nuclear waste disposal process, there are still some nuclear by-products which result in the production of nuclear waste.



Weapon decommissioning

- In the process of nuclear weapon decommissioning, the radioactive substances which are left in bombs have to be processed somehow.
- As a result, many radioactive compounds will be left over after the decommissioning process.
- These compounds have to be examined carefully and have to be classified appropriately before deciding how to deal with them.



Medical purposes

- Radioactive waste is also produced in medical research and treatment facilities.
- Examples include the treatment of thyroid cancer, lymphoma and bone cancer.
- Radioactive compounds are also used for brachytherapy and external radiotherapy.



Legacy waste

- Many areas which have been historically used for mining or military purposes are still contaminated with radioactive materials.
- This waste has to be removed or stored somehow.
- There are several cleanup programs which have the purpose of finding solutions on how to deal with the legacy waste.



Industrial waste

- There are also some industrial processes which can cause radioactive waste.
- Among others, this includes the process of radiography as well as applications such as oil well logging.



Wars

- Although this will hopefully never happen again in the future, nuclear wars have a significant potential for the production of nuclear waste on a large scale.
- This includes nuclear waste as a by-product from weapon production.
- Moreover, if nuclear weapons are used, large areas of land will be contaminated for a quite long period of time.



Natural nuclear waste sources

- There is also naturally occurring nuclear material in our environmental system.
- These natural radioactive materials can lead to radioactive waste through the intervention of industrial processes.
- For example, coal power plants emit small concentrations of radioactive compounds.
- Moreover, the oil and gas industry also produces radioactive by-products like radium and radon.



Effects

- **Transportation issues**
- **Storage issues**
- **Long-term contamination of storage spaces**
- **Scavenging**
- **Nuclear accidents**
- **Health effects**
- **Social costs**
- **Effects on nature**



Transportation issues

- Although the transportation of nuclear waste is usually done with great care, there is a possibility for leaks or accidents related to the transport of radioactive material.
- If this happens, radioactive material can contaminate the surrounding area and make it unusable for farming or other purposes in the near or also in the far future since many radioactive compounds have long half-lives which means that it takes quite long for them to entirely decay.



Storage issues



- Radioactive waste is often stored in mills or other spaces deep in the ground.
- If the storage processes are not executed with great care, there can be severe adverse effects on the surrounding environment.
- If there are leaks in the storage space, radioactive material could contaminate the soil.
- Moreover, through rainfalls, the radioactive compounds can also reach the groundwater and contaminate it which may lead to severe health issues not only for humans but also for many animals.
- Thus, the inappropriate storage of radioactive waste can lead to huge adverse consequences for the whole ecological system.

Long-term contamination of storage spaces

- Moreover, the storage spaces itself will be contaminated for a quite long period of time as well and we will not be able to use them for other purposes during this time.



Scavenging



- The scavenging of abandoned nuclear materials leads to a contamination of people dealing with these substances.
- Since there is a market for many scavenged goods, especially in developing countries, people are willing to take the risk and make good amounts of money in the short term.
- However, the long term consequences are horrible since people get contaminated with radioactive compounds and will suffer diseases or in the worst case eventually die.
- Moreover, many people are not even aware that the materials they are dealing with are indeed radioactive, thus having no idea how dangerous their behavior really is.
- Making things worse, people who had been involved in scavenging may contaminate other people through daily interactions who had never been involved in scavenging activities.

Nuclear accidents

- Nuclear accidents are a great threat to the ecological systems as a whole. Nuclear accidents can have severe adverse impacts and can lead to all sorts of pollution.
- If there is an accident in a nuclear power plant, contaminated cooling water can reach the environment and contaminate the surrounding area.
- Moreover, if there are explosions or other types of issues that cause radioactive material to get into the air, the consequences may be dramatic since the radioactive material can be carried through winds quite far and thus not only contaminate the near surroundings but also areas that are far away from the original accident location.



Health effects

- The exposure to radioactive compounds can cause serious health problems or even death for humans as well as for all kinds of animals.
- The main issue of radioactive compounds is that they are likely to cause cancer which in turn kills many people each year.
- Moreover, scientists found that the exposure to nuclear substances can change our DNA and thus alter the genes of future generations.



Social costs



- There are great social costs related to radioactive waste.
- Since radioactive waste usually has long half-lives, it contaminates storage spaces for a quite long time.
- This areas can no longer be used for other purposes due to this contamination.
- Moreover, if nuclear waste is not treated appropriately, it can harm the lifes of people in a dramatic way.
- Especially in poor countries, people are not aware on how dangerous nuclear waste really is and thus often get contaminated by scavenging activities.

Effects on nature

- Radioactive waste has a significant adverse effect on nature.
- Since radioactive waste is often stored in remote places which are the living space for many animals, these animals may become contaminated with the radioactive material and thus suffer from the consequences.
- Moreover, it may also the gene structure of animals and plants which may in turn hurt humans through the food chain.



Solutions

- **Vitrification**
- **Synthetic rock**
- **Ion exchange**
- **Geological disposal**
- **Above-ground disposal**
- **Space disposal**
- **Transmutation**
- **Reuse**
- **Government management plans**
- **Education and public awareness**



Vitrification

- For storing the nuclear waste in a long-term manner, it has to be stabilized into a form in which it will not react nor degrade.
- There is a process called vitrification which should accomplish this.
- Vitrification is a process in which high-level waste is mixed with sugar and then calcined in order to stabilize the nuclear waste.



Synthetic rock

- The synthetic rock method is another way to deal with the nuclear waste which is currently developed for U.S. military waste.
- The synthetic rock method includes the use of perovskite, hollandite and zirconolite.
- These substances should bind the radioactive compounds and thus reduce their nuclear activity.



Ion exchange

- Ion exchange is a method often used for medium-level active waste. In this process, the radioactivity is concentrated into a small volume.
- The remaining low-level nuclear waste can then be mixed with substances like cement to get a solid waste form.



Geological disposal

- For a long-term solution, many scientist prefer the disposal of radioactive substances in stable geological formations between 500 and 1000 meters below the surface.
- Mining techniques or tunnel boring machines should be used in order to dig tunnels in the ground.
- The goal of geological disposal is to get rid of high-level radioactive waste by permanently isolate it from the human environment.



Above-ground disposal

- Another form of disposal for radioactive waste is to seal it in a steel cylinder with an inert gas and to place this construct in a concrete cylinder.
- The concrete cylinder acts as a radiation shield and thus helps to mitigate the exposure of the nuclear radiation to humans.
- In contrast to the geological disposal, the above-ground disposal method has some advantages.
- It is relatively cheap and the nuclear waste can be retrieved in later stages for reprocessing purposes.



Space disposal



- Space disposal could be a method used to get rid of nuclear waste, but it seems not a practical method in the near future.
- Space disposal means to bring the radioactive waste out of our atmosphere and just to drop it into space.
- This would remove the nuclear waste from our planet.
- Although the idea seems to be quite promising, there are several problems related to it. In order to get the waste into space, many transportation vehicles have to be used. This increases the probability that one of them will eventually fail.
- A failure of a launch vehicle could potentially lead to catastrophic results, as it may lead to a spread of radioactive material over the whole planet, thus contaminate our whole environment.
- The risk of this method seems to be too high in order to justify it. Moreover, technology at this point in time is not sophisticated enough to accomplish this process in an economic manner.
- It is just too expensive to carry out space disposal of nuclear waste compared to the alternatives.

Transmutation

- Transmutation means transforming high-level nuclear waste into less-harmful, short-lived radioactive waste.
- Although transmutation may be a valid instrument to get rid of radioactive compounds, it has its problems when applying it to practical situations.
- Transmutation has been banned various times in history due to the possible dangers.
- Right now, intensive research is done in order to develop the transmutation method further with the goal to eventually make it a valid method to deal with high-level active waste.



Reuse

- Another way to deal with radioactive waste is to reuse them.
- Reusing radioactive compounds doesn't solve the problem of radioactivity, however, it may reduce the total amount of nuclear waste produced.



Government management plans



- Governments worldwide are in charge to find solutions to the nuclear waste problem.
- There are different approaches on how to deal with nuclear waste.
- Moreover, there are big differences in level of strictness in regulations.
- Europe tends to be more strict than the U.S. when it comes to radiation limits than the U.S.
- However, nuclear waste is a serious problem and potential issues with it could potentially spill over across borders.
- Thus, governments should work together and present frameworks which are consistent with latest research and act according to that.

Education and public awareness



- In order to mitigate the issue of radioactive waste, we also have to inform the public about the negative adverse consequences of nuclear waste.
- We have to show them how this waste affects the living conditions of people and how it can potentially affect our whole environment.
- By educating people about the adverse effects of nuclear waste, we could convince them to save energy in their daily lives and thus to contribute to a reduction in nuclear waste.
- Therefore, it is crucial to start the education already in young ages.
- We have to show children in school how our energy is produced, what effect this energy production has on the environment and what everyone of us can do to mitigate this problem.
- Children are then likely to also convince their parents to save energy.
- Thus, the awareness concerning the issue of nuclear waste of the whole population will increase and therefore the behavior of many people will start to change their behavior in favor of a more resource-saving way of life.

Examples of nuclear accidents

- 1957 Windscale, UK
- 1959 Sodium Reactor Experiment, USA
- 1961 SL-1, USA
- 1966 Enrico Fermi Unit 1, USA
- 1978 Three Mile Island, USA
- 1986 Chernobyl, Ukraine
- 2011 Fukushima Daiichi, Japan



Conclusion



- Nuclear energy is one of the most preferred strategies to produce electricity since it is relatively cheap.
- Industries thus like to advocate for this energy source.
- However, nuclear energy and the resulting nuclear waste also has significant downsides.
- The production of nuclear waste in large amounts as well as potential nuclear accidents are a crucial threat to our environment.
- Small mistakes in the handling of radioactive substances can cause catastrophic outcomes.
- Therefore, we should consider the transition from nuclear to renewable energy sources.
- This transition process is already discussed by many governments, however, it will take quite a long time to abandon nuclear energy completely.
- In order to avoid nuclear waste and the adverse consequences, we should financially support our best researchers and work together to make this transition process feasible already in the near future.

Sources

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