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Nuclear Waste and its Disposal

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Abstract: ***The waste left out after the usage of radioactive materials in nuclear reactors and also in the production of nuclear weapons is known as radioactive waste. In the last few decades' radioactive material has been actively exploited in a large scale as an important resource, it has hence resulted in production of tremendous amount production of radio active waste. Radio active waste management is an imperative in todays day and age. In a situation where radio active waste is not effectively disposed, the radiation of he waste is capable of causing serious problems to humans as well as the environment. In this paper we will briefly discuss the usage of radioactive materials in energy generation and will discuss in length the challenges and solution for efficient waste management.***

I. INTRODUCTION

Similar to all other industries the production of electricity also leads to the production of waste. Regardless of the fuel being used in the production of electricity it should be observed that the safeguard of life and the environment is maintained. For this to happen radioactive waste should be contained and managed and some of it would clearly need deep and permanent burial. Nuclear power is characterised by the very large amount of energy produced from a very small amount of fuel, and the amount of waste produced during this process is also relatively small. However, it is to be noted that much of the waste produced is radioactive and therefore must be carefully managed as hazardous material. Every part of nuclear fuel cycle ends up producing some radioactive waste .All toxic waste needs be dealt with safely.

II. NUCLEAR CYCLE

Production of radio active waste takes place in all parts of the nuclear cycle. The nuclear cycle is essential un producing electricity from nuclear substances. The fuel cycle comprises of the mining and milling of ore, its processing and conversion into nuclear fuel, its use in the reactor), the treatment of the used fuel that is taken from the reactor, and to conclude disposal of the waste. While waste is produced during mining and milling and fuel fabrication, the majority (in terms of radioactivity) comes from the actual 'burning' of uranium to produce electricity. Where the used fuel is reprocessed, the amount of waste is reduced materially.

III. GENERATION OF RADIOACTIVE WASTE

The generation of radioactive waste is observed to happen from a number of sources like nuclear fuel cycle and nuclear weapons reprocessing, medical wastes, industrial wastes, as well as naturally occurring radioactive materials. In nuclear fuel cycle radioactive waste is generation takes place both in the front end as well as backend of the cycle. It is observed that the waste coming from the front end of the nuclear fuel cycle is alpha emitting waste caused due to extraction of uranium. Commonly its contents also include radium and its decay products to a large extent.

While on the backend of the cycle the waste mostly contains spent fuel rods, contains fission products that tend to emit beta and gamma radiation, and actinides that emit alpha particles. As of May 2014, there were 437 nuclear reactors operating for generation of electricity and more than 70 new nuclear plants under construction. In the last four decades, 71,780 metric tons of nuclear fuel was produced. We know that high level nuclear waste is a byproduct of recycling of used nuclear fuel, which in its terminal stage will be disposed off in a permanent disposal facility. Where in spent nuclear fuel the contents are 95 percent uranium and 1 percent other heavy elements.

A generic nuclear power plant in a year is known to generate 20 metric tons of nuclear fuel. The worrying fact however about the waste is that it is known to be dangerous for tens of thousands of years. Historically speaking transuranic waste has been accumulating since the 1940s with the beginning of the United States nuclear defense program.

It was believed that an ideal way of permanently isolating radio active wastes was found in the bedded salt which is free of fresh flowing water, easily mined, impermeable and geologically stable environment. However even this proposition served to be hazardous in the long run.

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IV. TYPES OF RADIOACTIVE WASTE

Radioactive waste is basically any material which is originally radioactive or which has been affected or contaminated by radioactive material to such an an extent that it is no longer deemed fit for usage. The ruling of the government decides whether certain materials are categorised as nuclear waste.

Every radionuclide has a half-life – the time taken for half of its atoms to decay, and thus for it to lose half of its radioactivity. Radionuclides which have a long half life tend to emit alpha and beta particles which makes their handling easier. Where as the nuclide with short half lives emit the most penetrating gamma rays. Eventually all radioactive waste decays into non-radioactive elements.

The rate of decay depends upon the radioactivity of an isotope. Radioactive waste is typically classified as either low-level (LLW), intermediate-level (ILW), or high-level (HLW), dependent, primarily, on its level of radioactivity

V. CLASSIFICATION OF RADIOACTIVE WASTE

According to the International Atomic Energy Agency it has been classified in the following six categories;

1) *Exempt Waste:* It consists of radio active material which is at such a low level that it is not known to be harmful to any form of life or the environment. Such materials are not rendered harmful so they do not require a disposal facility for it.
2) *Very Short Lived Waste:* It has radio nuclides which have a very short half life. Since this material undergoes decay in a short period of time this it is also harmful for a short period of time. To ensure safe disposal this material is stored until the radioactivity falls to the level of exempt waste
3) *Very Low Level Waste:* Exempt waste and very low-level waste (VLLW) contains radioactive materials at a level which is not considered harmful to people or the surrounding environment. The waste is ultimately disposed off with domestic waste. Some countries however are developing strategies for VLLW disposal facilities.
4) *Low Level Waste:* Low-level waste (LLW) has a radioactive content not exceeding four giga-becquerels per tonne (GBq/t) of alpha activity or 12 GBq/t beta-gamma activity. LLW does not require shielding during handling and transport, and is suitable for disposal in near surface facilities.
5) *Intermediate Level Waste:* Ntermediate-level waste (ILW) is more radioactive than LLW, but the heat it generates (<2 kW/m^3) is not sufficient to be taken into account in the design or selection of storage and disposal facilities. Due to its higher levels of radioactivity, ILW requires some shielding.ILW typically comprises resins, chemical sludges, and metal fuel cladding, as well as contaminated materials from reactor decommissioning. Smaller items and any non-solids may be solidified in concrete or bitumen for disposal. It makes up some 7% of the volume and has 4% of the radioactivity of all radioactive waste
6) High-level waste (HLW) is sufficiently radioactive for its decay heat (>2kW/m^3) to increase its temperature, and the temperature of its surroundings, significantly. As a result, HLW requires cooling and shielding. HLW arises from the 'burning' of uranium fuel in a nuclear reactor. There are two distinct kinds of HLW:

a) Used fuel that has been designated as waste.
b) Separated waste from reprocessing of used fuel.

HLW has both long-lived and short-lived components, depending on the length of time it will take for the radioactivity of particular radionuclides to decrease to levels that are considered non-hazardous for people and the surrounding environment. If generally short-lived fission products can be separated from long-lived actinides, this distinction becomes important in management and disposal of HLW.

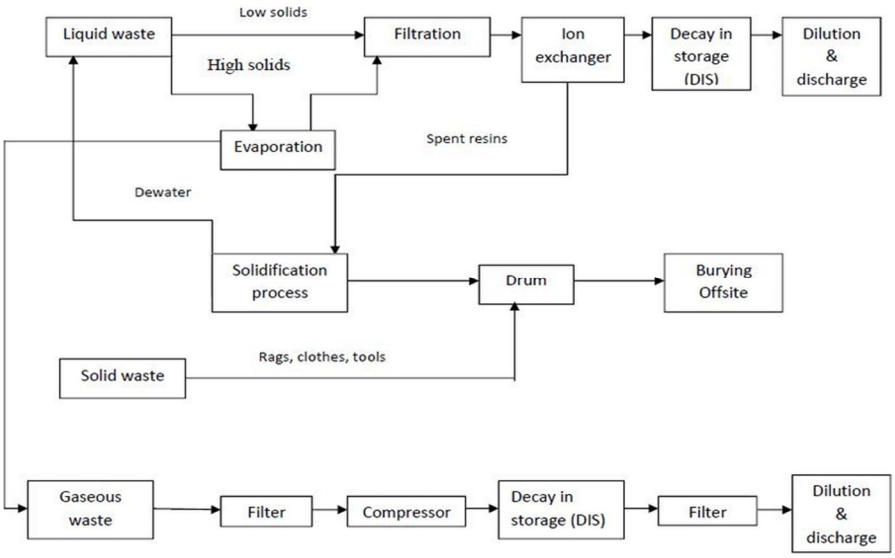
HLW is the focus of significant attention regarding nuclear power, and is managed accordingly.

VI. PROCESSING RADIOACTIVE WASTE

It is seen that radioactive material becomes non radioactive over a period of time so the ideal way to dispose off nuclear waste is by storing it till the time it looses its Radioactivity. However, the problem here is that different radioactive materials have varying half lives hence different storage times.

Due to this categorisation in processing takes place:

1) In case of very short lived radioactive waste disposal is done by storing the waste in buildings until they are non radioactive.



The block diagram above shows simple handling system required for radioactive waste.

2) The process of removing radioactive impurities from liquids is as follows;

a) Filtering

b) Routing through demineralizers

c) Boiling off the water hence evaporating it leaving behind solid which is treated accordingly.

d) Decay in storage

After following this procedure, the water has to be sampled. If the sample meets the standards, the water is stored in tanks and is used in plants or is safe to be released otherwise reprocessing is modeled.

3) When the waste is in gaseous form, it first filtered then compressed to take up less space, and are then allowed to decay for a certain period of time. Similar to liquids sampling of the gas is done and if it is found non harmful it is either reused in the plant or left into the environment. If found harmful it is retreated.

VII. STORAGE AND DISPOSAL OF WASTE

A. Deep geological repository

B. Spent Fuel Tank

C. Dry cask Storage

D. Ducrete

1) *Deep Geological Repository:* A deep geological repository is located below the ground level so that provision for the storage for the HLW can be made and the radiations do not harm any form of life. Making such a provisions also ensures that the decay process is not affected by any human activity.

2) *Spent Fuel Pool:* Water is a natural effective barrier to radiation, due to this property spent fuel tanks contain thermally controlled water. Once the spent fuel is extracted from the reactor to change it with new fuel, the old fuel is stored in the spent fuel pool. It is imperative to keep the spent fuel under water to overcome the heat which is being dissipated due to the decay of fission products which aids in limiting the radiation levels in the spent fuel pool. Once the generated heat abates the spent fuel is hence transferred to the ground level where its storage is done in specifically designed casks which provide radiation shielding.

3) *Dry Cask Storage:* After cooling HLW is cooled and is transferred to dry cask storage at the ground level. Casks are fabricated with steel and surrounded by inert gas.

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VIII. TREATMENT AND CONDITIONING OF RADIOACTIVE WASTE

A. Before disposal, nuclear waste needs to be in solid form and resistant to leaching.
B. Packaging should be appropriate to the waste and its disposal.
C. High-activity waste requires shielding.

Treatment and conditioning processes are used to convert a wide variety of radioactive waste materials into forms that are suitable for their subsequent management, including transportation, storage and final disposal. The principal aims are to:

1) Minimize the volume of waste requiring management via treatment processes.
2) Reduce the potential hazard of the waste by conditioning it into a stable solid form that immobilises it and provides containment.

A systematic approach typically incorporates:

a) Identifying a suitable matrix material – such as cement, bitumen, polymers or borosilicate glass – that will ensure stability of the radioactive materials for the period necessary.
b) Immobilising the waste through mixing with the matrix material.
c) Packaging the immobilised waste in, for example, metal drums, metal or concrete boxes or containers, or copper canisters.

A better approach for the same is to in cooperate those wastes into a crystalline form of geochemically stable natural minerals. It is to be noted that HLW is essentially the primary focus of attention, it consists a mere 1 percent of the total radioactive waste however this waste is extremely dangerous. Both ILW and HLW require shielding, so the handling and conditioning may be in hot cells of various kinds to provide that.

IX. CONCLUSION

It is important to identify, classify, store, transport and dispose off radioactive waste after treatment. With the growth in the number of nuclear reactors radioactive waste has seen a significant increase. It is important to reduce the radioactivity of high level waste which can be achieved by nuclear transmutation. Similarly, other methods of reprocessing such as using the low level radioactive waste in usable products. To sum it up by following rules and regulations of radioactive waste management, public and the environment will be safe guarded by radiations of nuclear waste.

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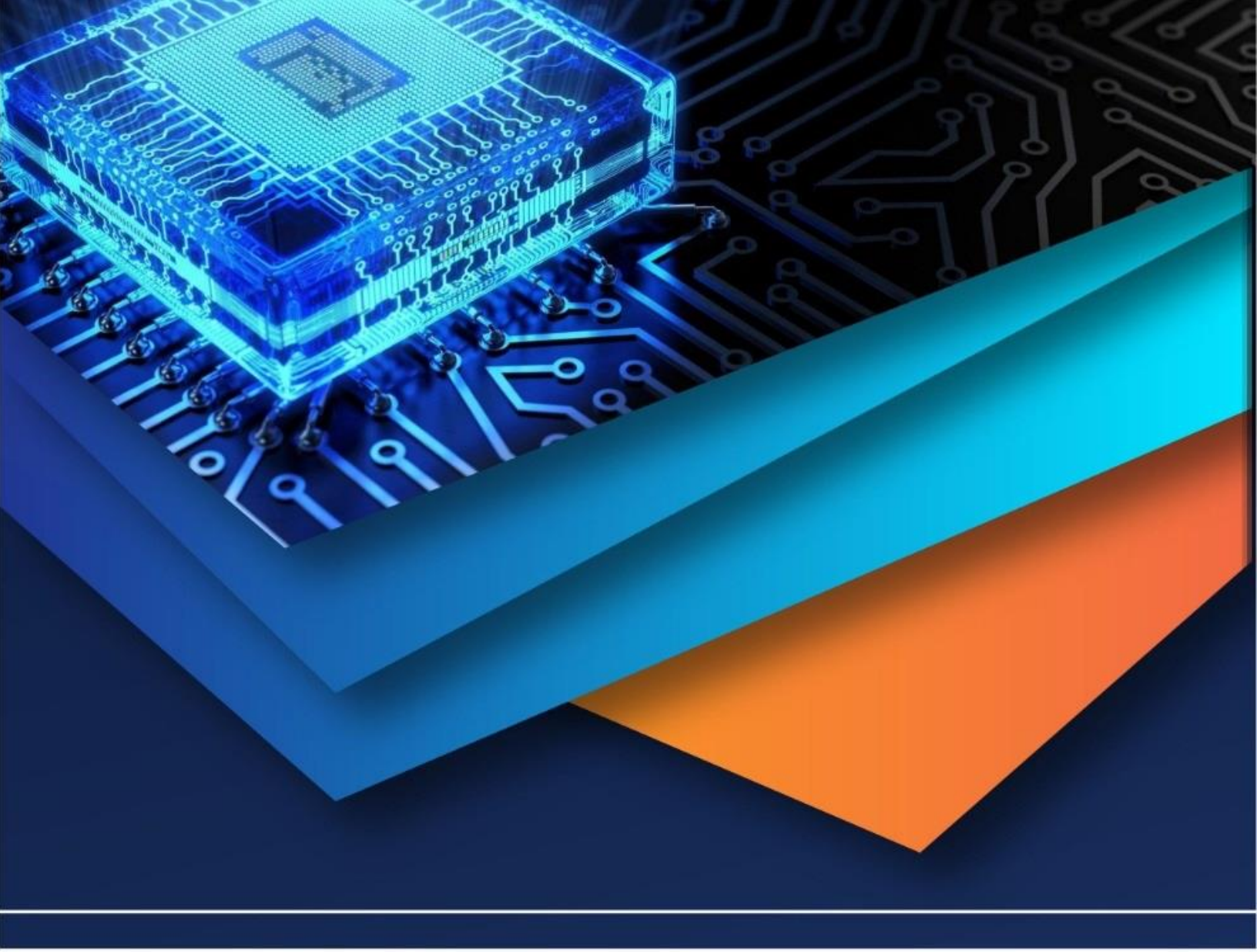

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