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# NUCLEAR WASTE MANAGEMENT: A NIGERIAN CASE STUDY

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## Abstract

Nigeria is among the top new comer countries on the African continent. Albeit the public acceptance and the effort by government, one major potential setback to this is the management and proliferation of nuclear waste. Three major Spent Nuclear Fuel management approaches i.e. SNF reprocessing, deep geological repository and SNF export where studied together with five factors that affect policies on nuclear waste management in the Nigerian context. At the end of the study SNF export was found to more suitable than the other two approaches. Notwithstanding if Nigeria is to manage its SNF for a long term solution then deep geological repository approach should be adopted.

Keywords: Spent Nuclear Fuel (SNF), Nigeria

## 1.0 Introduction

Most heavy elements are unstable in nature; they try to achieve stability by the release of particles (alpha and beta) and energetic photons (gamma rays) in form of radiation. In the process of achieving stability they split into two lighter elements (Nuclear fission). The elements that undergo these are called radioactive elements and they can be found at the bottom of the periodic table. Radioactivity is vital to human life it has a wide range of applications i.e. power generation, medical operations, military, industrial and research activities. But its major setback is the waste generated from all these activities and weapons proliferation. For the safety of both humans and the environment this waste requires careful management. Nuclear waste is classified into several categories. Nuclear waste is classified into several classes, although several countries have their own classification, a globally accepted system was developed by the IAEA as it accommodates all types of waste and disposal solution. The IAEA classification system is based on the activity content and half-life. At the bottom we have Exempted waste (EW) which is from non-radioactive materials, Very short lived waste (VSLW) its stored for a limited period just few years to decay, Very low level waste (VLLW) it does not require high engineered containment and isolation system, Low level waste (LLW) it contains little quantity of long-lived radionuclides so its require high engineered containment and isolation system for up to few hundred years, its stored in Near surface disposal facilities( NSDFs) , Intermediate low level waste (ILW) this requires a greater degree of containment and isolation, tens to a few hundred meters deep underground, High level waste (HLW) it has high level of activity to the extent it requires shielding in handling operations, it also contains long lived radionuclides, it requires deep geological disposal facilities (GDF).[1]

From the IAEA classification we have seen that nuclear waste is stored according to the activity content of the waste. Most countries are already into the near surface disposal approach for

VSLW, VLLW, and LLW. While the HLW and long lived ILW the GDF approach has been considered by countries like Sweden, France, Finland and USA.

Another approach is the spent nuclear fuel (SNF) reprocessing. SNF is reprocessed in order to recover uranium and plutonium that will be reinserted into nuclear reactors or nuclear weapons.

Russia, Japan and China are for SNF reprocessing approach and some prefer to export the waste abroad to be processed or disposed like the Netherland.

Low Level Waste has limited amounts of long lived radionuclides, so it can be kept in storage facilities for some time until it decays to a safe level. LLW waste can be stored in a near surface disposal facilities. LLW cover a wide range of waste, they consist of contaminated gloves, rags, papers, clothing, resins, syringes, reactor water etc. their radioactivity can range from just above background radiation to very high level radiation. High Level Waste is characterized with having long lived radionuclides. It comprises of spent nuclear fuel, highly irradiated nuclear components like control rods, fissile materials, liquid/solid waste from fuel reprocessing. Due to long lived radionuclides in HLW it cannot be managed by decay storage, disposal is the only option providing a safe, secured and permanent solution [3]. Transuranic waste are subset of HLW containing alpha-emitting isotopes with atomic number higher than that of uranium and with half-life of more than 20 years they are primarily produce in military related nuclear activities [4].

Different countries have different approaches in managing these nuclear waste, depending on Energy policy, Geological conditions, Military ambitions, Technological culture, Political culture and civil society. In Nigeria a nuclear energy strategy has been put in place, it is only a matter of time the country will be generating parts of its energy using nuclear power technology. With this development, there is need to look at the waste management approaches in managing HLW/SNF and TRU from the twin reactors.

As observed by Högselius; [6] five broad factors affect nuclear waste management policies in each country: Military ambitions and non-proliferation, Technological culture, Political culture and civil society. To find a suitable approach in managing Nigerian SNF waste, these factors need be observed in the Nigerian context. This paper will give an overview of the different approaches in managing HLW/SNF and TRU and observing the various factors that affects nuclear waste management policies.

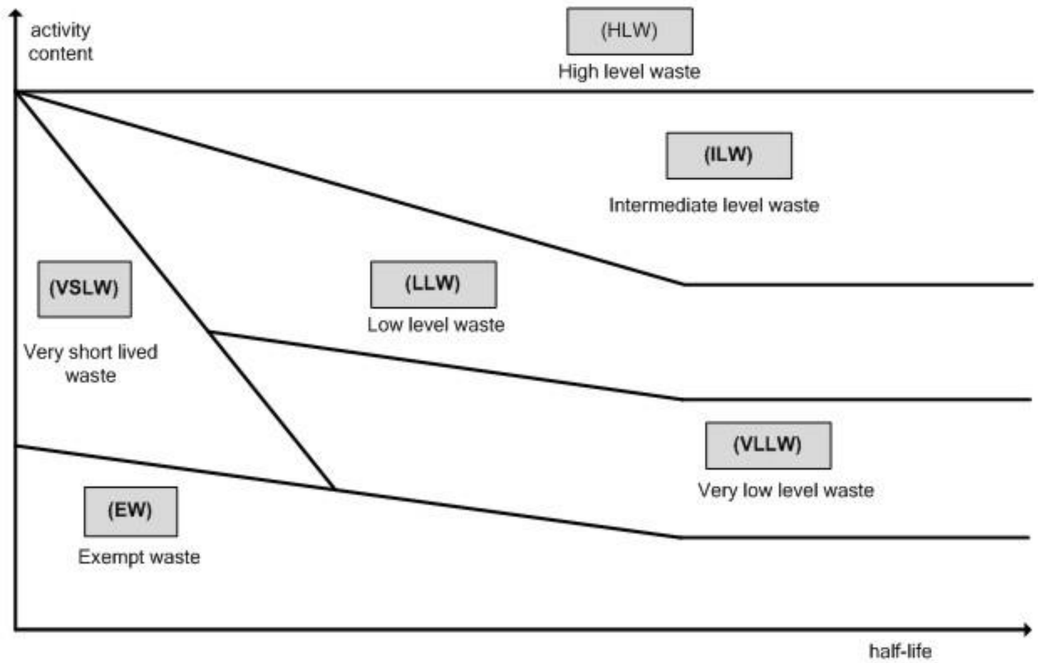


*Fig 1: IAEA classification of Nuclear waste (source:www.citron.ro)*

## 2.0 Waste Management Systems

### 2.1 Deep Geological Repository

The deep geological repositories are constructed in predominantly salt, crystalline rock or clay host rock formations [7]. HLW/SNF is first stored in a water pool to cool off the fission heat and to slow the decay reaction of fissile materials for some limited time (5 - 10 years) [8]. After which the waste will be transferred into dry casks. Finally, after a minimum period of 50 to 100 years of interim storage the waste is now transported to the disposal site. The waste is properly sealed and shielded in the casks; they are designed to withstand corrosion, earthquakes, tornados and also with a passive cooling system [9]. Deep geological repositories are hundreds of meters or several kilometers deep. Although up to date no such facility is in operation but some countries have already started construction like the Onkalo disposal facility in Olkiluoto, Finland and östhammar, Sweden [8]. Notwithstanding LLW is also disposed in an underground repository some tens of meters deep examples are Himdalen disposal facility, Norway and Nevada taste site in the US.

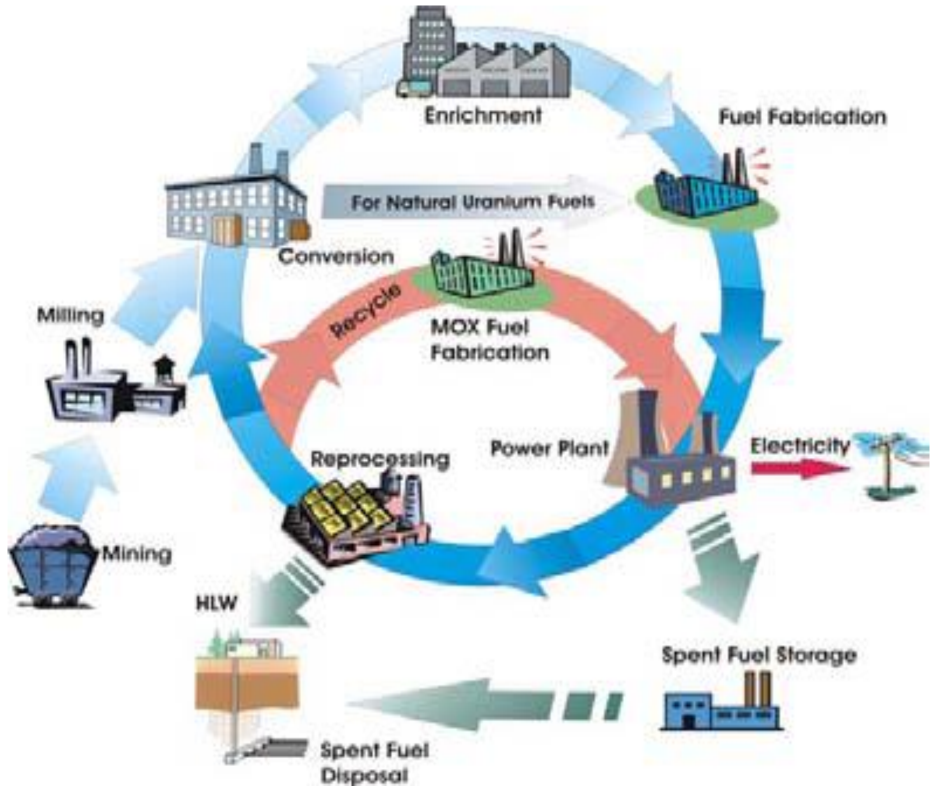


*Fig 3: schematics of nuclear fuel cycle*

## 2.2 Spent Nuclear Fuel Reprocessing

After the initial cooling at the reactor pools, SNF is transported to the reprocessing facility, where the Uranium and the Plutonium are separated from the minor actinides and fission products by means of the PUREX (Plutonium and Uranium Redox Extraction) process [10]. After separation the fission products and actinides are vitrified and stored as HLW in deep geological repositories. However, since SNF is composed of more than 96% of Uranium and Plutonium, the final HLW volume is reduced about 80%, its radioactivity level decreases about 90% and its decay heat is also reduced [11]. The extracted plutonium can be reprocessed into Mixed Oxide Fuel (MOX), while the extracted uranium as Reprocessed Uranium Oxide (REPUOX), the former is fed back into the reactor while the latter is stored due its high radioactivity level, high cost and technological limitations. Some of the reprocessing plants are found in countries like India, France and Russia.

*Fig 3: Orano reprocessing plant, France*

### 2.3 Spent Nuclear Fuel Export

Countries with limited technologies to handle their nuclear waste prefer to export their SNF to more advance countries abroad to reprocess or disposed directly with waste return to the mother country or no return at all after reprocessing. Such countries are the Netherlands, Bulgaria, Ukraine and Italy among the 32 nuclear states. Ukraine and Bulgaria export their SNF to Russia while Netherland and Italy exports to the UK. Russia is the major exporter of nuclear goods and services at the same time the major importer of SNF from other countries for reprocessing or disposal.

## 3.0 Factors Affecting Nuclear Waste Management Policies

### 3.1 Military Ambitions and Non-proliferation

Nigeria is among the Non-Nuclear weapon states (NNWS) who signed the Non-proliferation treaty (NPT) back in the 70s. That they agreed on not acquire nuclear weapons and not to seek or receive assistance in the manufacture of this weapons. As observed by Högselius; [6] that military ambition with respect to nuclear weapons influences nuclear weapon states (NWS) to go into SNF reprocessing. Although reprocessing to produce plutonium appears to be easier and cheaper to master than uranium enrichment. Later when the need arise for civil nuclear power these countries found it easy to use their military reprocessing competence for civil purposes.

### 3.2 Technological culture

The nuclear fuel cycle is complex. To master all the steps i.e. from uranium mining, conversion, enrichment, fabrication, utilization to reactor construction and back-end activities such as interim storage of SNF, reprocessing and waste treatment a country must be technologically advanced which is not so for developing countries like Nigeria. On the other hand SNF reprocessing is considerably difficult, expensive and risky.

### 3.3 Political culture and civil society

Countries with Autocratic or semi-autocratic form of government (North Korea, China, and Russia) find it easy to incline towards reprocessing-oriented strategies than those practicing democratic form of government where there is room for criticism. Nigeria been a democratic nation and abundant renewable energy sources gives room for anti-nuclear movement. Although a study by Sambo; [12] revealed that the use of Nuclear power in Nigeria is generally accepted by the public but a major concern from the public is waste management and proliferation. As a NNWS; Nigeria with every tendency will go for Geological disposal repository approach rather than SNF reprocessing.

### 3.4 Energy policy

Countries with expansive nuclear energy policies (large number of nuclear reactors in operation) see reprocessing, as a way to reduce the volumes of their SNF. Albeit **t**he Nigerian National Energy Policy of 2003 explicitly calls for the development and exploitation of uranium resources in Nigeria [13]. Nigeria is a new comer country hoping to generate about 5000MW of electricity from nuclear energy by 2035. The nuclear waste that will be generated minimal compared to that generated by nuclear giants like France, USA, Russia and the likes.

### 3.5 Geology

Direct disposal happens to be challenging from a geological perspective. This is so due to lack of scientific and technological competencies within the geological sciences and to the existence of suitable geological formations within the country. Despite the fact that Nigeria lacks the scientific and technological competencies, its geological formations are suitable. The dominant type of basement rock in Nigeria is granite [14]. It is found almost all over the country except in the Niger-delta region. As such different countries are constructing deep geological repository on granite bed rock like the Onklo facility in Finland and Forsmark facility in Sweden.

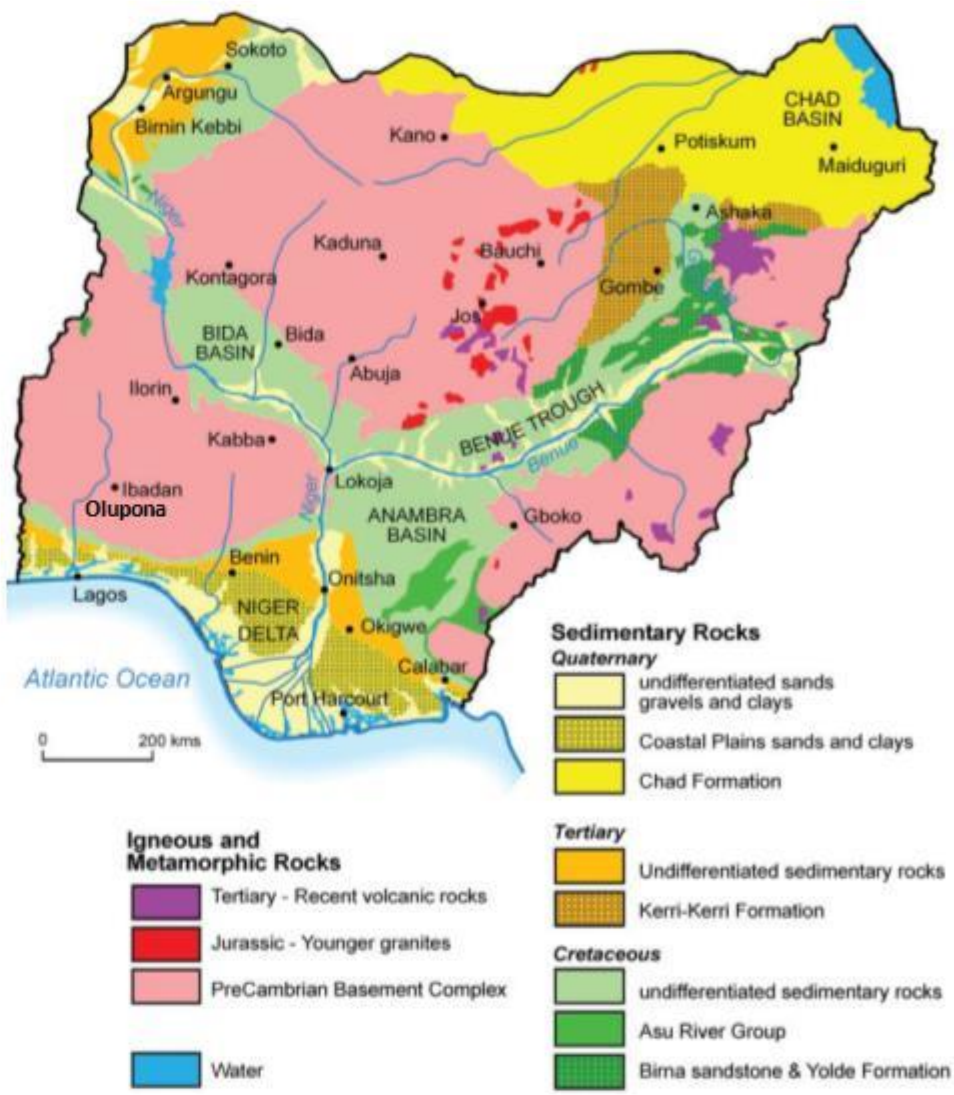


Fig 2: Generalized geological map of Nigeria (source: MacDonald et al., 2005).

## 4.0 Conclusion

Five broad factors that affect nuclear waste management policies were observed in Nigerian context. Base on the current study deep geological repository approach is found to be suitable for Nigeria and it has the following advantages over SNF reprocessing.

- It is less expensive than SNF reprocessing.
- It reduces the risk of nuclear weapon proliferation because there is no production of pure plutonium.
- Extraction of uranium and plutonium in SNF reprocessing, increases exposure risk i.e. the reprocessed uranium oxide (REPUOX), has high level of radioactivity than natural uranium.
- Nuclear wastes are buried for good and never to be retrieve unlike SNF processing where even after reprocessing large volume of LLW nuclear waste still need to be disposed.

Some disadvantages of this approach are:

- It require certain geological formations i.e. the host rock should be a crystalline, salt, granite or clay bedrock
- An impending danger is left for future generations. Humans are always curious there is all possibility that future generations will explore these geological sites.

If at all Nigeria is to manage its SNF, deep geological repository approach is recommended by this study. But looking at the current situation, Nigeria is planning to enter into NPP build-own-operate-transfer (BOOT) agreement with US, Russia, China, or Korea, the decision is still underway. For now, Nigeria should leverage this agreement to export SNF to any of the countries that finally got the contract, considering the level of technical knowhow in the country and cost. Subsequently, if Nigeria wants to manage its SNF for a long term solution then deep geological repository approach should be adopted.

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