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Corrosion Related to the Nuclear Waste Containers

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1- Introduction to the Nuclear Waste

Nuclear energy has gained widespread acceptance as a technology for generating power over the past few decades. As of April 2018, it played a significant role in supplying about 10% of the world's electricity from about 440 nuclear reactors operational, while there are currently 60 new nuclear power plants under construction in 15 different countries. Table 1 shows the dependence of different countries across the world on nuclear technology in 2021, by presenting the proportion of nuclear power in their overall electricity generation.[1]

Table 1. Percentage of electricity generation derived from nuclear power in 2021.[1]

Argentina	Belgium	Canada	France	USA	South Korea	Sweden
7%	51%	14%	33%	20%	28%	31%

All industrial processes invariably lead to the generation of waste, necessitating the need for safe and efficient waste management practices. The widespread utilization of nuclear technology has given rise to a substantial volume of waste material in the form of high-level radioactive fuel waste. Radioactive waste is a byproduct of the utilization of radioactive materials in various spheres such as nuclear reactors, research, medicine, education, and industry. The spent fuel can be regarded to be a resource for reuse or to be waste, depending on the policy and strategy of the Member State in the International Atomic Energy Agency (IEAE). As the radioactivity content of various types of radioactive waste changes greatly, the waste can be categorized into different classes as follows: exempt waste (EW), very short-lived waste, very low-level waste (VLLW), low-level waste (LLW), intermediate-level waste (ILW), high-level waste (HLW), which their proportion in total volumes in storage and disposal is shown in Figure 1.[2] The Canadian Nuclear Safety Commission (CNSC) regulates all steps in the management of radioactive waste in order to protect the health, safety and security of persons and to protect the environment. Considering the risk to the health and safety of humans and the environment, different considerations are taken to store and monitor nuclear waste. This work will shade up a concise overview of Canadian efforts and challenges in disposing of high-level radioactive waste, with a long-term perspective, run by the Nuclear Waste Management Organization (NWMO).

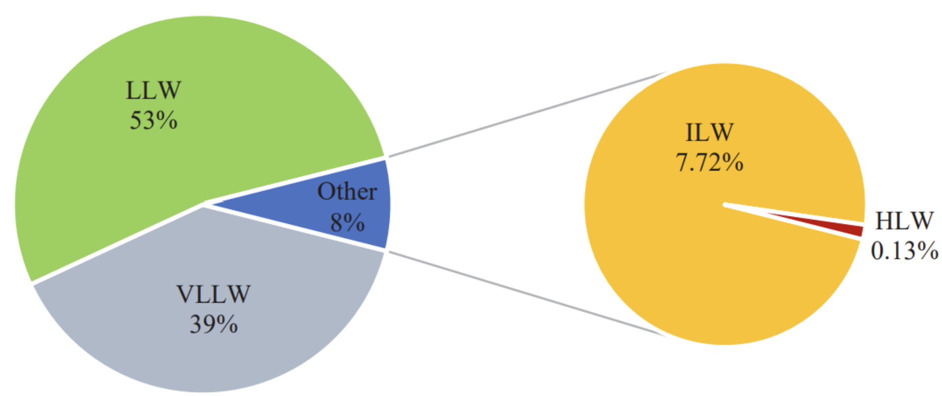

Figure 1. Share of various types of radioactive waste in total volumes in storage and disposal.[2] **© IAEA, 2018**

2- Technical Issues to Manage the Nuclear Waste

The fuel waste contains uranium, fission products, and plutonium, depending on the initial fuel type and operating conditions of the reactor. In Canada, once the nuclear fuel is removed from a reactor, they are kept for 6 to 10 years in a water pool where their heat and radioactivity are reduced. The used nuclear fuel pools are constructed in-ground and have been designed to meet seismic standards, ensuring their ability to withstand earthquakes. These pools are situated within separate buildings, distinct from the reactor buildings. Also, robust, heat-resistant, and water-tight liners are installed in the pools to thwart any water leakage through possible defects in the concrete. Furthermore, all nuclear power plant operators in Canada have taken measures to acquire supplementary transportable equipment, including items like portable generators and pumps, to guarantee the capability to replenish water in the pools, regardless of the severity of an accident.[3]

After 7 to 10 years, the bundles are transferred to the dry storage containers and silos. The dry storage containers have been designed with a minimum expected lifespan of 50 years. These containers are subject to continuous monitoring, and research studies have shown that, with consistent maintenance and thorough inspections, they can be safely utilized for significantly extended durations. There are three types of dry storage employed in Canada: Concrete canisters, Modular Air-cooled Storage (MACSTOR) units, and dry storage containers. Dry storage containers are made of reinforced concrete encased in interior and exterior shells made of carbon steel. The containers are transportable and are filled with helium (an inert gas), preventing potential oxidation. After 50 years, the life of the container could be extended, or the used fuel could be repackaged.[3]

As of 2022, Canada's current inventory is approximately 3.2 million used nuclear fuel bundles. At the end of the planned operation of Canada’s existing nuclear reactors, the total number of used fuel bundles could potentially reach approximately 5.5 million,[4] which illustrates a long-term solution for disposal of the nuclear waste is required in Canada. To achieve this goal, there is currently a worldwide initiative aimed. These disposal strategies are commonly known as geological repository solutions, involving the utilization of both natural geological formations and engineered barriers to safely store spent fuel in underground containers for durations extending into millions of years. This approach involving the disposal of the used fuel 500 to 1000 meters underground in a multi-barrier system called a deep geologic repository (DGR) has been adopted. Figure 2 presents the conceptual design of a DGR.[5] The used nuclear fuel bundles may be placed in carbon steel containers coated with 3 mm of copper (Cu), called used fuel containers (UFCs) resisting against corrosion during the first million years of emplacement.[6] Carbon steel is chosen for its ability to withstand mechanical, hydraulic, and/or hydrostatic pressures of up to 45 MPa (glacial design load). Based on the examinations, the UFC was pressurized beyond the design load and plastically buckled at a pressure of 63 MPa. Finally, the UFC was further collapsed to the maximum degree, i.e., the cylindrical portion of the container was fully flattened until the end effect from the hemispherical heads prevented further propagation of the collapse. In addition, a helium leak test was performed to confirm the integrity of the containment boundary, and no breach was reported.[4] Also, Cu is a suitable coating material due to its excellent resistance to corrosion,[6] and UFCs are then surrounded by bentonite clay within the DGR.[5] Well-preserved antiquarian artifacts with minimal corrosion provide compelling evidence for the low corrosion rate of Cu in DGRs.[7]

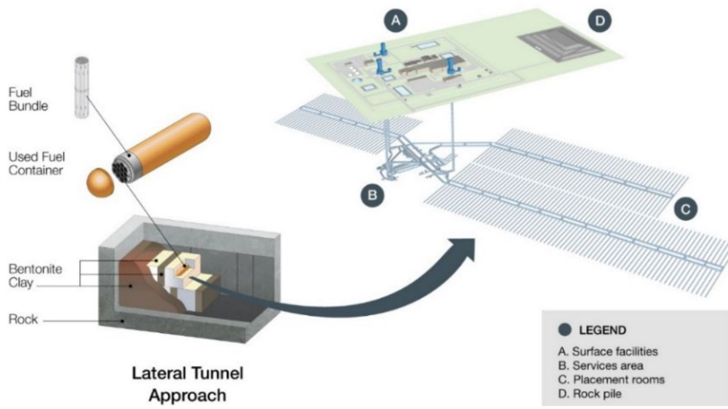

Figure 2- The schematic of the proposed system for the burial of nuclear waste in a DGR.[5] © 2017 David S. Hall, Mehran Behazin, W. Jeffrey Binns, Peter G. Keech. Licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives License (http://creativecommons.org/licenses/by-nc-nd/4.0/)

Corrosion could lead to failure for a number of these storage methods. It has the potential to affect the cooling systems of storage pools, which, if compromised, could lead to overheating, ignition, and the release of radiation from the waste. Corrosion of the used fuel container in the DGR could also result in the leakage of radioactive materials into the DGR and the surrounding environment. In either scenario, the consequences could include a high incidence of cancer, rendering land unusable, devastating ecosystems, necessitating the long-term displacement of many people, and endangering the relationships with indigenous communities by damaging their traditions.

3- Corrosion in the Nuclear Waste

Nuclear fuel waste can lead to corrosion primarily due to the presence of certain corrosive factors associated with radioactive materials. For instance, radioactive decay emits radiation, including alpha, beta, and gamma radiation. This radiation can damage the structure of materials over time, making them more susceptible to corrosion.[8] Also, nuclear fuel waste often contains radioactive elements that can undergo chemical reactions with the materials used in storage or containment structures. These reactions can produce corrosive byproducts weakening the integrity of the containers.[9]

The UFC will undergo an evolving environment after burial, as portrayed in Figure 3, and, thus, will be susceptible to various corrosion processes. In the initial stages of emplacement, the container will be exposed to a warm oxidizing environment with temperatures of up to 90 °C, and it is at risk of corrosion due to oxidizing agents such as O_2, trapped in the repository on sealing, and potentially radiolytically produced species such as HNO_3. Over the course of the first few centuries, there will be a gradual transition in environmental conditions. The environment will shift towards a cooler, anoxic, and reducing state. During this phase, the primary available oxidant for Cu will be remotely generated sulfide ions (SH^-).[5]

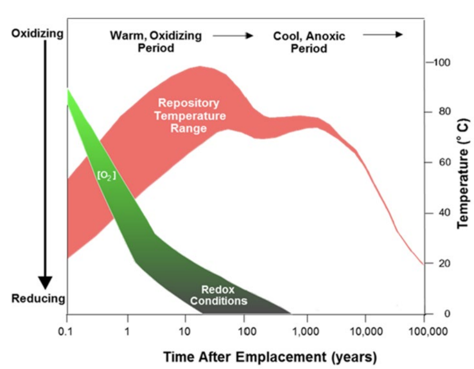

Figure 3- The evolution in expected conditions in a DGR after the emplacement.[5] **© 2017 David S. Hall, Mehran Behazin, W. Jeffrey Binns, Peter G. Keech. Licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives License (http://creativecommons.org/licenses/by-nc-nd/4.0/)**

Once the Cu coating loses the ability to protect the UFC against corrosion, the groundwater, and other species can diffuse into the container and react with the fuel waste. The release of 90% of the radionuclides held within the solid-state matrix of the used fuel will be controlled by the corrosion and dissolution of the UO_2 matrix. In oxidizing conditions, UO_2 can undergo oxidation to reach the +6 oxidation state (U^{VI}), such as UO_2^{2+}, and subsequently dissolve. It is now widely recognized that in the presence of oxidizing agents, this dissolution process should be regarded as a corrosion reaction, wherein the oxidant is consumed to convert the insoluble U^{IV} (in UO_2) to the much more soluble U^{VI} (as UO_2^{2+}). Figure 4(a) illustrates the thermodynamic driving force behind a corrosion process. In this context, it is important to note that the redox potential of the groundwater needs to have a more positive value than the equilibrium potential for fuel dissolution. The driving force responsible for corrosion can be calculated as the potential difference between $E_{Red/Ox}$ and E_e UO_2/UO_2^{2+}. As shown in Figure 4(b), the radiolytic production of oxidants due to the alpha, beta, and gamma radiolysis of water, along with the interaction between cathodic oxidant processes and anodic fuel dissolution, collectively constitute the comprehensive fuel corrosion process ($UO_2 + Ox \rightarrow UO_2^{2+} + Red$).[8]

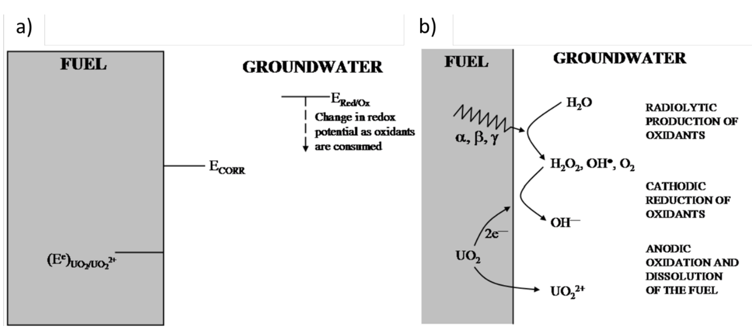

Figure 4- (a) The thermodynamic driving force for fuel corrosion in groundwater, (b) the fuel corrosion process.[8] **© 2008. NACE International**

Considering the possible corrosion processes occurring in the long-term disposal plan, UFCs is designed to withstand uncertainties and potential corrosion threats. Also, they are supposed to remain functional and prevent any leakage of used nuclear fuel into the environment over an extended period. Furthermore, the multi-barrier system is designed to guarantee safe protection for the used fuel, particularly against corrosion. For instance, bentonite clay primarily comprises montmorillonite clay, with substituted central atoms carrying a net negative charge. Groundwater cation ions interact with these negatively charged sites, causing bentonite to swell. This swelling behavior serves to restrict the movement of groundwater species and the diffusion of oxygen toward the container surface. Additionally, the cation exchange properties of bentonite clay play a crucial role in preventing corrosive species from migrating towards the container. As a result, the cation exchange process effectively traps cationic radionuclides within the buffer box in the event of nuclear waste leakage, thereby mitigating further harm to the environment.[10] Therefore, there are endless ongoing efforts to ensure that the long-term disposal plan will not harm the environment and people because if it fails, there will be serious consequences to face.

4- Stakeholders in the NWMO Plan

The long-term disposal of nuclear waste in a DGR affects not only the environment but also many various communities and groups. Crystally, the environment, NWMO, and the people in the nuclear industry will be the main stakeholders. Also, there are minor stakeholders, such as academic researchers, local workers, and interested communities, particularly First Nation and Métis communities in the study areas, involved in the NWMO plan.[11]

Regarding its influence on the environment, nuclear energy is a key and efficient player in the battle against climate change despite all its risks and shortcomings. It is safe to say it is currently one of the most realistic ways to decarbonize the electric sector[12]; however, it can also bring about serious negative impacts. There are two major types of negative environmental impacts of nuclear power: catastrophic accidents, and nuclear waste. Catastrophic accidents and nuclear waste can be managed and controlled by the cooperation between the international organizations and governments to minimize the negative environmental impacts, but if they fail, it can lead to environmental contamination, high incidences of cancer, and the long-term relocation of many people.

In this regard, the Fukushima Daiichi nuclear disaster can be a good example, which happened as a result of a sequence of equipment failures, nuclear meltdowns, and the release of radioactive materials at the Fukushima I Nuclear Power Plant in Japan, following the devastating Tōhoku earthquake and tsunami on March 11, 2011. This incident stands as the most significant nuclear disaster since the Chornobyl catastrophe in 1986, with radiation levels surpassing official safety standards. Thanks to high level of standards in the nuclear waste managing, it is reported the spent fuel storage pools in the power plant survived the earthquake, tsunami and hydrogen explosions without significant damage to the fuel, significant radiological release, or threat to public safety; however, the accident caused massive devastation, economic losses, and forced the relocation of over 100,000 people.[13] In addition, over a million tonnes of treated waste water have accumulated in the nuclear power plant since the devastating tsunami in 2011.

Japan has recently started releasing this water into the ocean, and this process is expected to take 30 years to complete. While the Japanese government claims that the discharged water will pose minimal risk to humans and marine life, the true impact of this decision is still under huge debate.[14] That is one of the main problems in the nuclear industry that governments can make decisions that might substantially harm the environment in either the short term or the long term.

5- The Impact of Nuclear Waste on the Environment

Nuclear waste, once buried, can substantially affect human health due to the potential for leakage and radiation. As high-level radioactive waste has extremely lengthy half-lives, the corrosion of the materials used to contain the waste makes the disposal plan of the waste so challenging. Over time, any material used for burial will inevitably corrode, leading to the release of radioactive substances. This leakage, in turn, can contaminate groundwater, jeopardize the safety of drinking water sources, and release radiation into the environment.[15] In the following, some examples are provided to show how nuclear waste management significantly has the capacity to impact the environment and human health.

In Wolfenbüttel, Germany, the Asse II mine, used for storing low- and intermediate-level radioactive waste, has recently been realized to be an unsuitable location for such storage. This mine is plagued by numerous faults and cracks, allowing saline water to spread through the area and causing a flood risk near the storage facilities. To prevent any contact between this water and the radioactive waste containers, an ongoing effort has been made to collect and safely dispose of the water because such contact could accelerate the corrosion of the storage containers, potentially leading to the release of radioactive materials into both the atmosphere and the saline water. To mitigate this risk to human health, the German Bundestag has formulated a plan that is set to commence in 2033. This plan entails the retrieval of the waste and is expected to cost approximately €3.35 billion to fulfill. This situation serves as a stark reminder of how inadequate site assessments can lead to potential disasters and significant financial burdens for the community.[16]

In 1947, during the Cold War, over 50 mills and processing facilities were constructed to refine uranium ore in the United States. Unfortunately, the waste produced at these sites was handled improperly, resulting in the dispersal of more than 250 million tons of tailings into nearby communities, contaminating streams and groundwater aquifers. Once efforts to remediate these sites commenced, the government primarily focused on mitigating radiation exposure; however, a critical issue went largely unaddressed: water pollution. Numerous sites struggled to meet water quality standards and consequently sought exemptions to bypass these standards.[17]

In 1999, the United States inaugurated the Waste Isolation Pilot Plant (WIPP), marking the debut of the first underground repository authorized for the safe and permanent disposal of radioactive waste. WIPP operated smoothly and without significant incidents until the year 2014 when an incident occurred where a waste drum unexpectedly exploded, resulting in the release of small amounts of plutonium and americium. Fortunately, this accident did not lead to any public health concerns, but it serves as a poignant illustration of how swiftly situations can take a turn for the worse when dealing with the disposal of nuclear waste.[18]

In Canada, *The Nuclear Fuel Waste Act* was approved, which specifies the Nuclear Waste Management Organization (NWMO) to develop a plan for managing Canada's high-level nuclear waste, mainly used nuclear fuel.[19] The strategies related to the disposal of nuclear waste are commonly known as deep geological repository (DGR) solutions, involving the utilization of both natural geological formations and engineered barriers to safely store used fuel in underground containers for durations extending into millions of years. This approach, involving the disposal of the used fuel 500 to 1000 meters underground in a multi-barrier system, can offer a safe and permanent solution to preserve high-level nuclear waste.[5]

6- Environmental Assessment

The process of selecting a location for constructing a DGR is inherently complex and often faced with social tensions. Only four countries have managed to successfully site a repository for used nuclear fuel: Finland, Sweden, France, and Switzerland. In addition, progress on the disposal of high-level nuclear waste remains sluggish on a global scale. South Korea is still in the early stages of site selection for a deep geologic repository, with a target selection date set for 2030 and no plans for operations until 2053. This indicates a prolonged timeline for the development of their repository. China has made progress by selecting a site for a repository after an extensive 33-year period of site investigations. Construction is scheduled to be completed by 2050. Germany amended its *Repository Site Selection Act* in 2017, aiming to choose a repository site by 2031. Finally, Canada is positioned to make a significant decision about the site selection due in 2024.[11]

One of the primary concerns when it comes to DGRs is the contamination of soil, groundwater, and surface water. In Canada, the responsibility for protecting the health and safety of workers, the public, and the environment in this context falls under the purview of the Canadian Nuclear Safety Commission (CNSC). To address the protection of groundwater at nuclear facilities, the CNSC underscores the significance of not only controlling potential releases of radioactive materials but also implementing a comprehensive groundwater monitoring program.[20] Beside this, there is a list of acts, mentioned in the following, that should be considered to realize the environmental assessment of the safe storage of used nuclear fuel.

As nuclear fuel contains toxic materials, it is important to consider the *Canadian Environmental Protection Act*, which outlines the acceptable levels of toxic material that can be released into the environment. This act serves as a regulatory mechanism to address environmental pollution concerns that may not be covered by existing federal laws. The emphasis is on preventing any release, but if that is not possible, the responsible entity must take steps to remedy the situation and reduce any potential danger to the environment or to human life or health resulting from the release of the substance.[21]

Nuclear waste can be a significant threat to *The Species at Risk Act*. This is because its disposal requires DGRs to safely store nuclear waste, which can potentially harm species at risk and their habitats if containment is breached. *The Species at Risk Act* is a federal legislation that upholds Canada's commitments under the International Convention on Biological Diversity. It aims to prevent wildlife species from disappearing by protecting endangered or threatened organisms and their habitats. The Act's scope is not limited to species currently at risk but also includes those whose existence or habitats are in danger. The Act provides a method to determine the necessary steps to safeguard both healthy environments and threatened habitats.[22] Any potential site for a DGR must be assessed for the presence of species at risk to ensure compliance with the Act.

To regulate the activities of the Canadian nuclear industry, *The Nuclear Safety and Control Act of Canada* was replaced with the *Atomic Energy Control Act* of 1946. It aims to curb risks to national security, the health and safety of individuals, and the environment in the context of nuclear energy and nuclear substances. It mandates that nuclear waste must be stored in a way that guarantees the safety of both individuals and the environment. Furthermore, the Act established the CNSC as a regulatory body to oversee the aforesaid aspects.[23]

7- NWMO Plan from Different Perspectives

Finding suitable locations for repositories is a notoriously challenging endeavor, and this difficulty doesn't solely stem from technical issues. The process is also due to the difficulty of identifying a socially acceptable site. Canada, in conjunction with the NWMO responsible for its repository plan, has made substantial progress in establishing a permanent solution for nuclear waste disposal, surpassing the advancements of many other countries in this regard. The NWMO should balance two distinct priorities to establish a DGR. Their approach, known as "Adaptive Phased Management" approved by the Canadian government, has been designed to address both the need to locate a technically suitable site for a repository and the identify a willing host community. From the outset, NWMO made it clear that it didn't necessarily entail selecting the site with the best technical characteristics, but rather identifying a site that was technically adequate and, crucially, had strong local support. From 2010 to 2022, the NWMO declined the potential sites and host communities from a starting number of twenty-two to two. During this process, one community made the decision to opt out due to insufficient local support for the project. Meanwhile, the other sites were eliminated based on factors such as less suitable geology or environmental considerations. Currently, NWMO is considering two potential sites, one in northern Ontario and another in southern Ontario, each with distinct geologic settings and different social and economic landscapes, adding complexity to the decision-making process. Both of the potential repository sites are located within the province of Ontario, a region that hosts 20 out of the 21 nuclear reactors in Canada and serves as the primary storage site for the country's spent fuel waste.[11,24]

7-1- NWMO Plan: Environmental Perspectives

The first site is located to the north of the town of Ignace and the territory of the Wabigoon Lake Ojibway First Nation. This site is situated within the classic Canadian Shield landscape of northwestern Ontario, composed of a mountain belt that existed billions of years ago. The proposed site is positioned within a substantial expanse of granitic rock referred to as the Revell Batholith. Granite, owing to its strength, which facilitates the maintenance of open shafts during construction and operation, as well as its low porosity and permeability, is generally regarded as an ideal candidate for building repositories. The proposed site also shares similar geological and geochemical characteristics with repository sites in Finland and Sweden. This similarity means that there is a wealth of international experience and expertise that can be drawn upon when it comes to the construction of a repository in granite.[11] Another potential DGR site is in southern Ontario, nestled within the heart of agricultural land in the town of Teeswater. This site falls under the jurisdiction of the municipality of South Bruce and resides on Saugeen Ojibway First Nation territory. In contrast to the igneous rocks found at Ignace, the municipality of South Bruce sits atop sedimentary rocks that have existed for hundreds of millions of years. Specifically, the repository would be situated in clay-rich limestone, which is an attractive choice due to its strength and low permeability. Additionally, a tight shale layer is directly above the limestone, providing an additional barrier to potentially delay the migration of any escaped radioactive materials toward the surface. It's worth noting that this selection of clay-rich limestone as a repository site is quite unique, with no comparable rock type under consideration for such a purpose anywhere else in the world.[11]

Overall, the proposed disposal concept remains consistent for both sites. The primary difference between the two sites is the spacing of these containers. In the granitic site located in northern Ontario, they would be positioned closer together, while in the sedimentary site in southern Ontario, they would be spaced farther apart. This adjustment in container spacing is necessary to ensure that the lower repository temperature is maintained.[11]

7-2- NWMO Plan: Stakeholders' Perspectives

The Canadian plan for geologic disposal of nuclear waste was progressed based on investigations conducted at the country's underground research laboratory in Whiteshell, Manitoba. The environmental impact assessment for this plan, submitted in 1994, outlined the strategy but did not specify a particular repository site. Following this, a series of public consultations were held in five provinces: Saskatchewan, Manitoba, Ontario, Quebec, and New Brunswick. In 1998, the Seaborn Panel, a federal environmental assessment review panel, determined that while the proposed plan was technically sound, it lacked sufficient public support to be deemed feasible. The panel put forth numerous recommendations, with a strong emphasis on the need for "*early and thorough public participation in all aspects of managing nuclear fuel wastes*" for any future plan to succeed in Canada. Consequently, Canada returned to the drawing board to amend its approach to nuclear waste disposal.[25] Hence, the NWMO plan currently involves a wide range of people from diverse groups, including the people in the nuclear industry, CNSC, NWMO, scientists, workers, and local people. Furthermore, the challenges belong to a very unusual timeframe. The management of nuclear waste inherently encompasses a vast scope, affecting numerous societies, both in the present and far into the future, often beyond our current imagination, necessitating multi-generational strategies.[26]

The NWMO has emphasized that even if local municipalities or townships support their plans, they will not proceed without the consent of the Indigenous communities. To achieve this, the NWMO has been actively engaging in direct communication and collaboration with local First Nations communities from the very beginning of the Adaptive Phased Management Plan. Recently, Indigenous groups have started to participate in environmental assessments of nuclear waste proposals. They want to ensure that they have informed consent before approving the waste projects.[11] However, obtaining Indigenous consent is a complicated process. For instance, while the Vice President of Indigenous Relations, Bob Watts, believes that storing nuclear waste in a DGR does not raise significant concerns due to the scientific basis supporting it, some local communities are not convinced of its safety issues, and they still oppose the NWMO plan. For instance, sea levels are increasing and water may penetrate the DGR barrier system due to global warming.[27] Despite this opposition, various communities have voluntarily participated in the initial assessment to determine the suitability of their geological location as a DGR site selection process in the past decade. Currently, the ongoing siting process is exclusively focused on two potential locations: Ignace and South Bruce.[24]

It is worth noting that hosting a DGR could bring significant benefits to the host community. In the case of the Ignace site, the local economy has traditionally relied on mining and forestry, industries that are vulnerable to economic fluctuations and often experience "boom-and-bust" cycles. By hosting a nuclear waste repository, the community could potentially have a more stable and long-lasting source of economic activity for decades to come. However, since there is no prior experience with the nuclear industry in the area, NWMO would need to help the local community become familiar with it, which could pose a challenge. In contrast to the Ignace site, the South Bruce area has a well-established history with the nuclear industry. Not far from the proposed repository site, Bruce Power operates the largest nuclear power plant in Canada, providing employment opportunities for many local residents.[11]

7-3- NWMO Plan: Societal Perspectives

In addition, NWMO should ensure that the host community is informed prior to expressing consent. However, ascertaining whether a community is fully informed about a technically complex proposal is a difficult task. Experts in social science argue that people do not necessarily need a detailed technical understanding of a project to express their priorities for their community confidently and effectively. Instead, being "informed" can also encompass having an awareness of the project. Surveys conducted by NWMO and Ontario Power Generation reveal that only 60 percent of residents in South Bruce and its surrounding areas are aware of the site selection process.[28] A low turnout in a referendum, for instance, could suggest a lack of willingness, a lack of information, or possibly both. Once the township of Ignace, Wabigoon Lake Ojibway Nation, the municipality of South Bruce, and Saugeen Ojibway Nation have officially communicated their willingness to host the repository, NWMO will choose the final location.[11]

The proposed DGR site will be also subjected to an integrated assessment process by the new *Impact Assessment Act* of 2019, which mandates an examination not only of environmental impacts but also of social and economic impacts. This assessment process essentially involves a joint review conducted by the CNSC and the new Impact Assessment Agency. In addition, while the government bears the formal responsibility for consultation, NWMO will be required to demonstrate that they possess a comprehensive understanding of how a DGR will affect local First Nations communities. Additionally, they will have to showcase their engagement efforts with these affected Nations to eliminate any concerns.[11] The Government of Canada has a constitutional obligation to consult with Indigenous communities before taking any action that could potentially affect their traditional or treaty rights. Inadequate consultation with Indigenous nations in Canada can result in legal action and potentially significant financial penalties.[29] This unique process of Indigenous consultation adds complexity to the definition of a consent-based approach when selecting a DGR site, compared to many other countries. Therefore, there is a clear process to ensure engagement with First Nations is not simply a box-checking exercise in Canada. However, it is unclear how the NWMO plan would proceed if the next generations of Indigenous people choose to revoke their consent.

8- Summary

The disposal of nuclear waste is a demanding topic, and the existing methods, whether it is temporary storage in spent fuel pools or storage in geological repositories, both face the risk of corrosion-related problems. Any failure in these storage methods can potentially lead to the release of radioactive materials into the environment. To avert such catastrophic scenarios, people in the nuclear industry consistently monitor and maintain these storage facilities endlessly and attempt to improve the plans designed to store nuclear waste.

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