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REVIEW ARTICLE

CURRENT PRACTICES AND EFFICACY OF IMPROVEMENTS IN RADIOACTIVE MANAGEMENT SYSTEM OF PAKISTAN – A REVIEW

Sofia Laraib, Sana Zulfiqar*, Noshabah Tabassum, Shakira Mukhtar

Department of Environmental Sciences, Fatima Jinnah Women University, Rawalpindi, Pakistan
****Corresponding Author Email: sanazulfiqar@fjwu.edu.pk.***

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ABSTRACT

Radioactive materials are characterized by continuous emission of radiations that cannot be controlled by chemical methods. The high energy radiations pose threat to both environment and life forms. Nevertheless, they are also used in number of anthropogenic activities. Radioactive and nuclear advancements are the signs of industrial development, but simultaneously proper handling and management of radioactive waste is a paramount problem in developing countries like Pakistan. This article will explain Pakistan's current status for the safe management of radioactive waste, its limitations and what will be the possible alternatives to these problems. It also highlights various waste management and disposal strategies opted in Pakistan. Strategic division plan (SDP), PNRA, PAEC are the supreme bodies dealing with the facilities and licensing of radioactive waste.

KEYWORDS

Radioactivity, Waste, Management, Geology, Disposal, Environment

1. INTRODUCTION

Radioactivity refers to the disintegration of atomic nuclei into energetic radiations; α-alpha, β-beta and γ-gamma particles. These radiations can penetrate and decay other materials releasing large amount of energy. Radioactive substances are those that possess radioactive properties. The radioactive property of number of elements such as uranium, radium etc. have been used to generate electricity, and other useful purposes [1].

In this era of rapid industrialization, the energy demands are increasing and merely the reliance on fossil fuels does not fulfill the energy requirements. The access to renewable sources of energy is also limited, shifting the focus to nuclear energy as an alternative. The nuclear reactions are the hub of radioactive processes, which implies that the development of nuclear technology generates a large amount of radioactive waste [2].

Radioactive waste is also called as *Radwaste.* The term "radioactive waste" is used to refer to the residual content of nuclear processes, either anthropogenic or naturally present in the environment [3]. Radioactive waste tends to decay and emit radiations continuously, posing serious threat to the environment and public health. The material has radionuclides that are unstable atoms of an element that decay, emitting energy in the form of radiation. Different radioactive materials have different emissions depending upon their nature [4].

A crucial property of radioactivity is that it can neither be destroyed nor neutralized by chemical methods [5]. Through the environmental carriers, such as water and air, they are carried to the water bodies, soil and may accumulate in living species, therefore increasing the exposure to humans. The resultant adverse impacts demand adequate treatment and management of the radioactive waste prior to disposal, and to avoid any accident [6].

International Atomic Energy Agency (IAEA) has categorized radioactive waste into six classes based on their radioactivity. *Low Level Waste (LLW)* consists of materials with short span radioactivity and may include paper, clothing, tools etc. *Intermediate-level waste (ILW)* have high relative radioactivity and involves metal fuel, resins and chemical sludge. *High Level Waste (HLW)* is the most persistent with high radioactivity, and directly obtained from nuclear plants and processes itself [7]. *Very low-level waste (VLLW)* refers to the material obtained from construction or demolition of nuclear facilities. *Very short-lived radioactive waste* is obtained from medical and research institutes and have very short half-life. *Exempt waste* contains very low radioactive content and requires no regulation [8].

Radioactive waste management deals with the precarious waste originating from various sources like nuclear power reactors, application of radionuclides in medical, research and agriculture etc. The main organization playing a leading role in Pakistan for the safe management of radioactive waste is *Pakistan Atomic Energy Commission (PAEC),* while the sole entity for dealing with the facilities related to ionizing radiation and safe disposal of radioactive waste is *Pakistan Nuclear Regulatory Authority (PNRA)* [9].

Current advancements in nuclear renewable energy resources have paved a path leading to the sustainability and greener future. But simultaneously the improper handling and management of radioactive materials have serious implications on environment and human health. Improper handling may lead to health impact like transmission of infectious diseases like neurological disorder, HBV, HCV, TB, Mutagenicity, typhoid etc. as well as mutations in the natural genes and various genetic disabilities that persist into generations [10]. According to a global inventory of uranium mining and milling UMM, 1.2 billion tons of radioactive waste is being reported in national profiles in which 75 % is reported to be in storage while 25% is in final deposit (Figure 1).

This review paper provides the comprehensive information regarding the current radioactive waste management practices in Pakistan. It also explores possible disposal methods so that the detrimental environmental impacts can be reduced.

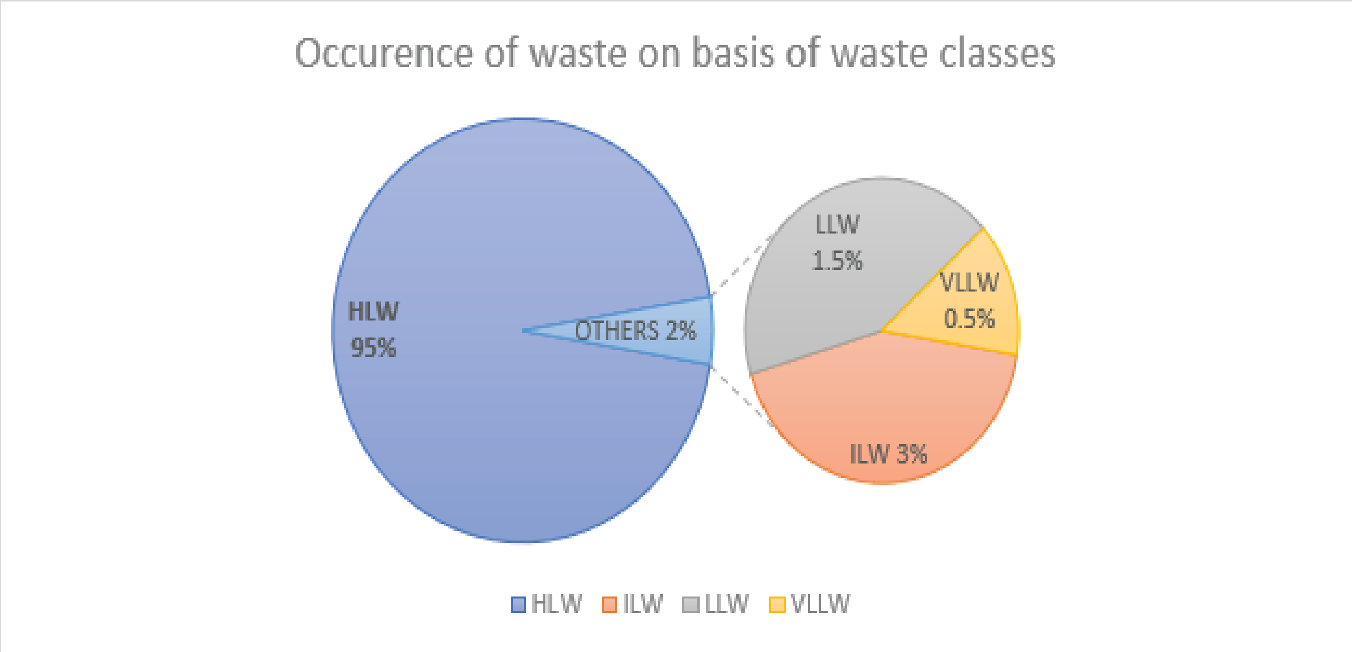

Figure 1: (IAEA, 2018)

2. METHODOLOGY

Relevant research article, news articles and databases of various organizations of national and international level have been consulted to analyze the various trends implemented for radioactive waste management in Pakistan and alternatives for the improvement of waste disposal system.

3. RESULTS AND FINDINGS

Nuclear development and the production and management of radioactive waste are the two frontiers for the development of any country. Wiser management and proper disposal of radioactive waste are the ways to the sustainable nuclear energy production. Three basic doctrines opted by developing countries for the management of radioactive waste are concentrate-and-contain, dilute-and-disperse and delay-and-decay. While in developing countries like Pakistan radioactive waste disposal is still underprivilege [11]. Radioactive waste generated is categorized based on their forms i.e. solid, liquid and gaseous.

Solid radioactive waste collected at *Karachi Nuclear Power Plant* (KANUPP) usually contains spent fuels, LLW (combustible), LILW (noncombustible), spent resin and used Ra needles. The fate of these component differs from each other depending upon their radioactivity. The spent resins and LILW are directed to the storage after processing while LLW are taken for incineration and stored in trenches after being sealed in plastic bags. Ra needles collected mainly from Sindh and Baluchistan, after being conditioned in cement tanks, are disposed of in trenches. Liquid waste is first converted into low level waste in storage and after dilution the waste is discharged in sea. Radioactive waste in the form of gasses are passed through various filters and then discharged through stack.

Radioactive waste collected at *Pakistan Institute of Nuclear Science and Technology* (PINSTECH) is first segregated into solid liquid and gaseous waste and then dispose of in various forms. Solid waste comprising of LLW (compactable), ILW (non-compactable) are directed to the trenches for near surface disposal while (disused sealed radioactive sources) DSRS collected mainly from Punjab, KPK, AJK and federal area conditioned in cemented slots and then directed to the storage. LLW and ILW in liquid form are stored in underground trench for decay and delay and discharged in shallow ground pits. Gaseous waste at the site is filtered by using charcoal and HEPA (high efficiency particulate absorbing) and discharged through stack in the air.

Solid waste collected at *Chasma Nuclear Power Plant* (CHASNUPP) powerplant mainly consist of spent resin, decontaminated equipment, spent filters and contaminated soft waste are directed to the interim storage. Liquid waste composed of clean drains, process drains, floor and chemical drains are directed to the interim storage after being conditioned and evaporated in storage tanks. Gaseous waste is collected and discharge after filtration [12]. By 2030, Pakistan has set goal to produce 8,800 MW of nuclear energy with the Chinese assistance.

4. DISCUSSION

Waste constitutes a big hazard and therefore cannot be disposed loosely in the environment. Radioactive waste has a life of about 10,000 years and more, so safe disposal is an art and engineering challenge. Solid waste is first compacted, conditioned and then disposed in the trenches or deep down the earth crust whereas liquid waste is first decayed, diluted and then disposed [13]. There are many techniques and modes for ensuring the safe disposal of waste.

In Pakistan the LLW is being disposed at New labs, PINSTECH. PINSTECH (Pakistan Institute of Nuclear Science and Technology) is trenches type disposal site located in the capital city, Islamabad with the depth of 4m and capacity of 180m^3. It started operation in 1998 and is still working [14].

Whereas for the disposal of other waste classes there are different modes (Table 1).

Table 1: Facilities foresaw for the Disposal of Radioactive Waste [15].

Class of Waste	Disposal locale
Very low-level waste	Surface disposal in earthen trenches
Low and Intermediate level short lived waste	Near surface
Low and Intermediate level long lived waste	Intermediate depth/ deep geological area
High level waste	Deep geological location

4.1 Geological mode of isolation and disposal

Geological repository involves radioactive waste disposal deep within the earth's crust. The depth should be more than 1500 ft. whereas deep holes are at 4000 ft. below surface. It is proven good in a sense that the impervious rock can be located for disposal. There are two types of storage tanks bare fuel (metal shielded) cannisters or casks-based system and storage module (concreate shielded) or concreate cannisters. These casks can store the waste for temporary period but if they are buried in the earth's crust they can be properly disposed. Fabrication done with metal shielded casks mainly of noble metals or carbon steel because it will resist corrosion [16]. Pakistan have two working fabrication plants; *Pakistan Nuclear Power Fuel Complex* located 175 km south near Islamabad and *Kundian Nuclear Fuel Complex*.

There are several limitations to the geological mode of disposal i.e., waste due to its heat can melt rocks, uncertain chemical reactions could occur, unreliable soil stability, groundwater contamination and unpredictable seismic activity [17]. It demands the adoption of non-geological techniques to dispose radioactive waste as an alternative.

4.2 Alternate isolation and disposal methods

4.2.1 Space disposal

Outer space is an ideal disposal site for radioactive waste. Waste can be placed in orbital transfer by vertical spacecraft and ejected to other planet or stars in the outer space. NASA is much interested in making this alternative feasible in near future. There are few limitations to this approach; due to the presence of gravitational force, it needs very high energy to get out of this, ozone depletion will occur and there will be more UV rays reaching earth and transportation to ejection site is difficult and if spacecraft fails to lift returns, radioactivity will spoil the stratosphere of earth [18]. The space disposal of HLW is creatively redesigned for the safety and achievement of efficiency. The package will allow to fly low until it attain the earth's escape velocity to avoid the probability of falling back on the land in case of any malfunctioning. The package will be monitored by various space watchdogs and there are specific lunar points where these packages will park and make disposal possible [19].

4.2.2 Ice disposal

Ice disposal is another alternative for radioactive waste disposal. The waste is buried in deep ice beds i.e. Pacific or Antarctica and all radioactive waste will be best cooled by ice. The cask or canister is buried about 1 mile under surface and allow it to melt downward for about 5-10 years. Anchored cables can be used for retrievability of cask in a period of 200-400 years and will reach bottom in 30,000 years approximately [20]. A spherical container of size $3x10^7$ with a radius of approximately 0.2m can hold HLW of the whole world for 30 years. These containers can be buried underneath the ice sheets at the depth of about 20-100 m of Greenland or Antarctica. This method of disposal is much environmentally friendly because any catastrophe like climate change or snowmelt may not cause contamination of radioactive waste [21].

4.2.3 Transmutation

Transmutation is an alternative method to geological disposal. It includes the transformation of radionuclides of longer life span to their short-lived isotopes. It greatly reduces the residence period of radioactive substances, minimizing the exposure to the living species. Nevertheless, the unwanted fissional products may also produce. The radioactive waste is separated into various parts according to their final use or disposal procedures, and then various actions are performed to convert them into relatively less toxic actinides [22]. The process is carried out by nuclear explosion, fission reactors, fusion reactors and charged particle accelerator but its economically expensive method.

4.2.4 Seabed disposal

Radionuclides possess long lives usually thousands of years. Prolonged exposure to living species is hazardous and serious threat to public health. The scenario demands isolation of radionuclides, far away from the human environment. The seabed disposal is one of the solutions [23]. The sequestration hole is drilled in the sea bed. The radioactive waste is contained in the designed containers, shifted to ships and transferred to the sea-bed repository [24]. The waste is enclosed in concreate cannisters which is transferred into seabed and guided to drilled hole. It can dispose as much as $400m^3$ per year, but this method is too tricky and reliable for waste from few reactors [25]. The sea bed disposal method is reported to have few environmental impacts, including contamination of immediate sea-water. Moreover, it's an expensive method of radioactive waste disposal.

5. CONCLUSION

Generation of Nuclear energy is beneficial because of no carbon emissions, renewable energy resource, industrial development and economic feasibility however the radioactive waste produce during the generation and the consumption of this energy implicate detrimental effects on environment as well as on human health. Moreover, the mitigation and disposal cost of radioactive waste are too exorbitant for the developing countries like Pakistan. To overcome these challenges there are several alternatives for the handling of radioactive waste and reducing the production of this kind of waste where possible. Also, at government level the national policies regarding radioactive waste are being formulated and implemented for lowering the threats of any serious disasters in future.

REFERENCES

[1] Rutherford, E., Chadwick, J., Ellis, C.D. 2010. Radiations from radioactive substances. Cambridge University Press.

[2] Zhang, X., Gu, P., Liu, Y. 2018. Decontamination of radioactive wastewater: State of the art and challenges forward. Chemosphere.

[3] Thakur, M.A., Jadhav, M.M., Chavan, M.N., Ranveer, M.A. 2015. Radioactive Waste Management. International Journal of Innovations in Engineering Research and Technology. (IJIERT), 2(5), 8.

[4] Merk, B., Litskevich, D., Bankhead, M., Taylor, R.J. 2017. An innovative way of thinking nuclear waste management–Neutron physics of a reactor directly operating on SNF. PloS one, 12(7), e0180703.

[5] Chulikov, V., Pauls, A., Savchenko, V. 2014. Transmutation of Radioactive Waste.

[6] Ikemoto, T., Magara, Y., 2011. Measures against impacts of nuclear disaster on drinking water supply systems in Japan. Water Practice & Technology, 6 wpt20110078.

[7] Ali, S.H.A., Iqbal, S., Awan, M.S. 2015. Nuclear Waste and Our Environment. American Journal of Social Science Research, 1(2), 114-120.

[8] International Atomic Energy Agency. 2018. Status and Trends in Spent fuel and Radioactive Waste Management, IAEA Nuclear Energy Series No. NW-T-1.14, Vienna.

[9] Pakistan Nuclear Regulatory Authority (PNRA): Convention on Nuclear Safety, Report by the Government of Islamic Republic of Pakistan for the seventh review meeting, 2018.

[10] Nasir, T., Ali, S., Farid, M., Shahbaz, M., Rizwan, M., Hannan, F., Ahmad, R. 2015. Infectious and Radioactive Waste Management in a Diagnostic and Nuclear Medicine Centre. American Journal of Environmental Protection, 4(5), 245-250.

[11] Arshad, S.H., Ali, Iqbal, S., Awan, M.S. (May 27, 2015). Nuclear Waste and Our Environment. American Journal of Social Science Research, 1(2), 114-120.

[12] Shah, Z. 2014. Current Status of Radioactive Waste Management in Pakistan. Retrieved November 26, 2018, from https://gnssn.iaea.org/.../Current status of NSDF-24-2-14.pdf

[13] Chapman, N., Hooper, A. 2012. The disposal of radioactive wastes underground. Proceedings of the Geologists' Association, 123(1), 46-63.

[14] Cuccia, V., Uemura, G., Ferreira, V.V.M., Tello, C.C.O.D., Malta, R.S.V. 2011. An updated overview of low and intermediate level waste disposal facilities around the world.

[15] Mannan, Latif. 2014. Radioactive waste management, Asian Nuclear Safety Network, International Atomic Energy Agency.

[16] Krauskopf, K. 2013. Radioactive waste disposal and geology. Springer Science & Business Media, 1.

[17] Khopkar, S.M. 2015. Environmental Pollution Monitoring and Control. Second Edition, pp. 541, New Age International (P) Ltd., Publishers, New Delhi, ISBN: 978-81-224-3804-8

[18] Alexander, W.R., McKinley, L. (Eds.). 2011. Deep geological disposal of radioactive waste, 9.

[19] Kim, H., Park, C., Kwon, O.J. 2016. Conceptual design of the space disposal system for the highly radioactive component of the nuclear waste. Energy, 115, 155–168. https://doi.org/10.1016/j.energy.2016.09.012

[20] Brookins, D.G. 2012. Geochemical aspects of radioactive waste disposal. Springer Science & Business Media.

[21] Philberth, K. 2018. The Disposal of Radioactive Waste in Ice Sheets. Journal of Glaciology, 19(81), 607-617. doi:10.3189/S0022143000215517

[22] Gonzalez-Romero, E.M. 2011. Impact of partitioning and transmutation on the high-level waste management. Nuclear Engineering and Design, 241(9), 3436-3444.

[23] McAllister, K.R. 2013. Sub-Seabed Repository for Nuclear Waste-a Strategic Alternative-13102. WM Symposia, 1628 E. Southern Avenue, Suite 9-332, Tempe, AZ 85282 (United States)

[24] Hollister, Charles D., Steven Nadis. 1998. Burial of Radioactive Waste Under the Seabed, Scientific American, 278(1), 60-65.

[25] Vesilind, P.A., Peirce, J.J., Weiner, R.F. 2013. Environmental pollution and control. Elsevier.