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T01 - ADNAN .

Integrated Modeling Approach for Wasteform Degradation in Disposal Environments: Utilizing Phreeqc and GOLDSIM Software

T02 - GUPTA Merry

Thermal spike effects in swift heavy ion irradiated zirconolite

T03 - PARVEEN SINGH -

Integrating Artificial Intelligence in Degradation Modelling of Disposed Radioactive Wasteforms

T04 - STEPANYAN Yervand

Radioactive Waste Management at the Armenian Nuclear Power Plant.

T05 - XU Kai

Volatilization and Precipitation of Troublesome Elements during HLLW Vitrification

T01

Integrated Modeling Approach for Wasteform Degradation in Disposal Environments: Utilizing Phreeqc and GOLDSIM Software

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This research abstract proposes an exploration of the utilization of Phreeqc and GOLDSIM software for wasteform degradation modeling in a disposal environment. The objective of this study is to develop a comprehensive understanding of the long-term behavior and performance of wasteforms, specifically focusing on their degradation processes and potential impacts in a disposal setting.

The research methodology involves the integration of experimental data, theoretical modeling, and the combined use of Phreeqc and GOLDSIM software. Experimental data will be collected through laboratory analysis and characterization of wasteforms and disposal environment, including their chemical composition, physical properties, and degradation kinetics. These data will serve as input parameters for the modeling process.

Phreeqc, a geochemical modeling software, can be utilized to simulate the complex chemical reactions occurring within the wasteforms and the surrounding disposal environment. It will help to evaluate the dissolution, precipitation, and geochemical interactions of the wasteform components over time. The outputs from Phreeqc will be further integrated into GOLDSIM, a dynamic simulation software, to model the overall degradation behavior and predict the release of radionuclide from the wasteforms into the surrounding medium.

The outcomes of this research will contribute to a better understanding of wasteform degradation in disposal environments and its potential environmental impacts. By combining Phreeqc and GOLDSIM, the study aims to simulate the degradation processes, assess the long-term behavior of wasteforms, estimate the source term, and subsequently transport of radionuclide along environmental media pathways.

Furthermore, the research will provide insights into the optimization of waste management strategies by evaluating the performance of disposal facilities, including engineered barriers and monitoring systems. The modeling results obtained through Phreeqc and GOLDSIM will inform decision-making processes related to engineering design, long-term safety assessments, and regulatory compliance of disposal facility.

In conclusion, this research abstract proposes the utilization of Phreeqc and GOLDSIM software for wasteform degradation modeling in a disposal environment as part of the ICTP Workshop. The research aims to develop a comprehensive understanding of wasteform behavior, contribute to waste management strategies, and ensures the long-term safety and environmental sustainability of disposal facilities.

T02

Thermal spike effects in swift heavy ion irradiated zirconolite

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Zirconolite considered as a potential candidate for the immobilization of high level radioactive wastes, has been studied with swift heavy ions (120 MeV Au^{9+}) to account its behaviour in electronic regime [1]. *In-situ* X-ray diffraction (XRD), offline SEM and TEM microscopy have been employed to analyze the structural damages so produced by irradiation in single phase prepared samples of monoclinic zirconolite structure (2M-type) [2]. Step-wise structural modifications in the form of loss of crystallinity, broadening of diffraction peaks along with appearance and enhancement of broad amorphous hump have been observed in irradiated XRD patterns. The trend of fluence dependent amorphous fraction infers the formation of ion tracks due to thermally induced spikes in the lattice along the ion trajectory. Further, the track diameter determined from thermal spike model calculations is ~7 nm, which is found to be similar as observed from XRD, SEM and TEM analysis. Irradiation induces strains and defects/vacancies along with swelling of the crystal lattice. Besides, complete amorphization is not achieved even on irradiation at the highest fluence of 1×10^{14} ions/cm^2. Moreover, nano-grain formation has been observed at such a high fluence.

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T03

Title: Integrating Artificial Intelligence in Degradation Modelling of Disposed Radioactive Wasteforms

Abstract: The disposal of radioactive waste is a significant environmental and health concern, and accurate modelling of waste degradation is essential to ensure safe disposal. Traditional methods for modelling degradation rely on empirical data and manual input, which can be time-consuming and prone to errors. In recent years, the integration of artificial intelligence (AI) techniques in degradation modelling has shown promising results.

This poster explores the potential of AI in degradation modelling of disposed radioactive wasteforms. Specifically, the use of machine learning algorithms and deep learning neural networks to predict degradation rates and estimate the remaining lifespan of wasteforms will be discussed. Additionally, the use of data mining techniques to identify patterns and correlations between degradation factors will be highlighted.

The benefits of integrating AI in degradation modelling of disposed radioactive wasteforms include increased accuracy, efficiency, and reduced costs. This approach can also lead to the discovery of previously unknown relationships between degradation factors and inform future waste disposal strategies.

References:

1. Y. Zhang, J. Yang, and Z. Liu, “A review of artificial intelligence in radioactive waste management,” J. Environ. Radioact., vol. 192, pp. 23–29, 2018.
2. P. H. L. Nadeeka, et al., “Degradation modelling of disposed radioactive wasteforms: A review,” J. Environ. Manage., vol. 242, pp. 12–26, 2019.
3. S. Khodayarifard and S. Zakeri, “Application of artificial neural networks in prediction of leaching behavior of radioactive wasteforms,” Environ. Monit. Assess., vol. 186, no. 9, pp. 5621–5631, 2014.

T04

Radioactive Waste Management at the Armenian NPP

Lead Engineer of Ageing Management Group of the Armenian NPP, Yervand Stepanyan

National Legislative Bases in the field of Radioactive Waste Management:

- Law of the Republic of Armenia “On the Safe Use of Atomic Energy for Peaceful Purposes”. ՀՕ-285 01.02.1999
- Law of the Republic of Armenia “On Licensing”. ՀՕ-193 08.08.2001
- “Radiation Safety Standards”. Decree of the Government of the Republic of Armenia 1219-Ն 18.08.2006
- “Order of Radioactive Waste Management”. Decree of the Government of the Republic of Armenia 631-Ն 04.06.2009
- “Radiation Safety Rules”. Decree of the Government of the Republic of Armenia 1489-Ն 18.08.2006.

Relevant Regulatory and Operational Documents which includes:

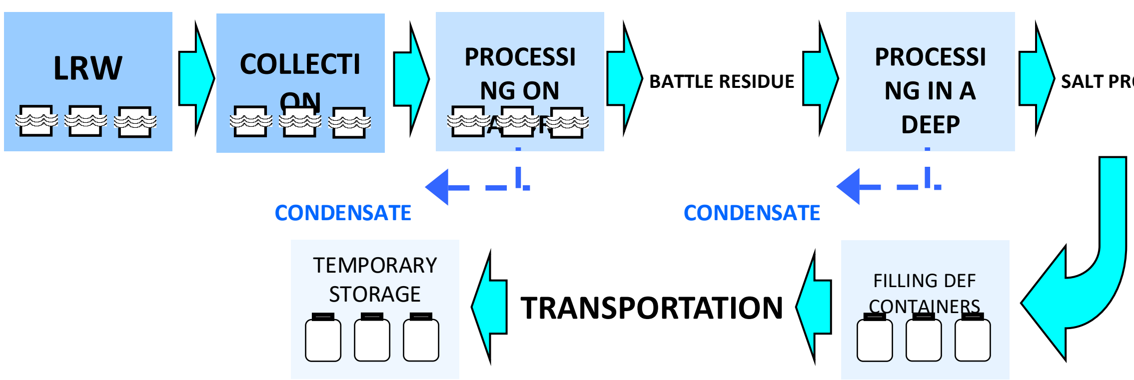
- Regulatory documents, national norms and standards;
- Quality Assurance Programme and Administrative Management Programme for RW Management at the ANPP;
- Guidelines, procedures and programmes for RW management at the ANPP.

These documents define procedures for RW management, people in charge, RW transportation routes, their accountancy, and methods for monitoring the condition of storage facilities.

Radioactive waste at the Armenian NPP is generated during daily cleaning and decontamination of the premises of the Controlled Access Area (CAA), during equipment decontamination and repair, during maintenance activities in the CAA, etc.

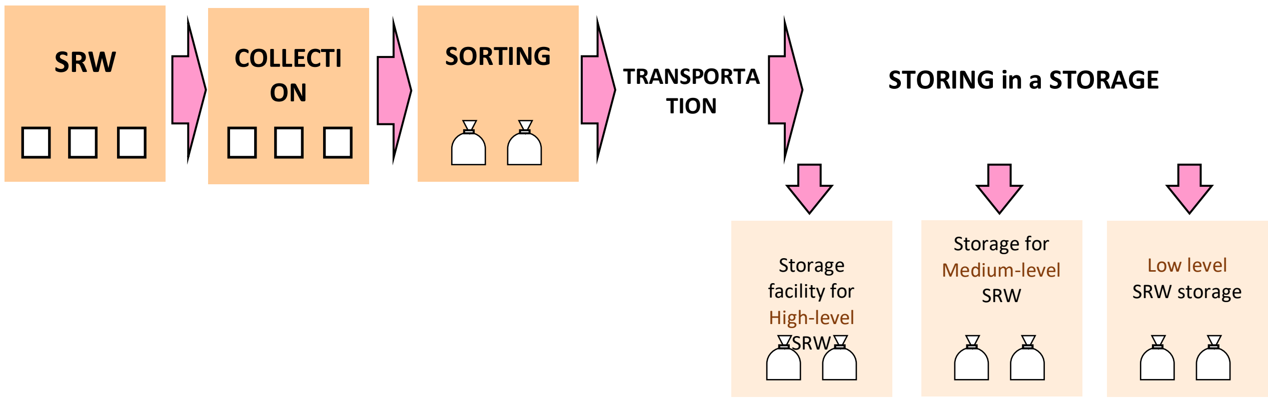
The RW also includes parts of process equipment that cannot be decontaminated or irradiated in the reactor, instrumentation, pipeline or protection fittings, overalls and personal protective equipment contaminated above acceptable standards, ventilation system filters, spent sources of ionizing radiation, appliances, water from special laundry rooms, sanitary locks, sanitary inspections, etc.

Liquid Radioactive Waste handling by following scheme:



Liquid radioactive waste is processed on water purification system evaporators. To reduce the volume of LRW at the deep evaporation facility (DEF), the distillation residue is processed to a salt concentrate, which is poured into metal barrels in a hot molten state, turning into a monolith after cooling.
DEF containers are located in a reactor auxiliary building, in a solid intermediate level waste storage facility and at a site for temporary storage of DEF containers on the roof of the reactor auxiliary building.

Solid Radioactive Waste handling by following scheme:



As part of the activities to extend the life of the power unit 2 at the Armenian NPP, a "Programme of measures for management of radioactive waste present at the ANPP and generated during the additional life of the power unit 2 of the Armenian NPP" was developed.
The programme presents more than 50 measures for the management of radioactive waste available at the ANPP and generated during the additional life of the ANPP power unit 2 and a schedule for their implementation.
The term for the implementation of activities is planned to finish until 2026.

Significant activities that are planned in the framework of LTO

1. Construction of a hangar-type storage facility for low-level radwaste and medium-level radwaste storage in non-retrievable shielded canisters:
- Siting;
- Designing;
- Equipment and material procurement;
- Construction and commissioning.
2. Supply of non-retrievable canisters.
3. Replacement of deep evaporation facility (DEF):
- Equipment and materials procurement;
- Designing;
- Implementation of construction and installation activities, commissioning activities and required tests.
4. Procurement of 1000 pieces of metal canisters to contain salt cakes generated during processing at DEF.

T05

Volatilization and Precipitation of Troublesome Elements during HLLW Vitrification

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Vitrification has been considered the primary option for immobilization of the high-level radioactive liquid waste (HLLW), because of the relative simplicity of the process, the structural flexibility, and the good long-term durability of glass. However, the high temperature (~1150 °C) of glass melting would induce the loss of volatile species including radionuclides (such as Tc) and non-radioactive elements (such as Na and B) [1,2]. The loss of radionuclides would bring about the environmental issues, while the loss of Na and B would cause fluctuations in composition and consequently affects the properties of the glass products. On the other hand, since the high density and the low solubility of platinum group metals (PGM, including Ru, Rh and Pd) in the glass, PGM could easily precipitate in the bottom of the glass melter that would cause serious operation accidents during vitrification of HLLW [3]. In order provide the fundamental basis for the safe and efficient operation of the HLLW melter, this work will present our recent studies on the volatilization behaviors of Re (surrogated for Tc) and non-radioactive elements including Na and B during HLLW vitrification, as well as the precipitation behaviors of PGM in the simulated glasses.

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