



PROGRAM AND ABSTRACTS

Research Conference on Post-accident Waste Management Safety (RCWM2016)

November 7, 2016
Iwaki Business Innovation Center “LATOV” 6F
(Iwaki-city, Fukushima)

Organized by
Collaborative Laboratories for Advanced
Decommissioning Science
(CLADS)

Japan Atomic Energy Agency (JAEA)

Research Conference on Post-accident Waste Management Safety (RCWM2016)

Greeting

Thank you for your participation in the “Research Conference on Post-accident Waste Management Safety (RCWM2016)”. The purpose of this conference is to provide the place and occasion to share the experiences in safe handling and management of radioactive waste in order to promote the research activities in Japan.

Purpose

To accomplish the decommissioning of the Fukushima Daiichi Nuclear Power Station (NPS), we need to gather the knowledge of domestic and foreign experts, and share understanding of the present needs and future issues. It is also necessary to strengthen R&D activities in the waste management field.

Collaborative Laboratories for Advanced Decommissioning Science (CLADS) is responsible to promote international cooperation in the R&D activities on the decommissioning of Fukushima Daiichi NPS and to develop the necessary human resources.

In this conference we hope that international experts share the information on the present state of Fukushima Daiichi wastes and the wider experiences in the waste management.

Toru Ogawa
Director General of CLADS

Program

- 12:00- Registration
- 13:00-13:05 Opening Remarks T.Ogawa (CLADS)
- 13:05-13:35 [“Management of Solid Waste Arising from Fukushima Daiichi Decontamination and Decommissioning”](#)
Mr. T.Kobayashi (TEPCO HD)
- 13:35-13:55 [“Activities of CLADS Waste Management Division”](#)
T.Ashida (CLADS)
- 13:55-15:25 Session 1 Experiences of waste management in countries
Facilitator: K.Kostelnik (CLADS)
- [Legacy Waste Management in the United States](#)
Mr. R.Seitz (SRNL)
 - [Waste Management for Decommissioning in the UK](#)
Dr. R.Orr (NNL)
 - [Plan and Implementation of Nuclear Waste Management in Finland](#)
Dr. K.Rasilainen (VTT)
- 15:25-15:40 Coffee break
- 15:40-17:10 Session 2 Research activities of universities
Facilitator: Prof. S.Suzuki (U.Tokyo)
- [Recovery and Volume-reduction Solidification of Radioactive Elements from Solid Waste](#)
Prof. K.Takeshita (Tokyo Inst. Tech)
 - [Rapid Analysis of Sr-90](#)
Assoc. Prof. Y.Takagai (Fukushima U.)
 - [Activity of National Institute of Technology, Fukushima College](#)
Assoc. Prof. S.Suzuki (NIT Fukushima C.)
- 17:10-18:00 Poster presentation
- 18:30- Reception (LATOV 3F La•Pa•Pa)

Abstract

Management of Solid Waste Arising from Fukushima Daiichi Decontamination and Decommissioning

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1. Waste Arising from 1F Decontamination and Decommissioning

Not only large amount but also many kinds of radioactive wastes (gaseous, liquid and solid wastes) are generated by decontamination and decommissioning works in Fukushima Daiichi (1F), different from decommissioning at ordinary nuclear power stations. Most radioactivity has been concentrated in the solid wastes to be safely stored in 1F site and prevent release and dissemination of radioactivity to the environment.

2. Waste Flow from Waste Generation to Storage

These solid wastes have been temporarily stored in the tentative storage areas. Then, they are transferred to the storage buildings step by step and stored there until waste processing and disposal phase. However, because of the limitation of the capacity of the storage buildings, the wastes should be volume-reduced as much as possible and more stabilized to be able to put them into the storage buildings.

3. Current Status of Tentative Storage

At present, approximately 300,000m³ of rubble, etc. (rubble, felled tree, and used radioactive protective equipment) stored in 1F site are categorized as follows: (1) Rubble (contaminated metal, concrete, and miscellaneous combustible materials, etc.) stored in tentative storage areas, such as outdoor, sheet covered, container, or soil covered storage, etc. depending on their surface dose rate, (2) Felled trees (trunks, roots, leaves and branches) stored in outdoor accumulation or underground storage pools to reduce fire risks, and (3) Used radioactive protective equipment (coveralls, masks, shoes, and gloves, etc.) stored in outdoor container prior to incineration. In terms of the secondary wastes arising from contaminated water treatment, (4) Used absorbent towers stored in racks or box culverts depending on required shield, and (5) Sludge and concentrated liquid stored in the existing buildings or tanks.

4. Future Challenge

The volume of rubble, etc. is estimated to reach 750,000m³ in 2028, which will exceed tentative storage capacity. Therefore, reuse and recycling process of low contaminated concrete and metals should be established to reduce the volume. In addition, the estimation of the waste volume should be precise as much as possible applying for knowledge and experiences obtained since the accident. Then volume reduction facilities and additional storage buildings will be designed and installed in a planned manner according to the volume estimation. Finally, tentative storage areas will be released step by step after newly installed storage buildings begin operation.

In terms of the secondary wastes generated in the process of contaminated water treatment system, the large size waste storage building will be constructed to accommodate the wastes from present racks and box culverts. However, because potential risk of leakage still remain, application of dehydration technology is under development using mock-up equipment by the International Research Institute for Nuclear Decommissioning (IRID) in order to stabilize the slurry wastes arising from multi nuclide removal facility (ALPS).

In addition, characterizing the wastes are indispensable for waste processing and disposal in future, so the new research laboratories will be constructed adjacent to 1F site by the JAEA.

Activities of CLADS Waste Management Division

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Introduction of CLADS

Collaborative Laboratories for Advanced Decommissioning Science (CLADS) of JAEA was established in 2015 to promote research and development towards the decommissioning of the Fukushima Daiichi Nuclear Power Station (1F). To achieve this mission, CLADS consists of four divisions.

- (1) Waste Management Division
- (2) Fuel Debris Handling and Analysis Division
- (3) Severe Accident Propagation Behavior Evaluation Division
- (4) Remote System and Sensing Technology Division

Main efforts of the CLADS are as follows;

- (1) Establishment of a platform to rally the wisdom of experts from around the world
- (2) Enhancement of in and outside Japan research on decommissioning
- (3) Enhancement of human resource development in mid-and-long term
- (4) Establishment of an information dissemination function

Additionally, as an international research and development base, “International Collaborative Research Building” has been constructing near the 1F as a core of the CLADS.

Research and Development of Waste Management

The accident at the 1F and restoration works have produced significant volume of various waste. The characteristics of the 1F accident waste are very different from usual waste generated from ordinal nuclear power stations. The research and development works such as characterization of the waste, investigation on safe storage, processing and disposal of the waste are carried out based on the “Mid-and-Long-Term Roadmap”[1]. The contents of R&D activities of CLADS Waste Management Division are as follows.

- (1) Characterization
 - Analysis of various wastes
 - Evaluation of the amount and composition of radioactivity
 - Collection of physical/chemical data
 - Development of analysis method
- (2) Storage
 - Soundness of stainless vessel used for cesium adsorption apparatus
 - Safety technology for storing nuclear accident-derived wastes
- (3) Processing
 - Technology survey
 - Fundamental test of solidification
 - Technology selection
- (4) Disposal
 - Understanding of the existing disposal concepts
 - Examination of disposal concept of accident-derived wastes
 - Examination of new disposal concept

These results are integrated to the basic concept of processing and disposal for solid radioactive waste shown in the Roadmap.

References

[1] Inter-Ministerial Council for Contaminated Water and Decommissioning Issues, Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO’s Fukushima Daiichi Nuclear Power Station, June 12, 2015.

Legacy Waste Management in the United States

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Introduction

Remediation efforts result in large amounts of waste, which has resulted in the need for a comprehensive waste management strategy that includes multiple treatment, storage and disposal options. The options involve considerations for waste acceptance criteria (WAC) and appropriate characterization and a variety of waste forms, containers, transportation options, as well as regulatory approaches that allow for public input. Dedicated on-site disposal cells have been developed at multiple United States Department of Energy (USDOE) facilities and new disposal capacity is being developed at commercial low-level waste (LLW) disposal facilities (see Fig. 1). Facilities designed for disposal of hazardous wastes are also being used for disposal of low activity radioactive waste resulting from remediation efforts. A number of USDOE and commercial facilities are designed consistent with requirements for disposal of hazardous wastes, and thus, are acceptable for disposal of mixed wastes comprising radioactive and non-radioactive hazards. These facilities have a range of different disposal capacities up to more than 15 million tons of waste.



Fig. 1: Facilities with liners and leachate collection systems used for disposal of remediation wastes at the USDOE Hanford (left) and Idaho (right) sites, respectively. The Idaho facility has been used for disposal of reactor vessels from decommissioned test facilities on site as well as a variety of other remediation wastes. (Courtesy: USDOE)

Regulatory Approach

Decision-making for remediation and disposal of mixed waste is conducted through a United States Environmental Protection Agency (USEPA) regulatory process involving a rigorous approach for evaluation of alternatives. The approach is conducted with requirements for public involvement, including external regulatory oversight. The generally applied approach involves nine criteria in a structured framework for decision-making (see Table 1). This process has proven to be very effective in evaluating options and communicating the benefits of the selected alternatives, including on-site disposal cells at the major sites. The USEPA has a number of prescriptive requirements (e.g., disposal facility design, waste treatment) that can have advantages for consistency and public acceptance, but can also pose challenges for unique site-specific wastes. The prescriptive design for disposal facilities has been very successful for public acceptance. However, the prescriptive approach for waste treatment can lead to situations where the standard treatment may not be optimal for a specific waste and it is necessary to justify a different approach. When it is necessary to model the performance of some waste forms for a performance assessment, there is a need to develop parameters to support the modeling effort. This has been a challenge, because the detailed data for a performance assessment are not typically collected to support disposal of hazardous wastes.

Table 1: Based on nine criteria used for decision-making.

<p>Regulatory</p> <ol style="list-style-type: none"> 1. Protection of Human Health 2. Compliance with Federal and State Regulations
<p>Optimization</p> <ol style="list-style-type: none"> 3. Long-term effectiveness (e.g., WAC and safety assessment) 4. Reduction of toxicity, mobility or volume of contaminants (e.g., treatment, containers) 5. Short-term effectiveness (e.g., worker protection, transportation) 6. Implementability at the site (e.g., WAC) 7. Cost effectiveness
<p>Stakeholders</p> <ol style="list-style-type: none"> 8. Regulatory acceptance 9. Community acceptance

Addressing Challenging Wastes

Remediation has resulted in the generation of a wide variety of wastes that have required a strategic approach to manage. The vast majority of the wastes are routine and relatively straightforward, although disposal capacity is needed (e.g., soils, lightly contaminated debris). However, a variety of specific, more challenging wastes are also produced (e.g., reactor components, ion exchange resins, etc.). These more unique wastes lead to challenges for identification of appropriate treatment and disposal options and also may test the standard regulatory approaches. Solid secondary wastes like ion exchange resins illustrate a variety of strategic challenges associated with remediation wastes in the United States. The presentation includes some practical handling and treatment challenges as well as challenges to identify inputs and assumptions required to model the waste forms.

For efficient identification of research priorities, it is critical to integrate the performance assessment activities with the research teams that conduct research to support the analyses. Initial performance assessment modeling is used to identify assumptions and parameters that are important for the conclusions of the analysis. The researchers and performance assessment modelers work together to identify key areas of need. This provides a benefit for the efficiency of the process (i.e., research is focused on the significant needs) and it also helps the researchers provide justification for the testing and characterization work that they will be conducting.

Summary

When considering alternatives for treatment, storage and disposal, there are a number of factors that are addressed in the national strategy. It is a combination of regulatory and technical challenges. The regulatory challenges include: balancing prescriptive and performance based approaches, establishing WAC for treatment and disposal facilities, implementing decision approaches capable of considering multiple criteria, and allowing for a transparent approach with public involvement. Technical challenges will typically focus on the most challenging, unique wastes. The technical efforts must consider WAC for treatment, storage and disposal facilities; transportation requirements; requirements for waste form and containers. The regulatory and technical considerations should be linked to the overall plan for remediation to help identify critical assumptions that may impact the options for final disposal of waste. Given the large amounts of input and assumptions for modeling, it is important to integrate data collection and modeling efforts to help prioritize efforts on the data and assumptions that are most significant for the decision to be made.

Waste Management for Decommissioning in the UK

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The United Kingdom was one of the first countries to adopt nuclear energy as a source of civil electricity production. Indeed, the UK Calder Hall nuclear reactors were, in 1956, the world's first to generate electricity on an industrial scale. Ultimately 26 Magnox reactor units (now closed), 14 Advanced Gas Reactor (AGR) units and one Pressurized Water Reactor (PWR) were built in the UK. To support the development and operation of the UK nuclear power station fleet, research/prototype reactors and research facilities were built as well as plants for enrichment of uranium, fuel fabrication, spent fuel storage and spent fuel reprocessing.

Several research/prototype reactors and other plants have already been successfully decommissioned in the UK but many nuclear facilities remain. The Sellafield site is the largest nuclear site in the UK and represents its largest decommissioning challenge. It is expected that decommissioning and site restoration will continue beyond the year 2100 [1]. Decommissioning the facilities will generate a range of wastes, the majority of which will be classed as Low Level Waste (LLW), destined for near-surface disposal [2]. However, particular challenges during decommissioning arise from the retrieval and management of Intermediate Level Wastes (ILW) and nuclear materials currently stored in legacy facilities.

In the early 1980s the UK initiated a programme to develop treatment processes for solid and slurry ILW from spent fuel reprocessing. A phased development approach was established, from laboratory scale experiments to commissioned plant operation. From this work, four waste cementation plants were built at Sellafield to process operational arisings from reprocessing. These plants have now been operating for over 25 years and produced more than 50,000 waste packages. Considerable experience has been established in the UK on the cementation of wastes, development of criteria for disposability [3] and the demonstration of wastefrom performance. This experience has been built on to manage decommissioning wastes.

The highest priority tasks at Sellafield are decommissioning the high-hazard legacy plants from historic fuel reprocessing operations that currently store higher activity wastes and materials [1]. Unlike feeds to current waste plants at Sellafield, the ILW from the legacy plants will be a heterogeneous mix of materials, exhibiting a range of hazards, and will vary over the waste retrieval period. In addition, there are significant practical constraints on the engineering that can be implemented to mitigate the hazards from these wastes. These challenges require a more flexible and pragmatic approach than in previous waste treatment processes.

This presentation will provide a brief overview of the UK framework for the management of radioactive wastes. Experience gained from the development of waste treatment and cement immobilization of reprocessing wastes will be summarized before discussing the different challenges posed by ILW retrieved from UK legacy facilities during decommissioning. Examples of strategies for wastes at the UK Sellafield site and associated research will be discussed.

References

- [1] Nuclear Decommissioning Authority, Strategy Effective from April 2016.
- [2] Nuclear Decommissioning Authority, Radioactive Wastes in the UK: A summary of the 2013 Inventory.
- [3] Geological Disposal Generic Waste Package Specification, Radioactive Waste Management Limited.

Plan and Implementation of Nuclear Waste Management in Finland

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Introduction

Finnish nuclear waste management programme is today globally the most advanced one vis a vis low and intermediate level waste and spent nuclear fuel management. The plans and schedules developed over 30 years ago are implemented today with only minor modifications. The features of Finnish success story cover e.g. coupling scientific research, decision making, regulatory needs, and implementor needs in the programme. The well-tested practices in siting a nuclear waste repository, and related site investigations, may be of interest in other countries as well, although one cannot directly transfer methods or approaches from country to country. The characteristic Finnish approach has been to step wise go deeper and deeper into site investigation and disposal concept development using subsequent safety assessments as measure of understanding.

Low and intermediate level waste management

Currently there are two operating licensed low and intermediate level waste repositories in Finland, located at the operating NPP sites Loviisa and Olkiluoto. They are geologic repositories at the depth of around 100 m in crystalline bedrock. There are well-developed plans to extend the repositories in order to dispose of future decommissioning wastes of the respective NPPs.

High level spent nuclear fuel management

Finland will probably be the first country to license a deep geological repository for spent nuclear fuel. The repository will most likely be based on the KBS-3V concept, with V standing for vertical, meaning that individual disposal canisters containing the spent fuel bundles will be disposed of in individual vertical deposition holes, one canister per hole. The systematic programme for spent fuel disposal has so far lasted over 30 years, see Fig. 1.

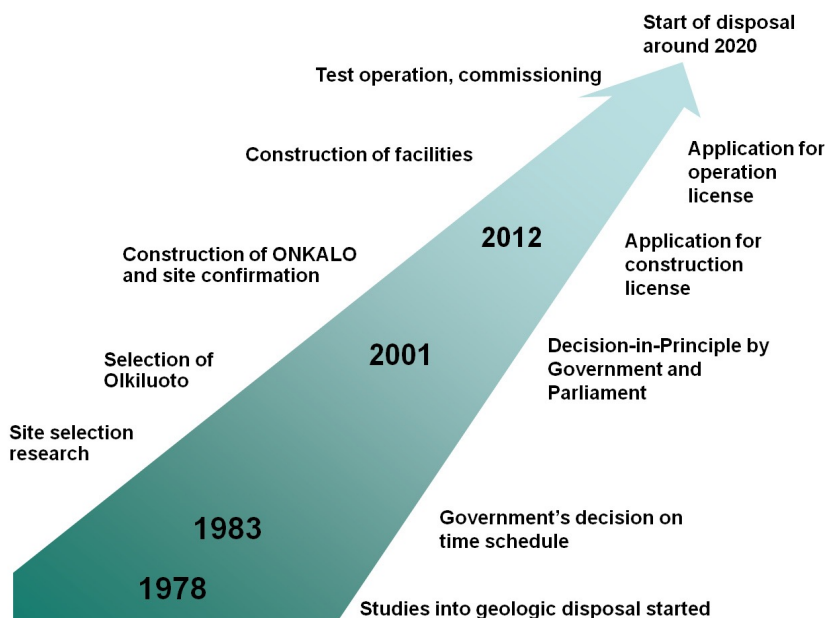


Fig. 1. Timeline of spent fuel disposal in Finland [1].

Costs of nuclear waste management

The total costs of all nuclear waste management arising from reactors currently running or under construction was estimated to be 6,5 B€ in 2012, with spent fuel management covering

for 3,5 B€. This estimate covers the management of operating waste, spent fuel, and decommissioning waste. Cost estimate for the future management of currently existing (end of 2015) nuclear waste is around 2,45 B€ (no discounting). The money for nuclear waste management is collected from nuclear waste producers into the State Nuclear Waste Management Fund with the idea that at all times there is enough money to manage the currently existing nuclear waste even if the nuclear waste producers would go bankrupt.

References

[1] Posiva, 2013. Safety Case for the Disposal of Spent Nuclear Fuel at Olkiluoto - Models and Data for the Repository System 2012, Report Posiva 2013-01, p. 49.

Recovery and Volume-reduction Solidification of Radioactive Elements from Solid Waste

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Large amounts of radioactive nuclides were released to the environment by the hydrogen explosion of the buildings of 1F NPP during March 11 to 15, 2011 and forest and farmland were contaminated by the fallout of radioactive elements. Then, large amounts of solid wastes such as soil, tree and rubble were generated. Their generation amounts in the 1F NPP site were about 82500 m³ for cut tree and 155100 m³ for soil and rubble. Since these wastes cause the exposure of workers to radiation, the radioactive elements has to be recovered from these wastes, concentrated and immobilized in stable materials. The decontaminated solid wastes are re-used for pavement materials, construction materials etc. As a result, the working environment in 1F NPP site will be improved and the nuclear decommissioning of 1F NPP will be promoted greatly. A part of the contaminated soil is stored with rubble, but the recovery of soil does not progress enough. The results of radiation measurement carried out by JAEA in March, 2015 suggest that high ¹³⁷Cs radiation of ten thousands to millions Bq/kg was observed in the soil near the reactor buildings. Those of ⁹⁰Sr in the sampled soils were low values in the range of 300 to 1500 Bq/kg [1]. According to the progress of the decommissioning of 1F NPP, treatment techniques of contaminated soil will be required. Especially, Cs and Sr are adsorbed strongly into 2:1 type layered clay minerals, such as vermiculate and montmorillonite. The development of high decontamination technology is indispensable for the desorption of radioactive elements and the reuse of decontaminated soil.

Based on recognition of such current status, an integrated system for the recovery, concentration and immobilization of radioactive elements from environmental waste materials such as soil and tree is developed in this study. However, we have no experience on the treatment of large amounts of environmental wastes. In the current stage, most of radioactive elements (Cs and Sr) in contaminated soil is transferred to 2:1 type layered clay minerals such as vermiculate and montmorillonite and adsorbed strongly into them. Especially, the adsorption of Cs is very strong. Under these circumstances, we develop a new integrated system for the recovery, concentration and immobilization of radioactive elements in the contaminated soil. For the cut tree, the same system will be developed in parallel with the fundamental research on the chemical characteristics of radioactive elements in ash obtained by the combustion of cut tree and the adsorption of them into the ash. This is because the chemical conditions of radioactive elements in the ash are unknown and the fundamental knowledge is needed for the development of suitable system. Then, a new technique to remove Cs from the contaminated soil and highly volume-reduced waste is

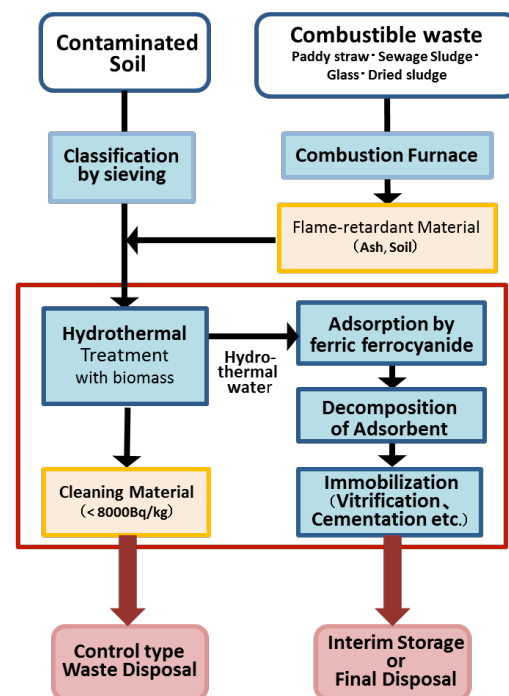


Fig.1 Removal process of Cs from contaminants of Fukushima Daiichi nuclear accident

required for the economical and safe disposal. In this study, we introduce a new recovery and volume-reduction solidification process of these solid wastes.

Firstly we studied the removal process of Cs from contaminated soil, which consists of sieving of contaminated soil, hydrothermal decomposition of clay minerals, adsorption of Cs in ferric ferrocyanide, thermal decomposition of ferric ferrocyanide adsorbing Cs, leaching of Cs from the residue with water and vitrification of Cs, shown in Fig.1, Clay minerals that adsorb strongly Cs was separated by the sieving of contaminated soil. Secondary Cs in clay minerals was recovered to water by a hydrothermal decomposition method with plant biomass under the conditions of 180-250°C and 1.0-4.0 MPa [2]. Cellulose and hemicellulose in the plant biomass were decomposed to some organic acids and these organic acids in the subcritical water dissolved clay minerals, especially vermiculite which adsorbs Cs very strongly. More than 95% of Cs in vermiculite was released in hydrothermal water by a repetition of hydrothermal operation and concentrated by a typical Cs adsorbent, ferric ferrocyanide (Prussian Blue), which was decomposed in air at 300°C [3]. Cs in the residue was recovered easily by pure water. Finally Cs was solidified and further concentrated in borosilicate glass. Mass and radioactive balances of the proposed process were estimated from the results of fundamental experiments. The volume of vitrified waste is reduced to about 1/20000 of that of contaminated soil [4]. These results suggest that both the removal of Cs from contaminated soil and the high volume-reduction of Cs waste can be attained by the introduction of the proposed process.

References

- [1] TEPCO Homepage, www.tepco.co.jp/nu/fukushima-np/.../t120730_02-j.pdf
- [2] I.Takatsuka, H.Takahashi, T.Fukuda, M.Harigai, Y.Inaba and K.Takeshita, "Fundamental Study on Cs Elution Technique from Vermiculite by Hydrothermal Treatment Using Cellulose-based Biomass (in Japanese)", *Journal of the Society for Remediation of Radioactive Contamination in the Environment*, **4(3)**, 231 – 238 (2016)
- [3] J. Munezawa, N.Ito, R.Ogata, S.Inoue, Y.Inaba and M.Harigai, "Development of Cesium Recovery System for High Efficiency and Volume Reduction- Behavior of Cesium salt in Combustion Treatment of Prussian Blue – (in Japanese)", *Journal of the Society for Remediation of Radioactive Contamination in the Environment*, **4(1)**, 35-44 (2016)
- [4] K. Takeshita, "Removal Process of Radioactive Cesium from Soil contaminated by Fukushima Daiichi Nuclear Accident", *Atalante 2016*, Keynote Lecture (Paper No.169), Le Corum, Montpellier, France (2016)

Rapid Analysis of Sr-90

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Radioactive strontium-90 scattered by nuclear power plant accident was specifically quantified by conventional inductively coupled plasma quadrupole mass-spectrometry (ICP-QMS) preceded by on-line chelate column separation (based on lab-on-valve) and oxygen reaction (designated the cascade step). The proposed system overcomes the isobaric interference of ⁹⁰Zr, whose soil concentration exceeds that of ⁹⁰Sr by more than six orders of magnitude. In addition, the system requires no ultimate mass spectrometry or radioactive ⁹⁰Sr standards. The radioactive ⁹⁰Sr standard was replaced with the stable isotope ⁸⁸Sr as a pseudo-standard. The modified ICP-QMS system yielded a precise, reproducible sharp ⁹⁰Sr peak in the ICP-MS profile. The elution time of ⁹⁰Sr was highly reproducible (RSD = 0.5 %). After implementing the cascade-step, the detection limit (DL) was 0.28 Bq/L (0.06 ppq) in ⁹⁰Sr analysis and 2.9% of repeatability (10 ppq ⁹⁰Sr (n = 10)) within approximately 20 min. Solid sample was able to be applied after the treatment of microwave digestion system. The ⁹⁰Sr from environmental contaminated soil samples collected from areas at a distance of 10 and 20 km from the Fukushima daiichi nuclear power plant ranged from 52 Bq/kg to 73 Bq/kg, with no statistical difference between the proposed and general methods at 95% confidence level. The analytical technique has overcome the analytical problems in radiometry and conventional ICP-MS by using chemical system. The proposed method offers an attractive alternative use for ICP-other ionization mass spectrometry as an enrichment or purification step, thereby expanding the scope of ICP-mass-spectrometric analysis.

References

[1] Y. Takagai, M. Furukawa, Y. Kameo, and K. Suzuki, *Anal. Methods*, **6**, 355 (2014).

[2] M. Furukawa and Y. Takagai, *Anal. Chem.*, **88**, 9397 (2016).

Activity of National Institute of Technology, Fukushima College

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Introduction

Decommissioning of Fukushima Daiichi nuclear power station is a national challenge. Mid-level engineer training from a medium- to long-term perspective on to proceed with decommissioning is a pressing issue. A training of practical engineer is the theme of technical college as institution of higher education of the National. In particular, National Institute of Technology, Fukushima College (NIT, Fukushima College) is located in the most close to the Fukushima Daiichi nuclear power station in the higher education of the National. Therefore in NIT, Fukushima College, a position to lead the national colleges across the country in the field of decommissioning education has been required.

Students of NIT Fukushima College have an interest in decommissioning technology. Some students choose nuclear power-related companies in place of employment. In order to meet the medium- and long-term theme of the region, incorporate the decommissioning basic research in graduate research and special studies carried out human resource development through research.

The establishment of decommissioning human resource development consortium

NIT, Fukushima College had been submitted as a business representative on the public offering of Education, Culture, Sports, Science and Technology Ministry. As a result, our application has been adopted by the business for one year as a feasibility study. Application title was "Human resources training on the decommissioning of nuclear power plant, based on study for graduation --- interdisciplinary challenge from Fukushima".

In the wake of this adoption, "Decommissioning human resource development consortium" was established in 2015 March 17 by NIT, Fukushima College. In this council, the nationwide technical colleges, universities and research institutions pursue together human resource training in the medium- to long-term perspective. Place the Council of the Secretariat in the Fukushima College, Takayuki Nakamura Fukushima College president was appointed first chairman, and Tetsuji Choji Kagoshima college president was appointed vice chairman. 2016 April at 34 technical colleges, 9 universities, 3 local government relationship, 6 private companies have joined.

Education program on decommissioning

This educational program is designed to correspond with the "human resource development and cooperation between higher education and research institutes in the medium-and-long term viewpoint" which is related to a governmental medium-and-long term roadmap for TEPCO's Fukushima Daiichi Nuclear Power Plant. This education program is constituted by three pillars; research and

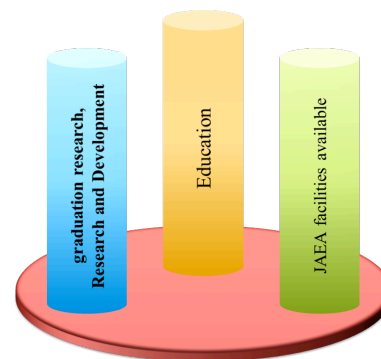


Fig. 1 Three pillars of education program on decommissioning

development, education and the facilities available (Japan Atomic Energy Agency Naraha Remote Technology Development Center).

In 2015, classes on decommissioning have been offered in two subjects new. Classes are "decommissioning and Society" of the 3-year target, a "decommissioning engineering" of the 4-year target, any one credit, was carried out in the intensive course format.

In 2016, internship programs for decommissioning and the two new lectures have been started. At the same time, the Technical College has promoted the cooperation in graduate research and special research. In 2017, by starting classes on decommissioning in first grade and fifth grade, education program on decommissioning will be completed. Internship is carried out complexly at two locations of companies and city office. In the company learn the decommissioning technology. In the city office understand the duties as a government on decommissioning.

Overview of Creative Robot Contest for Decommissioning

In order to get interested in the decommissioning to the young generation believes that education through the robot is effective. In addition, a variety of practices, such as PBL education and active learning lesson can be seen in each technical college. This Robocon also carried out by such PBL and active learning. It is the purpose to have an interest in decommissioning to the student through the manufacturing of robot. At the same time, it aims to cultivate the contributing to the "creativity education" "problem-solving ability" and "ability to identify challenges" students.

Overview of the competition challenges are as follows.

1) Field

To select the playing field in each team from the two fields of the following assumes the reactor building.

- a) Mock-up stairs
- b) Standard step field

2) Field environment

a) Mock-up stairs and b) standard test field have a common environment for the following.

- a) It is no darkness lighting
- b) Not be able to face up to the body to operate the robot by remote
- c) Radio wave does not reach because there is a thick wall of concrete

3) Challenges of robot

a) Mock-up stairs

- Carry the luggage of weight 5kg to the second floor from the first floor. And come back to its original location by placing the luggage.
- Examine the thing that is put on the second floor. It should be noted that the location is undefined.

b) Standard step field

- Examine the field of shape (such as area and irregularities).
- Check things that are located in the field. It should be noted that the location is undefined.

There were submitted from all over the country in the national and public technical colleges of the 13 colleges 15 team in this contest. Results of document screening, was observed participation of 15 teams.

Abstract of Poster Presentation

***In situ* X-ray Absorption Spectroscopy Study on Hydrogen Recombination Reaction of Precious Metal Nanoparticles Catalysts**

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Abstract

In case of severe accidents in nuclear power plants, and during long-term storage of radioactive waste, hydrogen is generated. The research on hydrogen recombination into safe water by precious metal nanoparticle catalyst has attracted attention. In this study, the mechanism of catalyst poisoning of carbon monoxide has been investigated by in-situ time-resolved analysis on the precious metal using Dispersive X-ray Absorption Fine Structure (DXAFS) at SPring-8. It is found that formation of surface oxide plays an important role in the hydrogen recombination, and CO inhibits the absorption and causes a decrease in activity. Furthermore, the use of ceria-composite-oxides, having oxygen storage capacity, as the support was found to reduce CO poisoning. It was possible to obtain useful guidance in catalyst design.

Application of Automotive Catalyst to Hydrogen Recombiner

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Abstract

At the severe accident of the Fukushima Daiichi nuclear power plant, seawater has been injected for cooling the reactor. When the nuclear waste should be kept isolated, water is decomposed to generate hydrogen and oxygen by radiation in the container. So that highly active recombiner catalyst is required. The intelligent automotive catalyst was found to have excellent activity to recombine hydrogen from a room temperature. In our laboratory, robust catalyst materials have been developed for water vapor and the catalyst poison such as carbon monoxide inhibits the hydrogen oxidation reaction. We are aiming at the realization of highly active recombiner.

Results of Preliminary Analyses on Natural Convection Behavior of Hydrogen Gas Generated in a Radioactive Long-Term Waste Storage Container

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Abstract

In the radioactive waste storage container, because the concentration of hydrogen gas generated by the decomposition of water by radiation increases with time, it is important to accurately grasp the behavior of the hydrogen gas in the sealed container for safety improvement of the storage container. Since the hydrogen gas is heated by the radioactive material accumulated in the storage container, it is conceivable that natural convection is formed. Therefore, in order to clarify quantitatively the natural convection behavior of hydrogen gas due to the decay heat of radioactive materials in the long-term waste storage container, preliminary analyses were performed on the system of a small-scale experimental apparatus in which specification of the long-term radioactive waste storage container is simply simulated. From the present results, the perspective which can predict natural convection phenomena in the long-term waste storage container numerically was obtained.

A Plan of Basic Experiments for Performance Evaluation of a Long-Term Radioactive Waste Storage Container for Reducing Hydrogen Gas Concentration

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Abstract

In the decommissioning of nuclear power plants, the long-term management of radioactive waste of fuel debris, etc. are necessary. In the process, hydrogen which is the flammable gas is generated by the decomposition of water by radiation. Therefore, it is important to ensure the safety of the waste storage container to reduce the concentration of hydrogen gas, and to keep below the explosion limit (4%). Consequently, a basic experiment to investigate the effectiveness of the waste storage container with the flammable gas concentration reduction mechanism using the passive autocatalytic recombiner (PAR) has been planned. The present study describes the research plan to use a small modeled experimental apparatus.

Potential Applicability of Bioconsolidation for Retardation of Diffusional and Convective Transfer of Effluent Radioactive Species - The technological Basis and Prospect for Actual Application -

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Abstract

Bioconsolidation by anaerobic metabolic activities of in-ground microbes was intended to densifying the soil for the purpose of mitigating the effluent aqueous radioactive species accompanied by the transfer of in-ground environmental water. Similar biological process has been found in the spontaneous formation of hard and rigid calcium carbonate scale on the inner wall of drainage pipes in landfill sites, which is sufficiently densified to prevent water from permeating out. The artificial conditioning for the in-ground formation of calcite is expected to contribute to reducing the effluent of radioactive substances from the decommission site. The authors showed that feeding calcium ion and nutritious organic substances with water into the ground can lead to the generation of microbe-derived calcite solid phase which forms dense interconnections amongst the constituent soil particles. To enhance the crystal nucleation of the calcite sub-micron particles, the nucleation-promotive effect of adding carbonyl-containing resin into the soil is to be further investigated. The appropriate conditions for the continuous and short-term growth of the soil-bridging calcite phase need to be experimentally clarified in the future investigation. In parallel with carrying out these fundamental laboratory experiments, the authors seek for collaborative opportunities to implement more actual on-site examinations with the help of advices by those who have superior and broader expertise on what are the more actual technical requirements for the mitigation technologies of the radioactive effluents.

Enhanced Desorption of Cs from Cs Collapsed Interlayer Region of Vermiculitized Biotite by Hydrothermal Treatment with Eluting Cations

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Abstract

Natural soil has ability of immobilizing radiocesium (Cs) within phyllosilicate fraction. The objectives of present study are to clarify how Cs fixation on vermiculite is influenced by structure change caused by Cs sorption at different loading levels and how Cs desorption is affected by various replacing cations induced at different treating temperature. As a result, more than 80% of Cs was readily desorbed from vermiculite with loading amount of 2% saturated Cs (5.49×10^{-3} mmol g⁻¹) after four cycles of treatment of 0.01M Mg²⁺/Ca²⁺ at room temperature, but less than 20% of Cs was desorbed from saturated vermiculite. These distinct desorption patterns were attributed to inhibition of Cs desorption by interlayer collapse of vermiculite, especially at high Cs loadings. In contrast, elevated temperature significantly facilitated divalent cations to efficiently desorb Cs from collapsed regions. After five cycles of treatment at 250 °C with 0.01M Mg²⁺, ~100% removal of saturated Cs was achieved. X-ray diffraction analysis results suggested that Cs desorption was completed through enhanced diffusion of Mg²⁺ cations into collapsed interlayer space under hydrothermal condition resulting in subsequent interlayer decollapse and readily release of Cs⁺. The results were expected to provide new insights to explore available decontamination technology for Fukushima Cs-contaminated soils.

**A Study of the Economic Effects by the Nuclear Industry and
Development of Human Resources in Regional Economy
from the Point of the Younger Generation Consciousness Concerning
Nuclear Energy**

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Abstract

The restoration work from the nuclear accident in Fukushima would continue about 40 years. Development of human resources engaged in the work is very important to conduct the long-term restoration. We surveyed opinions of the Japanese and French young generations' attitude toward nuclear energy after the accident. Opinions of about 100 students of National Institute of Technology in Japan were compared with those of French students.