**Knowledge Management Learned from Decommissioning and Environmental Remediation after an Unexpected Radiological Contamination occurred at Fukushima Dai-ichi NPP Accident**

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**Abstract**

The Fukushima Dai-ichi Nuclear Power Plant (NPP) Accident resulted in severe damage of cores in units 1 to 3, and subsequently entailed not only contamination of facility but also widely-spread radiological contamination in environment due to the release of radioactive nuclides. Decommissioning activities will require at least 30-40 years with various stages of operation, such as contaminated water treatment, decontamination of reactor buildings, retrieval of spent fuel (SF) from SF pools, inspection of Primary Containment Vessel (PCV) and Reactor Pressure Vessel (RPV), and retrieval and further management of damaged fuel and melted debris. Especially, a water injection for core cooling is a pressing issue to stabilize the melted debris, which leads to produce a large amount of contaminated water. Environmental remediation is a crucial issue to return a normal life for local residents. On-site cleaning and off-site remediation produce various kinds and enormous amount of contaminated material with low to high radioactivity. Knowledge management of on-site and off-site issues over generation are critical to achieve the cleaning and remediation requiring a couple of decades. In addition, knowledge obtained through a long term-operation should be shared globally.

**Management of Contaminated Water**

The management of contaminated water that produced daily 400t and currently downs to ca. 200t due to the effectiveness of protection of ground water intrusion is one of the highest priority prior to the discharge of melted debris. The amount reaches ca. 850,000 m3 (as of February, 2016) and initially contained fission product elements and actinides. The contaminated water has been cleaned by multi-nuclides removal system except tritium. Such processes produce a large number of highly radioactive secondary wastes, such as zeolite column, filters with precipitates, which have to be stabilized for long term storage.

Other comprehensive efforts are to prevent an intrusion of ground water to minimize contaminated water, and to protect a discharge of contaminated water to sea. The following countermeasures for the former are implemented: p**umping from the well on the land-side of the building into the sea (groundwater bypassing system), p**umping of ground water by sub-drain outside of the reactor buildings, w**aterproof pavement** to prevent groundwater inflow, and installation of **land-side impermeable frozen walls. The latter measures are heightening and doubling of tank fences,** g**round improvement**by sodium silicate (water glass), installation of **sea-side impermeable walls, and increase the number of tank. These various kinds of measures teach us a plenty of instructive knowledge, which should be summarized and reported for sharing globally.**

**Management of On-Site Contaminated Material**

**Large amount of high to low contaminated soil, trees, bricks, etc., are produced by on-site remediation to reduce a radiation exposure and to prepare a working field toward decommissioning. Organic materials, i.e. trees and grasses, should be incinerated not only to reduce a volume but to stabilize in order to avoid heat generation by decomposition. Recycle or re-use is potential option for some of contaminated material such as bricks and concrete. Moreover, highly radioactive secondary wastes are produced by contaminated water treatment. The storage and disposal of contaminated materials ranging low to high radiation dose are critical issue.**

**Characterization of Environmental Contamination**

No framework to explore a contamination was established before the accident. Air dose rate has been monitored within a 1 km mesh using air planes and vehicles to figure overall contamination map and use the data to classify restricted area. Such monitoring has continued to examine the effect of remediation after passing some period. Collection, integration and management of the enormous monitoring data are essential for designing a remediation plan and administration management, implementing each remediation work and evaluating their effect.

**Implementation of Environmental Remediation**

Lots of remediation means have been invested depending on an objective target, its characterization, a degree of contamination and its location. The experiences have accumulated through the practical implementation. The knowledge should be collected and reviewed in an integrated manner for utilization globally. Other large lesson is to select a remediation method by considering a treatment of secondary waste, such as contaminated water, minimization of secondary contaminated materials and cost-effectiveness. Remediation work required many workers. For instance, several workers engaged in operation for a week for a Japanese medium class of house.

Remarkable number of packages with wide variation of radioactivity and kind of material were produced by remediation. Total amount of contaminated materials was estimated ca. 22 million m3 containing soil, flammable organics such as trees and grasses. Finding storage sites is quite influential to progress a remediation. However, in early stage it encountered the difficulty to find a site due to fear of radiation by local residents. It was learned that classification of contaminated materials prior to packaging was recommended depending on a kind of contaminant so that it would help reduce the volume of flammable material and recycle or reuse them at the interim/disposal site.

**Public Communication and Information Disclosure**

Public acceptance and information disclosure are critical issue to progress decommissioning and environmental remediation. Public concerns much on the release of radioactive material from the site. Every countermeasure to be taken for site cleaning and decommissioning should be disclosed to public and comprehended in stakeholders. Prefectural government and municipalities require enough information for decommissioning and environmental remediation. Most essential party is a local community and resident, who require knowing information on radiological influence and remediation, including precise dose rate, etc. For environmental remediation, finding a site of storage of contaminated material is much concerned by a community. A dialogue with residents by a small group and visiting a site are essential to accelerate a positive action. Critical issues arose from local residents and public. The knowledge should be collected and managed to learn a lesson how to communicate citizens.

**Example of Knowledge Management**

The progress of decommissioning is monthly reported as “Summary of Decommissioning and Contaminated Water Management” by the Secretariat of the Team for Countermeasures for Decommissioning and Contaminated Water Treatment by the Ministry of Economy, Trade and Industry (METI). This report includes confirmation of the reactor conditions, progress status by each plan, such as contaminated water countermeasures, fuel removal from the spent fuel pools, fuel debris removal, plans to store, process and dispose of solid waste and decommission of reactor facilities, reduction in radiation dose and mitigation of contamination, etc.

The FY2014 Decontamination Report published by the Ministry of Environment (MOE) summarizes whole activities with establishment of regulatory framework, contamination survey, preparation of remediation, implementation of remediation, waste handling and storage and public communication [2]. This report provides one of the essential records of knowledge. Through this experience, it was recognized that systematic knowledge management would be required to address the current remediation activities and prepare for any unexpected future event.

References

1. http://www.meti.go.jp/english/earthquake/nuclear/decommissioning/pdf/20160225\_e.pdf
2. MOE, FY2014 Decontamination Report, March, 2015