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Final Report of the

International Mission on

Remediation of Large Contaminated Areas Off-site the Fukushima Dai-ichi NPP

7–15 October 2011, Japan

CONTENTS

The Mission Team uses the term ‘remediation’ in accordance with the IAEA Safety Glossary. The Team understands that in the Japanese language there is only one word for both remediation and decontamination.

EXECUTIVE SUMMARY

In response to a request made by the Government of Japan, the IAEA organized a fact-finding Mission to support the remediation of large contaminated areas off-site of the Fukushima Dai-ichi Nuclear Power Plant (NPP). The Mission Team included 12 international experts.

The Mission had three objectives:

1. Provide assistance related to Japan's plans to remediate large areas contaminated by the accident at the Fukushima Dai-ichi NPP;
2. Review Japan's ongoing remediation related strategies, plans and activities, including contamination mapping; and
3. Share its findings with the international community as part of the joint effort to broadly disseminate lessons learned from the accident.

The Mission included an assessment of information provided to the Team, open discussions with relevant institutions in Japan, and visits to the affected areas, including several demonstration sites. The Team also visited the Fukushima Dai-ichi NPP. The authorities of Japan provided comprehensive information on their remediation programme.

Overview

Remedial actions are based on how the affected areas are characterized. The isotopic composition of the fallout included mainly volatile radionuclides (e.g. I, Te and Cs), but Cs-134 and Cs-137 are currently the dominant contaminants and are mainly contained in the topsoil layer. Shorter-lived isotopes have already decayed. The remediation programme covers about 500 km^2 where radiation dose levels are above 20 mSv/a and about 1300 km^2 where radiation dose levels are between 5 mSv/a and 20 mSv/a.

Based on the current schedule of activities, the Team focused on the remediation of affected areas outside the 20 km restricted area (see Figure 1). The Team agrees with the prioritization and general strategy being implemented and is of the opinion that additional missions could be beneficial at the appropriate time to (a) confirm the progress made and (b) address the remediation challenges within the 20 km zone.

Restricted Area, Deliberate Evacuation Area, Evacuation-Prepared Area in case of Emergency And Regions including Specific Spots Recommended for Evacuation (As of August 3, 2011)

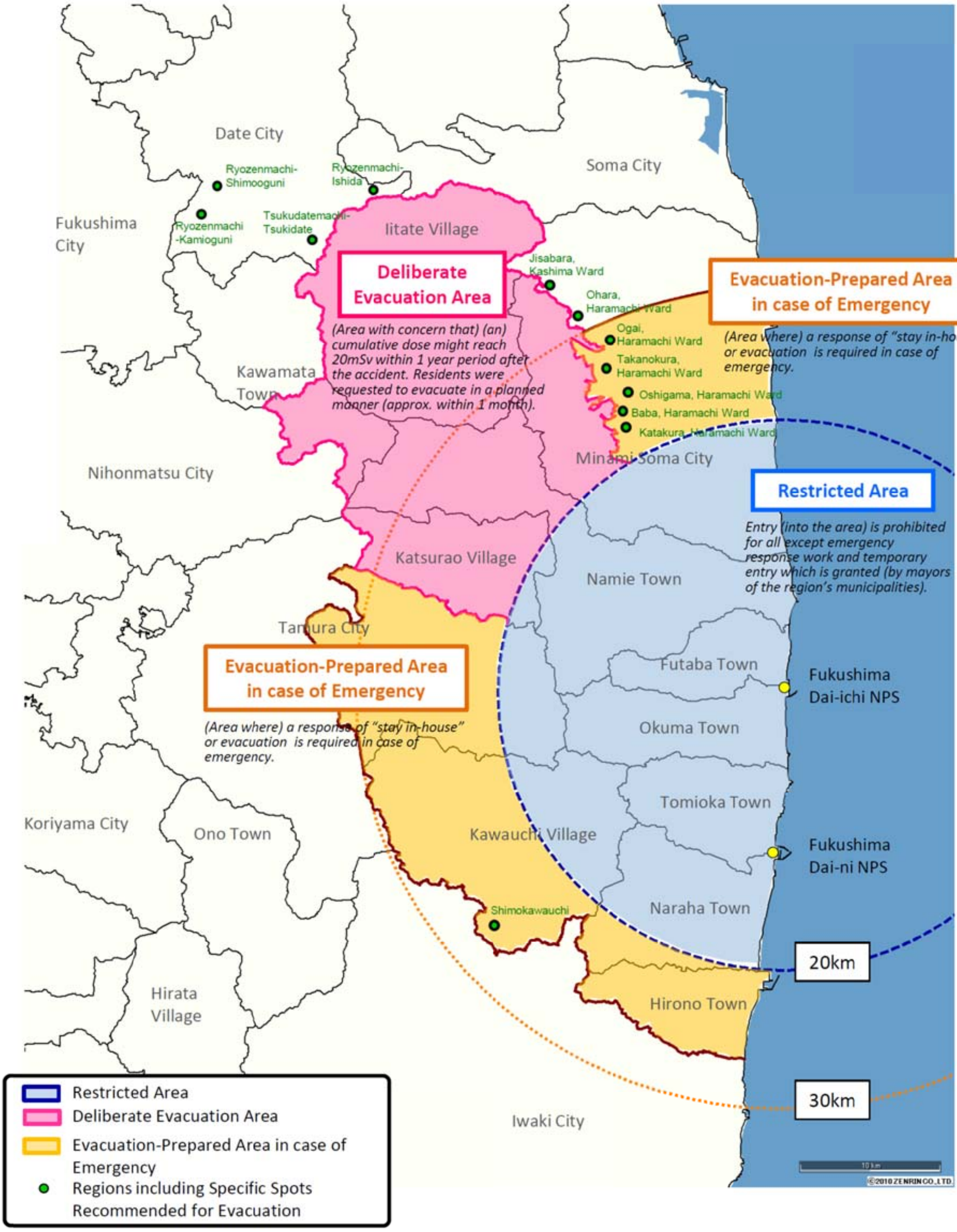


Figure 1: Overview of the different designated areas around the Fukushima Dai-ichi NPP. The Government's instructions for the "Evacuation-Prepared Area in case of Emergency" were lifted on 30 September 2011.

Main findings

This report presents the main conclusions of the Mission. It highlights nine areas of important progress to date and offers advice on twelve points where the Mission Team felt that current practices could be improved. The advice covers improvements in strategy, plans and specific remediation techniques, taking into account both international standards and experience from remediation programmes in other countries. Japan is encouraged to continue its current remediation efforts and to take into consideration the Mission's advice for future remediation activities.

Highlights of important progress

Highlight 1: The Mission Team appreciates that Japan has gone forward very quickly and allocated the necessary legal, economic and technological resources to develop an efficient remediation programme to bring relief to the people affected by the Fukushima Dai-ichi nuclear accident. Priority has been given to children and the areas that they typically frequent.

Highlight 2: The Fukushima Decontamination Promotion Team, which consists of resident staff in Fukushima from the Ministry of the Environment (MOE), the Local Emergency Response Headquarters and the Japan Atomic Energy Agency (JAEA), coordinates and shares information with relevant ministries and agencies, and communicates with and provides technical support to the Fukushima prefecture and relevant municipalities. The Mission Team welcomes Japan's efforts to establish a practical catalogue of remediation techniques.

Highlight 3: The Team acknowledges that the Act on Special Measures explicitly stipulates stakeholder involvement. The Team appreciates that the Government is not waiting for the new Act to come into force, but has already started implementing this aspect of the remediation plan.

Highlight 4: The Team appreciates the strong commitment to remediation demonstrated at the Fukushima prefecture and at local levels. The Team benefitted from visiting school sites, from which the contamination had been removed to a large extent by volunteers, mostly parents of the pupils. The Team in particular acknowledges the efforts of the municipal administrations and the large number of volunteers as an important and effective self-help method.

Highlight 5: The Team acknowledges the practical measures taken by the JAEA in public information and its involvement in the programme based on the needs of the local residents.

Highlight 6: The Team considers the use of demonstration sites to test and assess various remediation methods to be a very helpful way to support the decision-making process.

Highlight 7: The Team acknowledges the impressive monitoring and mapping effort by the Japanese authorities as a good basis for a successful remediation programme. The extensive, real-time monitoring system that is currently being set up and the transparent online availability of the resulting data are important measures to reassure the public and the international community.

Highlight 8: The Team recognizes that, in the early phase of the accident, conservatism was a good way to manage uncertainties and public concerns related to reference levels related to food and agriculture.

Highlight 9: The Team appreciates the fact that some school sites were remediated mostly by volunteers with the technical support and guidance of the JAEA. The Team was informed that 400 school playgrounds had already been appropriately remediated (as of 30 September 2011).

Advice

Point 1: The Japanese authorities involved in the remediation strategy are encouraged to cautiously balance the different factors that influence the net benefit of the remediation measures to ensure dose reduction. They are encouraged to avoid over-conservatism which could not effectively contribute to the reduction of exposure doses. This goal could be achieved through the practical implementation of the Justification and Optimization principles[1] under the prevailing circumstances. Involving more radiation protection experts (and the Regulatory Body) in the organizational structures that assist the decision makers might be beneficial in the fulfillment of this objective. The IAEA is ready to support Japan in considering new and appropriate criteria.

Point 2: It is appropriate to consider further strengthening coordination among the main actors, through the establishment of a more permanent liaison between the organizational structures of the Government of Japan and the prefectural and municipal authorities.

Point 3: The central and local governments are encouraged to continue strengthening the involvement of and cooperation between various stakeholders. The authorities might wish to strengthen the engagement of appropriate universities and/or academia in the process of further developing a stakeholder involvement strategy and implementation methods, which would be based on stakeholder needs and domestic cultural settings.

Point 4: Access to the “Deliberate Evacuation Area” is free and unmarked. The Team encourages considering the use of appropriate indications/markings of the routes and simple instructions for the public when entering or leaving these areas. These indications/markings are considered important tools for informing the public and avoiding unnecessary radiation exposures to individuals.

Point 5: It is important to avoid classifying as “radioactive waste” waste materials that do not cause exposures that would warrant special radiation protection measures. The Team encourages the relevant authorities to revisit the issue of establishing realistic and credible limits (clearance levels) regarding associated exposures. Residues that satisfy the clearance

[1] IAEA Safety Glossary 2007 STI/PUB/1355 (ISBN:978-9290-058908-9).

level can be recycled and reused in various ways, such as the construction of structures, banks and roads. The IAEA is ready to support Japan in considering new and appropriate criteria.

Point 6: The Team draws the authorities' attention to the potential risk of misunderstandings that could arise if the population is only or mainly concerned with contamination concentrations [surface contamination levels (Bq/m^2) or volume concentrations (Bq/m^3)] rather than dose levels. The investment of time and effort in removing contamination beyond certain levels (the so-called optimized levels) from everywhere, such as all forest areas and areas where the additional exposure is relatively low, does not automatically lead to a reduction of doses for the public. It also involves a risk of generating unnecessarily huge amounts of residual material. The Team encourages authorities to maintain their focus on remediation activities that bring the best results in reducing the doses to the public.

Point 7: The management of the collected data should be formally described in a data management plan.

Point 8: With respect to the remediation of agricultural areas, the Team considers that for the next cropping season there is room for reducing some of the conservatism (such as that in the factors determining the transfer of radioactive caesium from soil to crops) by taking into account data and factors published by the IAEA and the results obtained from the demonstration sites. The IAEA is ready to support Japan in considering new and more appropriate criteria.

Point 9: With respect to waste in urban areas, the Team is of the opinion that it is obvious that most of the material contains very low levels of radioactivity. Taking into account the IAEA safety standards, and subject to safety assessments, this material might be remediated without temporary and/or interim storage. It is effective to utilize the existing municipal infrastructure for industrial waste. The IAEA is ready to support Japan in considering new and appropriate criteria.

Point 10: Before investing substantial time and efforts in remediating forest areas, a safety assessment should be carried out to indicate if such action leads to a reduction of doses for the public. If not, efforts should be concentrated in areas that bring greater benefits. This safety assessment should make use of the results of the demonstration tests.

Point 11: The Mission Team encourages the Japanese authorities to continue the useful monitoring of freshwater and marine systems.

Point 12: The Mission Team encourages the Japanese authorities to actively pursue appropriate end-points for the waste in close cooperation with stakeholders. The national and local governments should cooperate in order to ensure the provision of these facilities. A lack of availability of such an infrastructure would unduly limit and hamper successful remediation activities, thus potentially jeopardizing public health and safety.

1. INTRODUCTION

The accident at the Fukushima Dai-ichi NPP led to the radioactive contamination of large areas. The Government of Japan has formulated a programme for the recovery of these areas.

As a major part of this recovery programme in off-site areas near the Fukushima Dai-ichi NPP, Japan is launching remediation efforts. The final aim of the recovery strategy, and therefore of the remediation programme, is to improve the living conditions of the people affected by the accident.

The IAEA organized the “IAEA International Fact Finding Expert Mission of the Fukushima Dai-ichi NPP Accident Following the Great East Japan Earthquake and Tsunami”, held on 24 May – 2 June 2011. The conclusions of this mission were presented in the International Ministerial Conference held in Vienna from 20 to 24 June 2011.

In response to the request made by the Government of Japan, the IAEA organized this second fact finding mission to support the remediation of contaminated off-site areas. For this second mission an Expert Team of 12 international experts was assembled (the Mission Team members are listed in Annex 1).

This Mission is in line with the Action Plan on Nuclear Safety that was approved by the Board of Governors on 19 September 2011 and endorsed by the 151 Member States of the IAEA. In particular, the Mission is in connection with actions to strengthen the emergency response to nuclear accidents and the protection of people and the environment from ionizing radiation.

2. INSTITUTIONAL ARRANGEMENTS

Basis for review

In the Japanese administrative system, the national government, the prefectures and the municipalities play specific roles in disaster management and environmental protection. In line with this general institutional framework, the remediation programme is being conducted with the following basic approach:

- The national government provides policies and standards, conducts remediation in areas which are in “emergency exposure situation” and promotes the efforts of local governments by taking technical and financial measures.
- Local governments (prefecture and municipalities) formulate and implement remediation plans in areas which are in “existing exposure situation”.

The information on the relevant legal and regulatory framework was reviewed in light of the IAEA safety standards. The applicable IAEA safety standards and supporting publications were:

- INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1 (2006)
- INTERNATIONAL ATOMIC ENERGY AGENCY, International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources, International Basic Safety Standards; IAEA SAFETY STANDARDS SERIES No. GSR Part 3 (Interim) (2011)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, General Safety Requirements Part 1, IAEA Safety Standards Series No. GSR Part 1 (2010)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5 (2009)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Release of Sites from Regulatory Control on Termination of Practices, IAEA Safety Standards Series No. WS-G-5.1 (2006)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Environmental and Source Monitoring for Purposes of Radiation Protection, IAEA Safety Standards Series No. RS-G-1.8 (2005)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Non-technical Factors Impacting on the Decision Making Processes in Environmental Remediation, IAEA-TECDOC-1279, IAEA, Vienna (2002)

- INTERNATIONAL ATOMIC ENERGY AGENCY, Technologies for Remediation of Radioactively Contaminated Sites, IAEA-TECDOC-1086, IAEA, Vienna (1999)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Characterization of Radioactively Contaminated Sites for Remediation Purposes, IAEA-TECDOC-1017, IAEA, Vienna (1998)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Remediation of Sites with Dispersed Radioactive Contamination, Technical Reports Series No. 424, IAEA, Vienna (2004)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Management of Long Term Radiological Liabilities: Stewardship Challenges, Technical Reports Series No. 450, IAEA, Vienna (2006)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Environmental Consequences of the Chernobyl Accident and their Remediation: Twenty Years of Experience Report of the UN Chernobyl Forum Expert Group "Environment" (EGE) Radiological Assessment Reports Series 8
- INTERNATIONAL ATOMIC ENERGY AGENCY, Remediation Process for Areas Affected by Past Activities and Accidents Safety Guide IAEA Safety Standards Series 4301(2007)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Remediation of Areas Contaminated by Past Activities and Accidents Safety Requirements, IAEA Safety Standards Series 4300 (2003)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Guide on Decontamination of Rural Settlements in the Late Period After Contamination with Long-Lived Radionuclides- Working material TC Project RER-9059 (2001)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Planning for Cleanup of Large Areas Contaminated as A Result of A Nuclear Accident, Technical Reports Series 327 (1991)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Cleanup of Large Areas Contaminated as A Result of A Nuclear Accident, Technical Reports Series 300 (1989)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Disposal of Waste from the Cleanup of Large Areas Contaminated as A Result of A Nuclear Accident, Technical Reports Series 330 (1992)
- ICRP 109. Application of the Commission’s Recommendations for the Protection of People in Emergency Exposure Situations (2008)

- ICRP 111. Application of the Commission's Recommendations for the Protection of People Living in Long-Term contaminated Areas after a Nuclear Accident or a Radiation emergency (2009)

Findings

Legal framework for remediation

On 26 August 2011, The Parliament (Diet) of Japan approved the *"Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District – Off the Pacific Ocean Earthquake that Occurred on March 11, 2011".* This Act is the main instrument adopted to deal with the remediation programme for the areas affected by radioactive pollution, and will enter into force on 1 January 2012. The Government plans to develop activities under this Act through specific policy documents including the basic principles and standards.

The Act establishes, among others things, the main purposes of the remediation programme; the distribution of roles and responsibilities among the involved institutions, namely the central government and prefectural and municipal governments; the role of stakeholders; basic lines for monitoring, decontamination and waste management; and the provision of financial resources.

Decision making process

To properly implement the remediation activities under the Act, the Ministry of the Environment, in consultation with the relevant administrative bodies and stakeholders, is in charge of developing the basic principles regarding the handling of environmental radioactive pollution.

These principles were formally approved by the Cabinet. In the meantime, the Nuclear Emergency Response Headquarters on 26 August 2011 established the "Basic Policy for Emergency Response on Decontamination Work", which is in line with the Act and permits the start of activities for remediation in advance.

The "Policy and Guidelines for Environmental Remediation" and guidelines for the decision-making process on decontamination to be conducted by local authorities have been prepared reflecting comments from relevant ministries and agencies as well as from the local authorities, so those comments were reflected in the decision-making process.

The Emergency Evacuation Preparation Zone was lifted on 30 September 2011, taking into account technical advice from the relevant body, namely the Nuclear Safety Commission (NSC), the conditions of the NPP and the results of the radiological monitoring in the area.

This is one example of shifting from an emergency exposure situation to an existing exposure situation.

Roles and responsibilities

Under the Act on Special Measures, the Ministry of the Environment is the leading Ministry for implementing the decontamination activities in cooperation with other relevant organizations. The roles and responsibilities of the relevant organizations are as follows:

- The Government Nuclear Emergency Response Headquarters (GNER-HQs), headed by the Prime Minister and consisting of all the Cabinet members, decides the basic policy to respond to the emergency (including the remediation policy). The Support Team for Residents Affected by Nuclear Incidents, under the GNER-HQs, headed by the Minister of the Ministry of Economy, Trade and Industry (METI) and the Minister for the Restoration and Prevention of Nuclear Accidents, implements the model remediation programmes according to the "Urgent Decontamination Implementation Policy";

- MOE is responsible for formulating an implementation policy for the decontamination activities. It also has a responsibility for the treatment of contaminated solid waste, including disaster debris and contaminated soil;

- The Ministry of Education, Culture, Sports, Science and Technology (MEXT) is responsible for implementing monitoring and coordination of activities for monitoring by relevant ministries and other organizations;

- The Ministry of Agriculture, Forestry and Fisheries (MAFF) is responsible for the formulation of an implementation policy for the decontamination of farmlands and forests;

- The Ministry of Health, Labour and Welfare (MHLW) is responsible for occupational (including radiation) safety of workers implementing decontamination activities;

- The Nuclear Safety Commission (NSC) gives necessary advice to the government on technical standards on remediation; and

- The Japan Atomic Energy Agency (JAEA) provides technical support for model decontamination programmes and monitoring and communicates with local authorities and residents about technical issues.

Local governments shall, through cooperation with the national government, carry out their role in accordance with the natural and social conditions of their respective areas in handling the environmental pollution from radioactive materials discharged by the accident.

The relevant nuclear power operator shall implement the necessary measures to deal with the environmental pollution from radioactive materials discharged by the accident and cooperate with the measures taken by national or local governments to deal with the radioactive environmental pollution.

The Fukushima Decontamination Promotion Team was established last August to promote decontamination activities. The team, consisting of government officials and JAEA representatives, communicates and coordinates with the local authorities. The team conducts and coordinates the so called demonstration projects.

Highlights of important progress

Highlight 1: The team appreciates that Japan has been going forward very quickly and with the allocation of the necessary resources (legal, economic and technological) to develop an efficient programme for remediation to bring relief to the people affected by the Fukushima Dai-ichi nuclear accident. Priority has been given to children and to those areas where they typically spend most of their time.

Highlight 2: The Fukushima Decontamination Promotion Team, consisting of resident staff in Fukushima from the Ministry of the Environment (MOE), the Local Emergency Response HQs and the Japan Atomic Energy Agency (JAEA), shares information and coordinates with the relevant ministries and agencies, communicating with and providing technical support to the Fukushima prefecture and relevant municipalities. The Team welcomes the Japanese efforts to establish a practical catalogue of remediation techniques.

Advice

Point 1: The Japanese authorities involved in the remediation strategy are encouraged to cautiously balance the different factors that influence the net benefit of the remediation measures to ensure dose reduction. They are encouraged to avoid over-conservatism which could not effectively contribute to the reduction of exposure doses. This goal could be achieved through the practical implementation of the Justification and Optimization principles[2] under the prevailing circumstances. Involving more radiation protection experts (and the Regulatory Body) in the organizational structures that assist the decision makers might be beneficial in the fulfillment of this objective. The IAEA is ready to support Japan in considering revised, new and appropriate criteria.

Point 2: It is appropriate to consider further strengthening coordination among the main actors through the establishment of a more permanent liaison between the organizational structures of the Government of Japan and the prefectural and municipal authorities.

[2] IAEA Safety Glossary 2007 STI/PUB/1355 (ISBN:978-9290-058908-9).

3. STAKEHOLDER INVOLVEMENT

Basis for review

As stated in the IAEA safety standard "*the decision making process shall provide for the involvement of a wide range of interested parties in the definition, implementation and verification of remediation programmes and for regular public information exchange on the implementation of these programmes*." (WS-R-3).

There are many definitions for the word "Stakeholder". The IAEA Handbook on Nuclear Law states that:

"*Owing to the differing views on who has a genuine interest in a particular nuclear related activity, no authoritative definition of stakeholder has yet been offered, and no definition is likely to be accepted by all parties. However, stakeholders have typically included the following: the regulated industry or professionals; scientific bodies; governmental agencies (local, regional and national) whose responsibilities arguably cover nuclear energy; the media; the public (individuals, community groups and interest groups); and other States (especially neighbouring States that have entered into agreements providing for an exchange of information concerning possible trans-boundary impacts, or States involved in the export or import of certain technologies or material).*"

The Team recognizes that stakeholders are not necessarily those living in areas to be remediated, but could be physically situated also much further away.

The objective is to seek and promulgate safety through technically and economically optimal solutions of remediation processes that are, at the same time, acceptable to the stakeholders. Since remediation involves many steps, careful consideration must be given to understanding and ensuring that each step is an integral part of a well-functioning remediation system. This means that the output of a step has to be a compatible input to the following step.

For example, what appears to be a seemingly good step if viewed in isolation (e.g. cleaning soil more than radiation protection considerations would suggest) will complicate the next step (in this case by creating much more waste than necessary, leading to an increasing anxiety among the public in the next remediation steps, i.e. how to find storage and disposal locations for the waste). Optimum consideration of the system as a whole is the key for all stakeholders in their involvement and for their information.

Taking into account that remediation of this scale is a complicated and long term process, stakeholders have an important, sometimes governing, influence on it.

Decisions regarding particular remediation issues like the recycling and reuse of material should be given considerable attention by stakeholders.

In light of international experience, the Team emphasizes the balance between "rights" and "responsibilities" of stakeholders. Namely, all stakeholders with an interest in remediation should be provided with an opportunity for full and effective participation. With this right, however, come certain obligations on all sides for openness, cooperation and goodwill.

Wide possibilities for stakeholders to be involved and informed ensure that as remediation planning and implementation proceed, stakeholder needs and concerns are properly addressed. Based on international experience this has many benefits, such as:

- Timely stakeholder involvement increases the credibility of the whole remediation process and the probability of success;
- Public confidence is improved if issues that are raised by the public are taken seriously and are carefully and openly discussed and evaluated;
- Stakeholder involvement may result in attention to issues that otherwise might not be identified and addressed;
- Timely stakeholder involvement provides improved opportunities for innovation and an influx of ideas. This may not happen if the stakeholders are not engaged early enough or are not convinced about technology demonstrations, related R&D or debate;
- Stakeholder involvement enhances the possibility of delivering a project on time, within cost estimates and through good performance by providing a unified vision of risks, plans and developments. It reduces costly delays to projects by avoiding and effectively resolving conflicts among interested parties;
- Remediation of this scale requires particular project management skills and attention. Early stakeholder involvement provides better identification and mitigation of project risks which enables an improved risk management process to be implemented in order to ensure the success of the entire remediation operation (including disposal of remediation wastes); and
- Experience in many countries has shown that transparency can be an effective tool to enhance safety performance.

Managing expectations is essential from the onset of stakeholder engagement. It is important to clearly identify the objectives so that stakeholders can understand the extent of their involvement and responsibility.

Relevant international experience

The Team considered it to be important that all parties involved in remediation projects understand the issues that may affect decisions and are able to benefit from the experience that has already been acquired in other countries. It is recognized, however, that different experiences may not be universally relevant and that some issues have a particular national character.

The Team noted that the IAEA, UNSCEAR, WHO and others devoted significant efforts to learn lessons about involving and informing stakeholders, in particular the public, after the

Chernobyl accident. The Team is of the opinion that many of these important lessons are also applicable to the Fukushima Dai-ichi NPP off-site remediation strategies, plans and activities.

In the Team's view, important and relevant lessons learned from the Chernobyl accident include the following:

- Psychological consequences were clearly observed and documented;
- Many people were traumatized by their evacuation and relocation, the subsequent breakdown of their social contacts, their fear and anxiety about health effects they might ultimately suffer from;
- Elevated levels of anxiety and unexplained physical symptoms among affected people were reported;
- Self-perception as "Chernobyl Victims or Invalids" and not as "Chernobyl survivors" was observed;
- Over the years, the most significant problems have become the severe social and economic depression of the affected Belarusian, Russian and Ukrainian regions and the associated serious psychological problems of the general public and emergency workers; and
- Recent research shows that social and economic restoration of the affected regions must be a priority.

Findings

Concerning the Fukushima Dai-ichi NPP's accident, the Team noted that there were issues that raised concerns among the stakeholders, which would benefit from lessons learned from the Chernobyl accident. For example, there is a rising concern about how the contamination from the accident will affect children's health, including thyroid abnormalities. It might be beneficial for the stakeholders to know that in the case of the Chernobyl accident children and adolescents received substantial thyroid doses in the spring of 1986 due to the consumption of milk contaminated with radioiodine. Many thyroid cancer cases that were detected were likely to be associated with this type of radiation exposure. With regard to milk and other food in Japan, the Team appreciates that the country's food control system appears to be in very good order.

Relevant structures and processes

In the Japanese administrative system, municipalities and prefectures have strong autonomy and play significant roles in disaster management and environmental protection, including the remediation process. The national government provides the legal framework, policies, standards, and financial and technical support, and conducts remediation for areas which are in "emergency exposure situations" - in this case areas where citizens could be exposed to an annual dose above 20 mSv.

Local governments implement remediation plans for areas which are in “existing exposure situations”, i.e. areas below 20 mSv/year. In these areas the ultimate decision whether to remediate or not rests with the landowner.

The “Act on Special Measures concerning the Handling of Radioactive Pollution”, which will enter into force 1 January 2012 but which the Government already implements to a large extent, explicitly recognizes stakeholder involvement. The purpose of the Act is to promptly reduce the impacts of environmental pollution by instituting measures taken by stakeholders, especially the national and local governments, as well as the relevant nuclear power producer.

Under the ‘Basic Policy for Emergency Decontamination Work’ established on 26 August 2011, several important policy, guidelines and documents have been issued. These include stipulations of how stakeholders are to be involved in the process.

Practical involvement of stakeholders

There is understandable anxiety in the society about the current radiation situation. The Team noted that in the early phases of the accident many doubts were expressed about the accuracy and timeliness of the information provided by the central authorities.

The Team observed that revised ways and new efforts to inform and involve stakeholders, in particular the public, are being implemented by the central authorities. At a local level, the Team was impressed by the strong commitment to the remediation efforts shown by the Fukushima prefecture and the municipalities.

The Mission Team recognized the following important players in the practical stakeholder involvement:

- The *Fukushima Decontamination Promotion Team* under the Ministry of the Environment is tasked to communicate and coordinate activities with local municipalities, assisting them in their preparation of remediation plans, by dispatching experts and promoting model remediation projects in 12 municipalities affected by elevated radiation levels. JAEA, being a member of the Promotion Team plays an important role in interacting with the public and other stakeholders.
- Having established a “Fukushima office”, the JAEA interfaces with relevant Fukushima prefecture organizations and citizens. With regard to technical issues, the Mission Team appreciated that JAEA provided a telephone hot-line for health consultations, dispatched experts to stakeholders (ministries, local governments, city administration, etc.), sent researchers to Fukushima prefecture schools from kindergartens to junior high schools at their request, held briefings on radiation in schools, took time and effort to answer questions from parents and teachers, and prepared written material for the benefit of the local people. In the demonstration test sites described elsewhere in this report, the JAEA works in close cooperation with the residents and landowners, and carries out activities subject to their consent.
- *Cities, villages and their citizens:* the Team benefitted from visiting some school sites, from which the contamination to a large extent had been removed in a well-organized manner by volunteers, mostly parents of the pupils. The Mission Team acknowledged

the effort of the city administration and the large number of volunteers as an important and effective clean-up and self-help method.

Highlights of important progress

Highlight 3: The Mission Team acknowledges that the Act on Special Measures explicitly stipulates stakeholder involvement. The Mission Team appreciates that the Government is not waiting for the new Act to come into force, but has already started implementing this aspect of the remediation plan.

Highlight 4: The Team appreciates the strong commitment to remediation demonstrated at the Fukushima prefecture and at local levels. The Team benefitted from visiting school sites, from which the contamination had been removed to a large extent by volunteers, mostly parents of the pupils. The Team in particular acknowledges the efforts of the municipal administrations and the large number of volunteers as an important and effective self-help method.

Highlight 5: The Team acknowledges the practical measures taken by the JAEA in public information and its involvement in the programme based on the needs of the local residents.

Advice

Point 3: The central and local governments are encouraged to continue strengthening the involvement of and cooperation between various stakeholders. The authorities might wish to strengthen the engagement of appropriate universities and/or academia in the process of further developing a stakeholder involvement strategy and implementation methods, which would be based on stakeholder needs and domestic cultural settings.

4. RADIATION PROTECTION

Basis for review

The information on the relevant legal and regulatory framework was reviewed in light of the IAEA safety standards. The applicable IAEA safety standards and supporting publications were

- INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1 (2006)
- INTERNATIONAL ATOMIC ENERGY AGENCY, International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources, International Basic Safety Standards; IAEA SAFETY STANDARDS SERIES No. GSR Part 3 (Interim) (2011)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, General Safety Requirements Part 1, IAEA Safety Standards Series No. GSR Part 1 (2010)
- Classification of Radioactive Waste. General Safety Guide GSG-1, IAEA, (2009)

The Basic Safety Standards (BSS) define the requirements on protection of people and the environment. These requirements reflect a broad international consensus on the requirements for safety.

For post-accidental conditions, the BSS recommend a reference level in the range of 1-20 mSv/year. It is an international consensus that the reference levels have to be defined taking into account the specific circumstances of an exposure situation. This includes the level of activity in the environment, environmental conditions and people's life style.

The BSS require that any measure taken is justified to ensure that it does more good than harm and that it is commensurate with the risk.

Usually, remediation actions also have social and economic implications and decisions have to take into account all aspects of a specific situation. The optimization of protection and safety – as required by the BSS - is a process for ensuring that exposures and the number of exposed individuals are as low as reasonably achievable, with economic, societal and environmental factors taken into account to ensure that the level of protection will be the best possible under the prevailing circumstances. It requires both qualitative and quantitative judgments to be made.

Any reasonable steps shall be taken to prevent doses remaining above the reference level. The exposure has to be assessed for the more highly exposed individuals in the population.

The optimization of protection and safety, when applied to the exposure of workers and of members of the public is an iterative and prospective process for ensuring that the magnitude and likelihood of exposures and the number of individuals exposed are as low as reasonably achievable. It requires both qualitative and quantitative judgements to be made.

According to IAEA Safety Standards[3], remedial work should not be carried out by persons younger than 18 or by women who have notified their employer of a pregnancy or breast feeding. The dose limits for remediation workers should be established according to occupational exposure requirements as follows:

- An effective dose of 20 mSv per year averaged over five consecutive years (100 mSv in 5 years), and of 50 mSv in any single year;
- An equivalent dose to the lens of the eye of 20 mSv per year averaged over five consecutive years (100 mSv in 5 years), and of 50 mSv in any single year;
- An equivalent dose to the extremities (hands and feet) or the skin of 500 mSv in a year.

Remediation work may generate residues that contain enhanced levels of activity. Accordingly, waste arising from remediation operations will have to be managed as radioactive waste and be either stabilized in situ or disposed of in appropriate disposal facilities.

According to the BSS, for legal and regulatory purposes radioactive waste is defined as material for which no further use is foreseen and that contains, or is contaminated with, radionuclides at activity concentrations or activities greater than the clearance levels established by the regulatory body. In the GSG-1 referred to above, radioactive waste with activity concentrations that are about 100 times higher than the clearance levels is classified as Very Low Level Waste (VLLW). Such waste does not meet the criteria for clearance, but it does not need a high level of containment and isolation and, therefore, is suitable for disposal in near surface landfill type facilities with limited regulatory control. Such landfill type facilities may also contain other hazardous waste. Typical waste in this class includes soil and rubble with low levels of activity. Concentrations of longer lived radionuclides in VLLW are generally very limited.

Such waste, arising from remediation operations, should be accommodated within an existing waste management system established for normal practices, particularly if the amounts of waste expected are small.

If the existing waste management system is not capable of dealing with the types and quantities of waste that will be generated during the remediation activities, the system should be adapted or supplemented accordingly.

Clearance levels for radionuclides are given in the BSS for material which is intended to be used without any restrictions. Clearance levels for material that is going to be disposed of in landfills may be derived by national governments taking into account the specific circumstances, the radionuclides involved and the specification of the landfill.

It is the responsibility of the government to set reference levels for the disposal of residues in municipal landfills or for landfills to be especially designed for the disposal of those residues.

[3] See details in: IAEA Basic Safety Standards, GOV2011/42, 15 August 2011

In view of the strong absorption of caesium by the soil, the definition of the reference level should in particular focus on Cs-137 rather than on the relatively short-lived Cs-134.

Findings

The Japanese government has defined a set of reference levels to control the exposure of the public. In areas where the annual effective dose is estimated to be above 20 mSv, the national government aims to reduce the estimated annual exposure dose to less than 20 mSv; in areas where an estimated annual exposure dose is less than 20 mSv, the national government will work with municipalities and local residents to conduct effective remediation work, with a long term target of keeping the estimated annual exposure dose below 1 mSv.

Specific attention is being given to the exposure of children. Therefore, initial efforts focus on measures to reduce exposures in schools and kindergartens, with the aim to reduce the exposure to children to an effective dose of 1 mSv per year during the time children are at school.

This approach is in accordance with the recommendations of the International Commission on Radiation Protection and the BSS.

Exposure of remediation workers

The “Basic Principles Based on the Act on Special Measures Concerning the Handling of Radioactive Pollution” developed by the Japanese national authorities include the following requirement: *“Full attention shall be paid to occupational safety and the health of those who engage in the handling of the environment pollution such as radiation protection and the amount of radiation that the relevant workers receive shall be controlled”*.

According to information obtained from Japanese counterparts, the application of personal protection equipment is required for remediation workers, including protective clothes and face masks, to prevent the surface contamination of workers and incorporation of radionuclides.

Currently, the JAEA programme of whole body counter measurements is in place for residents of ten towns (Namie, Iitate, Kawamata, Hirono, Naraha, Futaba, Okuma, Tomioka, Kawauchi and Katsurao) within the deliberate evacuation area and restricted area. The expansion of this programme to remediation workers could be considered.

When visiting the decontamination demonstration sites, it was found that the radiation monitoring equipment is in place during the remedial work and the measured levels of gamma radiation dose rates are properly recorded. Measurements of beta contamination were not systematically included during remedial operations in visited demonstration sites. In any case, the monitoring of the contamination of remedial workers should be carried out after the completion of their daily work.

It was especially noted that all persons involved in remedial work were provided with advance training and information on the remedial operations including radiation protection measures. According to IAEA standards for an existing exposure situation and for the remediation of areas with residual radioactive material, the exposure of workers undertaking remedial actions should be controlled in accordance with the relevant requirements for occupational exposure in planned exposure situations. The responsibility for such control shall be assigned to remediation worker employers.

The national government requirements regarding remediation worker safety are the basis for municipal requirements as established by the above mentioned basic principles document.

The Team noted that remediation activities include the voluntary involvement of local residents. For instance, 500 volunteers were involved in clean-up operations for a school environment in the Fukushima prefecture (Tominari Elementary School) visited by the Mission Team. In this case, the radiation protection advice was given by a competent governmental and municipal body. The advice was specific to the remediation option and technology applied.

With regards to the available information on dose rates and radioactivity concentration levels present in the areas of decontamination operations, the above requirements for occupational exposure of remediation workers are feasible.

The Team points out that the responsibility for the control of the exposure of workers undertaking remedial actions should be assigned to remediation worker employers (which are the national government institutions or municipalities depending, on the value of the expected annual dose (above or below 20 mSv/year, respectively).

The Team also considered that it would be useful to apply the monitoring of contamination of remedial workers' bodies after the completion of daily work. The JAEA programme of whole body counter measurements should be extended to remediation workers.

Use of clearance levels

As reflected in the advice in Points 1 and 5, the Team considers the introduction and implementation of specific clearance levels for disposal in landfills or other specific purposes taking into account clearly defined designated purposes as very useful. A number of countries have set activity levels for the particular disposal of material in landfills. For example, in Sweden, material with Cs-137 activities of 5 Bq/g may be disposed of in landfills for municipal waste. In Germany, activities up to levels of 8 Bq/g may be disposed of in landfills. All these values were derived to comply with a de-minimis dose to members of the public in the order of 10 µSv/y, giving specific consideration to the pathway of exposure during transport and management of the waste. Long-term issues such as the possible impact on the groundwater and its subsequent use by humans were also considered.

Any specific levels defined for conditional reuse, recycling or waste disposal in a landfill are subject to a safety assessment of the specific site and practice, and any effort should be commensurate with the associated risks.

Key elements for the successful continuation of remediation measures include unconditional and conditional reuse and recycling of residues as well as planning, construction and operation of landfills for the residues.

Assessment of exposures

The decision on measures to be taken is currently based on the external exposure; other pathways such as the intake of food are not explicitly taken into consideration. While the intake of food is very likely not an important pathway, due to the strict activity limits for foodstuffs, its contribution to the dose should be explicitly assessed. This is to achieve a comprehensive and transparent overview of the radiation sources and their magnitude. This is also an important input for the optimization of any remediation measures.

The exposure of the public is the determining criterion for remediation actions. Due to the strict control of activity levels in food, the external exposure from radionuclides deposited on the ground is the most important pathway. Currently, Cs-134 and Cs-137 are present in about equal activities, but due to the decay characteristics, the contribution of Cs-134 is much higher than that of Cs-137. However, since Cs-134 decays faster than Cs-137, the external dose rate will decrease significantly during the coming years. This relationship is illustrated in Figure 2, where the decline of the gamma dose rate due to radioactive decay is shown for Cs-134, Cs-137 and the sum of both radionuclides respectively.

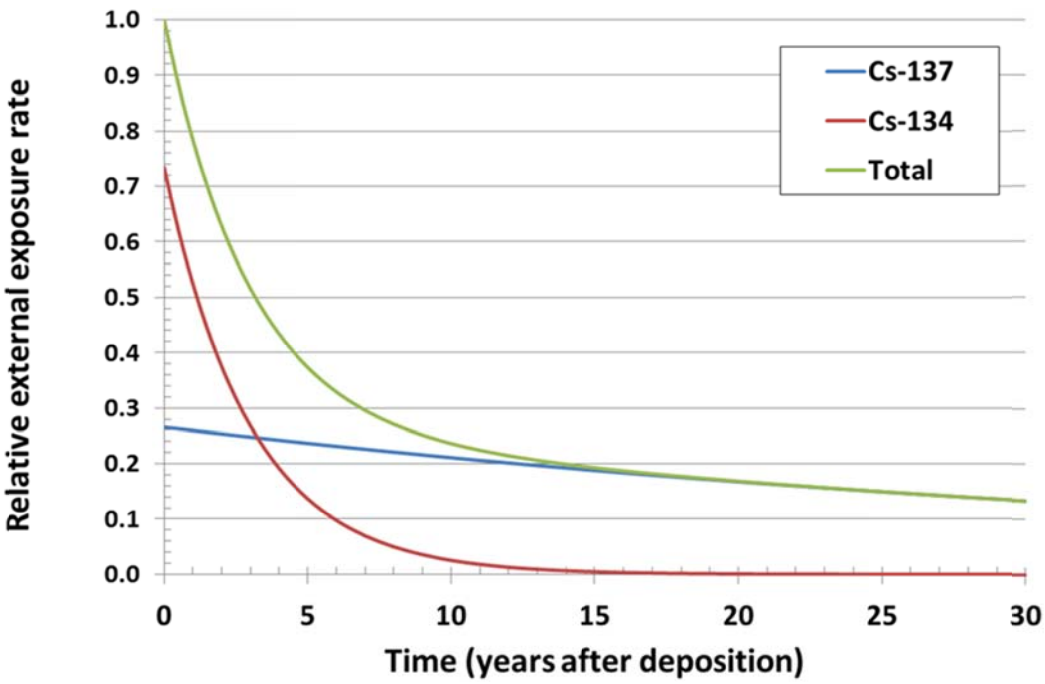


Figure 2: Reduction of the relative external exposure rate subsequent to deposition of Cs-134 and Cs-137 (ratio = 1) due to radioactive decay.

Usually, the reduction of the external dose rate is more pronounced due to weathering effects and ongoing attenuation effects arising from the migration of caesium into deeper soil layers. Migration of caesium in soil is in general very slow, but even thin layers of soil contribute significantly to the attenuation of the radiation.

The considerable reduction of the gamma dose rates during the coming years suggests that in areas with exposures that are relatively close to the lower band of reference levels for existing exposure situation (1-20 mSv per year), decisions on drastic remediation action require thorough consideration of all factors involved, such as the dose reduction (beyond the radioactive decay), costs, generation of waste and social implications.

As discussed in Section 3 of this report (stakeholder involvement), providing information to the public is a key issue for the involvement of the population in the remediation process. The Team noted that access to the ‘Deliberate Evacuation Area’ is free. However, appropriate indications when entering or leaving these areas may be considered as an important issue for the information of the public.

The Team encourages the respective authorities to optimize all remediation measures to the extent possible in the context of ensuring that all the steps are integrated in the optimum way, as is mentioned in Point 1 of the Team’s advice.

Advice

Point 4: Access to the “Deliberate Evacuation Area” is free and unmarked. The team encourages considering the use of appropriate indications/markings of the routes and simple instructions for the public when entering or leaving these areas. These indications/markings are considered important tools for informing the public and avoiding unnecessary radiation exposures to individuals.

5. REMEDIATION STRATEGY IMPLEMENTATION

Basis for review

This section of the report (sub-sections 5.1-5.7) discusses the Japanese remediation strategy and its practical implementation.

The Team notes that remediation of this scale is a multidimensional challenge. In order to make good and well-informed decisions on what to clean-up, when and by whom, a strategy is needed.

In the Team's experience, a successful remediation strategy includes such main elements as:

- Requirements and classification as to what constitutes such contamination that requires remediation, which materials can be reused and recycled and what are the condition to do that. Commonly these limits are referred to as 'clearance levels';
- Objective of each technology option available for remediation. The Team is aware of about 60 technology options available;
- Constraints on implementation for each technology;
- Effectiveness of technology options, including such factors as quantities and characteristics of wastes generated;
- Wastes generated in each step of remediation, their respective waste management options and their availability;
- Doses received during implementation;
- Side-effects each technology might have;
- Experience gained elsewhere and lessons learned in using the remediation technology; and
- Cost/benefit considerations.

The Mission Team recognized that there is quite some experience and lessons learned in different countries in implementing various remediation approaches and technologies. One important lesson learned is that what works in one country under certain conditions does not automatically work well in another country under the same or different conditions.

The Team emphasizes that remediation should always be considered as a system of many sequential and sometime parallel steps and processes. These steps and processes should not be viewed in isolation but integrally linked to each other. Namely, successful remediation with acceptable end results to all stakeholders requires that the output of one step is fully compatible as an input to the next remediation step.

For example, from the very beginning of planning remediation activities, one should keep in mind that the generation of radioactive wastes (quantities and types) from any remediation step should be kept to the minimum. Also, such remediation techniques that produce no, or very little radioactive waste, should be favoured.

The justification principle as expressed in the international standards stipulates that the introduction of a remediation strategy needs to produce more good than harm. In other words, the benefits need to exceed the associated burden and costs. The reduction of exposures to the public also needs to be optimized, i.e. the residual levels of radiation in the environment should be as low as reasonably achievable with social and economic aspects factored in. The simple reduction of existing doses by the application of any clean-up strategy *per se* may not produce the desired benefits, especially if they create additional problems (such as waste and negative social impact) and excessive cost. In other words, the burden may be disproportional to the benefits the remediation will bring.

Another factor that is very important in the context of environmental remediation is that solutions are also site-specific. Lessons learned with other events shall always be taken into account in the decision making process but they may not be readily transferable from one situation to another.

Last but not least, decisions in these circumstances are not based only on technical matters and evidence. Several socio-psychological elements play an important role in the decision making process. Therefore, the key issues include stakeholder involvement, which is discussed in Section 2 of this report.

Gathering international experience and learning from lessons, careful system-approach planning as well as testing and demonstrating feasibilities and the effectiveness of various remediation approaches and technologies are therefore important before large scale remediation implementation starts.

Findings

In the following, only generic findings are presented. More detailed findings are presented in connection with each sub-section 5.1–5.7.

Overview of the on-going remediation activities

The Team appreciates that Japan has been going forward very quickly and with the allocation of the necessary resources (legal, economic and technological) to develop an efficient programme for remediation. There are various on-going remediation activities related to monitoring and mapping, data management, agricultural areas, urban decontamination, forest areas, aquatic areas and waste management. These are discussed in more detail in the subsequent sections of this report.

On a general level, the Team wishes to note the following two remarks:

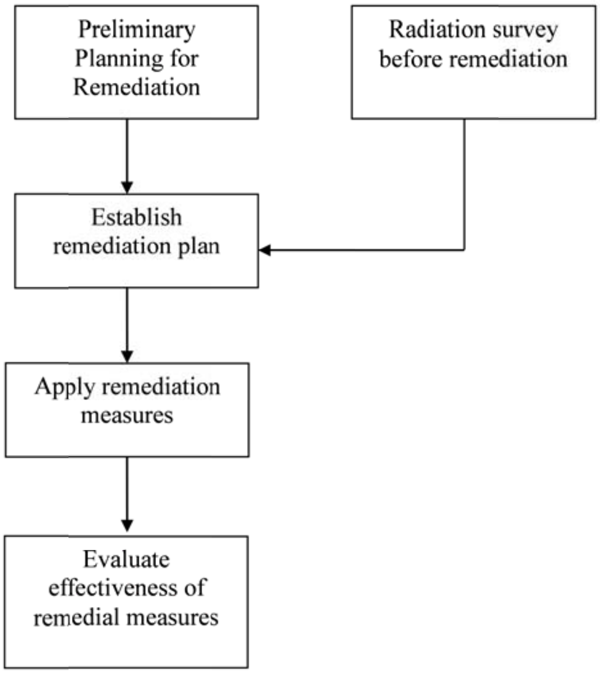
- The Team notes that the main strategy adopted by the Japanese authorities relates to the concept of decontamination. At this stage, it is important to stress that decontamination is only one of the many available options to be used to achieve the reduction of doses in the case of radioactivity concentrations in the environment caused by an accidental release. Other options need to be considered and the one (or ones) to be selected need to derive from a process of optimization of the protection, which the Team wishes to identify more in the decision making process.

In the decontamination efforts perpetrated by the Japanese counterparts, the Team observed that the major strategy being considered is the removal of top soil (up to 5 cm of the soil layer) due to the well-known behaviour that radiocaesium accumulates in this part of the soil. While this strategy has the benefit of reducing radionuclide concentrations in the upper layer of soils and consequently the dose, it also involves a risk of generating unnecessarily huge amounts of residual materials, some of which can be classified as 'radioactive waste'.

If removal of the top layers of the soil is one of the selected options for wider use, a similar system would be useful that is in place for naturally occurring radioactive material residues (so-called NORM residues) in many countries and is based on safety assessments. This would allow the removed material to be used in selected applications, e.g. together with clean material in the construction of structures, banks or roads that will not pose undue risks to members of the public. This system is known as clearance and specifically in the present situation conditional clearance could be considered. This is recognized as an applicable strategy also in the IAEA Safety Standards. The classification of the material resulting from the remediation operations as radioactive waste should not be automatic. In fact, the Team finds that doing so could create unnecessary major challenges for the Japanese authorities without providing any benefit in terms of reducing doses to the public.

- The team recognizes and values the strategy of involving local people to help themselves with the decontamination of their properties. However, it has been noticed that for more complex work specialized services will be required and this will obviously add costs to the remedial actions. Whenever local residents become involved in the clean-up of their properties it is important to observe that appropriate training, supervision and technical assistance are given. Radiation protection measures and monitoring should also be in place, when integrating local people in remediation work.

The logical sequence of the remediation efforts involved can be summarized as shown next page.



Highlights of important progress

Highlight 6: In the Team's view, the approach for using demonstration sites to test and assess various remediation methods is a very helpful way to support the decision-making process.

Advice

Point 1 is also applicable here.

Point 5: It is important to avoid classifying as "radioactive waste" waste materials that do not cause exposures that would warrant special radiation protection measures. The Team encourages the relevant authorities to revisit the issue of establishing realistic and credible limits (clearance levels) regarding associated exposures. Residues that satisfy the clearance level can be used in various ways, such as the construction of structures, banks and roads. The IAEA is ready to support Japan in considering revised, new and appropriate criteria.

Point 6: The Team draws the authorities' attention to the potential risk of misunderstandings that could arise if the population is only or mainly concerned with contamination concentrations [surface contamination levels (Bq/m^2) or volume concentrations (Bq/m^3)] rather than dose levels. The investment of time and effort in removing contamination beyond certain levels (the so-called optimized levels) from everywhere, such as all forest areas and areas where the additional exposure is relatively low, does not automatically lead to a reduction of doses for the public. It also involves a risk of generating unnecessarily huge amounts of residual material. The Team encourages authorities to maintain their focus on remediation activities that bring the best results in reducing the doses to the public.

5.1. Monitoring and mapping

Basis for review

The monitoring of radiation levels and the mapping of the distribution and level of radioactive contamination are necessary tools for both the preparation and the verification of a successful remediation effort.

Radiological monitoring is a well-established subject and consequently there are a series of IAEA reports and guides that the review is based on. These are in particular:

- IAEA Safety Guide No RS-G-1.8 'Environmental and Source Monitoring for the Purposes of Radiation Protection' (2005)
- IAEA TECDOC 1017 'Characterization of radioactively contaminated sites for remediation purposes' (1998)
- IAEA Technical Reports Series No. 450 'Management of Long Term Radiological Liabilities: Stewartship Challenges' (2006)

Technological progress in environmental mapping, e.g. in geo-information systems and GPS, is so recent and has been so rapid that a complete set of standards has not yet been established by the IAEA. However, most of the basics are included in an IAEA TECDOC:

- IAEA TECDOC 1363 'Guidelines for radioelement mapping using gamma ray spectrometry data', 2003

It can be expected that updated guidelines on environmental mapping will be one of the outcomes of the environmental mapping efforts in Japan over the coming years.

Findings

National monitoring and mapping efforts

The Japanese government has outlined the responsibilities of the different government agencies regarding radiation monitoring and mapping in the Comprehensive Monitoring Plan from 2 August 2011. The overall responsibility and coordination falls to MEXT, but MOE, MHLW, MAFF and MLIT, as well as a number of other agencies and organisations, are also involved. JAEA is playing a key role as keeper of the data base, technology provider and liaison to the universities.

Radiation levels are monitored at different geographic scales using the appropriate technology for each case: airborne and vehicle based surveys for the large scale overview (up to 160 km from the Fukushima Dai-ichi NPP), soil samples (2,200 locations, within 100 km of the NPP and surrounding areas within the Fukushima prefecture), sea water and soil samples off the coast, and hand-held dosimeters and spectrometers for local radiation maps and decontamination test sites. Typically, the data are given as aerial dose rate 1 m above ground, but often the surface dose rate and the concentration in Bq/kg or Bq/m^2 are also used.

Three airborne surveys around the Fukushima Dai-ichi NPP were carried out in April, May and June 2011 by MEXT in cooperation with the US Department of Energy (DoE). These surveys use high sensitivity gamma detectors (NaI scintillators) carried by helicopters flown at an altitude between 150 and 300 m. The results are given as dose rates at 1m above ground by taking the altitude appropriately into account. The range of the surveys has been expanded step by step to cover further prefectures. The next airborne survey planned for November 2011 will cover the entire Eastern part of Japan, from the Aichi to Aomori prefectures, using four helicopter teams in parallel. Further airborne surveys are planned in the future, with the next one after November expected to take place in the spring of 2012. The importance of this mapping effort is perhaps best illustrated by the creation of the deliberate evacuation area North-West of the 20 km exclusion zone, which was based on these results.

MEXT is currently in the process of setting up a real-time monitoring system that will eventually cover the Fukushima prefecture with about 2700 monitoring stations. Twenty monitoring stations have already been deployed in the Fukushima prefecture. This information is available online at www.r-monitor.jp. The system is similar to other national monitoring networks, e.g. the one maintained in Germany by the Bundesamt für Strahlenschutz, which has 2150 monitoring stations[4]. However, the new Japanese system uses more advanced, contemporary technology, e.g. where the German system uses phone lines for the data transmission, the Japanese system uses satellite links. The monitoring station, which was under construction and which the Team could inspect, was located next to the entrance of an elementary school and it featured a solar panel and a display. 2700 monitoring stations are under an on-going open bidding process. Almost every school, from nursery to university, will eventually be equipped with an online monitoring station. For the citizens of Japan this system represents an unprecedented amount of readily available, real-time information. The transparent online availability of the resulting data is an important measure to reassure the Japanese public as well as the international community.

MAFF has conducted investigations on the concentration of radioactive material in agricultural soil, in cooperation with MEXT. Samples have been taken at 360 points in the Fukushima prefecture and at about 220 points in the five surrounding prefectures (Miyagi, Tochigi, Gunma, Ibaraki and Chiba). The results were compiled into a map that was published on 30 August 2011.

In addition to the monitoring and mapping of the radioactive contamination on land, MEXT is also carrying out a monitoring programme of the ocean offshore of the Miyagi, Fukushima and Ibaraki prefectures. The monitoring plan includes sea water and marine soil samples. Most measurements concern I-131, Cs-134 and Cs-137, but some measurements on Sr and Pu

[4] available online at odlinfo.bfs.de

isotopes were taken as well. The results of the measurements from March to May have been used as input values for a simulation of radioactivity concentrations in the Pacific Ocean in the coming years.

Japan is carrying out a very comprehensive national monitoring and mapping effort of the radioactive contamination following the Fukushima accident. The Team did not find anything that obviously would have to be added to this effort.

Local monitoring efforts

In addition to the large national programmes, the aerial surveys and the R&D efforts by JAEA and by universities and research institutes, there are additional examples of monitoring efforts at the local level, e.g. by municipalities. In one municipality visited by the Team it was found that copies of local radiation dose maps of the area with a 1 km grid were available at the city hall. They were apparently the result of a municipal initiative and had a resolution that made it possible to identify individual buildings.

Another example that the Team noticed between site visits was a solar powered LED dose rate display visible from the car. The display was similar to those that show temperature and humidity that were used in other locations or those that indicate your speed. These activities do not yet all appear to be coordinated and their data are not yet collected centrally anywhere. MEXT only collects the data down to the prefecture level. More and closer coordination of the monitoring and mapping initiatives below the prefecture level would enable the spreading and application of the best ideas and practices and the collection of locally generated data.

Applications of modern technology

In the 25 years since the Chernobyl accident there have been a large number of technological developments that directly or indirectly affect radiation monitoring and environmental mapping.

It is possible to access the information of the Japanese radiation monitoring stations online at any time[5], from anywhere and in real time, based on the combination of technologies and information (GPS, GIS, WWW, satellite uplinks).

The Team appreciates the technological development. As a liaison with universities, JAEA can play an important role in this and Japanese companies are world-leading in several relevant technologies.

JAEA is making efforts to fill the gap between large area airborne monitoring and hand-held dosimeters through the introduction of an unmanned aerial vehicle (UAV) system, which can

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[5] available online at www.r-monitor.jp

be used in areas that are impossible to reach by car. Also UAVs are a technology that has only really taken off in the last few years, and that only now is being developed for environmental monitoring applications. JAEA is using a UAV helicopter that carries a detector system comprised of NaI and plastic scintillators as well as a dust sampler. The helicopter is radio- as well as GPS-controlled and scans are performed from a height of 20-80 m. It can stay in the air for about 90 min at a time. The data are transmitted to a vehicle on the ground in real time, where they can be used to assemble a radiation map.

JAEA is also developing and improving detector technology for local applications. One example is the scintillating fibre detector that JAEA demonstrated to work as well or better than more conventional detectors. It allows the rapid measurement of radiation profiles and e.g. makes it possible to quickly see the difference between an area that has gone through a remediation effort already and a neighbouring area that has not.

Mapping of private properties

It is foreseen that the remediation of private properties outside of the 20 km exclusion zone and the deliberate evacuation area will be carried out by the municipalities, local companies and/or by the residents themselves. It is known from the decommissioning test sites that small scale hot spots can be expected to occur on private properties, e.g. at the drain pipes from the roof. This leads to the question of how best to assess if and where these small scale hot spots exist on a given property and to confirm that they have been successfully removed after remediation. Monitoring data are typically only available with a resolution of the order of 100 metres at best. This of course does not show which area at a drain pipe or at the foot of a tree might require special attention, while this is exactly what local residents would be interested in. An exacerbating circumstance in this case is the low level of trust that many residents appear to have in their government.

One possible way to address this issue would be the provision of mobile gamma spectrometers and a corresponding mapping service. Technologically, it would be straightforward to provide compact and light mobile gamma spectrometers in a backpack configuration. These kinds of backpack detectors are available from a number of suppliers already. They can be provided in a configuration that requires no expert knowledge from the user and also gives the user no opportunity to interfere with the equipment. In simple words, the detector would only have an on/off switch.

These detectors can be calibrated and maintained by service staff and given out to local residents with instructions about how to collect the data. The data are extracted from the returned detectors and sent to a mapping service, which in turn returns a local radiation map to the residents. This can be done first before the remediation effort and then be repeated afterwards, to clearly either demonstrate the success of the remediation or to illustrate that the remediation is not yet complete. The residents collect the data themselves, the backpack detectors can be provided by local government and the mapping service could be certified by an outside organisation, e.g. by the IAEA. This automatically also would address the issue of trust of the residents in information from their government – because they themselves would be generating the information.

Highlights of important progress

Highlight 7. The Team acknowledges the impressive monitoring and mapping effort of the Japanese Authorities as a basis for a successful remediation programme. The extensive, real-time monitoring system that is currently being set up and the transparent online availability of the resulting data are important measures to reassure the public and the international community.

5.2. Data management

Basis for review

Data management is a rather recent topic that has emerged due to the Freedom of Information legislation enacted by many countries in combination with the realisation that data are valuable and cannot always be easily reproduced.

Guidelines on data management have been drafted by funding agencies in a number of countries, but there are no accepted international standards yet. In some countries these guidelines are under discussion right now.

A very basic coverage of the subject is included in

- IAEA Technical Reports Series No. 450 'Management of Long Term Radiological Liabilities: Stewartship Challenges' (2006)

The more detailed requirements for a data management plan of the US National Science Foundation have been used as guidelines in this case. They can be found at

http://www.nsf.gov/pubs/policydocs/pappguide/nsf11001/gpg_2.jsp#dmp.

Findings

The idea that data require management is based on the one hand on the legal requirement to be able to make publicly held data accessible and on the other hand on the recognition that data, especially scientific data, are a valuable resource that often represents a considerable investment. The legal requirements arise from the applicable freedom of information laws that many countries have nowadays - in Japan the corresponding law is the "Law Concerning Access to Information Held by Administrative Organs" which has been in force since 2001.

The environmental monitoring data from Japan after the Fukushima Dai-ichi accident are not only a crucial input for any remediation activity, but they also represent an immensely valuable scientific resource for future analysis. The collected data will be more complex and detailed then those collected following the Chernobyl accident 25 years ago, due to the technological progress in the intervening time. The volume of data will also simply be much larger.

The management of the collected data should be formally described in a data management plan. In a scientific experiment such a plan would be drawn up in advance. In this case, however the time for action is now, at the transition from emergency measures to long-term monitoring.

Elements of a data management plan

While the general idea of a data management plan is the same in different countries and circumstances, there is some variety in the type of information required. For example, the National Science Foundation (NSF) in the USA requires a short two-page data management plan as part of all grant applications. Such a plan is expected to address the following points[6]:

- the types of data, samples, physical collections, software, curriculum materials, and other materials to be produced in the course of the project;
- the standards to be used for data and metadata format and content (where existing standards are absent or deemed inadequate, this should be documented along with any proposed solutions or remedies);
- policies for access and sharing including provisions for appropriate protection of privacy, confidentiality, security, intellectual property, or other rights or requirements;
- policies and provisions for re-use, re-distribution, and the production of derivatives; and
- plans for archiving data, samples, and other research products, and for preservation of access to them.

A very useful practical resource for the preparation of a data management plan is the online data management planning tool of the UK Digital Curation Centre[7]. The UK Digital Curation Centre was launched in 2004, by a consortium comprising the Universities of Edinburgh and Glasgow (which together host the National e-Science Centre), UKOLN at the University of Bath, and STFC, which manages the Rutherford Appleton and Daresbury Laboratories.

Data management plans are not limited to data from natural sciences or engineering; they are also found in the social sciences. A comprehensive example, that in turn is also applicable for natural science and/or engineering data, is the list of the elements of a data management plan provided by ICPSR at the University of Michigan[8].

A data management plan for radiation monitoring data

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[6] http://www.nsf.gov/pubs/policydocs/pappguide/nsf11001/gpg_2.jsp#dmp

[7] available online at https://dmponline.dcc.ac.uk

[8] Inter-University Consortium on Political and Social Research, University of Michigan, http://www.icpsr.umich.edu/icpsrweb/content/ICPSR/dmp/framework.html

Several Individual pieces of a data management plan already exist or are emerging: quality assurance was discussed at the Conference for the Preparation of the Distribution Map of Radiation organised by MEXT in August 2011 and the real-time access to monitoring data since September 2011 constitutes a de-facto policy of transparency. However, a formal and comprehensive data management plan does not yet exist.

Advice

Point 7: The management of the collected data should be formally described in a data management plan.

5.3. Agricultural areas

Basis for review

The applicable IAEA safety standards and supporting publications were:

1) INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1 (2006)
2) INTERNATIONAL ATOMIC ENERGY AGENCY, International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources, IAEA Safety Series No. 115 (1996)
3) INTERNATIONAL ATOMIC ENERGY AGENCY, Non-technical Factors Impacting on the Decision Making Processes in Environmental Remediation, IAEA-TECDOC-1279, IAEA, Vienna (2002)
4) INTERNATIONAL ATOMIC ENERGY AGENCY, Technologies for Remediation of Radioactively Contaminated Sites, IAEA-TECDOC-1086, IAEA, Vienna (1999)
5) INTERNATIONAL ATOMIC ENERGY AGENCY, Characterization of Radioactively Contaminated Sites for Remediation Purposes, IAEA-TECDOC-1017, IAEA, Vienna (1998)
6) INTERNATIONAL ATOMIC ENERGY AGENCY, Environmental Consequences of the Chernobyl Accident and their Remediation: Twenty Years of Experience Report of the UN Chernobyl Forum Expert Group "Environment" (EGE) Radiological Assessment Reports Series 8
7) INTERNATIONAL ATOMIC ENERGY AGENCY, Planning for Cleanup of Large Areas Contaminated as A Result of A Nuclear Accident, Technical Reports Series 327 (1991)
8) INTERNATIONAL ATOMIC ENERGY AGENCY, Cleanup of Large Areas Contaminated as A Result of A Nuclear Accident, Technical Reports Series 300 (1989)
9) INTERNATIONAL ATOMIC ENERGY AGENCY, Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments Technical Reports Series 1616 (2009)

Findings

The Team was informed that the target for remediation of farm land is the reduction of the total annual dose to the public by 50% in the next two years. This refers only to the areas where the current dose is between 1 and 20 mSv/year. In the long term the total dose should be reduced to under 1mSv/year.

A threshold as basis for the selection of remedial actions

The selection of remedial actions for agricultural land is linked strongly to the threshold concentration of 5000 Bq/kg of radioactive caesium (Cs-134 and Cs-137) in the soil. For a radioactivity concentration in the soil of up to 5000 Bq/kg, reduction of the air dose rate and uptake of radioactive caesium by crops will be envisaged by deep ploughing or appropriate agrochemical and agronomic practices. Above this concentration, topsoil removal will be considered in addition to other practices.

Japanese authorities calculated that 6300 hectares of paddy fields and 2000 hectares of upland fields are characterized by a caesium concentration in soil above the threshold of 5000 Bq/kg.

Since the provisional regulation value for radioactivity in rice, set by the Japanese authorities, is 500 Bq/kg, a conservative transfer factor of 0.1 implies that the temporary permissible concentration for cultivation of rice paddy soil is 5000 Bq/kg.

The transfer factor of 0.1 was derived by the MAFF using data (564 data records) from 43 years of research on the transfer of caesium from paddy soil to brown rice collected by the National Institute for Agro Environmental Sciences. The observed transfer rates for 17 locations from all over Japan and a wide range of soil types varied between 0.00035 and 0.64, which averaged out at 0.012 (geometric mean). The ministry adopted the conservative value of 0.1 (90^{th} percentile of the observed transfer factors), nearly 10 times the average rate[9]. This rate was a good measure to reduce uncertainty in the Japanese population about the quality of the food produced.

However, the first preliminary results from the demonstration sites established by the Japanese authorities in the affected areas indicate that the actual transfer factor is likely significantly lower than 0.1, as anticipated. For instance, on the demonstration site in Iitoi (Iitate village) 30 km from the nuclear power plant, a transfer rate of 0.0065 was reported, 15 times lower than the established conservative rate of 0.1. This would also be consistent with

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[9] The reference index (0.1) of the transition of radioactive caesium from soil into brown rice was published on 8 April as a reference for consideration whether the planting of rice was suitable or not.

On 22 April, the Director-General of the Nuclear Emergency Response Headquarters instructed the government of Fukushima prefecture to restrict rice farming in the evacuation area, planned evacuation area and emergency evacuation preparation area, based on the result of soil surveys and consultation with the government of Fukushima prefecture.

Although the Director-General of the Nuclear Emergency Response Headquarters ordered the Fukushima prefecture not to plant the rice on 22 April, a Q&A regarding the production of vegetables “mentioned that the planting of agricultural products other than rice w[ould] not be restricted”.

the transfer factors in IAEA TECDOC 1616 from 2009[10], observed for clay-rich lowland paddy soils, similar to those soils found in the affected area of the Fukushima prefecture. In TECDOC 1616 transfer rates for brown rice grown on clay-rich soils are reported to range between 0.0014 and 0.15, with an average of 0.017 (geometric mean).

The Team was informed that the local governments are measuring radioactive caesium concentrations in rice planted and harvested after the accident during the current cropping season of 2011. Based on the data thus obtained, MAFF will calculate transfer factors of radioactive caesium from soil to brown rice and determine the transfer factor as an aid to reaching a decision on the feasibility of rice planting in the 2012 cropping season.

The Team is of the opinion that the conservatism in the transfer factor can be reduced when the tests in the affected area are completed and realistic factors have been firmly established.

It is expected that availability of caesium for the crops will further decline, due to increased fixation of caesium in the clay-rich soils. The Team, therefore, also advises that continuous testing is needed to fine-tune the reference level for the coming cropping seasons, and this for a wide range of soils and crops in the affected area.

Such testing results will be useful for planning appropriate and effective remedial actions.

Remedial options tested and implemented

Over the past months, the Japanese authorities have been testing options of how to remediate agricultural land affected by the Fukushima nuclear accident, with a focus on those techniques that are known to be the most efficient, such as topsoil removal and deep ploughing. Since 16 June, in nineteen sites, at a distance ranging between 30 and 160 km from the nuclear power plant, efficiency assessments have been carried out and estimations made of the amounts of waste generated (topsoil with elevated radioactivity levels), time needed and costs involved in carrying out the remediation.

a) Removal of topsoil: In the demonstration sites the following options for removal of topsoil were tested:

- Removal of the first 4 cm of topsoil;
- Removal of topsoil using soil hardener (3 cm); or
- For meadows, removal of grass and upper root-top soil layer (3 cm).

Measurements showed that removal of topsoil (a layer between 2 and 4 cm) is the most efficient countermeasure to drastically and rapidly reduce radioactive caesium in the soil (Figure 3). Reported efficiencies of this method varied between 75 and 97%.

Despite the high efficiency, the disadvantage is the volume of the disposed soil, with up to 400 ton/hectare (for 4 cm removal of topsoil) (Figure 4). An additional disadvantage is the

[10] http://www-pub.iaea.org/books/iaeabooks/8103/quantification-of-radionuclide-transfer-in-terrestrial-and-freshwater-environments-for-radiological-assessments

time needed to carry out the remediation, ranging between one and ten days per hectare (including time to let the topsoil harden after having applied the hardener solution).

Although the efficiency in radioactivity reduction is high, the radiation air dose rate is not always reduced in the same proportion. The reason is found in the small size of the paddy fields, surrounded by forests, with higher radiation levels. Therefore the Team advises the use of an integrated landscape approach in remediation, taking into account the field margins around agricultural land as well, which are often covered by forest.

Figure 3: Testing top soil removal after using soil hardener (Courtesy of MAFF-JAEA-NARO).

Figure 4: Temporary storage of removed topsoil from a paddy field at the demonstration site in Iitate village. (Giovanni Verlini, MTPI, IAEA)

b) Deep ploughing: A promising and less expensive option for decontaminating soils, in particular for lower soil radioactivity concentrations, is deep ploughing to bury the radioactive topsoil into the subsoil (Figure 5). Several ploughing depths have been tested, ranging from 30 to 60 cm. Air dose rates on the surface of ploughed land were reduced by a factor of 2.3, while with normal ploughing (rotary cultivation) these were reduced by only a factor of 1.8. The biggest advantage of deep ploughing is that it is less time consuming and does not generate soil that needs to be disposed of.

However, only ploughing depths of up to 45 cm can be carried out by normal agricultural machinery. In addition, assessment of soil conditions or groundwater levels is required before carrying out this type of remediation action. Fixation of caesium in permanently flooded soils (i.e. under the groundwater table) may be lower than in soils that are not permanently flooded. As caesium fixation determines the availability of radioactive caesium for the plants, this aspect is crucial.

Figure 5: Sampling soil for the assessment of efficiency in reducing soil radioactivity by deep ploughing. (Courtesy of MAFF-JAEA-NARO)

c) Draining suspended soil from paddies: A third tested method was a method specifically targeting flooded soils (i.e. rice paddies), focussing on the reduction of radioactivity levels in the soil by puddling the thin layer of topsoil under flooded conditions, draining the suspended soil (clay to light silt fraction), separating the sediments from water, and finally disposing only the sediments (Figure 6).

The efficiency of this technique in reducing the radioactive caesium concentration and external dose rate, at the test site, was 36% and 15% respectively. However, it was estimated by the authorities that the efficiency of this kind of remedial action (reduction of the radioactive caesium concentration) can go up to 71%, depending on soil properties, i.e. clay and humus contents .

An important advantage of this technique was the lower amount of waste that was generated, up to 33 times less, as compared to the technique based on topsoil removal (of 4 cm). Therefore, this method can minimize the deterioration of soil fertility. However, it has to be taken into account that the efficiency of this method is relatively low for soils which contain high amounts of soil organic matter, providing aggregation of the soil particles and preventing the dispersion of soils.

Figure 6: Draining suspended soil from paddies as a remediation option.
(Courtesy of MAFF-NARO).

d) Phytoremediation: Phytoremediation was also tested, using for instance sunflowers to extract caesium from the soil. However, as expected from lessons learnt from the remediation of soils affected by the nuclear accident in Chernobyl, results were not satisfactory, with an absorption of caesium concentrations per unit area by sunflowers of only 0.05% of caesium in the soil at planting date. The disposal of the crop residues is an additional challenge, which needs special incineration facilities, such as those tested at the demonstration sites in the affected area of the Fukushima prefecture (Figure 7).

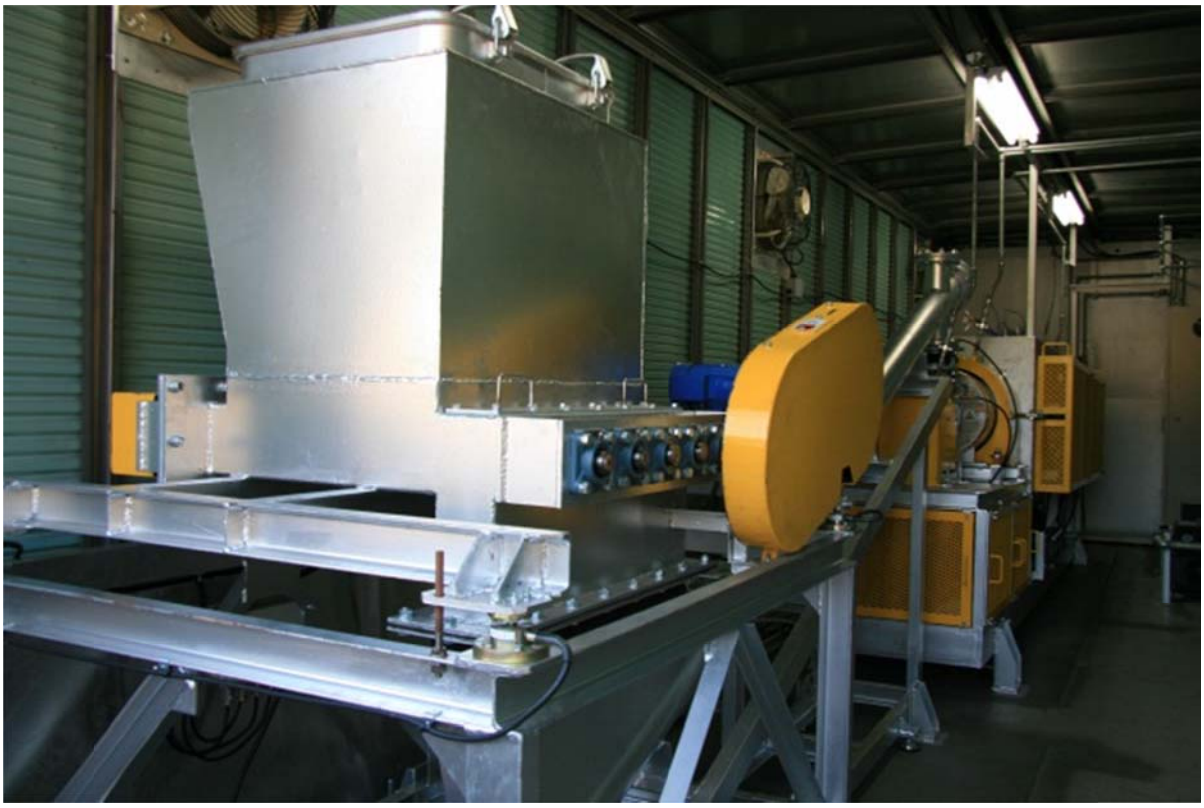

Figure 7: Incineration facilities for crop residues tested at a demonstration site in the affected area (Giovanni Verlini, MTPI, IAEA)

e) Agrochemical and agronomic options: Besides soil-based remedial options, such as topsoil removal and deep ploughing, which are currently the most important focus of the remediation of affected agricultural land in Japan, the application of potassium (K) and nitrogen (N) fertilization techniques, and adapted land use/management and agricultural water management practices may be agrochemical and agronomic options to minimize radioactive caesium in the local foodchain.

Assessment of the use of potassium fertilizer has been started to further minimize Cs-137 transfer into the local foodchain. Potassium is known to behave similarly to caesium in the soil. By adding potassium, caesium will be taken up less by the crops. As the tested physical remediation techniques may influence soil quality (the most fertile part of the soil can be found in the topsoil), agrochemical options are a crucial complement to the above mentioned soil-based remediation measures, such as topsoil removal and deep ploughing. Currently, 80-100 kg per hectare of potassium is recommended.

To identify the best agronomic options to remediate affected agricultural land, it is advisible to link radioactivity levels of soil with soil properties. In particular, information on the potassium status of the soil will be essential to predict the efficiency of potassium fertilizer application in reducing the transfer of caesium from soil to crop.

Holistic and area-wide approach

Planning agricultural countermeasures to remediate affected farmland is a task that needs to take into account radiological, food safety, ecological, socio-economic and cultural issues within a holistic and interdisciplinary frame.

The Team agrees with continuing in the same intensive and successful way to screen radioactivity concentrations in foodstuff samples. However, foodstuff analysis should be integrated in all test sites as a parameter to assess the efficiency of the remediation. In addition, it will encourage people to start farming their lands again, and will further increase the confidence of local, national and international consumers (Figure 8).

Figure 8: Sampling a rice crop to measure radioactivity concentration in grains at a demonstration site after remediation (Giovanni Verlini, MTPI, IAEA).

To complement the data from the assessment of the efficiency of remediation strategies to mitigate the consequences of the Fukushima accident for agriculture, the Team advises the establishment of cost-benefit analyses at the different levels of the decision-making process. These should consider the relationship between dose reduction and costs, including those costs related with temporary and final disposal of removed soil and crop residues.

The Japanese counterpart has developed a preliminary, but already comprehensive, catalogue of all possible remedial actions. The counterpart is encouraged to also develop a decision-tree to assist communities with the selection of the most efficient and cost-effective remedial actions, taking into account the reduction of radiation doses and the activity concentration of radionuclides in the soil and foodstuffs, and the amount of generated waste (soil/crops) to be disposed of.

An area-wide landscape approach is also crucial as soil redistribution in mountainous catchments, such as in specific areas of the Fukushima prefecture, can lead to the redistribution of radionuclides from the uplands to rice paddies and river systems in the lowlands through erosion of soil from steep uncovered hillslopes or forest tracks, in particular after extreme rainfall (Figure 9).

Figure 9: Small-holder farming systems in the Fukushima prefecture: An area-wide landscape approach is crucial (Gerd Dercon, NAFA, IAEA).

Highlights of important progress

Highlights 5 and 6 are also applicable here.

Highlight 8. The Team recognizes that in the early phase of the accident, conservatism was a good way to manage uncertainties and public concerns related to reference levels in the context of food and agriculture.

Advice

Point 8. With respect to the remediation of agricultural areas, the Team considers that for the next cropping season there is room for reducing some of the conservatism (such as that in transfer factors quantifying the transfer of radioactive caesium from soil to crops) by taking into account data and factors published by the IAEA and the results obtained from the demonstration sites and current surveys. The IAEA is ready to support Japan in considering new and more appropriate criteria.

5.4. Urban decontamination

Basis for Review

The review of countermeasures for urban decontamination was based on the requirements set out in the technical recommendations contained in safety standards and IAEA Nuclear Energy Series, Technical Report Series and Technical Documents listed below:

INTERNATIONAL ATOMIC ENERGY AGENCY, Planning for Clean-up of Large Areas Contaminated as A Result of A Nuclear Accident, Technical Reports Series 327 (1991)

INTERNATIONAL ATOMIC ENERGY AGENCY, Clean-up of Large Areas Contaminated as A Result of A Nuclear Accident, Technical Reports Series 300 (1989)

EURANOS: Generic Handbook for Assisting in the Management of Contaminated Inhabited Areas in Europe Following a Radiological Emergency (2007)

INTERNATIONAL ATOMIC ENERGY AGENCY, Guide on Decontamination of Rural Settlements in the Late Period After Contamination with Long-Lived Radionuclides, work material from TC Regional Project (2004)

ICRP Annals of the ICRP Publication 111 – Application of the Commission’s Recommendations to the Protection of People Living in Long-Term Contaminated Areas After a Nuclear Accident or a Radiation Emergency (2009)

The following documents and presentations were provided by the representatives of the Japanese Government (Ministry of Foreign Affairs (MOFA), Ministry of the Environment (MOE), Support Team for Residents Affected by Nuclear Incidents in Cabinet Office, National Emergency Response Headquarters (NER HQ), Japan Atomic Energy Agency (JAEA), and Atomic Energy Society of Japan (AESJ)) for discussions with the IAEA Team related to urban decontamination.

1. Outlines of the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials Discharged by the NPS Accident Associated with the Tohoku District - Off the Pacific Ocean Earthquake that Occurred on March 11, 2011

2. Basic Principles Based on the Act on Special Measures Concerning the Handling of Radioactive Pollution [Draft Outline]

3. Responses on the proposed topics for discussions with regard to the Act on Special Measures concerning the Handling of Radioactive Pollution and attachments prepared by Ministry of the Environment

4. Additional Report of the Japanese Government to the IAEA, September 2011 – Chapter IV Immediate Actions to Assist Residents Affected by the Nuclear Accident (Actions in Off-Site) with the following attachments:

- Attachment IV-10 Decontamination Measures in Date City
- Attachment IV-11 The Basic Approach to Clean-up Work (Decontamination) in Residential Areas (Except Restricted Area and Deliberate Evacuation Area) in Fukushima Prefecture

5. Remediation Effort in Japan, presentation by Support Team for Residents Affected by Nuclear Incidents in Cabinet Office

6. JAEA Remediation Activities, presentation by JAEA

7. JAEA Activities towards Environmental Restoration of Fukushima, presentation by JAEA

8. JAEA Remediation Activities- Demonstration Projects, presentation by JAEA

9. Environment Remediation Techniques for Briefing (Provisional version Ver. 2） presentation, prepared by Clean-up Subcommittee Committee for Investigation of Nuclear Safety Atomic Energy Society of Japan (AESJ).

Findings

Decontamination of settlements is one of the main countermeasures to be applied to reduce external exposure of the public and clean-up workers during the initial stage of the response to a severe nuclear emergency. The immediate purpose of settlement decontamination is usually the removal of radiation sources distributed in urban environments inhabited by humans or isolation of the sources from the inhabited environment.

The contributions of different urban surfaces to human external doses and the associated opportunities for dose reduction are determined by settlement and house design, the construction materials, the habits of the population, the mode of radionuclide deposition (dry or wet), the radionuclide and physicochemical composition of the fallout, the season and the time since the fallout. Surfaces such as trees, bushes, lawns and roofs become relatively more contaminated under dry conditions than when there is precipitation. Under wet conditions, horizontal surfaces receive the highest levels of contamination, including soil plots and lawns.

Due to natural weathering processes and to human activities, radionuclides become detached from the surfaces on which they were deposited and transported within settlements. Contaminated leaves and needles from trees and bushes are removed from settlements after seasonal defoliation and radionuclides deposited on asphalt and concrete pavements are eroded or washed off via sewage systems. Particularly high Cs-137 activity concentrations have been found around houses, where rain has transported radioactive materials from roofs to the ground.

Analysis of the sources of external exposure in different population groups living in areas contaminated with air-borne radionuclides revealed that a significant fraction of the dose is usually received by people from sources located in soil, on coated surfaces like asphalt and concrete and to a smaller extent on building walls and roofs. In order to ensure high decontamination effectiveness and to keep the associated costs low, validated models of urban decontamination were developed by Japanese demonstration projects and provided with sets of model parameters and practical recommendations for clean-up. In this demonstration framework, a preliminary remediation assessment based on well-developed cost-benefit techniques has been performed in order to justify decontamination and to optimize its implementation.

The Team noted that when moving from demonstration tests into large scale remediation, in accordance with present radiation protection methodology, a decision on intervention (decontamination) and selection of optimal decontamination technologies should be made giving consideration to the costs of all actions and social factors. The calculated cost should address the various decontamination technologies for which an assessment of the averted dose has been made.

The Team's visits to sites have shown that decontamination of urban areas is actively pursued in contamination affected areas. In the Team's view, the priorities are clearly established starting with the deliberate evacuation area and so called "hot spot" areas, kindergartens and schools, then community centres followed by individual settlements.

Also, based on visits to the sites, the Team noted the utilization of proven technologies for the decontamination of roofs, building walls, playgrounds, swimming pools, parking lots, and asphalt covered areas. Thorough measurements and mapping of the contamination are carried out to ensure the most effective results and the elimination of hot spots. The most effective decontamination methods that are pursued involve the removal of the upper soil layer. The tests performed indicate the use of different methods to achieve a significant reduction of dose rates.

The contaminated material that is removed and collected was temporally stored at sites because of the removal option used and the absence of interim storage facilities. The current practice is either to bury the material in near surface trenches and cover it with a layer of clean topsoil or to collect it in a pile on the ground and to cover it with plastic sheets and sand bags to provide additional shielding. Both measures were considered as temporary measures before transport to interim storage.

The measurements indicate that a large part of the contaminated material collected from clean-up actions at urban demonstration sites is only slightly contaminated. Adequate pathways for such material could be found outside of the category of radioactive waste.

The portion of the removed material that qualifies as radioactive waste generated from urban decontamination should be disposed of in accordance with established regulatory requirements.

Model demonstration tests have been conducted by JAEA in several schools for the decontamination of swimming pools using a flocculation-precipitation process developed for this purpose. Locally available natural zeolite powder has been used for the capture of radiocaesium. In demonstration tests, pool water was pumped into a series of 1 tonne tanks and treated. The purified water was discharged and the radioactive residue collected for storage. The process scheme is illustrated in Figure 10.

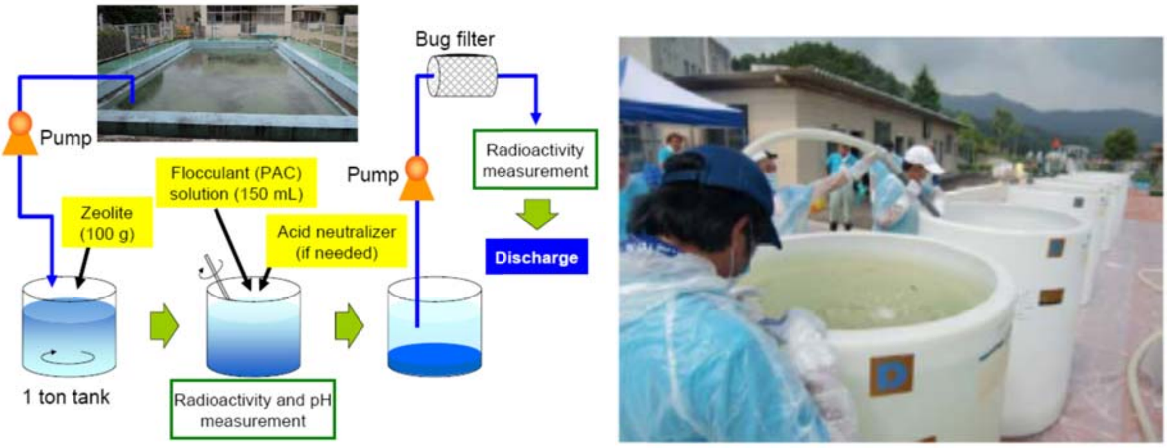

Figure 10: Decontamination of swimming pool water

Removal of radiocaesium from swimming pool water was also successfully tested using grafted adsorbent columns. The column method requires careful removal of suspended matter to prevent clogging so it can be used more effectively for decontamination of relatively clean water.

The visit to Date city provided an opportunity to witness larger scale decontamination of residential and surrounding areas, where various techniques were tested for decontamination (Figure 11).

Figure 11: Example of the demonstration of decontamination of various residential areas

In another example of a demonstration trial, contaminated topsoil (5 cm) was removed from a schoolyard resulting in a reduction of up to 95 % in the dose rate. The removed soil was emplaced in a 1.5 m deep trench that was dug out at one side of the schoolyard and covered with a mixture of soil removed from the trench and clean soil (Figure 12).

Figure 12: Example of demonstration of decontamination of school yard

The Clean-up Subcommittee Committee for Investigation of Nuclear Safety, Atomic Energy Society of Japan (AESJ) has prepared a catalogue of environmental remediation techniques that is intended for use in selecting suitable options for implementation as appropriate. The basis for the catalogue's development is EURANOS reports and other materials summarizing lessons learned. Based on a review of existing information on available techniques, this catalogue summarizes the key features of a selection of techniques that are applicable to the situation in Japan. The techniques include those that are suitable for buildings (external and internal) and public facilities like parks, athletic fields and roads, e.g. water spraying, scrubbing, wiping, containment, roof replacement, strippable paints, grinding, vacuum cleaning, soil removal, mowing, etc. Contamination removal efficiency, worker dose, and generation of secondary waste are amongst the important factors suggested for consideration in selecting appropriate techniques for particular applications.

The material in the catalogue is presented in such a way that non-technical readers will be able to understand the advantages and disadvantages of particular decontamination technologies, the optimal use of each and how it is to be utilized. The results of all demonstration tests performed in various areas to be decontaminated will be used to validate technical options listed in the catalogue and their performance. Besides urban areas the catalogue also includes information on decontamination techniques applicable to other areas such as agriculture land and forest and even processes for treatment of material coming out of the tsunami disaster.

The Team appreciated that the development of the catalogue is a commendable effort by the Clean-up Subcommittee Committee for Investigation of Nuclear Safety, Atomic Energy Society of Japan (AESJ). The catalogue is a very valuable tool since it simplifies the decision making process and provides a basis for stakeholder participation in decision making.

Highlights of important progress

Highlights 4, 5 and 6 are also applicable here.

Highlight 9**:** The Team appreciates the fact that some school sites were remediated mostly by volunteers with the technical support and guidance of the JAEA. The Team was informed that 400 school playgrounds have already been appropriately remediated (as of 30 September 2011).

Advice

Point 9: With respect to waste in urban areas, the Team is of the opinion that it is obvious that most of the material contains very low levels of radioactivity. Taking into account the IAEA safety standards, and subject to safety assessments, this material might be remediated without temporary and/or interim storage. It is effective to utilize the existing municipal infrastructure for industrial waste. The IAEA is ready to support Japan in considering new and appropriate criteria.

5.5. Forest areas

Basis for Review

Countermeasures for forested areas contaminated with radionuclides are only likely to be implemented if they can be accepted by foresters or landowners on a practical basis and also be accepted by the general public. Based on lessons learned from the Chernobyl accident, forest countermeasures are labour-intensive and expensive, cannot be implemented quickly and have to be planned carefully. They are likely to be long-term activities and their beneficial effects take time to be realized.

The known forest countermeasures can be broadly categorized into: (a) management; and (b) technological countermeasures.

Among management-based countermeasures, restrictions of various activities normally carried out in forests have been successfully implemented:

- Restricted access, including restrictions on public and forest-worker access;
- Restricted harvesting of food products by the public. The most commonly obtained food products include berries and mushrooms;
- Restricted collection of firewood by the public; and
- Alteration of hunting practices.

Fire prevention is particularly important in order to avoid secondary contamination of the environment.

The technologically-based countermeasures include the use of machinery and/or chemical treatments to alter the distribution or transfer of caesium in the forest. However, the cost-effectiveness of many technological countermeasures is questionable, especially when applied on a large scale. Thus, it is to be expected that such countermeasures will be restricted to small-scale cases only, if they are feasible at all. Such cases might include small areas of urban woodland, such as parkland, which is likely to be visited frequently by large numbers of people, rather than extensive and remote forest areas.

Technological countermeasures might include the mechanical removal of leaf litter or scraping of soil layers, clear cutting and ploughing, and the application of calcium and potassium containing fertilizers. However, any of these methods can damage the ecological functioning of the forest when applied outside of the normal schedule of forestry operations. These factors and the high economic costs of such operations, means that the practical use of such techniques as countermeasures remains largely speculative. Therefore, such measures have not been applied after the Chernobyl accident other than in small-scale experiments.

The results of cost-benefit calculations indicate that the management options likely to result in the least overall detriment are those which limit access and consumption of forest foods. Options which involve technological intervention, application of chemicals, or altering the harvesting patterns in forests are unlikely to be used in practice.

Findings

The Mission Team understands that authorities in Japan are considering three possible options for remediation of the forest areas. The option that is considering remediation of the forest in the neighbourhood of urban settlements and agricultural lands looks most realistic for implementation.

Advice

Point 10. Before investing substantial time and efforts in remediating forest areas, a safety assessment should be carried out to indicate if such action leads to a reduction of doses for the public. If not, efforts should be concentrated in areas that bring greater benefits. This safety analysis should make use of the results of the demonstration tests.

5.6. Aquatic areas

Basis for review

Aquatic environments include rivers, irrigation reservoirs, fish ponds, lakes and coastal areas. The last are being directly affected by the release of radionuclides from the affected NPP. Freshwater environments receive radionuclides from erosion and runoff of the soils in the watersheds. This contribution has a long term source of activity; the accumulation of the relevant radionuclides will preferentially take place in sediments. Organisms feeding on them may incorporate caesium to different degrees depending on the individual species and environmental conditions.

Findings

The monitoring of river water, sediments and fish is being conducted by different organizations; a limit for fish of 500 Bq/kg is applied. Remediation of these areas was not addressed in detail by the Japanese counterparts during the meeting with the Mission Team. However, the exposure to members of the public through this pathway generally is of minor importance.

Advice

Point 11. The Mission Team encourages the Japanese authorities to continue the useful monitoring of freshwater and marine systems.

5.7. Waste Management

The Team recognised that managing contaminated disaster waste, in particular identifying appropriate end-points, is currently a key issue for successful remediation activities in Japan. Challenges in waste management also emphasize the benefits from identifying such remediation approaches that produce no or limited amounts of waste as reflected in the advice in Points 1, 5, 6, 8, 9 and 10.

Since in Japan, the waste issues are one of the key issues under discussion and consideration, the Team wishes to express its deliberations in more detail in the following.

Basis for the review

The IAEA Fundamental Safety Principles, Safety Fundamentals No.SF-1 state that "Radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations; that is, the generations that produce the waste have to seek and apply safe, practicable and environmentally acceptable solutions for its long term management. The generation of radioactive waste must be kept to the minimum practicable level by means of appropriate design measures and procedures, such as the recycling and reuse of material."

This principle is further elaborated in "Predisposal of Radioactive Waste, General Safety Requirements Part 5, No. GSR Part 5". For example, measures to control the generation of radioactive waste, in terms of both volume and radioactivity content, have to be considered. The control measures are generally applied in the following order: reduce waste generation, reuse items as originally intended, recycle materials and, finally, consider disposal as waste.

The review of management of contaminated material from remediation was based primarily on the requirements set out in IAEA Safety Standards Series and the technical recommendations contained in IAEA Nuclear Energy Series, Technical Report Series and Technical Documents listed below:

1. Policies and Strategies for Radioactive Waste Management, NES NW-G-1.1 (2009)
2. Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5 (2009)
3. Review of the Factors Affecting the Selection and Implementation of Waste Management Technologies; IAEA TECDOC-1096, IAEA, Vienna (1999)
4. Strategy and methodology for radioactive waste characterization, TECDOC-1537 (2007)
5. Development of specifications for radioactive waste packages, TECDOC-1515 (2006)
6. Methods for maintaining a record of waste packages during waste processing and storage, TRS-434 (2005)
7. Inspection and testing in conditioning of radioactive waste, TECDOC-959 (1997)
8. Characterization of radioactive waste forms and packages, TRS-383 (1997)
9. Requirements and methods for low and intermediate level waste package acceptability, TRS-864 (1996)
10. Quality assurance for radioactive waste packages, TRS-376 (1995)
11. Application of the Concepts of Exclusion, Exemption and Clearance, IAEA Safety Guide, Safety Standards Series No. RS-G-1.7 (2004)
12. New developments and improvements in processing of 'problematic radioactive waste, TECDOC-1579 (2007)

13. Retrieval and conditioning of solid radioactive waste from old facilities, TRS-456 (2007)

14. Predisposal management of organic radioactive waste, TRS- 427 (2004)

15. Application of ion exchange processes for the treatment of radioactive waste and management of spent ion exchangers, TRS-408 (2002)

16. Technologies for in situ immobilization and isolation of radioactive wastes at disposal and contaminated sites, TECDOC-972 (1997)

17. Containers for packaging of solid low and intermediate level radioactive wastes, TRS-355 (1993)

18. Improved cement solidification of low and intermediate level radioactive wastes, TRS-350 (1993)

19. The volume reduction of low-activity solid wastes, TRS-302 (1989)

20. Application of Thermal Technologies for Processing of Radioactive Waste, TECDOC-1527 (2006)

21. Status of technology for volume reduction and treatment of low and intermediate level solid radioactive waste, TRS-360 (1994)

22. Treatment and conditioning of radioactive solid wastes, TECDOC 655 (1992)

23. Combined methods for liquid radioactive waste treatment, TECDOC-1336 (2003)

24. Management of low and intermediate level radioactive wastes with regard to their chemical toxicity, TECDOC-1325 (2003)

25. Interim storage of radioactive waste packages, TRS-390 (1998)

26. Storage of radioactive wastes, TECDOC-653 (1992)

27. Regulations for the Safe Transport of Radioactive Material, 2009 Edition, No. TS-R-1

28. Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material, No. TS-G-1.1 (Rev. 1) [2008 Edition]

29. Disposal of Radioactive Waste, IAEA Specific Safety Requirements No. SSR-5 (2011)

30. Low and Intermediate Level Waste Repositories: Socio-economic Aspects and Public Involvement, IAEA-TECDOC-1553 (2007)

31. Considerations in the Development of Near Surface Repositories for Radioactive Waste, TRS-417 (2003)

32. Scientific and Technical Basis for the Near Surface Disposal of Low and Intermediate Level Radioactive Waste, TRS No. 412 (2002)

33. Technical Considerations in the Design of Near Surface Disposal Facilities for Radioactive Waste, TECDOC-1256 (2001)

The following documents and presentations were provided by the representatives of the Japanese Government (Ministry of Foreign Affairs (MOFA), Ministry of the Environment (MOE), Support Team for Residents Affected by Nuclear Incidents in Cabinet Office, National Emergency Response Headquarters (NER HQ), Ministry for Agriculture, Forestry and Fisheries (MAFF), Japan Atomic Energy Agency (JAEA), and Atomic Energy Society of Japan (AESJ)) for discussions with the IAEA team related to the management of contaminated material from remediation.

1. Outlines of the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials Discharged by the NPS Accident Associated with the Tohoku District - Off the Pacific Ocean Earthquake That Occurred on March 11, 2011

2. Basic Principles Based on the Act on Special Measures Concerning the Handling of Radioactive Pollution [Draft Outline]

3. Guidelines on Disposal Methods for Incinerated Ash and Other Waste with Radiation Levels higher than 8,000 Bq/kg up to less than 100,000 Bq/kg (Outline)- prepared by MOE

4. Responses on the proposed topics for discussions with regard to Act on Special Measures concerning the Handling of Radioactive Pollution and attachments prepared by Ministry of Environment

5. Additional Report of the Japanese Government to the IAEA, September 2011 – Chapter IV Immediate Actions to Assist Residents Affected by the Nuclear Accident (Actions in Off-Site) with the following attachments:

    a. Attachment IV-11 The Basic Approach to Clean-up Work (Decontamination) in Residential Areas (Except Restricted Area and Deliberate Evacuation Area) in Fukushima Prefecture

    b. Attachment IV-12 Guideline on Disaster Waste Processing in Fukushima Prefecture

    c. Attachment IV-13 Interim Storage for the Disposal of Disaster Waste in Fukushima Prefecture

    d. Attachment IV-14 Incineration Facilities and Monitoring of Disaster Waste Disposal in Fukushima Prefecture

    e. Attachment IV-15 Measurement of Incineration Ash and Interim Handling Thereof at Incineration Facilities for General Waste

f. Attachment IV-16 Promotion of Regional Disposal of Disaster Waste

g. Attachment IV-17 Regarding "The Approach to Immediate Handling of Secondary By-products of Water and Sewage Treatment in which Radioactive Materials were Detected"

h. Attachment IV-18 Temporary treatment of waste detected radioactive material

i. Attachment IV-19 Measurement Results for the Concentration of Radioactive Cesium in Incinerated Ash at General Waste Treatment Facilities

j. Attachment IV-20 Monitoring of Radioactive Materials at General Waste Treatment Facilities

k. Attachment IV-21 Handling of General Waste Possibly Contaminated by Radioactivity at General Waste Treatment Facilities

l. Attachment IV-22 Basic Policy for Emergency Response on Decontamination Work

6. Estimation on the Amount of Soil etc. Generated by Decontamination Work

7. Remediation Effort in Japan, presentation by Support Team for Residents Affected by Nuclear Incidents in Cabinet Office

8. JAEA Remediation Activities, presentation by JAEA

9. JAEA Activities towards Environmental Restoration of Fukushima, presentation by JAEA

10. Treatment of “Disaster Waste” that May be Contaminated with Radioactive Materials, presentations by JAEA

11. JAEA Remediation Activities- Demonstration Projects, presentation by JAEA

12. Development of Technologies for Removal of Radioactive Material from Agricultural Soil in Japan, presentation by MAFF

13. Environment Remediation Techniques For Briefing (Provisional version Ver. 2 presentation, prepared by Clean-up Subcommittee Committee for Investigation of Nuclear Safety Atomic Energy Society of Japan (AESJ)

Findings

Waste types, quantities and characteristics

Large volumes of contaminated material will be generated from massive clean-up/remediation activities in urban, agriculture, forest and aquatic areas that are affected mostly by radioactive caesium releases. The material would include soil, organic material, vehicles, building and road material, aqueous liquids, trees and stumps contaminated with Cs-134 and Cs-137. The radioactivity content of the contaminated material ranges from a few to several tens of thousands of Bq/kg.

The quantity of contaminated material that would be collected from clean-up depends on the extent and depth of the contamination, the characteristics of the affected environment (urban, forest, agriculture, etc.) clean-up criteria, and the timing when the remediation is done.

The authorities in Japan are considering nine reference decontamination cases that are based on annual effective dose and the type of area. The initial estimate of the amount of soil, etc. that would be generated from the different reference cases is given in Table 1.

[1000m^3]

Cases (For each case [20mSv or above, or 5mSv or above], we estimate the amount when forest is decontaminated 100%, 50%, or 10%.)			Land for Buildings	Land for Transportation	Agricultural Land	Forest	Other	Decontamination (Hotspot only)	Total
1-1	20mSv or above	Decontamination Forest : 10%	193	17	4,387	367	245	—	5,209
1-2		Decontamination Forest : 50%	193	17	4,387	1,387	245	—	6,229
1-3		Decontamination Forest : 100%	193	17	4,387	2,662	245	—	7,504
2-1	5mSv or above	Decontamination Forest : 10%	1,024	50	17,425	1,206	1,128	—	20,833
2-2		Decontamination Forest : 50%	1,024	50	17,425	4,562	1,128	—	24,190
2-3		Decontamination Forest : 100%	1,024	50	17,425	8,758	1,128	—	28,385
3-1	5mSv or above: Decontamination 1mSv or above: Decontamination (Hotspot only)	5mSv or above ・Decontamination ・Forest : 10% 1-5mSv Decontamination (Hotspot only) (Except forests)	1,024	50	17,425	1,206	1,128	399	21,233
3-2		5mSv or above ・Decontamination ・Forest : 50% 1-5mSv Decontamination (Hotspot only) (Except forests)	1,024	50	17,425	4,562	1,128	399	24,589
3-3		5mSv or above ・Decontamination ・Forest : 100% 1-5mSv Decontamination (Hotspot only) (Except forests)	1,024	50	17,425	8,758	1,128	399	28,785

Table 1. Estimated results of the amount of soil, etc. produced by different decontamination cases

As can be seen from the Table, the volume of contaminated material from the clean-up is estimated to be anywhere between 5 and 29 million m^3, depending on the annual exposure dose in targeted areas and the extent of forest and agriculture land decontamination.

It should be noted that the estimate appears to be based on thorough removal of contaminated material from all contaminated areas and it does not take into account either segregation at the source or the application of clean-up techniques that would not require removal (e.g. ploughing in) or timing (for example allowing natural decay of Cs-134 to the radioactive content of the soil).

Another point worth noting is that the volume of excavated soil is considerably higher than the geometric excavation volume due to a reduction in its density. For example, the volume corresponding to the removal of 5 cm layer from land surface is 50 000 m^3 per km^2 but the volume of removed soil to be handled will be considerably higher.

The contaminated debris (wood, concrete, and metal) from the destruction caused by the tsunami, so called “disaster waste”, amounts to 2.3 million tonnes just in the Fukushima prefecture which needs to be added to this volume. More than half of the disaster waste has already been collected in temporary storage sites in the municipalities of the Fukushima prefecture. It is estimated that up to 50% of such waste is combustible. It should be also noted that collected material is piled up by type (e.g. wood, rubble and metal) but not further segregated by the activity content. This means that further management of all material from designated piles is already determined, since now further segregation by the activity is not practical.

In the Team’s view, it is however clear that, irrespective of which reference case is adopted in practice, clean-up efforts will lead to the generation of huge volumes of contaminated material running into millions of m^3.

All of this generated contaminated material is to be collected, characterized for clearance or treatment and conditioning as required, stored and finally disposed of.

The Mission Team’s considerations related to waste management were trying to address the consequences of full implementation of the clean-up and the maximal volume of contaminated material that could be generated.

In order to put these quantities into perspective it is to be understood that a typical nuclear power plant with a 1000 MW(e) reactor generates 250-400 m^3/y of operational waste, which will result in a total of 15 000 - 25 000 m^3 of raw low level waste (LLW) for 60 years of operation. The decommissioning will add 5000 - 10 000 m^3 of generated waste. The disposable volume of the radioactive waste generated would be still much less after processing for volume reduction and final conditioning prior to disposal and classified mostly as LLW or VLLW. Therefore waste management strategies for NPPs are addressing volumes expressed in thousands of m^3 and management of contaminated material as result of accident needs to address millions of m^3. Moreover waste management strategies for NPPs are dealing with radioactive waste issues in long time frames (e.g. 60 - 100 years) whereas management of the bulk of accident generated contaminated material is planned to be implemented in a much shorter time frame.

In the Team's view, it can be easily concluded that a relative comparison of the volumes of radioactive waste generated from nuclear power plants and the volumes of "contaminated material" from post-accident remediation is meaningless since the difference amounts to several orders of magnitude, even if one tries to compare it with all VLLW and LLW from the life cycle of the existing NPPs in Japan. It is then also possible to conclude that pathways for management of these "materials" should have different considerations and end-points.

Clearance and waste classification issues

A major proportion of the very large volumes of generated material that is to be collected will likely be only slightly contaminated. At the outset, it is imperative to have clear criteria for what constitutes radioactive waste and which kind of material can be cleared (either conditionally or unconditionally) from the regulatory control as elaborated in Section 4 of the report.

As already noted contamination of areas affected by the deposition of radioactive Cs is the major focus of the clean-up. It is important to note that deposition of radioactive Cs in affected areas is not uniform. Since radio Cs is a gamma emitter it is possible to measure the dose rate with readily available instruments and to further characterize and map areas where clean-up is to be performed. Detailed mapping of areas prior to clean-up has been performed prior to implementation of demonstration projects. Therefore it is worthwhile to pursue segregation of material collected from the clean-up based on its radioactivity content at the point of collection.

The Team noted that segregation of the material based on activity at the point of collection from clean-up and prior to mixing all collected material in "temporary storage" would help simplify the determination of the further steps required to manage the volume of collected material. Such an effort may also contribute to better understanding for decisions on the establishment of criteria for unconditional clearance, conditional clearance, or classification as residues (not classified as radioactive waste), VLLW and LLW.

The unconditionally cleared material can be considered for recycling and reuse or conveniently managed as municipal solid waste utilizing existing infrastructure for transportation, handling, treatment for volume reduction and disposal in municipal solid waste landfills.

The management of conditionally cleared material could require particular arrangements for transportation, treatment, eventual recycling and disposal in designated landfills equipped with systems for leachate collection, control of gases and adequate monitoring.

Only the fraction designated as VLLW or LLW radioactive waste would be required to meet the corresponding requirements for transportation, adequate processing, packaging, and facilities for interim storage and disposal in licensed near surface facilities.

At present, it is not possible to estimate the relative proportions of these three categories that could come out of the segregation of contaminated material and the future consequences of the adoption of the proposed management options. The large volume is still the major concern. For example, it is not clear to what extent municipal solid waste landfills can accommodate additional quantities of unconditionally cleared material from clean-up campaigns, or how many existing landfills could be designated to receive conditionally cleared material, or to what extent the municipal solid waste management infrastructure is available for management of these additional volumes.

In the Team's view, the following aspects could contribute to the success of envisaged clean-up campaigns:

- Establishment of clearance levels to handle these massive volumes,
- establishment of criteria and a management system for conditional clearance on a case by case basis and
- possible revision of regulatory requirements related to the management of Municipal Solid Waste (MSW) to utilize existing infrastructure and to allow the acceptance of bulk quantities of unconditionally cleared and conditionally cleared material.

Waste management strategy

The key elements of the current waste management strategy have been formulated by the Government of Japan and they are already considering the three above mentioned pathways for contaminated material management options. These key elements include:

- collection of contaminated material in dispersed temporary storage facilities at or near the clean-up location
- transfer of contaminated material from temporary storage facilities into a smaller number of interim storage facilities
- volume reduction of combustible material by incineration in available municipal solid waste incinerators equipped with off-gas cleaning systems for retention of caesium
- volume reduction of soil using soil washing techniques to separate caesium or caesium rich soil constituents
- final disposal, depending on radioactivity content, in commonly used or specially designated municipal landfills or near surface disposal facilities
- establishment of an inventory of collected material to keep track of the activity and the amounts actually generated

The Team is of the opinion that the national strategy for dealing with disaster and clean-up waste is properly established and it is sound. The main technical challenges in waste management strategy implementation and consequently in the implementation and success of clean-up campaigns are:

– existence of the infrastructure that is required for management of such very large volumes of generated material (including collection and segregation at the source by the activity level);
– establishment of numerous temporary storage facilities, transportation, capacity for treatment for volume reduction and the needed capacity of municipal landfills for disposal of unconditionally or conditionally cleared material;
– determination of site locations for interim storage facilities for such volumes and the time frame for storage;
– establishment of designated final disposal locations for different types of wastes.

Utilization of existing infrastructure for management of municipal solid and industrial waste

It can be assumed that the existing infrastructure for the management of municipal solid and industrial waste is the only infrastructure that is presently available for management of disaster waste (from areas affected by the tsunami) and for the management of contaminated material from clean-up campaigns. The utilization of the existing infrastructure for municipal solid and industrial waste would require a better understanding of its ability to: (i) handle these unplanned additional quantities as well as (ii) handle contaminated material. In the text that follows these two issues are discussed assuming maximum volumes of material from clean-up campaigns and the management of disaster waste in the implementation period of 2-5 years.

In Japan, waste is divided into two major categories, “industrial waste” and “municipal waste”, and managed in accordance with the Waste Management and Public Cleaning Law established in 1970. The disposal of municipal wastes is the responsibility of the municipalities. The disposal of industrial wastes is the responsibility of the entities that generate the wastes.

For the purpose of this discussion it is assumed that the existing infrastructure for the collection, transportation, treatment, conditioning and disposal of MSW is optimised to respond to the needs of the total population, and it is based on the average density and distribution of inhabitants in all municipalities. In Japan annual generation of MSW by 127 million inhabitants is approximately 44 million tonnes (1.0 kg/capita/day), of which only around 5 million tonnes go for final disposal in municipal landfills (less than 12%). Nearly 32 million tonnes is incinerated to reduce volume and 10 million tonnes is recycled. The balance of the total (non-processable waste), together with residues from recycling and incineration comprise 5 million tonnes that are disposed of. The complete infrastructure for management of MSW is the responsibility of local governments, prefectures and it is optimized to these quoted quantities.

The amount of generated industrial waste is about 400 million tons, divided by volume in 20 separate categories. The disposal rate for the industrial waste is much smaller than for MSW, since only 5% or less than 17 million tonnes are disposed of in landfills. The collection of industrial waste and facilities for treatment are the responsibility of the waste generators. Although the disposal of the certain categories of industrial waste can be combined with disposal of municipal waste it is still the responsibility of the generator. The distribution of facilities for the treatment of industrial waste, as well as for its disposal is not uniform across the country, since it depends on concentrations of the various industries and commercial arrangements for eventual treatment and disposal.

These numbers point to the special features of waste management in Japan, namely high volume reduction and very low volumes that go for final disposal. Most waste is treated in incineration, dehydration, or milling plants. The major reason for this is limited space for landfills.

The Team understood that the total quantity of disaster waste is estimated at 25 million tonnes, but the ratio of contaminated disaster waste to clean is at the moment unknown to the IAEA team, except in the Fukushima prefecture where 2.3 million tonnes is reported to be contaminated. The maximum volume of contaminated material from the clean-up campaign is estimated at 29 million m^3. Assuming the bulk density of 1 tonne/m^3 the mass of contaminated material is 29 million tonnes. If such assumptions are correct then it is obvious that total the quantity of disaster waste and contaminated material from the clean-up is nearly equal to the annual generation of MSW for the whole of Japan.

However it is not possible to utilize the infrastructure for MSW in the whole of Japan for management of this additional load of waste. Most likely the infrastructure available in affected and neighbourhood prefectures will be the one to be predominantly utilized. It is worthwhile to note that the infrastructure for MSW in the prefectures of Fukushima, Miyagi and Iwate that are most affected by the tsunami and in Chiba and Ibaraki that are also affected by the tsunami and contamination to a lesser extent corresponds to the needs of only 4.4 to 11.6% of the total population in Japan. The Team considered it important to estimate to what extent the available infrastructure in these prefectures will be saturated if it is used for routine MSW streams as well as for these additional volumes of material from disaster waste and clean up.

Since both the number of incinerators for MSW and their possible throughput (186 000 tonne/day for all of Japan) are high, it could be assumed that the mass and volume of the additional load of combustible material coming out of the treatment of disaster waste and clean-up would not fully saturate available capacities especially if some industrial incinerators can be used to add capacity. However, this assumption requires a better understanding of available capacities in the directly affected region and the ability to use incinerators from the other prefectures. In any case treatment capacities can be gainfully utilized with eventual capacity additions. However, the criteria to use these incinerators to burn contaminated combustible material, related to worker protection, public exposure due to discharge limits for gaseous effluents, and management of radioactive ash, may present a challenge because of specific features of these incinerators such as their locations, design details and operating licences.

The situation regarding utilization of municipal landfills for disposal of treated and non-processed contaminated material appears to be a much bigger challenge. Landfills are classified into three types: isolated, leachate-controlled, and non-leachate-controlled. Isolated landfills are used for the disposal of hazardous industrial wastes. Leachate-controlled landfills are used for the disposal of both municipal and industrial wastes other than hazardous and stable wastes. Non-leachate-controlled landfills are used for the disposal of stable wastes, namely, waste plastics, rubber scrap, metal scrap, waste glass, ceramics, and demolition waste. The standards for landfill site structure and those for landfill site operation and maintenance have been established in accordance with landfill type. It can be concluded that adequate controls exists on most of these landfills and that their utilization for contaminated material is possible after a safety assessment to establish limits due to the radioactivity of material to be disposed of. However the available capacities in the existing landfills seem fairly limited. The data for all of Japan point to an available capacity for the next 19 years for MSW and only several years for industrial waste. The capacity limits should first be checked for the affected prefectures to come to a better estimate of the magnitude of the problem. Careful consideration should also be given to the establishment of limits for the recycle and reuse of material starting from segregation at collection points as well as from different treatment methods to resolve capacity limitation problems for utilization of municipal landfills.

The Team is of the opinion that the National Strategy rightly includes the use of existing infrastructure for municipal solid and industrial waste. This infrastructure exists and it would be able to handle contaminated material to a significant extent, especially if the following criteria are established to assist in the management of the post-tsunami and post-accident situation:

- occupational exposure limits for the collection of material for temporary storage and segregation at the point of collection to different streams related to activity;
- establishment of limits for direct recycle and reuse of slightly contaminated material (e.g. rubble, metal, soil, etc.);
- transportation of contaminated material to treatment facilities, non-processable contaminated material directly to disposal facilities and soil to either treatment or disposal facilities;
- acceptance requirements for contaminated material for incineration, radiation protection of workers, effluent release limits, and the transport of radioactive ash to disposal facilities.

On the other hand additional capacity for contaminated material treatment by incineration and soil treatment facilities will be needed probably on the contaminated territory. However the major capacity additions to the existing infrastructure are going to be facilities for interim storage, disposal of radioactive waste and landfills for disposal of slightly contaminated material.

Temporary storage

The mission team visited some sites where contaminated material generated from the clean-up of land, buildings, agricultural fields, swimming pools, forests, etc. has been temporarily stored. Examples of temporary storage of contaminated material are illustrated in Figure 13.

Figure 13: Temporary storage of contaminated material – examples from clean-up demonstration tests

According to the practice being followed, the contaminated material (e.g. soil, zeolite, etc.) is packed in plastic or jute bags and then piled up on a plastic sheet placed on the ground. The heap is then covered with a plastic sheet and sand bags are placed over the plastic sheet for shielding the radiation.

Sub-surface temporary storage is also practiced, as was done in a school playground visited by the Mission Team. In this case, the upper layer of soil removed from the playground was placed in a pit dug in the ground and then covered with uncontaminated soil. The Team was informed about more elaborate plans for sub-surface storage, as can be seen in Figure 14.

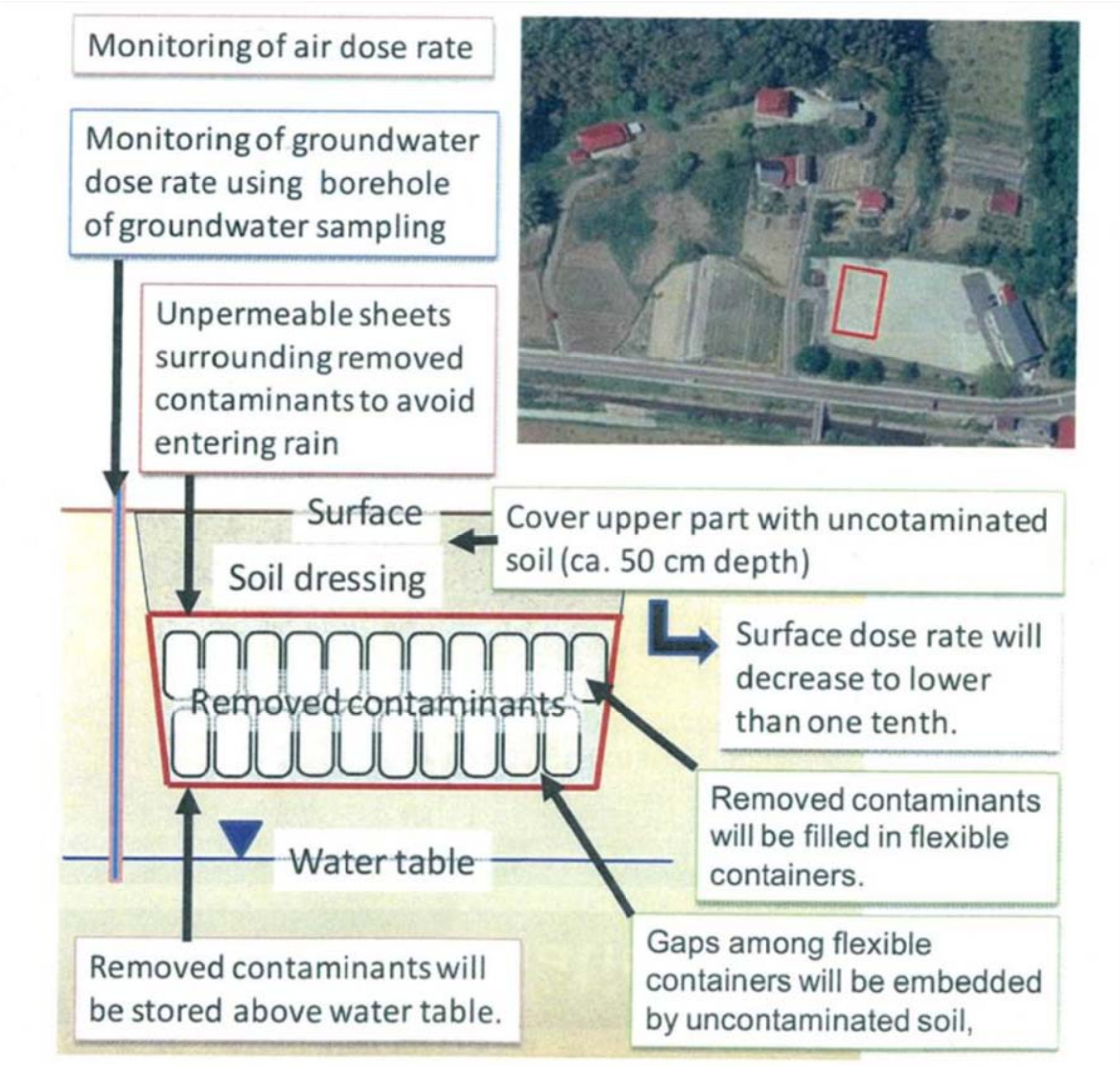

Figure 14: Temporary storage trench for removed contaminated material

Considering that easy retrieval of waste is a key feature of temporary storage, there is room for simplification of above arrangement.

Another storage strategy being tested and considered is a concrete box, 15 cm thick, 1.6 m^3 in volume, and with a weight of 4.2 tonnes (Figure 15). In a test case, contaminated soil removed from a paddy field and put in flexible bags was packed in such boxes and it was demonstrated that the dose rate can be reduced by more than 90%. The boxes are provided with lifting hooks.

Figure 15: Concrete box for temporary storage of contaminated material

These boxes have to be placed on adequate foundations and need a suitable sling attachment for lifting with a crane. It is estimated that 400 such containers are needed per hectare of land from which 5 cm of top soil is removed. Considering the very large areas that may have to be decontaminated by removal of topsoil, it is envisaged that such concrete shielding boxes can be used for the temporary storage of only limited quantities of removed soil with relatively high radioactivity content.

The Team considered that the demonstration projects have demonstrated their primary purpose which is the successful application of the selected clean-up technologies. However it needs to be noted that no further segregation of collected material was performed at the demonstration sites. All collected material was equally placed as bulk in temporary storage, which actually may add to the volume that needs to be further managed.

It would be very useful to consider performing measurements of the dose on every bag of collected material and segregation at the source based on the activity in each particular bag. It is recognized that high background field conditions may require special arrangements for the measurement of very low activities. However it should be possible to identify bags that are possible candidates for further screening and designation as cleared material. This approach could significantly decrease the volume of material that will require further management. The segregation at the point of collection is the only way that can help simplify the determination of further steps required to manage the volume of collected material.

The lessons learned from the Chernobyl accident indicate that the largest volumes of radioactive waste generated are located in the Chernobyl Exclusion Zone (CEZ). Sites for temporary storage of radioactive waste, of the trench and landfill type, were constructed shortly after the accident at distances of 0.5–15 km from the nuclear power plant site. They were created from 1986 to 1987 and intended for radioactive waste generated after the accident as a result of the clean-up of contaminated areas to avoid dust spread, reduce radiation levels and provide better working conditions. These facilities were established without design documentation, engineered barriers or hydrogeological investigations.

The majority of the temporary radioactive waste facilities consist of trenches in various types of geological settings, in which waste was stacked and covered with a layer of soil from the nearby environment.

These facilities are very variable with regard to their potential for release, which depends on the total radioactivity stored, the waste form (in particular timber), the retention capacity of the substratum along migration pathways and the location of the sites in hydrogeological settings.

Some of these temporary radioactive waste storage facilities, estimated to comprise about 800 trench facilities each with waste disposal volumes in the range of 8×10^2 to 2×10^6 m^3 are out of regulatory control because it is impossible to establish effective controls when only 50 % of the inventories of these facilities are known 25 years after the accident.

The Team wishes to point out the lessons learned from clean-up campaigns after the Chernobyl accident point out the risk of having many sub-surface temporary storage facilities.

Treatment and conditioning

With respect to the management of combustible contaminated material, the Japanese authorities are already coping with the management of contaminated ash from the incineration of municipal waste and contaminated sludge from municipal sewage treatment plants. Incineration normally achieves the highest volume reduction and converts the waste to a form which is suitable for subsequent immobilization and disposal. Guidelines have been issued for the management of incinerator ash and sewage sludge depending on their activity level. For example, incinerator ash having activity levels of 8000 Bq/kg or less is to be disposed of at conventional controlled type landfills without any further conditioning. The Team finds this approach to be fully aligned with established international practices.

For higher activity content of incinerator ash up to 100 000 Bq/kg, the proposed disposal pathway is in designated municipal landfills equipped with leachate control systems that can be further monitored. In the Team's view, this proposal is also very much aligned with established practices in a variety of Member States e.g. UK, Brazil, etc.), based on safety assessments performed for particular landfills before such material is disposed of. Ash is going to be fully immobilized by for example conditioning in cement or other suitable matrix prior to disposal.

The strategy for the management of disaster and clean-up waste aims to utilize municipal incinerators subject to the provision of adequate off-gas cleaning systems for the retention of caesium. The extent to which this can be done will depend on acceptance criteria for waste feed, effluent release limits and available excess capacity over and above the capacity for routine waste.

In the case of radioactive waste incinerators it is usually required to limit the content of radionuclides in material that is to be treated. Usually limits are set for beta/gamma activity at about 3.7×10^6 Bq/kg and alpha activity at about 3.7×10^5 Bq/kg. The stack release (discharge) limits for radionuclides are also set up. At the present moment such limits do not exist for the municipal or industrial waste incinerators that are planned to be used in the treatment of contaminated material. These limits by and large depend on the location of the facility, its design features especially related to the off gas system and the control of discharges. In the Team's view, this implies that although general guidance for incineration can be established by MOE, it would be prudent to perform safety assessments for all incinerators that are being considered for possible use in treating contaminated material.

That also implies that the characterization of material needs to be done before and after the treatment. Characterization before treatment is to ensure acceptance of contaminated material by the treatment facility and characterization after is to ensure either the need for conditioning (immobilization step) to be performed or to determine direct storage/disposal options.

One of the major disadvantages of incinerators is a low tolerance for non-combustible material that can be present in the inflowing material mix. This is usually resolved through either sorting material before it is sent to the facility or by fragmentation at the facility. Both methods are even more disadvantageous in the case of contaminated material, since sorting could increase workers' doses and fragmentation would require full control of dust that might be generated. Therefore, it would be worthwhile to consider the use of advanced incinerators in addition to the available capacity because these are less sensitive to the properties of inflowing material.

Advanced incineration systems apply plasma treatment of waste, enabling the melting of ash residues into a mineral-like or glass composite material. Particularly efficient are shaft furnaces supplied by plasma burners. These incinerators treat both organic and inorganic wastes such as glass, ceramics, construction materials, refuse, metal reinforcement, etc. practically without pre-treatment. Temperatures achieved in shaft furnaces with plasma burners (plasmatrons) are as high as 1400 – 1600 ^{o}C enabling melting (e.g. slagging) of the ash residue. Liquid slagging is the most significant advantage because the final product is a solid, chemically durable material suitable for long-term storage or final disposal. Such incinerators are used for radioactive material as well as for MSW and industrial waste.

Regarding the management of contaminated soil, the Japanese authorities are actively pursuing technologies and processes for volume reduction of contaminated soil. This is understandable considering that huge volumes of contaminated soil are estimated to be generated from clean-up efforts and direct disposal of soil in municipal landfills would saturate their capacities. The techniques being tested for volume reduction include separation of caesium rich soil constituents using soil washing methods or extraction of caesium from the soil using chemical agents. In the latter case, in trial experiments, soil containing inactive caesium was used to demonstrate the full release of caesium from the soil by treating it with dilute nitric acid at 200 ºC. Caesium was then separated from the acid using a small quantity of ferrocyanide sorbent. The results are encouraging and radioactive tests are planned. However, the challenges of large scale deployment of such a process deserve careful consideration.

There is significant experience with soil washing processes. These typically consist of several unit operations tied together in an integrated process to separate soil components from contaminating materials, and separate the contaminants from each other. Much of the system is based on commonly available mineral treatment technologies widely used in the mining industry, and has well known scale up parameters. Soil washing systems can be designed to accommodate a wide variety of soil types, including those with moderately high clay content.

The Team noted that the development of volume reduction technologies for contaminated soil should be pursued for industrial deployment, since the availability of interim storage facilities or disposal sites for soil could be considered as the most critical factor for successful implementation of the clean-up campaign.

With respect to the management of other non-combustible material, the Team encourages the development of criteria for the recycling and reuse of slightly contaminated metal and rubble to allow effective management of these types of waste.

Transportation

The existing transportation for MSW is planned to be used for the distribution of collected contaminated material. Only material that is not declared as VLLW and LLW radioactive waste would not be required to meet special transportation requirements. In the case that the existing transportation fleet is to be used for radioactive material special precautions to protect drivers and other workers as well as special features for the decontamination of vehicles should be used. The IAEA reference material related to the clean-up campaign after the Chernobyl accident provides experiences and lessons learned, for example as presented in the IAEA document ‘Clean-up of large areas contaminated as a result of a nuclear accident’, IAEA Technical Report Series No. 300, 1989.

The Team considers it worthwhile to point out the need to develop:

- A data handling system to control loading, transport and disposal;

- Transportation routes and truck control points to ensure compliance with the routing plan;
- Truck clean-up areas and monitoring points either at interim storage sites or disposal sites or between the contaminated and clean zones;
- An emergency response plan for the event of a transportation accident.

Interim storage

Storage in numerous dispersed locations as discussed above is envisaged as a temporary measure that has to be followed by relocation of the material in a smaller number of interim storage sites. Therefore identification of sites for the location of interim storage facilities is of high priority and this is recognized by the authorities in Japan. At the time of the Mission, the national government continued to discuss this matter with the prefectural authorities to find an agreeable solution and it is hoped that these efforts will be fruitful.

The Team noted that the technical approach would be to locate temporary storage facilities for combustible material at a reasonable distance from the treatment facilities, to locate treatable soil close to soil washing facilities and to locate storage facilities for waste that needs to be disposed of without any further processing close to locations of existing or purposely designed new disposal facilities.

The design of interim storage facilities should take into consideration key functional requirements, namely, to provide for the safe retrieval from storage pending transfer to a final disposal facility, to ensure water ingress and egress control, to provide an environment such that the waste packages do not degrade during the period of storage and are safe to retrieve and transfer to the final repository, to prevent inadvertent or malicious entry to the store, etc. Safety includes the operators who will access the store for operational duties and the public.

Existing caves, mines or tunnels, locations with limited or no human access, etc. could also provide suitable sites for storage facilities, as well as purposely designed in-ground trenches, storage surface mounds, etc.

The establishment of new interim storage facilities for contaminated material from the clean-up should be pursued either as fully dispersed or for 1-10 km^2 of the clean-up area, or by a limited number of sites or fully centralized.

Final disposal

The Team understands that the national government is responsible for the final disposal of waste from clean-up operations. Material that cannot be disposed of in conventional or special landfills will require establishing new disposal facilities.

The Team notes the importance of finding suitable locations as soon as possible for additional near surface disposal facilities and constructing such facilities with adequate capacities that would serve as final destinations for the large volumes of clean-up waste.

Three scenarios for disposal are usually considered in the clean-up of large areas. The first is fully dispersed disposal of contaminated material that is collected from 1-10 km^2 and concentrated in large piles or natural depressions close to the point of the highest contamination. The second option is the establishment of a limited number of larger disposal sites, and the third option is centralized disposal. Utilization of these scenarios in the case of the clean-up campaign in Japan very much depends on the final decision of the central and local governments on areas to be cleaned-up, volumes of waste that need to be disposed of outside of municipal landfills, the availability of locations for disposal sites and the results from stakeholder involvement.

A variety of generic designs are available for the disposal of the very large volumes of contaminated soil and other bulk materials arising from the clean-up operations. These designs include natural depressions, excavated trenches, surface mounds, existing excavations, abandoned mines, caverns or rock cavities and above or below ground concrete vaults. These designs incorporate engineered features like covers, liners and leachate collection systems as required. The selection of disposal sites will depend on the results of the stakeholder involvement, the nature and quantity of waste, site characteristics and engineered features, requirements for support services, operational monitoring and institutional control, including post-operational monitoring.

The Team noted that the landfill facilities being considered by Japanese authorities for the disposal of contaminated material (Figures 16 and 17) are provided with the engineered features mentioned above.

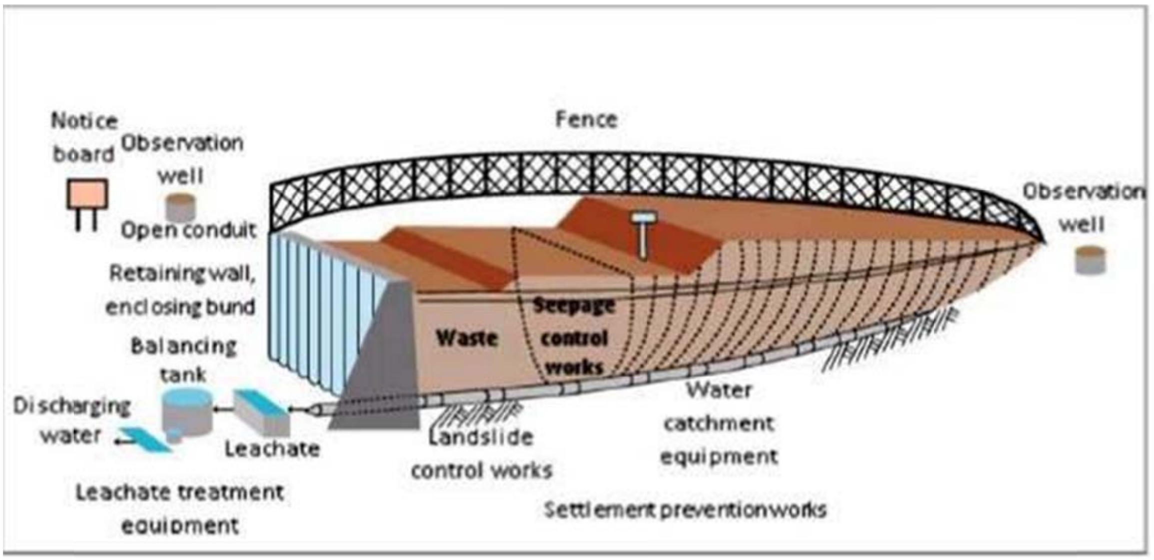

Figure 16: Controlled type of landfill site

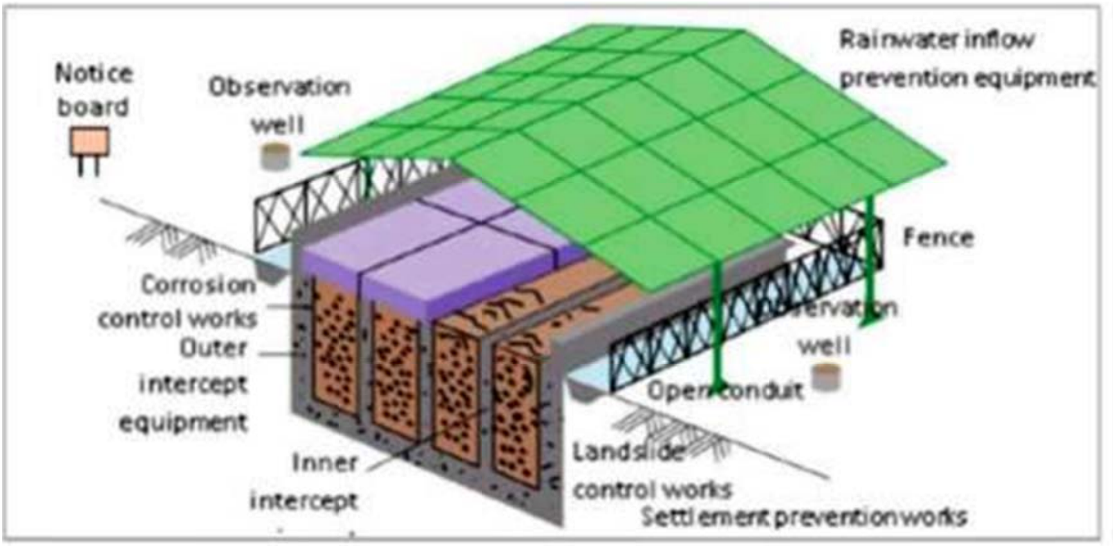

Figure 17: Strictly controlled type of landfill site

The selection of new disposal site(s) will have to take into account short and long term safety of public, workers, environment, availability of suitable disposal sites, time required to characterize site and construct facility, availability of equipment, to construct and operate, long term predictability of performance, establishment of institutional control after closure, consequence of failure, land area, cost and public acceptance, and last but certainly not least the results of stakeholder involvement.

The Team encourages the establishment of new near surface facilities for the final disposal of material considered as radioactive waste that needs to be stabilized and properly packaged. The capacity of the existing infrastructure including human resources to collect, characterize, handle, transport, treat, condition, store and dispose of contaminated material should be assessed and augmented as necessary.

Highlights of important progress

Highlight 6 is also applicable here.

Advice

Points 5 and 6 are also applicable here.

Point 12. The IAEA Mission team encourages the Japanese authorities to actively pursue appropriate end-points for the waste in close cooperation with stakeholders. The national and local governments should cooperate in order to ensure the provision of these facilities. A lack of availability of such infrastructure would unduly limit and hamper successful remediation activities, thus potentially jeopardizing public health and safety.

6. TECHNICAL MEETINGS AND VISITS

On 7 October 2011, the IAEA Mission Team held a preliminary meeting with all of Japan's relevant Government Offices, Ministries and Agencies involved in the effort to develop strategy and plans to implement countermeasures to remediate the off-site areas affected by the consequences of the nuclear accident in the Fukushima Dai-ichi nuclear power plant. The meeting was held in the Ministry Office of Foreign Affairs (MOFA) building.

On 8 October 2011, the IAEA Mission Team held a day-long meeting with the Ministry of the Environment and the Japanese counterparts in charge of supporting residents affected by nuclear incidents. This meeting was also held in the MOFA building.

On 9 October 2011, the IAEA Mission Team travelled to Fukushima to get first-hand experience of the work carried out in the area, as well as to meet local government officials. On their arrival in Fukushima, the IAEA Mission Team met members of the Fukushima Decontamination Team as well as staff from the Japan Atomic Energy Agency's (JAEA) Fukushima office and representatives from the Fukushima prefecture for a briefing on the environmental remediation efforts underway in the area.

In the afternoon of the same day, the IAEA Mission Team visited the area surrounding the Haramachi thermal power plant in the city of Minami-Soma. The city, once a renowned holiday destination, was badly affected by the tsunami that hit Japan's east coast on 11 March 2011. The IAEA Mission Team then visited a remediation model site located in the hills inland from the city of Minami-Soma, where methods and technologies for the remediation of forestry areas are being tested.

On 10 October 2011, the IAEA Mission Team visited four locations where model remediation projects are being carried out by the Fukushima Decontamination Team and JAEA. These include the Tominari Elementary school and the Shimooguni Central Assembly Hall, both located in the city of Date.

On the same day, the IAEA Mission Team also visited two sites where verification studies for the application of remediation technologies in agriculture are being conducted. Both sites are located in the territory of the village of Iitate. In one agricultural site, rice has been planted in a paddy where a layer of earth with elevated levels of radiocaesium was removed from the top soil. In a near-by site known as Iitate village clear centre, the IAEA Mission Team received a briefing on a series of tests that are being carried out on the combustion of crops and soil with elevated levels of radioactivity. In all of these demonstration sites, experts are evaluating the efficiency of a number of methods and technologies that can be used in environmental remediation strategies.

In the morning of 11 October 2011, the IAEA Mission Team paid a courtesy visit to Mr. Yuhei Sato, Governor of the Fukushima prefecture. In the afternoon of the same day, the IAEA Mission Team visited the accident site at TEPCO's Fukushima Dai-ichi nuclear power plant. Following the conclusion of the visit to the Fukushima prefecture, the IAEA Mission Team returned to Tokyo where it continued to meet with Japanese officials and draft its preliminary report.

On 12 October 2011, the IAEA Mission Team met with officials from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Atomic Energy Commission of Japan and the Nuclear Safety Commission, etc.

On 13 October 2011, the IAEA Mission Team had a day-long meeting with all of Japan’s relevant Government Offices, Ministries and Agencies for a final exchange of views and information on the situation in the off-site areas affected by the consequences of the nuclear accident in the Fukushima Dai-ichi nuclear power plant. The meeting was held in the Ministry Office of Foreign Affairs (MOFA) building. The IAEA also had a meeting with the members of a committee in JAEA which is considering a practical catalogue of remediation techniques.

On 14 October 2011, the IAEA Mission Team officially presented a final copy of the “Summary Report of the Preliminary Findings of the IAEA Mission on Remediation of Large Contaminated Areas Off-site the Fukushima Dai-ichi NPP” to the Government of Japan. Mr. Goshi Hosono, the country’s Minister of Environment, received the report on behalf of the Government.

Following the handover ceremony, Messrs Juan Carlos Lentijo and Tero Varjoranta held a concluding press conference at the Foreign Press Center/Japan, Tokyo.

LIST OF PARTICIPANTS

Mission Team

MISSION TEAM MEMBERS	
Juan Carlos **Lentijo** Team Leader	Consejo de Seguridad Nuclear, Spain
Tero **Varjoranta** Deputy Team Leader	Division of Nuclear Fuel Cycle and Waste Technology
Mikhail **Balonov**	Institute of Radiation Hygiene, St. Petersburg, Russian Federation
Gerd **Dercon**	Soil and Water Management and Crop Nutrition Section Joint FAO/IAEA Division of Nuclear Techniques
Zoran **Drace**	Waste Technology Section Division of Nuclear Fuel Cycle and Waste Technology
Igor **Gusev**	Division of Radiation, Transport and Waste Safety Department of Nuclear Safety and Security
Ralf **Kaiser**	Division of Physical and Chemical Sciences Department of Nuclear Sciences and Applications
Horst **Monken Fernandes**	Waste Technology Section Division of Nuclear Fuel Cycle and Waste Technology
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Susanta **Samanta**	Waste Technology Section Division of Nuclear Fuel Cycle and Waste Technology
Giovanni **Verlini**	Division of Public Information Department of Management (MTPI)

Special support from IAEA Headquarters:

Irena **Mele**, Waste Technology Section, Division of Nuclear Fuel Cycle and Waste Technology
Hiroko **Ratcliffe**, Division of Nuclear Fuel Cycle and Waste Technology
Celine **Philip** Division of Nuclear Fuel Cycle and Waste Technology

List of people the Team met during the Mission

NAME	MINISTRY/INSTITUTE/COMPANY
Ministry of the Environment	
Goshi Hosono	Minister of the Environment (Minister for the Restoration from and Prevention of Nuclear Accident and Minister of State for the Nuclear Power Policy and Administration)
Soichiro Seki	Director General for Water Environment
Yoshimi Okunushi	Director, Secretariat Division
Tsutomu Sakagawa	Director, Policy Planning Division Waste Management and Recycling Department
Mimi Nameki	Deputy Director, Policy and Coordination Division, Environmental Management Bureau
Hirotoshi Murayama	Deputy Director, Waste Management Division, Waste Management and Recycling Department
Masaru Moriya	Leader, Fukushima Decontamination Promotion Team LNER Headquarters
Cabinet Office	
Junya Nishimoto	Deputy Director-General for Coordination
Hidekazu Chayama	Head, Radiation Section, Support Team for Residents Affected by Nuclear Incident, Nuclear Emergency Response Headquarters
Motoharu Shirai	Director, Radiation Section, Support Team for Residents Affected by Nuclear Incident, Nuclear Emergency Response Headquarters
Hiroshi Nunota	Senior Specialist, Radiation Section, Support Team for Residents Affected by Nuclear Incident, Nuclear Emergency Response Headquarters
Ministry of Education, Culture, Sports, Science and Technology	
Fumiyasu Hirashita	Director, School Health Education Division, Sports and Youth Bureau
Naoaki Akasaka	Director, Office of International Relations, Nuclear Safety Division, Science and Technology Policy Bureau
Toshimitsu Ishii	Senior Specialist for Radioactive Waste Management, Office of Radiation Regulations, Nuclear Safety Division, Science and Technology Policy Bureau
Toru Kuga	Researcher, Office of International Relations, Nuclear Safety Division Science and Technology Policy Bureau
Ministry of Agriculture, Forestry and Fisheries	
Noritaka Akiyama	Deputy Director, Food Security Division, Minister's Secretariat
Tsutomu Tamura	Deputy Director, Plant Products Safety Division, Food Safety and Consumer Affairs Bureau
Kenji Ohara	Deputy Director, Animal Products Safety Division, Food Safety and Consumer Affairs Bureau
Ayako Takada	Deputy Director, Administration Division, Agricultural Production Bureau
Hiroyuki Nishiura	Director for International Affairs on Staple Food, Policy Planning Division, Crop Production Department, Agricultural Production Bureau
Makoto Nakatani	Director, Research and Development, Agriculture, Forestry and Fisheries

	Research Council Secretariat
Ikuo Ando	Manager, Research Cooperation, Agriculture, Forestry and Fisheries Research Council Secretariat
Seiji Tazo	Deputy Director, Research Policy Planning Division, Agriculture, Forestry and Fisheries Research Council Secretariat
Yutaka Maruyama	Principal Research Coordinator, Search, Extension, and Environment Policy Division, Forestry Agency
Takanori Shimizu	Deputy Director, Forestry Management Improvement Division, Forestry Agency
Hisashi Endo	Director, Ecosystem Conservation Office, Resources and Environment Research Division, Fisheries Agency
Toshiaki Ookura	Research Coordinator, Agriculture, Forestry and Fisheries Research Council Secretariat
Ministry of Health, Labour and Welfare	
Shoujirou Yasui	Occupational Health Specialist, Industrial Health Division, Industrial Safety and Health Department
Ministry of Foreign Affairs	
Ichiro Ogasawara	Deputy Director-General, Disarmament, Non-Proliferation and Science Department
Takashi Hatori	Director, International Nuclear Energy Cooperation Division, Disarmament, Non-Proliferation and Science Department
Daisuke Kiryu	Official, International Nuclear Energy Cooperation Division Disarmament, Non-Proliferation and Science Department
Yasunori Sota	Researcher, International Nuclear Energy Cooperation Division Disarmament, Non-Proliferation and Science Department
Nuclear and Industry Safety Agency	
Taku Ujihara	Deputy Director, Nuclear Power Licensing Division
Japan Atomic Energy Agency	
Kazuo Todani	Executive Director, Deputy Senior Director General, Headquarters of Fukushima Partnership Operations
Junichiro Ishida	Director, Office of Fukushima Partnership Operations for Environmental Remediation, Headquarters of Fukushima Partnership Operations
Shinichi Nakayama	Deputy Director, Office of Fukushima Partnership Operations for Environmental Remediation, Headquarters of Fukushima Partnership Operations
Kaname Miyahara	Senior Principal Researcher, Office of Fukushima Partnership Operations for Environmental Remediation, Headquarters of Fukushima Partnership Operations
Toshiro Nakai,	Senior Principal Engineer, Office of Fukushima Partnership Operations for Environmental Remediation, Headquarters of Fukushima Partnership Operations
University of Tokyo	
Kenkichi Ishigure	Professor Emeritus
Satoru Tanaka	Professor, School of Engineering
Central Research Institute of Electric Power Industry	

Masashi Inoue	Research Adviser
Tokyo Electric Power Company	
Ken Shimizu	Group Manager, Environmental Impact Assessment Group, Radiation Protection & Environment Department, Fukushima Daiichi Stabilization Centre
Atsufumi Yoshizawa	Unit Superintendent (No.5, 6), Fukushima Daiichi Nuclear Power Station
Akira Kawano	General Manager, Nuclear Power & Plant Siting Administrative Department, Fukushima Daiichi Nuclear Power Station
Shin Takizawa	Manager, Nuclear Power & Plant Siting Administrative Department, Fukushima Daiichi Nuclear Power Station
Fukushima Prefecture	
Yuhei Sato	Governor
Masao Uchibori	Vice Governor
Kazuhiko Ono	Senior Policy Administrator of the Social Affairs & Environment Department
Katsumasa Suzuki	Director of the Decontamination Countermeasure Division, the Social Affairs & Environment Department
Syunji Miura	Desk Chief of the Decontamination Countermeasure Division of the Social Affairs & Environment Department
Hiroyuki Sakai	Assistant Director & Desk Chief of the Decontamination Countermeasure Division, the Social Affairs & Environment Department
Minamisoma City	
Toshikazu Owada	Assistant Director, Citizen Affairs Department
Date City	
Shoji Nishida	Mayor
Takayuki Sato	General Manager, Radioactivity Measures Division
Hiroshi Ono	General Manager, Education Division, the Board of Education
Takahiro Hanzawa	Deputy General Manager, Radioactivity Measures Division
Yuitsu Horie	Manager, Radioactivity Measures Section
Yasuo Miyajima	Manager, a Public Institution Section, the Board of Education
Yoshiyuki Umetsu	Chief, Remove Radioactivity Charge, Radioactivity Measures Section
Makoto Sato	Chief, a Public Institution Management Charge, Public Institution Section, the Board of Education
Hiroshige Yagome	Chief, Secretary Charge, General Affairs Section, General Affairs and Planning Division
Yuriko Naito	Principal, Date Elementary school
Satsuki Katsumi	Former Principal, Date Elementary school

MISSION PROGRAMME

Day	Date	Agenda	
1	7.10.2011 (Friday）	Arr. Narita Airport	
		1100-1200:	Visit to IAEA Tokyo Office (TRO: Tokyo Regional Office)
		1400-1700:	Meeting with all relevant Government Offices, Ministries and Agencies (MOFA)
2	8.10.2011 (Saturday）	1000-1200:	Meeting with MOE、"Support Team for Residents Affected by Nuclear Incidents" in Cabinet Office, etc （MOFA）
		1330-1700:	Meeting with "Support Team for Residents Affected by Nuclear Incidents" in Cabinet Office, etc (MOFA)
3	9.10.2011 (Sunday）	1100-1230:	Meeting with Fukushima Decontamination Team and JAEA Fukushima Office
		1500-1600:	Visit to the surrounding areas of the Haramachi Thermal Power Plant （Minamisouma City）
		1615-1700:	Visit to Heart Land Haramachi (Minamisouma City)
4	10.10.2011 (Monday)	0900-1000:	Visit to a decontaminated site in Date City（Tominari Elementary School)
		1020-1100:	Visit to Shimooguni Central Assembly Hall, Date City
		1400-1600:	Visit to the site of a verification study on the development of decontamination technology of agricultural soils (Iitate Village)
5	11.10.2011 (Tuesday）	900-925:	Courtesy visit to the Governor of Fukushima Prefecture
		12:30	Arr. J Village
		1300-1500:	Visit to Fukushima Daiichi NPP
		To Tokyo	
6	12.10.2011 (Wednesday)	1000-1200:	Meeting with MEXT, "Support Team for Residents Affected by Nuclear Incidents" in Cabinet Office and JAEA (MOFA)
		1330-1700:	Meeting with MEXT, "Team in Charge of Assisting the Lives of Victims around the Nuclear Power Plant" in Cabinet Office and JAEA, and Preparation of a report (MOFA)
		1600-1630:	Courtesy visit to Dr. Kondo, Chairman of Japan Atomic Energy Commission
		1630-1700:	Courtesy visit to the commissioners of the Nuclear Safety Commission
7	13.10.2011 (Thursday）	1000-1200:	Meeting with "Support Team for Residents Affected by Nuclear Incidents" in Cabinet Office and JAEA (MOFA)
		1330-1700:	Meeting with MAFF, MOE , "Support Team for Residents Affected by Nuclear Incidents " in Cabinet Office and MHLW, and Preparation of a report (MOFA)
8	14.10.2011 （Friday）	1000-1200:	Meeting with Nuclear and Industrial Safety Agency (NISA) and MOE (MOFA)
		1330-1630:	Meeting with all relevant Government Offices, Ministries and Agencies (MOFA)
		1700-1730	Courtesy Visit to Minister Hosono* (MOE)
		1800-1900:	IAEA Press Conference (FPC)
9	15.10.2011 （Saturday）	Dep. Narita Airport	