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Determining the Best Way forward in Restoring Fukushima’s Environment

Briefing on R&D Results by the Headquarters of Fukushima Partnership Operations

On January 21, the Fukushima Environmental Safety Center of the Headquarters of Fukushima Partnership Operations, Japan Atomic Energy Agency (JAEA), held a R&D results briefing for FY2013 in Fukushima City. The purpose was to present the results of research undertaken by JAEA toward improving Fukushima’s environment as well as future research activities. This year’s briefing was the second to be held, following the first held last year. Approximately 200 people attended. Mr. Junichiro Ishida, Director of the Fukushima Environmental Safety Center started things off by giving an overview of the center’s activities. He was followed by Mr. Juichi Ide, head of Kawauchi Village’s Recovery and Reconstruction Division (see **Photo**), who recounted the village’s total evacuation in the wake of the accident at TEPCO’s Fukushima Daiichi Nuclear Power Station. He also gave a status report on residents’ subsequent return to their homes and described the challenges facing Kawauchi Village. Mr. Ide was followed by five researchers who discussed long-term environmental assessment as well as the latest technical developments concerning radiation monitoring and decontamination. The following provides an outline of the proceedings.

Initiatives by the Fukushima Environmental Safety Center

Junichiro Ishida

Director, Fukushima Environmental Safety Center, Headquarters of Fukushima Partnership Operations

JAEA is responding to the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, and has assigned its Headquarters of Fukushima Partnership Operations to serve as a "control tower" in leading this effort.

JAEA's R&D toward environmental restoration is largely classified as assessment study and technical development. In its assessment study, JAEA is proposing countermeasures to reduce radioactive exposure by advancing environmental monitoring and mapping technologies and carrying out modeling to predict future radioactive cesium.

JAEA currently conducts wide-area environmental monitoring with manned helicopters, and uses unmanned airplanes and unmanned helicopters in smaller target areas. It plans to use micro helicopters in even smaller areas of less than one square kilometer in the future.

It is also advancing visualization technologies by developing high-resolution cameras. Its aim here is to achieve even greater visualization of "hot spots" in helicopter-based monitoring.

In its technical development, JAEA is working to restore safe living environments by illuminating the mechanisms of the adsorption-desorption process of radioactive cesium and other phenomena, pursuing greater sophistication of decontamination technologies, and developing methods for reducing the volume of removed substances and disaster waste.

Conceptual image of a "visualized" hot spot

Working to Restore Kawauchi Village following Evacuation

Juichi Ide

Head, Recovery and Reconstruction Division, Kawauchi Village

Kawauchi Village is located in Fukushima Prefecture's Hama-dori region. Situated to the west of the Fukushima Daiichi and Fukushima Daini Nuclear Power Stations, it has an area of 197 km^2. Some 86% of this area is covered by mountain forest, while 5% is farmland. On March 12, immediately following the disaster, approximately 8,000 residents of Tomioka Town took refuge in Kawauchi Village. However, the subsequent explosion accident at the nuclear power station led to the mass evacuation of all residents of Kawauchi Village, including those from Tomioka, to Koriyama City on March 16.

Today, Kawauchi Village is divided into districts in which residents are not permitted to live and areas where evacuation orders are about to be lifted, depending on the amount of radiation measured there. Of the village's pre-disaster population of 3,028 people, 535 currently live in the village and 920 stay there at least four days a week, for a total of 1,455 people. The number of residents returning to the village continues to grow. However, the percentage of returning residents aged in their 40s or younger remains low at less than 40%. Thus, the question of how to encourage younger residents to return presents a challenge for the future.

On March 12, 8,000 Tomioka Town residents evacuated to Kawauchi Village.

When residents who have not returned to Kawauchi Village were asked their reasons for not returning, the most common response was “I am afraid of the radiation.” People who gave this response accounted for 19% of the total. Following this response were “I am concerned about the medical care environment,” “I am concerned about the living environment (shops, welfare, etc.),” “Even if I return, I won’t find work,” “My child attends school near our evacuation site,” “I can’t grow crops there,” “My house is in a hazardous zone,” and “I have found work near my evacuation site.” Two years and eight months since the disaster, residents are becoming increasingly polarized toward “returning” and “not returning.”

The biggest challenges toward the village’s restoration are decontamination and securing of employment opportunities. To address them, Kawauchi Village is executing initiatives in a variety of areas, among which are 1) securing employment and attracting businesses; 2) addressing housing shortages and encouraging permanent residence; 3) maintaining community roads; 4) developing an agricultural products cultivation plant on the Kawauchi Plateau; 5) improving convenience (developing commercial facilities, improving funeral centers, expanding available lodgings, etc.); 6) introducing renewable energy; 7) enhancing health, medical care, and welfare services (executing radiation countermeasures, building special nursing homes, improving clinics, etc.); and 8) enhancing educational environments. Through these initiatives, the village is aiming to achieve a population of between 3,000 and 5,000 in 10 or 20 years.

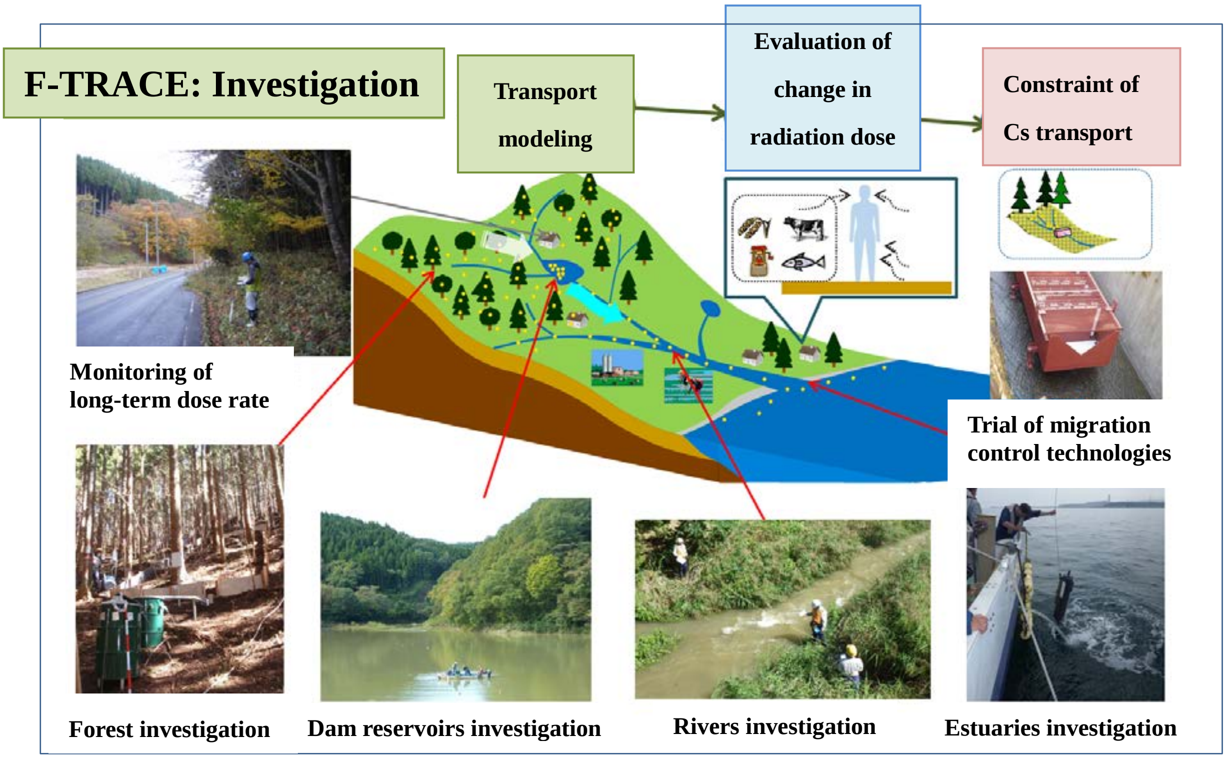
F-TRACE: Field and Laboratory Investigation

Kazuki Iijima

Fukushima Environmental Safety Center, Headquarters of Fukushima Partnership Operations

The Long-term Assessment of Transport of Radioactive Contaminant in the Environment of Fukushima (F-TRACE) project aims to investigate the behavior of radioactive cesium in the environment and develop a transport prediction model, estimate changes in radioactive doses from this transport, and propose countermeasures that will contribute to lower doses. Of these, I will describe our studies of the transport behavior of radioactive materials.

Our studies focused on forests, rivers, dams, and estuaries of six river basins of the Hamadori side. In the case of forests, we observed that radioactive cesium on the ground’s surface had not penetrated to a deep soil depth, but instead often stayed on the surface or within several centimeters under the surface. In a study that took place in a cedar forest in Kawauchi Village, we observed that radioactive cesium on the surface runs off at a rate of just 0.5% per year.



Additionally, we observed that, at some places on the bottom of the reservoir of Ogi Dam on the Oginosawa water system, radioactive cesium had accumulated to a thickness of several tens of centimeters. However, concentrations of radioactive cesium in the water fell below the detection limit. From this, we consider that cesium tends to be strongly adsorbed by sediment, and particularly small-grain clay.

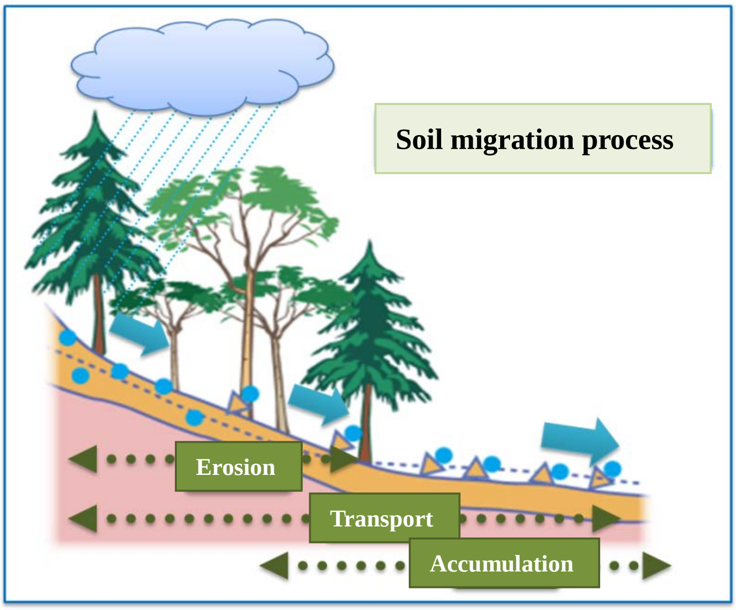
An examination of the Ukedo River's riverbed revealed that decay of the air dose rate in the upstream area is slower than radioactive cesium's physical decay. We consider this is due to the effect of inflow and accumulation of radioactive cesium from the river's vicinity. Conversely, decay of the air dose rate in the downstream area is faster than physical decay. We consider this is due to the fact that, on average, the downstream area has a greater amount of erosion than cumulative dose. We further investigated that, in the case of riverbeds, radioactive cesium accumulated on the river's floor tends to be easily eroded away, and that it accumulates relatively easily in areas that are ordinarily dry and inundated only during floods.

When we compared radioactive cesium amounts existing in the water, solids of the bottom soil, etc., for dams, rivers, and ponds, we observed that, in the case of ponds, comparatively large amounts of cesium tended to exist in the water. Thus we estimated the influence of organic matter. However, it must be noted that relatively large amounts of radioactive cesium exist in bottom soil, etc., regardless of the location, which suggests that radioactive cesium is strongly adsorbed by bottom sediments, etc.

F-TRACE: Analysis

Akihiro Kitamura

Fukushima Environmental Safety Center, Headquarters of Fukushima Partnership Operations



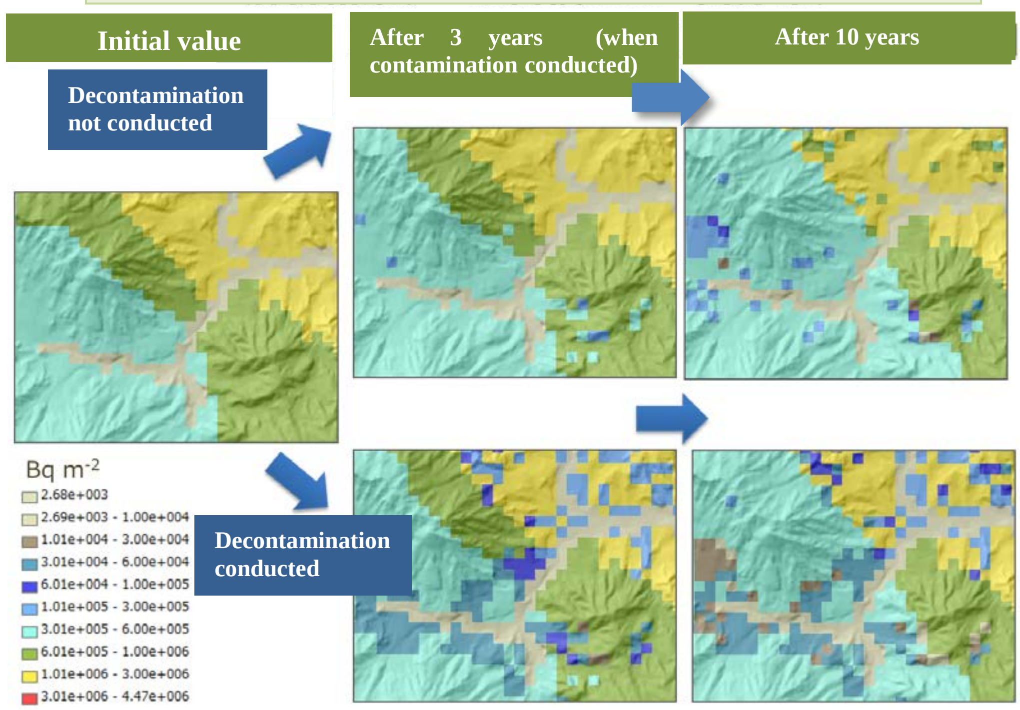
Here, I will talk about the development of migration prediction models for radioactive cesium that is taking place as part of the Long-term Assessment of Transport of Radioactive Contaminant in the Environment of Fukushima (F-TRACE) project. We are developing several mathematical models with the aim of estimating changes in future air doses and providing predictive information for effective migration control measures, etc., for reducing doses.

It is thought that radioactive cesium that falls to the ground moves together with soil loss and surface stream water. Given this, we developed an analytical model that combines an evaluation formula (soil loss predictive formula) and simple hydraulic formula. We then estimated the migration amounts of soil and radioactive cesium, with focus on the Hamadori side of Fukushima Prefecture. As a result, it was calculated that an amount equivalent to approximately 1% of the radioactive cesium that was deposited on the ground’s surface had run off during the first one year. Additionally, in the case of forests, which accounted for more than half of the target region, results showed that there was little runoff. On the other hand, it was estimated from the results of simulation that almost all of the radioactive cesium that flowed into rivers had reached the sea, with a portion remaining along the streams. We are also proceeding with several case studies on decontamination and migration measures and beginning preliminary studies of the results.

In addition, in calculations using river analysis codes, we have successfully recreated cases in which radioactive dose rises in a particular floodplain by using riverbed vegetation conditions that were obtained from a survey as inputted data. Furthermore, in calculations using estuary analysis codes, we confirmed that the distribution of salt concentrations when river water flows into an estuary is roughly the same as that of actual measurements.

Looking forward, in order to improve the reliability of our analytical models, we will make improvements in the models by making comparisons with the results of other analytical models and reflecting data from currently ongoing onsite surveys, and then we will tackle more specific and concrete issues such as migration evaluations at specific locations.

Results of analysis when decontamination was conducted and not conducted (spatial distribution of ^{137}Cs cumulative dose



Advancing Radiation Distribution Measurement Technologies

Tatsuo Torii

Fukushima Environmental Safety Center, Headquarters of Fukushima Partnership Operations

The accident at TEPCO's Fukushima Daiichi Nuclear Power Station spread radioactive materials over a broad area. Here, I will explain methods that JAEA developed to quickly ascertain the conditions of their distribution.

Iodine-131 has a short half-life. Because it decays in short period of time, details concerning its deposition amounts were unknown. However, the US Department of Energy conducted aerial monitoring from March 17 to April 5, a period shortly after the occurrence of the accident. From the results of measurement, the US DOE and JAEA team jointly developed a method for analyzing deposition concentration of iodine-131 on the ground that successfully clarified the regional distribution of the deposition. I should mention that the results obtained here matched the results of decay-corrected measurements that were taken on the ground three months after the accident. (For more details, see: http://fukushima.jaea.go.jp/english/topics/pdf/topics-fukushima026e.pdf)

On the other hand, unmanned helicopters have the advantage of being able to take measurements in places with high dose rates that people cannot easily approach as well as forests and other such locations. Even now, manned flights cannot be made over the Fukushima Daichi Nuclear Power Station by the aviation regulation of Japan. However, since the flight by unmanned helicopters is not forbidden by the regulation, the unmanned helicopter can fly into this area at the low altitude. We, then, can use a monitoring system installed on the unmanned helicopter to obtain detailed data.

Additionally, we have made it possible to show areas where radioactive materials are deposited in three dimensions by improving the resolution of the camera attached to the helicopter and taking wide-angle shots, and correcting pictures taken different points by method called artho-emage analysis.

Moreover, in order to measure the distribution of radioactivity quickly, we are jointly developing an unmanned airplane radiation monitoring system (UARMS) by collaboration with the Japan Aerospace Exploration Agency (JAXA).

In addition, we made improvements to a detector using plastic scintillation fibers (PSFs) so that it could take measurements of the distribution of radioactivity deposited in reservoirs even under water. We are now able to investigate in detail conditions in a reservoir by combining an underwater gamma-ray spectrometer that can be settled on the bottom of the water to measure radiation there with the PSFs. Based on the results, we dredged reservoir bottoms and effectively removed radioactive materials.

Looking forward, we will promote the transfer of technologies for the monitoring systems using unmanned helicopters and the PSF detectors to the private sector, and develop new detection and analysis methods of radiation distribution measurement.

Development of Information Dissemination System on Air Dose Rates in Fukushima Prefecture

Hiroshi Takemiya

JAEA has been promoting a new project of environmental monitoring in cooperation with the Fukushima Prefecture and Kyoto University. In the project, air dose rates are automatically measured by vehicle-mounted measurement devices (KURAMA-II) installed on public transport services such as route buses. Observed data are transmitted to the public as visual maps.

The purpose of the project is to provide information on the distribution of air dose rates in communities to residents of Fukushima Prefecture. Using public transport services enables to make continuous measurements of air dose rates over a wide area with high frequency for a long period of time.

The information dissemination system was developed to provide information on air dose rates in Fukushima prefecture as a part of this project. It utilizes technologies in computational science field to automatically correct and analyze measurement data and finally transmit the results with "visual" form. Automatic correction and analysis enables to provide information on air dose rate distributions in a timely manner.

Verification study of the project has been conducted since January of last year using route buses in four cities of Fukushima Prefecture. Visualized results have been transmitted to the public through the Fukushima Prefectural air dose rate notification system since August. Visualized results are also displayed on a large screen installed in the Unix Building, located in front of Fukushima Station. Information on the current distribution of air dose rate as well as temporal changes are also provided via the Internet. Moreover, we have succeeded in detecting and "visualizing" instances where dose rates on decontaminated roads have fallen significantly through the analysis of the data obtained for more than one year. The results help community residents understand decontamination effects.

We have a plan to increase the number of KURAMA-II devices in use and also expand the scope of measurement to include the northern Hamadori and southern Nakadori regions as well. In addition to the information on the distribution of air dose rates, various kinds of results of JAEA's current Fukushima reconstruction support projects, including decontamination projects, map projects, and long-term assessments, will be provided to help the further Fukushima's reconstruction.

Development and Demonstration of the Restoration Support System for Environment (RESET)

Takuya Yamashita

Fukushima Environmental Safety Center, Headquarters of Fukushima Partnership Operations

JAEA developed a system that can calculate and visualize the degree to which post-decontamination air dose rates have fallen compared to pre-decontamination levels in a short period of time. This system, called “RESET,” is intended for use by persons in charge of decontamination plans in municipalities located within special decontamination regions or regions having priority in contamination surveys. It can be used to forecast decontamination effects, select decontamination methods, and estimate decontamination costs. “RESET” stands for “the Restoration Support System for Environment.”

This system uses cloud computing to provide a high-quality computation environment with ordinary computers. Moreover, the system has been engineered to simplify data inputting. An operator designates on a map the scope of decontamination to be carried out and selects the method to be used, and then the system displays pre-decontamination dose rate data, predicted post-decontamination dose rate data, and an estimate of decontamination cost. The system has a built-in database that includes measurements from various monitoring activities, decontamination methods, decontamination coefficients and other items, and allows an operator to gain results simply by entering basic data.

We will accumulate data on the system’s actual use at decontamination sites, and strive to improve its practical precision while seeking to maintain balance with operability. We will also work to improve its evaluative precision for the decontamination of farmland and forests, and further develop it into a system that can handle small-scale decontamination evaluations, such as those for single-family homes.