Challenges of Agricultural land Remediation and Renewal of Agriculture in Iitate Village by a collaboration between scholar and NPO

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The accident at TEPCO's Fukushima Daiichi Nuclear Power Plant, which occurred in March 2011, became an unprecedented nuclear disaster. As a result, the forests, agricultural lands and oceans were contaminated extensively by radioactive cesium. In Iitate Village, Fukushima Prefecture, where evacuation continued after the nuclear power plant accident, decontamination work was carried out with thousands of workers for villagers' return in the spring of 2017.
The authors entered the village three months after the nuclear accident and have tested several ways of agricultural revitalization by developing farmland decontamination methods that farmers can clean up by themselves with collaboration of local farmers, NPO members and researchers. As a result, the rice harvested in the test field passed the official inspection of Fukushima Prefecture in 2014. Despite many efforts of local people, we have not yet succeeded to dispel the anxieties of publics who mistrust that Fukushima's agricultural crops might contain radioactive cesium. Such a so called "harmful rumor" prevents from regenerating local agriculture. In this paper, we review our challenges of agricultural land remediation and renewal of agriculture by a collaboration between scholar and NPO, and propose the scenario of rural resurrection of Iitate village.

Keywords: Fukushima, Iitate Village, collaboration, soil remediation, agriculture, forest


Collaboration of local farmers, NPO members and researchers.
This photo was taken after rice harvesting at Komiya, Iitate village, Fukushima on Oct. 6, 2013.

Monitoring Inspection for Radiocesium in Agricultural, Livestock, Forestry and Fishery Products in Fukushima Prefecture

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The Tohoku Region Pacific Coast Earthquake, which occurred on March 11, 2011, caused an accident at the Fukushima Daiichi power station operated by the Tokyo Electric Power Company. Radioactive material, such as cesium, released by the accident spread to farmlands in Fukushima and neighboring prefectures, and contaminated the soil and agricultural products. The Ministry of Health, Labor and Welfare established a provisional regulation level of 500 Bq/kg for radiocesium in cereals, vegetables, meat, and fishery products. In April 1, 2012, a new maximum limit of 100 Bq/kg was established as a new standard of radiocesium in general food. To verify the safety of agricultural products, the Nuclear Emergency Response Headquarters have been conducting emergency environmental radiation monitoring of agricultural and fishery products (hereafter referred to as monitoring inspections). Monitoring inspections were performed before shipment of the food products. If the radioactivity detected in the food exceeded the regulation level, the government would order the municipalities to suspend the shipment or limit consumption. By the end of March 2016, approximately 500 types of foods were selected, and 100,000 samples were analyzed in total. We summarized the monitoring inspections of radiocesium concentration levels in Fukushima Prefecture for 5 years.

The ratio in which radiocesium concentration exceeded the 100 Bq/kg from March 2011 to June 2011 was 18% in agricultural products (excluding rice), 3% in livestock productions, 49% in forest productions, and 52% in fishery produced. The maximum concentration of radiocesium in this period was 84,000 Bq/kg. The high concentration value could be attributed mainly to direct deposition of the fallout on plants that had already grown at the time of the accident. If people consume vegetables, fruits, forestry products, meat, milk, and fishery products grown in Sousou area during March to June 2011, the calculated internal exposure is expected to be 0.75 mSv/year.

After June 2011, radiocesium concentration reduced drastically. Radiocesium concentration in agricultural and livestock products hardly exceeded 100 Bq/kg. Radiocesium concentrations of forestry and fishery products have been falling every year, but there were a little sample which exceeded 100 Bq/kg. In addition to the decrease in the concentration of radioactive nuclides based on the physical half-lives, tillage also contributed to the decrease in the concentrations of radioactive nuclides in plants grown in the field, because radioactive cesium is firmly attached to the clay minerals, and by mixing, the concentration of cesium decreases. Application of potassium, an element homologous to cesium, to the field is another effective tool to minimize cesium uptake in the plants.

Rice is the main staple food of the Japanese diet, and the most valuable agricultural product. In 2012, Fukushima Prefecture decided to investigate the radiocesium concentration in all rice using custom-made belt conveyor testers. Notably, rice with radiocesium concentration levels over 100 Bq/kg were detected in only 71, 28 and 2 bags out of the total 10,338,000 in 2012, 11,001,000 in 2013, 10,956,000 in 2014 respectively. Since 2015, there were no bags which with higher radioactivity than 100Bq/kg.

Keywords: Radiocesium, Monitoring Inspection, Checking all bags of rice for radiation

Current status of reconstruction and challenges post the Fukushima disaster: Case study of Iitate Village

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Some farmers who evacuated due to the Fukushima Daiichi Nuclear Power Plant accident have resumed farming at the evacuation destination. On the other hand, many evacuees have discontinued agriculture for several reasons. Furthermore, as the number of areas where evacuation instructions have been canceled increases, new issues arise with regard to returning to the village or settlement at the evacuation destinations. This presentation considers the perspective of restarting farming and compares the current status of reconstruction of the affected farm village with that of a general rural village. Furthermore, it clarifies the challenges for future.
We investigated Iitate Village in Soma-gun, Fukushima Prefecture. The entire village was evacuated due to the Fukushima Daiichi Nuclear Power Plant accident. We conducted interviews and questionnaire surveys for farmers resuming farming at the evacuation destination and for evacuees being shifted to temporary housing. Through these surveys, we grasped the trends and intentions of farmers with regard to resuming farming as well as the conditions of temporary housing refugees.
Some large-scale farmers have resumed farming. The process of resuming farming for evacuees depends on their business contents. Floral cultivation farmers search farmland near the evacuation destinations. However, cattle breeding involves the use of a closed livestock barn. Therefore, farming can be resumed in an area where there are livestock barns. Restarting farmers use abandoned farmland and closed barn. Moreover, these farmers have high management skills and influence the community to resume farming. For example, they introduce new techniques in agriculture that were not previously used in the evacuation area.
On the other hand, most refugees placed in temporary housing have not resumed farming because these are mainly elderly people and semi-retired farmers. Thus, they do not possess management skills to secure agricultural land, work, and storage space necessary to resume farming as well as to purchase agricultural equipment.
Many farmers who have resumed farming consider returning to their villages, excluding those in the difficult-to-return area. However, they have not recover the scale of business before the accident. Further, there are no cases concerning relocation of all the living bases and farming in the evacuation destination. Many restarting farmers have chosen to continue farming both in Iitate village and at the evacuation destination.
As in many other middle and mountainous areas, Iitate Village had a declining population before the accident. In addition, Iitate Village has witnessed not only a few decades of population decline but also significant changes due to the accident. For example, vegetable gardens cannot be used for self-sufficiency around the house after the accident as used previously. Elderly people find it difficult to return to their home, and there is uncertainty concerning decontamination results. Therefore, it is necessary to consider agricultural assistance as an industrial policy to deal with issues that the policy has not covered so far.
Many issues relating to regional agriculture and community are more difficult post the accident than during evacuation. Among measures to be taken, long-term situations that consider the succession to the next generation are essential. Furthermore, researchers will need to focus on issues faced by residents over a long period of time.

Keywords: Post the Fukushima disaster, Restarting farming

Radiocesium runoff forms and its temporal variation at two rivers in Iitate, Fukushima

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Radionuclides were released by the accident at the Fukushima Daiichi Nuclear Power Plant, and radiocesium, ^{137}Cs and ^{134}Cs, were deposited on the soil surface. All of the residents within 50 km of the plant were forced to move. Six years after the accident, some residents are expected to return. However, decontamination efforts that remove topsoil around houses, agricultural lands, and forests requires a lot of time. Focusing on the forests, it is impossible to remove all of the topsoil, and thus estimates of radiocesium movements are needed. Radiocesium is adsorbed on soil and organic matter. Their movements would be equivalent to soil particle movements, through soil erosion and sediment transport. In this study, field monitoring was conducted to estimate radiocesium runoff from two comparative watersheds. Especially, radiocesium runoff forms and its temporal variation were focused.

The study sites were two watersheds in Iitate Village, Fukushima, Japan (Figure 1). The southern observation watershed (Hiso River watershed, 25.6 km^2) has higher radiation levels compared to the northern Mano River watershed (10.8 km^2). Forest accounts for close to 75% of the land area in both watersheds. Sediments containing radiocesium carried by runoff from surrounding lands into the rivers were monitored. A monitoring system is composed of a rain gauge, water level sensor, water velocimeter, turbidity sensor, and automatic water sampler (Figure 2).

Focusing on sediment particle size, more than 75% of the ^{137}Cs was adsorbed on finer particles such as clay, silt, and fine sand which were occupied less than 50% of suspended sediment as shown in Figure 3. Correlations between suspended sediment concentrations (SSC) with ^{137}Cs concentrations in storm waters are shown in Figure 4, and were approximately linear. These results mean radiocesium was discharged with the suspended sediment and organic matter. Comparing the two watersheds in the Figure 4, the slope of the regression line at Hiso was greater than that at Mano, which means radiocesium content in the suspended sediment at Hiso was larger than that at Mano. This also agrees with the distribution of radiocesium content in the topsoil shown in Figure 1. Comparing the slope of the regression lines from 2013 to 2016 in Figure 4, it decreased clearly with the lapse of time. The decreasing ratio for three years was 79% at Hiso and 83% at Mano. These ratios are much greater than the decay ratio of 6.7% estimated by physical half-life of radio-cesium. This high decreasing ratio might have been resulted due to the selective erosion and transportation of fine particles and organic matter in the hillslope and waterway. Monitored total amounts are summarized in Table 1. Hiso radiocesium losses were greater than those at Mano even though sediment yield was smaller, and this was due to the greater concentrations of radiocesium at Hiso. Spatially averaged ^{137}Cs contents at Hiso and Mano were 1017 kBq/m^2 and 421 kBq/m^2. Thus, decontamination of radiocesium in topsoil by natural soil erosion processes may not be effective. Focusing the form of radiocesium in the river water, most of ^{137}Cs was discharged as particulate form in the storm events. Its form accounted for greater than 95% of the total ^{137}Cs amount at both watersheds.

Keywords: Radiocesium, Sediment, Soil erosion, Fukushima

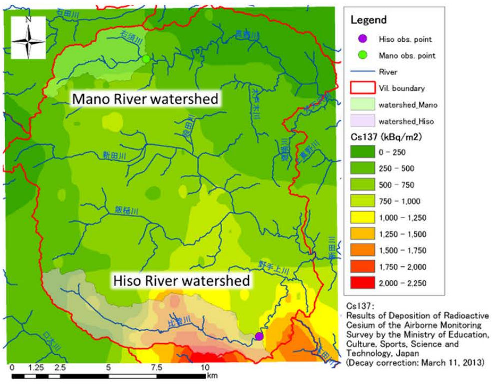

Figure 1. Study sites and ^{137}Cs levels in Iitate Village.

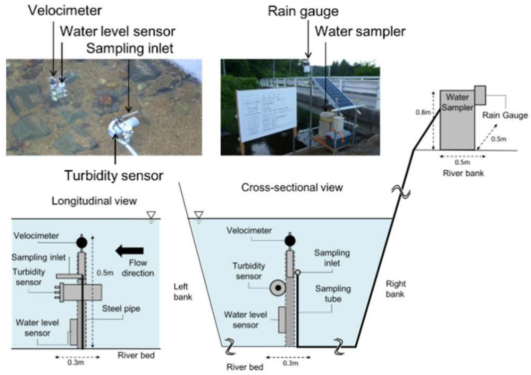

Figure 2. Instruments for field monitoring.

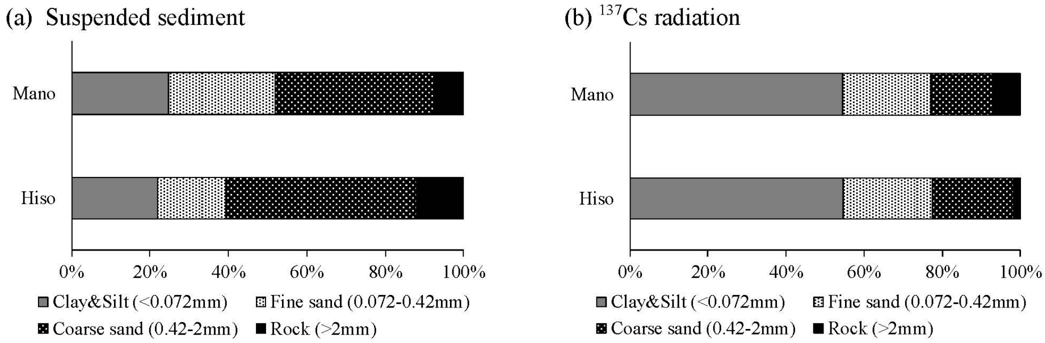

Figure 3. Ratios of each particle size in suspended sediment (a) or ^{137}Cs radiation (b) at Hiso in 2013.

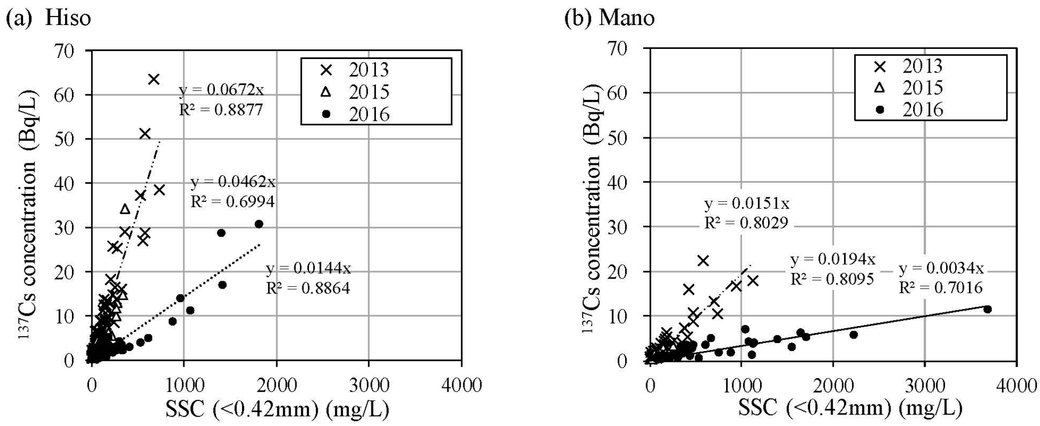

Figure 4. Relationships of SSC with ^{137}Cs concentration in the storm water at Hiso (a) and Mano (b)

Table 1. Monitored total amounts from June 2013 to December 2016.

Site	Year	Precipitation (mm)	Water runoff (mm)	Sediment yield (g/m²)	^{137}Cs runoff (Bq/m²) Storm Particulate	Storm Dissolved	Normal Particulate	Normal Dissolved	Total
Mano	2013	906	574	33	647	11	10	4	705
Mano	2014	1241	997	51	693	16	18	8	776
Mano	2015	1563	573	59 *	510 *	12	8	4	525 *
Mano	2016	1319	259	25 *	69 *	2	3	2	94 *
Hiso	2013	974	562	21	1387	26	12	5	1410
Hiso	2014	1595	1234	39	1000	21	19	8	2126
Hiso	2015	1639	753	74	2502	45	13	6	2604
Hiso	2016	1394	750	55	613	20	8	3	730

*Including missing values

Watershed Modeling Tools for Stakeholders: Utilizing Fallout Radionuclides to Assess Sustainable Management, Climate Change, Disaster Recovery and Community Resilience

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Existing isotope techniques based on fallout radionuclides and process-based soil redistribution modeling together are complementary techniques to provide more reliable and detailed data to a broad spectrum of stakeholders with different objectives: managers of natural resources and disaster managers of contaminated soils. On the one side, utilizing process-based model approaches and fallout radionuclides of surface atomic bomb tests more than half a century ago, enable to support more detailed soil and water conservation analysis of the past and future impact studies under changes of land use and/or climate around the world. While in the latter case the main objective is the sustainable use of natural resources, the same approach can also be used to assess a variety of land management strategies with the primary goal of minimizing erosion of radiation contaminated soils and increase the deposition of contaminated sediments before they reach a water body or stream. We present techniques to develop modeling tools for stakeholders to design, verify, validate and apply models assessing soil redistribution and the return periods of extreme events for agricultural soil conservation strategies as well as recovery of radiation contaminated soils.

The Geospatial Interface for the Water Erosion Prediction Project (GeoWEPP) is a quantitative, scenario-based watershed assessment model that is used around the world. GeoWEPP utilizes Geographic Information System (GIS) data such as digital elevation models (DEM), land use/cover and soils maps to derive and prepare valid model input parameters to start site-specific soil and water conservation planning for small watersheds. At its core is the WEPP model, a state-of-the-art, continuous simulation, process-based model for small watersheds and hillslope profiles within larger watersheds that can be of mixed land use such as agriculture, forest, rangeland, etc.

In Marchouch, Morocco, an agricultural experimental site provides five parallel transects with excellent data availability and a relatively high density of derived soil redistribution points based on ^{137}Cs and ^{210}Pb techniques. These transects are ideal to verify, validate and apply the GeoWEPP watershed simulations. Using these fall out "contaminants" as soil tracers, reinforces knowledge about the agro-environmental behavior of these anthropogenic radioisotopes (especially ^{137}Cs, but also new soil tracers such as ^{239}Pu and ^{240}Pu isotopes). The technique requires selecting stable reference sites in undisturbed areas that can be used in the future as background indicator if any other radioisotopic releases of Nuclear Power Plant accident occurs.

However, such simulation tools for sustainable development of natural resources (e.g. soil and water conservation and crop yields) and disaster risk reduction (e.g. flood risk and loss of biodiversity) are rarely performed within an integrated framework to account for the interests of a much larger, diverse group of stakeholders in a community. We therefore present a methodology to integrate quantitative models to drive the analysis of the complex, interdependent processes that interact within multi-dimensional, functional systems in landscapes. Creating potentially win-win situations based on quantitative measures among a larger group of stakeholders in a watershed is an important aspect of creating long-term

partnerships, particularly those in communities exposed to the need for natural resources development and higher risks of natural and man-made hazards (e.g. Fukushima Nuclear Power Plant Disaster). Resilience has been defined as a measure of geospatial and temporal functionality, its decay and recovery, in face of various extreme events, disasters and potential hazards. The functionality and resilience of a community are dependent on numerous components and dimensions. Seven dimensions of community resilience are represented in the holistic, interdisciplinary framework with the acronym PEOPLES: **P**opulation and Demographics, **E**nvironmental/Ecosystem, **O**rganized Governmental Services, **P** hysical Infrastructure, **L**ifestyle and Community Competence, **E**conomic Development, and **S** ocial-Cultural Capital. The ‘**PEOPLES** Resilience Framework’ provides the basis for the integration of quantitative and qualitative models that continuously measure the resilience of communities against extreme events or disasters in any or a combination of the above-mentioned dimensions.

Keywords: soil erosion, extreme events, isotopes, disaster, radioactive fallout, community resilience