Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

MAG34-P01 Room:Convention Hall Time:May 24 17:15-18:15

Simulation of dispersion of radionuclides released from the Fukushima Daiichi Nuclear Power-Plants

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[1]Japan Agency for Marine-Earth Science and Technology

We use a numerical model to investigate the dispersion of radioactive water released from the Fukushima Daiichi Nuclear Power-plants (FDNP) on March 2011. The numerical model is based on a three dimensional particle random-walk model and a z-coordinate ocean general circulation model developed at the Earth Simulator Center, JAMSTEC. Radionuclide concentrations are obtained from the density of particles per unit volume water. Experiments have been carried out for 137Cs for 4 months and the results show that coastal currents and meso-scale open oceanic eddies having large influence on the behavior of the radionuclides. The radionuclides in coastal currents remain along the coast where as the one in meso-scale open oceanic eddies rapidly escape to the interior of the Pacific along the Kuroshio extension. Most of the sediment accumulations of the radionuclides are found on the continental shelf regions.

Keywords: radioactive water, Fukushima Daiichi Nuclear Power-Plants, radionuclide dispersion model, ocean general circulation model

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Radiocesium released from Fukushima was contained in the sinking particles in the western North Pacific.

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[1]Japan Agency for Marine-Earth Science and Technology

We carried out the sediment trap experiments in the western North Pacific during autumn 2010 and summer 2011. The sinking particles were collected in the area before and after the accident of Fukusihma Dai-ichi nuclear power plant (FNPP). Cs-137 and Cs-134 were detected in the sinking particles at 500 and 4810 m depth after 25 March and 6 April forward, respectively. Because Cs-134/Cs-137 ratios were approximately 1.0, we assumed that these radioisotopes were released from FNPP. Using the time lag of the initial detection of radiocesium between 500 and 4810 m depth, the particle sinking rate was estimated as >180 m/day.

Keywords: Fukusihma nuclear power plant, radiocesium, sinking particle

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MAG34-P03 Room:Convention Hall Time:May 24 17:15-18:15

Transport of the Radioactive Materials to Fukushima City in the Fukushima Nuclear Accident

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In Fukushima Daiichi nuclear power plant located in the Pacific coast of Fukushima Prefecture, the earthquake and the resulting tsunami on March 11, 2011 caused radiation accident that made a lot of outflow for the surrounding environment. In this study, we investigated how radioactive materials are transported to the inland from the nuclear power plant by simulating the atmospheric dispersion of radioactive materials. In particular, consider where the radioactive materials which bring the high radiation doses were maintained for a long period in Fukushima city come from.

In computing the spreading of radioactive materials, we used the Weather Research & Forecast (WRF) model to reconstruct the atmospheric field at the accident, and then the particles assumed as the radioactive materials were flowing the calculated field. This Lagrangian advection-diffusion calculating is composed three parts, the advection part, diffusion part, and dry deposition part. The advection calculation use the wind speed calculated by WRF model to move the particles. The vertical diffusion calculation is described by the random-walk model. And, the dry deposition calculation is realized by dropping the particles near the surface on the ground at random.

Result of this advection-diffusion simulation, it is confirmed that the radioactive materials released from the nuclear power plant is progressing inland at about 14 and 19 JST on March 15, and after that the particles flowed into Fukushima city. In addition, when great amount of radioactive materials reached into Fukushima city in this study, it was the same time that radiation doses which were observed increased rapidly. Moreover, according to the observation of the Japan Meteorological Agency (JMA), it started to rain at this time. Therefore, it is thought that the high radiation doses at Fukushima city was caused by the large amount of radioactive materials dropped by rain.

Keywords: Radioactive Material, Dispersion, Numerical Simulation, Topography

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Quantitative analysis of precipitation over Fukushima to understand the wet deposition process in March 2011

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The Great East Japan Earthquake caused a severe accident at the Fukushima-Daiichi nuclear power plant (NPP), leading to the emission of large amounts of radioactive pollutants into the environment. The transport and diffusion of these radioactive pollutants in the atmosphere caused a disaster for residents in and around Fukushima. Studies have sought to understand the transport, diffusion, and deposition process, and to understand the movement of radioactive pollutants through the soil, vegetation, rivers, and groundwater. However, a detailed simulation and understanding of the distribution of radioactive compounds depend on a simulation of precipitation and on the information on the timing of the emission of these radioactive pollutants from the NPP. Past nuclear expansion studies have demonstrated the importance of wet deposition in distributing pollutants. Hence, this study examined the quantitative precipitation pattern in March 2011 using rain-gauge observations and X-band radar data from Fukushima University.

We used the AMeDAS rain-gauge network data of 1) the Japan Meteorological Agency (1273 stations in Japan) and 2) the Water Information System (47 stations in Fukushima prefecture) and 3) the rain-gauge data of the Environmental Information Network of NTT Docomo (30 stations in Fukushima) to construct 0.05-degree mesh data using the same method used to create the APHRODITE daily grid precipitation data (Yatagai et al., 2009, 2012). Since some AMeDAS data for the coastal region were lost due to the earthquake, the complementary network of 2) and 3) yielded better precipitation estimates.

The data clarified that snowfall was observed on the night of Mar 15 into the morning of Mar 16 throughout Fukushima prefecture. This had an important effect on the radioactive contamination pattern in Fukushima prefecture. The precipitation pattern itself does not show one-on-one correspondence with the contamination pattern. While the pollutants transported northeast of the NPP and through north Kanto (about 200 km southwest of Fukushima and, 100 km north of Tokyo) went to the northwest, the timing of the precipitation causing the fallout, i.e., wet-deposition, is important.

Although the hourly Radar-AMeDAS 1-km-mesh precipitation data of JMA are available publically, it does not represent the precipitation pattern in Nakadori, in central Fukushima prefecture. Hence, we used 10-minute interval X-band radar, located in north Nakadori to determine the start and detailed horizontal pattern (120-m mesh) of the precipitation. Since 1) and 3) are 10-minute intervals and 2) is hourly data, we are developing hourly gridded data and using 1?3) to verify and quantify the rain rate observed by the Fukushima University X-band data.

Keywords: precipitation, snowfall, wet deposition, fallout, radar, Fukushima

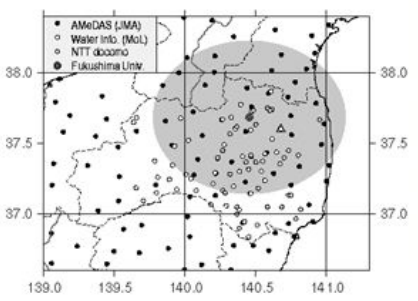

Fig.1 Rain-gauge distribution used in this study, and coverage of Fukushima University's X-band radar.

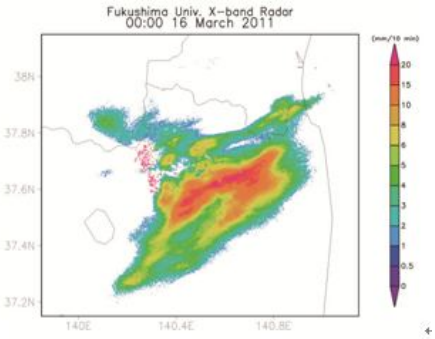

Fig.2 An example of rain rate pattern observed by the X-band Radar of Fukushima University.

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Atmospheric electricity changes around the 2011 off the Pacific coast of Tohoku Earthquake

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We have observed atmospheric electricity parameter (atmospheric ion concentration and atmospheric electric field) for validation of ”Lithosphere-Atmosphere-Ionosphere Coupling”. We have installed COM-3700, produced by Com System Inc., to observe ion content concentration at Akishima (Tokyo), Kiyosumi (the southern part of Boso Peninsula) and Uchiura (the southern part of Boso Peninsula). Field mills to measure atmospheric electric field have been installed at Chiba University (Chiba) and Kiyosumi. Ion content concentration, atmospheric electric field and weather conditions (temperature, humidity, air-pressure and window conditions) have also been observed simultaneously at Kiyosumi station. Therefore, we can verify relationship with variations among these parameters.

After the 2011 off the Pacific coast of Tohoku Earthquake(M9.0), anomalous increase of atmospheric ion concentration and decrease of atmospheric electric field have been recorded at our stations. It may response to increase of radioactive material in the atmosphere by the Fukushima Daiichi Nuclear Power Plant accident. We compare changes of atmospheric electricity parameter with those of radiation dose rate observed at the nearest monitoring-post.

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A quick report of measurement to estimate scattering of radioactive Cs with Japanese cedar pollen

TANAKA, Misako[1*], SATO, kaori[1], KITA, Kazuyuki[1], ONDA, Yuichi[2], Keisuke Sueki[2], Atsushi Shinohara[3], Akihiko Yokoyama[4], TSURUTA, Haruo[5], Hisao Nagabayashi[5], WATANABE, Akira[6], NAKAZAWA, Takakiyo[8], YOSHIDA, Naohiro[9], Monitoring team of Radioactives[10]

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A tremendous amount of radioactive matters have been released by the Fukushima nuclear plant accident. A significant part of them fell to leave and branches of Japanese ceader trees, which are commonly seen in the Japnease mountain areas. Attached radioactive cesium (Cs-134 and Cs-137) has been absorbed in the tree body and are sent to all of t, incluring flower and pollen. Because the Japanese cedar releases a large amount of pollens and they can be widely transported by winds, significant amount of radioactive Cs may be transported by the scattering of the pollens.

In order to monitor atmospheric radioactivity and to estimate the influence of the pollun scattering on it, we have started simultaneus observation of the atmospheric radioactivity and the scattered pollen amount. The density of Cs-134 and Cs-137 radioactivity is observed by collecting aerosols including pollen and by measuring gamma-ray emission from the collected aerosol. The observation was carried out at 11 stations: Fukushima-city, Sendai-city, Marimori-town, Minami-Soma city, Kawamata-town, Koriyama-city, Iwaki-city, Nikko-city, Hitachi-city, Mito-city, and Tokyo. We will report of preliminary analyses of the observed data to indicate influence of the pollen Cs.

Keywords: radioactive Cs, Pollen of Japanese cedar

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Modeling of long term diffusion of radioactive materials, and levy flight simulation considering topical wind direction

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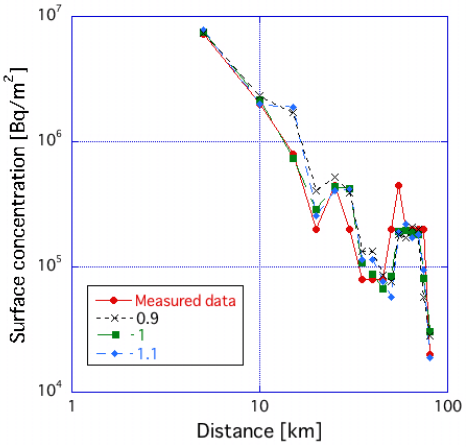
The environment around Fukushima has been contaminated by radioactive materials leaked from the Fukushima 1 Nuclear Power Plant, following the Tohoku earthquake and tsunami on 11 March 2011. Cs-134 and Cs-137 adhered to the ground surface and remain polluting surrounding environment because they have a long half-life. In addition, they diffuse gradually due to resuspension. In this study, we propose the simulation model suited for the long-term diffusion prediction of them, which has not studied enough, and verify the applicability of our model by comparing with measured data.

The ground surface concentration of Cs-134 and Cs-137 has been attenuated in a proportion to the power of the distance from the release point in Fukushima. In addition, concentration in the atmosphere has been attenuated following the same law in Chernobyl data. The exponent of distance from release point was about 1 on average in Fukushima. The exponent of distance is constant, regardless of the unit of distance. Levy flight is known as diffusion model showing the power law. A Levy flight equals a random walk in which the step-lengths have a probability distribution function of the power. Therefore, we conducted levy flight simulation regarding the existence probability of the particle as the surface concentration. We reproduced surface concentration on 5 November 2011 by using the initial condition data for 5 July 2011[1]. We used measured data of wind direction in the each step-direction of levy flight because of the wind direction is not isotropic.

The result is shown in Fig. As the result of the simulations, we succeeded in predicting the concentration more accurately than the case in which only decay of radioactive materials was considered. The simulation was the most accurate especially using exponent value 1. More accurate predictions will become possible to study further.

[1] Aircraft monitoring, Ministry of Education, Culture, Sports, Science and Technology

Keywords: Levy flight, Fukushima, Surface concentration, Long-term diffusion prediction, Cesium, radioactive material



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Ratio of I-131 to Cs-137 in deposition rate to soils affected by the accident of Fukushima Daiichi Nuclear Power Plant

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To clarify the effect of radioactive substances released by the accident of the Fukushima Daiichi Nuclear Power Plant (FDNPP) on terrestrial ecosystems, the Ministry of Education, Sport, Culture, Science and Technology (MEXT) organized intensive field studies on regional deposition of radioactive substances to surface soils in east Fukushima during June-July 2011. The data was open in August and September 2011 by the MEXT. In this report, a preliminary result is summarized by using those data to analyze regional distribution of the ratio of I-131 to Cs-137.

Keywords: deposition ratio, surface soils, Cs-137, I-131, regional distribution, Fukushima Daiichi Nuclear Power Plant

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What could be the consequences of the Fukushima Dai-ichi releases over mountainous areas?

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Getting a precise idea of the environmental consequences of the accidental nuclear releases like those of Fukushima Dai-ichi on mountainous area required a specific environmental monitoring program. This one could be comparable to that followed in France which mountainous areas have undergone the deposition of man-made radionuclides after the Chernobyl releases...

Field works were carried in mountainous areas where the distribution of artificial radionuclides is extremely heterogeneous. Thus patches or ”hot spots” concentrating radiocesium (over 100 kBq.m-2) were identified soon after Chernobyl accident in the topographic depressions occurring in meadow areas (over 2,000 m altitude). The aims of the project were (1) to identify the processes which have concentrated the released radionuclides (2) to develop a methodology for the mapping of the contamination of mountainous area. Thus the effect of geomorphology (i.e. the occurrence of snow drifts at glacial terrains depressions, where patches occurred) and the influence of vegetation cover (meadow/forest areas) on the distribution of 137Cs have been studied.

In addition, sampling and measurement of the local foodstuff products (such as milk, cheese, berries and games) as well as in situ gamma radiation monitoring were carried out to evaluate the dosimetric consequences for local inhabitants. A special attention has been paid on the activity recorded by milk and cheeses which has been studied at different scales (a single farm, a mountainous region, several massifs, etc.). Also at several stations the activity of 137Cs and 90Sr has been determined in the soil/plant/milk/cheese continuum, demonstrating the sensitivity of the transfer of such man-made radionuclides with respect to environmental conditions and agricultural practices.

Keywords: Radioactive releases, mountainous area, Fukushima Dai-ichi, 137Cs

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Dose rate map in and around Shizuoka Prefecture, central Japan, and pollution by Fukushima Nuclear Power Station

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A dose rate map in and around Shizuoka Prefecture, central Japan, was made to clarify the radioactive pollution by the Fukushima Nuclear Power Station, which caused the severe accident in March, 2011. A scintillation counter with a CsI(Tl) scintillator was used for measuring the dose rate distribution 1m above the ground surface. A spectrum analyzer with an NaI(Tl) scintillator was additionally used for identifying source radioactive elements. An area of low-level pollution (0.06-0.13 micro Sv/h) by Cs-134 and -137 was detected in the northeast Izu Peninsula, where original dose rates were during 0.02-0.04 micro Sv/h. The topography of the pollution area is characterized by a row of plateaus, valleys, and slopes, which are bounded by a ridge of 400-1000m height and the northwestern coast of Sagami Bay. This geographical situation of the pollution, as well as the precipitation and wind records, suggests that a radioactive cloud had reached this area by southwestward wind on March 21-22, 2011, and radioactive particles had been fallen by rain.

Keywords: dose rate, surficial distribution, Shizuoka Prefecture, spectrum analysis, pollution map, Fukushima Nuclear Power Station

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Radiation measurement at the top of Mt. Fuji

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We investigate energetic radiation associated with Fukushima nuclear power plant accident at the top and middle of the Mt. Fuji. Comparing with the NaI spectrum data of one year before, we did not observe the gamma radiation from the cesium at the top. When we did not detect the gamma radiation from the snow covered with the top. On the other hand, we detected radioactive materials at the middle point of the mountain.

Keywords: Radiation, Fukushima nuclear power plant accident, Mt. Fuji

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’Sedimentology’ of radioactive cesium under water

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For the purpose of establishing proper countermeasures on the radionuclide-concentrated sediments we need to have accurate understanding on the sedimentation and remobilization mechanisms of radionuclides in water. The background of distribution coefficients of radioactive cesium between aqueous phase and particle phase for non-conservative radionuclides dispersion model are examined.

Keywords: flocculation, adsorption, aggregate, decomposition of organic matters, radioactive cesium

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Estimation of Radioactive Contaminant Load from Abukuma River

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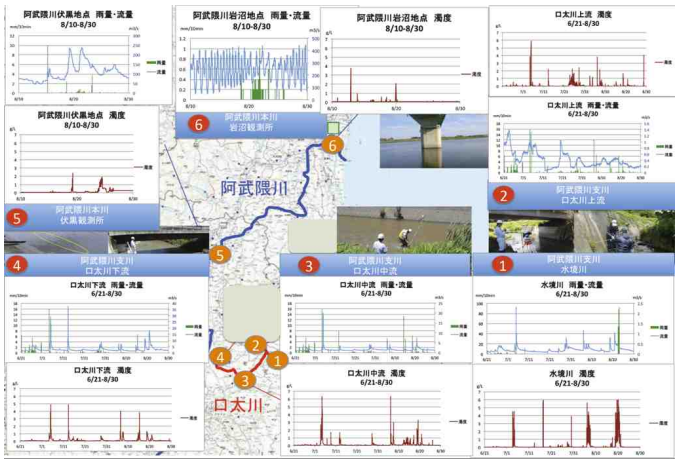
Most of radioactive material released from Abukuma River Basin, one of the largest stream near the contaminated zone of Fukushima, flowing most of the contaminated plane zone then flow into the Pacific Ocean, are in the suspended particulate form, more than 90 % in the upper stream and 70 % in the river mouth. Most of them are still trapped in the middle of the basin, however we find that significant amount are released during the heavy precipitation event. We also found that, at hydrological extremes the total loading increase more than 1000 times higher than the normal stream condition due to the catchment characteristics.

Keywords: Abukuma River, Radioactive loading



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Measurements of Cs-134 and Cs-137 released by Fukushima Dai-ichi Nuclear Power Plant in stream water and spring water

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[1]Graduate School of Life and Environmental Sciences, University of Tsukuba, [2]Meteorological Research Institute, Japan Meteorological Agency

Fukushima Dai-ichi nuclear power plant accident occurred on 11th march, 2011. After the accident, large amount of radionuclides was released into the atmosphere. With the rainfall event, the radionuclides fall into the ground. Through the hydrological cycle, it is probable to move into the soil surface through the process of infiltration and then reaches to the deep groundwater through percolation and then it discharges to the ocean through the spring and stream water.

The study examined the concentration of radionuclides ^{134}Cs and ^{137}Cs in small watershed covered by grassland, farmland and cultivated land. The study area is in Yamakiya district, Kawamata Town, Fukushima prefecture, located inside the voluntary evauation nuclear zone. The sample was taken from groundwater, spring water and stream water from 6th June to 31st August 2011. The taken water samples were filtered by a 0.45 micrometer membrane and measured the concentration of ^{134}Cs and ^{137}Cs.

The concentration of ^{134}Cs and ^{137}Cs were found in stream water less than 0.42 Bq/kg and 0.57 Bq/kg respectively. The concentration of ^{137}Cs in spring water ranges from 0.13 Bq/kg to 0.36 Bq/kg and less than 0.32 Bq/kg of ^{134}Cs. The concentration of ^{134}Cs and ^{137}Cs in spring and stream water showed the low value. However, the water sample after the rainfall event in high volume of stream water, the concentration of ^{134}Cs and ^{137}Cs found to be 0.82 Bq/kg and 1.18 Bq/kg respectively. The high concentration of Cs in stream water after the rainfall could be due to the Cs transfor from suspended sediment.

Keywords: cesium, Fukushima, stream water, spring water

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Distribution and movement of fallout radionuclides in throughfall, stemflow, and litterfall in a forested area

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Due to the Great East Japan Earthquake occurred on March 11, 2011, radionuclides such as Cs-134 and Cs-137 was released into the atmosphere from the Fukushima nuclear plant. It is important for carrying out the decontamination work to elucidate the dynamics of fallout radionuclides by water and/or soil particles. In this study, we aimed to understand the distribution and movement of fallout radionuclides in a forested area. We collected throughfall, stemflow, litterfall and measured the concentration of Cs-134 and Cs-137 using a Gamma-ray spectrometer.

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Rapid reduction of 137Cs caused by soil erosion on a typical agricultural

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[1]Graduate School of Life and Environmental Sciences, University of Tsukuba

The large amount of 1.5 x1017Bq of 137Cs was released into the environment by the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident in March 2011. Knowledge of the initial fallout distribution and the postdepositional Cs mobility in agricultural land is essential, as due to the biological uptake food is contaminated and health threatened. The fate of 137Cs in agricultural land depends on its radioactive decay, the downward diffusion in the soil and redistribution by soil erosion. In this study we document a.) diffusion in a typical agricultural field located 40km northwest of the FDNPP, b.) redistribution of 137Cs within the field by the soil erosion types interrill erosion, rill erosion and gully erosion, and c.) calculate 137Cs export for a period of five months since the FDIPP accident.

The study field with an area of 0.66ha consists of sandy loam highly susceptible to soil erosion. Few days before the accident the field was prepared for tobacco plantation with a ridge-furrow topography, but left abandoned due to radioactive contamination. During the rainy season in early summer the field was invaded by natural vegetation and by the end of the typhoon season the field was covered.

In order to document the diffusion of 137Cs, sectioned soil samples were taken at six ridge locations within the study field and at one undisturbed location outside to estimate initial contamination. A scraper plate was used in 5mm increments for the top 5cm and in 10mm increments for the depth of 5cm to 10cm. 137Cs inventories (Bq/m2) were computed on the basis of the dry mass of soil (<2 mm). All activities were corrected for decay from the time of soil sampling. The depth distribution of the undisturbed site was used to calculate redistribution of 137Cs within the field by interrill erosion attributed. Rills and gullies were mapped. The 137Cs redistribution of rills is based on cross-section measurements in 10m spacing of five representative rills with lengths between 50 and 120m. Activity of in-channel sediment was taken into account. The cross sections of gullies were taken in intervals between 4 and 8meters.

Results indicate an initial contamination of 392.7kBq/m2 with a diffusion of 95% in the uppermost 4cm. Soil erosion processes produced a high spatial variability of 137Cs content. Depending on slope angles interrill erosion reduced the activity by 33.9% to 50.5% with an average of 41% for the whole field. At upslope positions rill erosion reduced the activity up to 80%, as highly contaminated topsoil was eroded. Due to the storage of highly contaminated sediment on midslope locations the activity there was up to1.5 times higher compared with the undisturbed location. Rills in the lower slopes as well as the two incipient gullies were eroded below contamination depth. As rills and gullies covered only 4.7% and 0.4% of the field respectively, the total 137Cs export was 43% for a period of five months results. These findings help practitioners to evaluate the spatially distributed 137Cs contamination on field scale and to assist in decision making for usage restrictions.

Keywords: 137Cs, soil erosion