

# Effects of Ground Surface Decontamination on the Air Radiation Dose Rate

## –Results of a Decontamination Trial at a Playground Lot in a Fukushima Residential Area–

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The Japan Atomic Energy Agency decontaminated schools, playgrounds, swimming pools, and houses in nonevacuated, less-contaminated areas in Fukushima for environmental restoration. A small, 150 m<sup>2</sup> playground lot in the residential area was chosen for decontamination demonstration, which used routinely available tools and commodities to carry out the work. The surfaces of playground lot equipment, such as swings, slides, and horizontal iron bars, were completely decontaminated by brushing with water and/or detergent. Side gutters around the playground lot were cleaned by removing the mud and then brushed and washed with a high-pressure water jet (7 MPa). The air dose rate at the playground lot was dominated by radiation from the ground surface and adjacent surroundings, such as apartments and rice fields. Two or three centimeters of the surface soil contaminated with cesium was removed manually with shovels, hoes, and other gardening tools. This significantly reduced the average air dose rate of the entire playground lot from 1.5  $\mu\text{Sv/h}$  before decontamination to 0.6  $\mu\text{Sv/h}$ . These results showed that ground surface decontamination can contribute measurably to the reduction in air dose rate in relatively small areas in residential areas.

**KEYWORDS:** Fukushima, environmental restoration, playground lot, decontamination, side gutter, high-pressure water washing, air dose rate, ground surface, cesium, gardening tools

## I. Foreword

As a result of the nuclear accident resulting from the Great East Japan Earthquake on March 11 2011, it is necessary to decontaminate radioactive materials dispersed into the environment. The Japan Atomic Energy Agency is engaged in the decontamination and environmental restoration of schools, playgrounds, swimming pools, and houses in the areas in Fukushima where the order to evacuate was not issued. In the future, the general public is expected to participate in the decontamination work without prior training in environments other than the evacuation-directive areas. Therefore, it is important to show that the spaces in which children

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stay for long periods of time, such as schools and parks, can be decontaminated using basic tools that can be easily purchased at DIY stores. This trial was intended to test and evaluate a reduction in the air dose rate through the decontamination of a playground and playground equipment within an area of approximately 150 m<sup>2</sup> located in a residential area where the order to evacuate was not issued.

## II. Decontamination Test

### 1. Introduction

This test was intended to demonstrate the effects of ground surface decontamination on the air dose rate by decontaminating a playground with contaminated soil. A relatively small playground (approximately 150 m<sup>2</sup>) was chosen in order to confirm the localized contamination effect in an environment that is susceptible to background conditions in the surrounding area.

### 2. Decontamination Test

#### (1) Decontamination plan

Prior to decontamination, decontamination goals and plans needed to be established. **Figure 1** provides a full view of the playground targeted for decontamination. The triangle-shaped playground is surrounded by apartments, houses, parking lots, and rice fields.

In order to establish the decontamination goal, the air dose rate was measured at three heights above the surface of the asphalt outside the playground (1 cm, 50 cm, and 100 cm), without using a lead collimator (hereinafter referred to as “collimator”). The average values calculated from four measurement points were: 1.5  $\mu\text{Sv/h}$  on the asphalt surface; 1  $\mu\text{Sv/h}$  at a height of 50 cm; and 0.9  $\mu\text{Sv/h}$  at a height of 100 cm. Since cesium on asphalt is dissolved in rainwater and can easily run off, the dose rate was lower than that of soil. Furthermore, because this relatively small playground is affected significantly by gamma rays from the surrounding area, an air dose rate of 0.9  $\mu\text{Sv/h}$  (recorded 100 cm above the ground) was set as the decontamination goal.

Next, the contamination of all of the playground equipment was checked. The playground

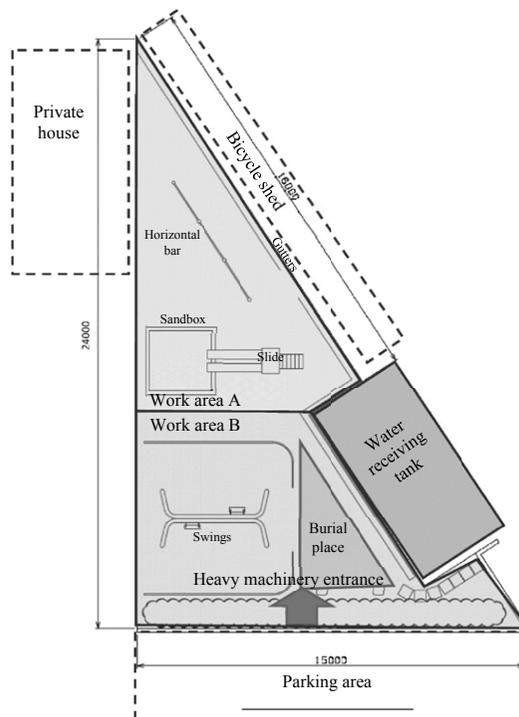


**Figure 1** View of the playground before decontamination

includes swings, a slide, a sandbox, equipment made of fiber reinforced plastic (FRP), and a horizontal bar, and plants are located at the stone-flagged entrance and around the gutters. Both concrete and iron grating covers are placed over the gutters, and the soil has been left unweeded.

At the time the test was carried out, Fukushima City made a recommendation to remove the top 5 cm of soil<sup>1)</sup> and dig 1.5-m deep burial holes (to be covered with 0.5 m of soil)<sup>1)</sup>. The demonstration aimed to remove a certain thickness of surface soil based on the measured radiation dose, but also to minimize the amount of material that had to be removed. Therefore, it was determined during the planning phase that the top 5 cm of soil would be removed from the entire playground area (approximately 150 m<sup>2</sup>) and that a burial hole would be dug that could contain the removed soil. The depth of the burial hole was designed so that 10.5 m<sup>3</sup> of soil could be overlaid with a soil cover 0.5 m thick, based on the following formula: 150 m<sup>2</sup> × 5 cm × loose soil volume factor. Since it was impossible to dig the hole by hand, heavy machinery was used to excavate a portion of planted area, where plants were pulled out. Concerning decontamination work in residential areas, it is important to demonstrate a method that the general public can implement. Therefore, except for the measurement instruments, we used tools that can be purchased from DIY stores, such as a high-pressure water sprayer and bamboo winnow. In addition, two working areas were created so that the work could proceed efficiently without the risk of re-contamination. **Figure 2** shows the layout of the playground.

The decontamination was conducted in the order of playground equipment, planted areas, soil, and gutters, and ground leveling was performed last using Soilex<sup>2)</sup>, which generates less fugitive sand as additional soil. Considering the drainage function of the playground, surface compaction was performed during ground levelling so that the ground sloped toward the



**Figure 2** Layout of the playground lot

gutters. Concerning the playground equipment, the elimination of loose contamination (which was not fixed firmly by paint, for example) was tested.

## (2) Radiation measurement method

### (a) Air dose rate

The air dose rate was measured for 30 seconds based on a time constant of 10 s using a NaI scintillation survey meter (Aloka, TCS-172) with a calibration constant of 1.0. The average of five measured values was recorded as the measurement value. The measurements were performed at the soil surface (1 cm), and at 50 cm and 100 cm above the ground.

When using the lead collimator for measurement on the surface, it was placed with the probe covered with a 7-mm-thick lead sheet (equivalent to a half-value layer of cesium ( $^{137}\text{Cs}$ )).

### (b) Surface contamination

Surface contamination was measured at a distance of 1 cm from the measured object, using a GM counter tube (Aloka, TG133) with a counting efficiency of 43%. When the background measurement was conducted, a 7-mm-thick lead sheet was placed between the measured object and the GM counter tube so that the detector would be hidden from the measured object.

When implementing the direct smear method, a filter paper used for the smears was placed inside a building with relatively low background radiation, enclosed with a lead wool mat (760 mm  $\times$  240 mm, with a lead equivalent of 10 mm), to create a background condition of around 100 cpm.

### (c) Measurement before decontamination

We measured the air dose rate before decontamination. First, we divided the playground into a grid with each block measuring 2 m  $\times$  2 m. At the 43 intersection points, we measured the air dose rate at the three sample heights (1 cm, 50 cm, and 100 cm above the ground)

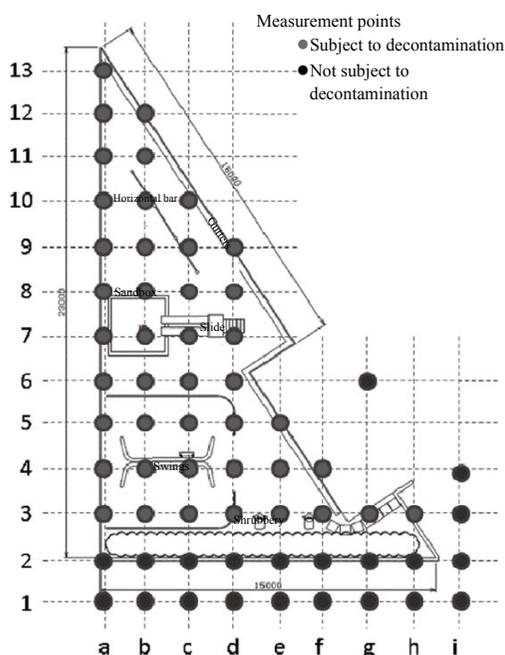


Figure 3 Air dose rate measurement points in the playground lot

using the NaI scintillation survey meter. **Figure 3** shows the positions of the measurement grid. Detailed measurement data are shown below in comparison with the values after decontamination; the average values were 2.4  $\mu\text{Sv/h}$  at the soil surface, 1.8  $\mu\text{Sv/h}$  at a height of 50 cm, and 1.5  $\mu\text{Sv/h}$  at a height of 100 cm.

**(3) Decontamination method tested**

(a) Decontamination of horizontal bar

Before decontamination, measurements were conducted according to the smear method using smear filter papers. After this, the horizontal bar was washed using water, neutral detergent, orange oil-based detergent (orange oil acts as a surfactant), and a brush (car-washing brush with Pacquin and polypropylene bristles). Measurement was then repeated according to the smear method after decontamination. Rust was filed away with abrasive paper (#80).

At the time of decontamination, the parts of the horizontal bar were washed in the order from higher to lower (while paying attention to the direction of water flow) and wiped with paper towels. However, we did not disassemble the fixing joints.

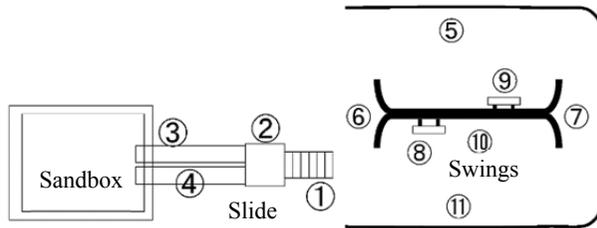
(b) Decontamination of the slide and swings

As described later, since washing with water and wiping produced a sufficient cleaning effect for the horizontal bar, the slide and swings were washed and brushed without detergent and eleven points were evaluated using the smear method. The same measurement method was used as described in Section II-2-(3)-(a) (**Figure 4**).

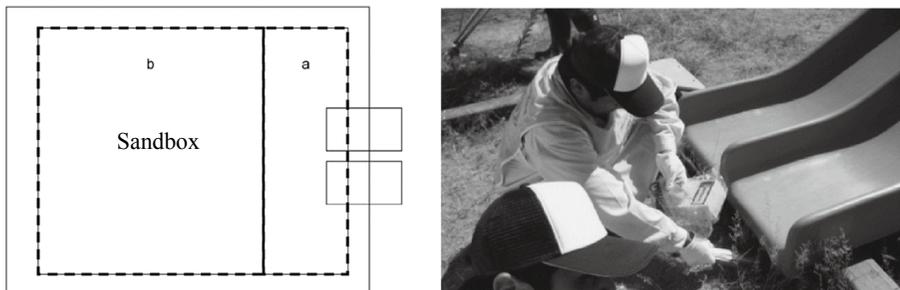
We decontaminated the fixing joints of the slide using a commercially available high-pressure water sprayer (water pressure =7 MPa, straight nozzle) without disassembling.

(c) Decontamination of sandbox

As the area of the sandbox into which water flows from the slide was highly contaminated, and the frame of the sandbox was made of wood, decontamination of the sandbox was performed after dividing it into the following three areas: (a) an area with a high degree of



**Figure 4** Air dose rate measurement points at and around the slide



**Figure 5** Air dose rate measurement points at the sandbox

contamination, (b) an area with a low degree of contamination, and (c) the wooden frame (**Figure 5**). In each area, after eliminating garbage and weeds, and removing the top 1, 3, 5, and 10 cm of the soil according to the topsoil removal method, we measured the air dose rate at the surface (1 cm) using a collimator and also measured the surface contamination density using a GM counter tube. For area (b), we performed the measurement at five points, positioned evenly, and evaluated the average value.

For the wooden frame, we implemented and evaluated four types of decontamination: water washing with a brush; wiping using a detergent containing orange oil; sanding with sandpaper; and sanding with an electric sander.

(d) Spot decontamination of soil

A circular area 100 cm in diameter was targeted for decontamination because it was less susceptible to the scattering effect of gamma radiation from the periphery of the site. After removing any garbage and weeds, the soil within the circle was then decontaminated according to the topsoil removal method. We removed the top 1 cm, 3 cm, and 5 cm of soil and measured the air dose rate at heights of 1 cm, 50 cm, and 100 cm above the surface using a GM counter tube.

(e) Decontamination of surface soil

As described later, since removing the soil up to 3 cm in depth was found to have a sufficient decontamination effect, decontamination was implemented by removing the top 3 cm of soil from the entire playground area. In this decontamination work, care was taken to remove the soil thinly and evenly using bamboo winnows and square shovels, which are used as farm tools. After decontamination, the air dose rate was measured at three heights (1 cm, 50 cm, and 100 cm) at the same measurement points as shown in Figure 3. For measurements taken at the soil surface (1 cm), a collimator was also used as well as a GM counter tube.

(f) Decontamination of gutters

For the gutters (made of concrete and with a pit width of 18 cm and a pit depth of 17 cm), garbage and sludge were first removed using tongs and shovels, respectively. The gutters were then washed with water and a brush (using scrubbing brushes with red fern bristles) before using a high-pressure washer (from a distance of 10 cm). Since the gutters were approximately 30 cm deep, the air dose rate was measured at a height of 1 cm from the bottom.

(g) Decontamination of gutter covers

The gutters had both iron gratings and concrete covers (25 cm wide  $\times$  60 cm long  $\times$  3.5 cm thick). Since the iron covers could be decontaminated by washing with water and brushes and the high-pressure washer, we conducted the test on the concrete covers. The decontamination effect was compared between water washing with brushes (scrubbing) and high-pressure washing.

(h) Shielding of buried soil

In order to check the shielding effect of the soil cover at the burial site, we measured the air dose rates (1 cm, 50 cm, and 100 cm above the surface) with soil cover thicknesses of 10 cm, 20 cm, 30 cm, and 35 cm.

#### (4) Test results

(a) Decontamination of horizontal bar

**Table 1** shows the results of decontamination of the horizontal bar. Each measured value (net) was calculated by deducting the background value from the raw (gross) measured value. As a result, we found that loose contamination (which was not fixed firmly by paint, for example) could be eliminated by water washing.

(b) Decontamination of slide and swings

**Table 1** Decontamination effects for the horizontal bar

Measurement point		Water washing	Mild detergent	Sandpaper	Detergent containing orange oil
Before decontamination	Measured value (Gross)	200	180	230	270
	Measured value (Net)	100	80	130	170
After decontamination	Measured value (Gross)	100	100	100	100
	Measured value (Net)	0	0	0	0
Decline rate (%)		100	100	100	100

**Table 2** Decontamination effects for the slide

Measurement point		①	②	③	④
Before decontamination	Measured value (Gross)	180	200	190	200
	Measured value (Net)	80	100	90	70
After decontamination	Measured value (Gross)	100	100	100	100
	Measured value (Net)	0	0	0	0
Decline rate (%)		100	100	100	100

**Table 3** Decontamination effects for swings

Measurement point		⑤	⑥	⑦	⑧	⑨	⑩	⑪
Before decontamination	Measured value (Gross)	180	200	250	300	280	200	250
	Measured value (Net)	80	100	150	200	180	100	150
After decontamination	Measured value (Gross)	100	100	100	100	100	100	100
	Measured value (Net)	0	0	0	0	0	0	0
Decline rate (%)		100	100	100	100	100	100	100

**Table 2** and **Table 3** show the results of decontamination of the slide and swings, respectively. Based on these data, it was found that loose contamination could be eliminated by water washing.

(c) Decontamination of sandbox

**Table 4** shows the result of decontamination of the sandbox. By removing the top 5 cm of soil, areas a and b were decontaminated to 350 cpm and 110 cpm, respectively. After

removing the top 10 cm of soil, both areas were decontaminated to 30 cpm; 70–90% of the contamination was contained in the top 1 cm of soil. **Table 5** shows the results of decontamination of the wooden frame. Sanding but not washing was required to achieve a sufficient decontamination effect.

(d) Effect of spot decontamination of soil

**Table 6** shows the results of the measurements conducted at the center of a circle with a diameter of 1 m. Although this showed 100% decontamination at the surface (1 cm above the ground), the air dose rate at a height of 100 cm above the ground was reduced by only 11%. This is because the greater the height, the more gamma rays from the periphery of the site reached the detector. This means that performing spot decontamination alone contributes little to the reduction of air dose rate in areas of widespread contamination.

(e) Effect of surface decontamination of soil

**Table 7** shows the average, maximum, and minimum values for all measurement points. Not only was the soil surface decontaminated as in the case of spot decontamination, but the air dose rate also declined more than it did following spot decontamination.

(f) Decontamination of gutters

**Table 8** shows the results of decontamination of the gutters. Although the elimination of

**Table 4** Decontamination effects for the sandbox

Decontamination item	Area a				Area b (average of 5 points)			
	Air dose rate		Surface contamination		Air dose rate		Surface contamination	
	Measured value (μSv/h)	Decline rate (%)	Measured value Net (cpm)	Decline rate (%)	Measured value (μSv/h)	Decline rate (%)	Measured value Net (cpm)	Decline rate (%)
Before decontamination	14	—	9,500	—	2.4 ± 0.4	—	842 ± 207	—
Elimination of garbage and weeds	13	7	—	—	2.3 ± 0.3	5	—	—
Removal of the top 1cm of soil	3.6	74	7,700	18.9	2.1 ± 0.3	11	900 ± 89	-6.9
Removal of the top 3cm of soil	2.1	85	1,000	89.5	1.3 ± 0.3	45	1,000 ± 0	-18.8
Removal of the top 5cm of soil	0.8	94	350	96.3	0.6 ± 0.0	74	110 ± 34	86.9
Removal of the top 10cm of soil	0.5	96	30	99.7	0.4 ± 0.1	83	30 ± 85	96.4

Above air dose rates were measured at a height of 1 cm.

**Table 5** Decontamination effects for sandbox wood frame

Measurement point		(Unit:cpm)			
		Water washing	Detergent containing orange oil	Sanding with sandpaper	Sanding with electric sander
Before decontamination	Measured value (Gross)	4,500	4,500	4,500	4,500
	Measured value (Net)	4,200	4,200	4,200	4,200
After decontamination	Measured value (Gross)	3,000	2,100	1,250	330
	Measured value (Net)	2,700	1,800	950	30
Decline rate (%)		36	57	77	99

sludge, water washing with brushes, and high-pressure washing had a high decontamination effect, the high-pressure washing showed the greatest effect.

(g) Decontamination of gutter cover

It was found that high-pressure washing produced a greater decontamination effect than water washing with brushes (**Table 9**).

(h) Results of shielding the buried soil

In order to check the shielding effect of soil cover at the burial site, air dose rates were

**Table 6** Spot decontamination effects on soil

Decontamination item	Surface (1cm)				50cm		100cm	
	Air dose rate		Surface contamination		Air dose rate		Surface contamination	
	Measured value ( $\mu\text{Sv/h}$ )	Decline rate (%)	Measured value Net (cpm)	Decline rate (%)	Measured value ( $\mu\text{Sv/h}$ )	Decline rate (%)	Measured value ( $\mu\text{Sv/h}$ )	Decline rate (%)
Before decontamination	2.6	—	1,400	—	2.1	—	1.8	—
Elimination of garbage and weeds	2.5	4	1,400	0	2.1	0	1.7	6
Removal of the top 1cm of soil	1.3	50	400	71	1.9	10	1.7	6
Removal of the top 3cm of soil	0.9	65	150	89	1.7	19	1.6	11
Removal of the top 5cm of soil	0.8	69	0	100	1.7	19	1.6	11

**Table 7** Decontamination effects for ground surface soil

Measurement point	Before decontamination ( $\mu\text{Sv/h}$ )			After decontamination ( $\mu\text{Sv/h}$ )		
	Average <sup>a)</sup>	Max.	Min.	Average <sup>a)</sup>	Max.	Min.
100cm	1.5	1.9	1.0	0.6	1.1	0.4
50cm	1.8	2.4	1.2	0.6	1.0	0.3
1cm	2.4	5	1.6	0.4	1.1	0.3
(Collimate)	—	—	—	0.2	0.4	0.1
Surface contamination (Net) (cpm)	—	—	—	18	550	0

<sup>a)</sup> Measurements were taken at 43 intersection points generated by dividing the playground lot into a 2 m × 2 m grid.

**Table 8** Decontamination effects for gutters

Decontamination method	Before decontamination ( $\mu\text{Sv/h}$ )	After decontamination ( $\mu\text{Sv/h}$ )	Decline rate (%)
Elimination of garbage	2.28	3.32	-46
Elimination of sludge	2.11	0.68	68
Water washing with brushes	1.4	0.43	69
High-pressure washing	2.75	0.74	73

**Table 9** Decontamination effects for gutter covers

Decontamination method	Before decontamination (cpm)	After decontamination (cpm)	Decline rate (%)
Water washing with brushes	6,000	2,500	58
High-pressure washing	6,000	1,200	80

**Table 10** Shielding effect for removed topsoil

Measurement height	Burial thickness				
	0 cm	10 cm	20 cm	30 cm	35 cm
100 cm	1.2	0.6	0.5	0.5	0.5
50 cm	1.4	0.6	0.5	0.5	0.4
1 cm	2.3	0.6	0.5	0.4	0.4
1 cm (Collimate)	—	—	—	—	0.1

measured at 50 cm and 100 cm above the ground at soil thicknesses of 10 cm, 20 cm, 30 cm and 35 cm. The measurements were evaluated based on the average values measured at five points. **Table 10** shows the measurement results.

### 3. Evaluation of Decontamination

In the case of loose contamination of the playground equipment, water washing produced a sufficient decontamination effect. However, the joint fixings of the playground equipment also need to be washed thoroughly and this involves disassembly and reassembly. Contamination adhering to the equipment also needs to be eliminated by removing the paint and replacing parts.

In the case of the sandbox, it was sufficiently decontaminated by removing the top 10 cm of sand. However, given that children dig and play in the sand, the landowner requested that the sand be replaced to a depth of 20 cm.

Concerning the wooden frame of the sandbox, the decontamination using an electric sander resulted in the highest removal of radioactive materials. However, it is important to use dust collectors to prevent scattering of contaminated wood dust. Wearing a mask is also required to prevent inhalation of the contaminated wood dust.

Spot decontamination of the soil was found to be effective in removing contaminated soil, but to have very little effect in terms of decreasing the air dose rate. In addition, removing the top 3 cm of soil removed approximately 90% of the contamination. This accords with the fact that 95% of radioactive cesium was distributed in the soil up to a depth of 2.5 cm<sup>3)</sup>. In addition, there was a 2–3 cm layer generated by weed mulch on the top of the playground's soil. Therefore, removing this layer produced a sufficient decontamination effect.

The surface decontamination of the soil reduced the air dose rate to below 0.9  $\mu\text{Sv/h}$ , which had been set as the target value. Since a lower air dose rate was achieved when using a collimator, it would appear that the air dose rate was increased by radiation from the periphery of the site rather than from the playground itself. When a collimator was used, the average dose rate at a height of 1 cm was 0.2  $\mu\text{Sv/h}$ . On the other hand, the average air dose rate at a height of 100 cm was 0.6  $\mu\text{Sv/h}$ . This difference of 0.4  $\mu\text{Sv/h}$  is considered to result from the influence of nearby buildings. On the other hand, the average air dose rate at a height of 100 cm was 1.5  $\mu\text{Sv/h}$  before decontamination but declined by 0.9  $\mu\text{Sv/h}$  after the topsoil was removed. From this, it was found that contamination from the soil surface contributed to more than half of the dose rate measured in the air at a height of 100 cm. It was also found that air dose rates were effectively reduced by decontaminating the soil directly beneath the surface. The dose rate at which decontamination is required at present is 0.23  $\mu\text{Sv/h}$ <sup>4)</sup>, which was calculated based on the annual additional radiation dose of 1 mSv. Since the average surface dose rate of soil is 0.2  $\mu\text{Sv/h}$ , the air dose rate is expected to be closer to 0.2  $\mu\text{Sv/h}$  as the decontaminated area

increases.

On the other hand, the dose rate of the gutters increased in spite of removing the garbage. This is considered to be the result of contaminated sludge being moved to the measurement site, although the measurements were taken in the same place before and after the garbage was removed. In addition, washing with brushes achieved the same level of decontamination as high-pressure washing.

The concrete covers were highly contaminated. Although high-pressure washing had a high decontamination effect, the contamination level could not be reduced to below 1,000 cpm. This means that radioactive cesium gained entry into the concrete joints. Therefore, a method that enables these joints to be washed is required in order to decontaminate the concrete completely. In this test, we used a 7-MPa high-pressure water sprayer equipped with a straight nozzle, and confirmed that high-pressure washing was effective to a certain degree. Although the effect of a device equipped with a rotary nozzle (which can produce higher pressure) needs to be tested for surface decontamination, such devices may be higher in cost than those easily purchased at DIY stores. Therefore, this is an issue for further study.

Concerning the shielding effect of the buried soil, it was found that a thickness of 30 cm could shield approximately 80% of the radiation dose rate. Since approximately 3 cm of topsoil was removed, there was no need to dig a 10-m<sup>3</sup> hole as originally planned; covering the soil to a thickness of approximately 0.3 m was sufficient to produce a superior shielding effect.

Finally, the following points were learned as a result of the decontamination tests, although more data need to be collected in the future:

First, a method for decontaminating the wooden frame as well as the rubber steps of the slide was also tested. For this, a mold-removing agent containing hypochlorous acid was used in order to remove cesium together with the dirt on the surface. This method produced decontamination effects but resulted in the bleaching of the wooden frame. In the case of the rubber steps, the dirt was removed by the foam that was generated when the detergent was sprayed on. There is a best moment to wipe off the detergent foam before the dirt adhered again, although it was not possible to conduct a test to verify this.

Second, combining an electrical sander with a dust collector expanded the scope of the decontamination. A field test of effective and efficient decontamination using general-purpose cleaning devices is expected before full-scale decontamination commences.

**Figure 6** shows a view of the playground after decontamination. This shows how the



**Figure 6** View of the playground after decontamination

playground was cleaned in comparison to its condition before decontamination as shown in Figure 1

#### 4. Conclusions

The loose contamination on the playground equipment was sufficiently eliminated by washing with water. Soil can be decontaminated by removing approximately 3 cm of topsoil. Although the gutters were decontaminated using water washing with brushes and high-pressure washing, there is an issue concerning the elimination of radioactive materials that have gained entry into concrete joints. On the whole, this demonstration has shown that implementing surface decontamination can reduce air dose rates at a height of 100 cm, and surface decontamination was shown to be more effective at reducing air dose rates than spot decontamination.

### III. Afterword

In this test, various decontamination methods were trialed for the purpose of checking the effect of surface decontamination on air dose rates for a playground with an area of 150 m<sup>2</sup>. Loose contamination on the playground equipment was shown to be removable by washing with water and brushes. For soil, implementing surface decontamination by removing approximately 3 cm of topsoil lowered the air dose rate at a height of 100 cm to 0.3 μSv/h below the original target of 0.9 μSv/h. For the gutters and the concrete gutter covers, high-pressure washing at a pressure of 7 MPa proved to be effective to a certain degree, but eliminating contamination in the concrete joints proved to be problematic. When placing a cover of soil on material removed during decontamination, a thickness of 30 cm was found to be effective in shielding approximately 80% of the radiation.

The data collected demonstrate that implementing surface decontamination can be more effective at reducing air dose rates than implementing spot decontamination in hot spots.

The results of this test, conducted in accordance with the decontamination instructions issued by the Fukushima Prefecture<sup>5)</sup>, are summarized in a 17-minute video. The video is posted on the Japan Atomic Energy Agency website<sup>6)</sup> and is also utilized in decontamination seminars held by the Fukushima Prefecture.

We are very grateful to Fukushima Prefecture and Fukushima City for their supporting in helping us to implement this test and evaluation.

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