5. Effects of Decontamination

5.1. Evaluation Pertaining to the Goals of the Basic Policy

The Basic Policy based on the Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District Off the Pacific Ocean Earthquake That Occurred on 11 March (hereafter refer to "Act on Special Measures") sets the goals for the measures for decontamination (Figure 5-1) and the Ministry of Environment (MOE) published the "Evaluation of the Goals of Basic Policy" in December 2013.

Basic Policy Based on the Act on Special Measures (excerpt)

(2) The following goals are set for the region with an additional exposure dose of less than 20 mSv/y.
a. The additional exposure dose of 1mSv/y or less shall be targeted as the long-term goal.
b. By the end of August 2013, the annual additional exposure dose of the general public shall be decreased by about 50% as compared with the value at the end of August 2011, by physical attenuation of radioactive materials and other effects also being taken into account.

c. It is important to restore the environment for children's life with peace of mind. Decontamination of children's living environments such as schools and parks shall be implemented with high priority, and by the end of August 2013, the annual additional exposure dose of children shall be decreased by about 60% as compared with the value at the end of August 2011, considering physical attenuation of radioactive materials and other effects.

Figure 5-1 Basic Policy based on the Act on Special Measures[133].

5.1.1. Facilities Subject to Evaluation

The evaluation was implemented covering about 33,000 facilities (about 12,000 facilities in Special Decontamination Areas; about 21,000 facilities in Intensive Contamination Survey Areas) and at about 330,000 measurement points (about 100,000 points in Special Decontamination Areas; about 230,000 points in Intensive Contamination Survey Areas), where the decontamination work had been carried out by the end of August 2013.

		School	Park, Square	Housing	Other facility	
Facility no.	Special Decontamination Area	24	123	4,645	153	
	Intensive Contamination Survey Area	2,229	1,980	12,513	456	
Measurement points no.	Special Decontamination Area	494	949	61,980	1,785	
	Intensive Contamination Survey Area	36,136	41,286	121,741	4,268	
		Road	Forest	Farmland	Pasture land	Total
Facility no.	Special Decontamination Area	1,792	2,319	3,204	111	12,371
	Intensive Contamination Survey Area	1,220	940	1,633	97	21,068
Measurement points no.	Special Decontamination Area	18,274	9,541	10,764	513	104,300
	Intensive Contamination Survey Area	8,496	2,678	10,404	2,919	227,928

＊ Special Decontamination Area･･･Tamura City, Kawamata Town, Kawauchi Village, Naraha Town, Okuma Town, Katsurao Village, Iitate Village (However, the measurement result of the data more than 3.8 μSv/h have been excluded)

Figure 5-2 Numbers of facilities and measurement points to be evaluated concerning the reduction of additional exposure dose[134].

[133]Source: Ministry of the Environment (MOE), Basic Policy Based on the Act on Special Measures Concerning the Handling of Radioactive Pollution, December 2011
[134]Source: Ministry of the Environment (MOE), "Evaluation concerning the goals of basic policy," December

5.1.2. Basic Approach of Evaluation Methods

The air dose rate at the end of August 2011 was estimated from the air dose rate measured before decontamination and the air dose rate at the end of August 2013 was estimated from the air dose rate measured after decontamination. The evaluation for each classification of facilities was done by integrating the air dose reduction rate by decontamination and the reduction rate by physical attenuation of radioactive materials and other effects.

It should be noted that the Basic Policy set its goal on the reduction of additional exposure dose. However, the additional exposure dose cannot be directly measured. The evaluation was done instead, on the assumption that the exposure dose was proportional to the air dose rate (Figure 5-3).

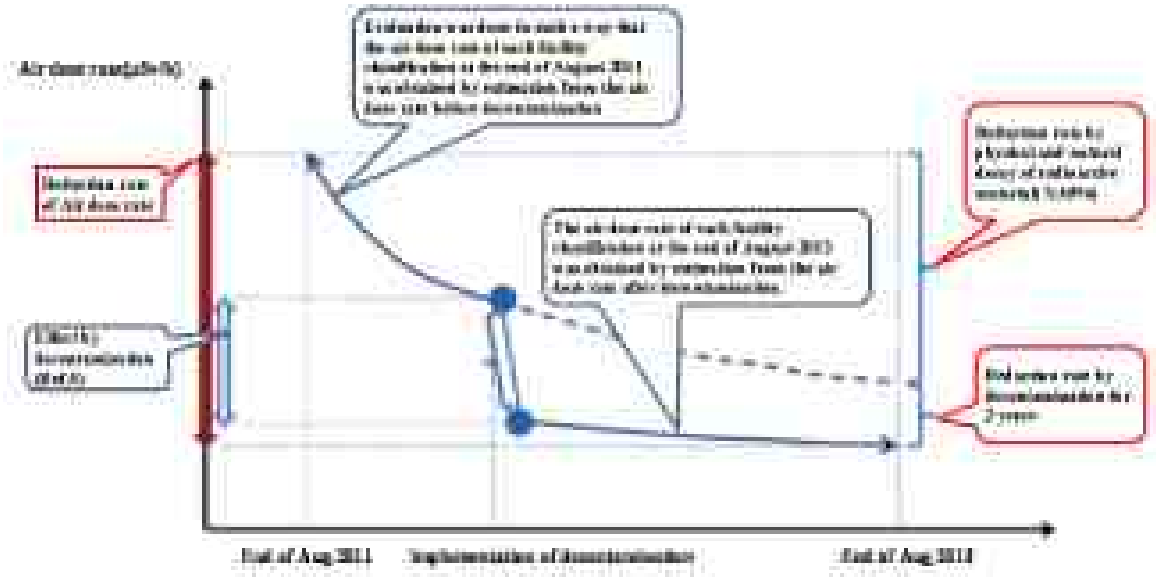

Figure 5-3 Basic concept of evaluation methods.

5.1.3. Evaluation Methods and Results

(1) Annual additional exposure dose of the general public

1) Evaluation methods

- The average additional radiation exposure dose was calculated for each facility classification* by estimating the air dose rate at the end of August 2011, using the measured values on a day before decontamination.
- The average additional radiation exposure dose was calculated for each facility classification* by estimating the air dose rate at the end of August 2013, using the measured values on a day after decontamination.
- The additional annual exposure dose was estimated as the total of the dose rate multiplied by a coefficient defined for each classified facility subject to life patterns.

* Concerning roads or forests, each unit divided by facility numbers in the investigation was dealt with as one facility. Evaluation of additional annual exposure dose of children was done in the same way.

2013 (Figure 5-3 to Figure 5-7 have the same source.)

2) Evaluation results

The goal of reducing the additional annual exposure dose was evaluated as having been achieved, as seen in the overall reduction rate of about 64% over the two year period (Figure 5-4).

	Additional exposure dose (%)	Contribution of physical attenuation effect (%)	Contribution of decontamination effect (%)
Goal	about 50	about 40	about 10
Special Decontamination Areas	about 67		about 27
Intensive Contamination Survey Areas	about 62		about 22
Overall	about 64		about 24

Figure 5-4 Evaluation results of reduction rate over 2 years (Annual exposure dose of the general public)

(2) Annual additional exposure dose of children

1) Evaluation methods

- The average additional radiation exposure dose was calculated for each facility classification* by estimating the air dose rate at the end of August 2011, using the measured values on a day before decontamination.
- The average additional radiation exposure dose was calculated for each facility classification* by estimating the air dose rate at the end of August 2013, using the measured values on a day after decontamination.
- The additional annual exposure dose was estimated as the total of the dose rate multiplied by a coefficient defined for each classified facility subject to life patterns.

2) Evaluation results

The goal of reducing the additional annual exposure dose was evaluated as having been achieved, as can be seen in the overall reduction rate of about 65% over the two year period (Figure 5-5).

	Reduction of additional exposure dose (%)	Contribution of physical attenuation effect (%)	Contribution of decontamination effect(%)
Goal	about 60	about 40	about 20
Special Decontamination Areas	about 66		about 26
Intensive Contamination Survey Areas	about 64		about 24
Overall	about 65		about 25

Figure 5-5 Evaluation results of reduction rate over 2 years (Annual additional exposure dose of children)

（3） Reduction rate of additional exposure dose for air dose rate range

Reduction rates of the additional exposure dose were evaluated for each air dose rate range before decontamination. Higher reduction rates of the additional exposure dose tend to be achieved in areas of higher air dose rate before decontamination. Higher reduction rates of children's additional exposure dose are higher than those of the general public for all air dose rate ranges.

Air dose rate (μSv/h)	Reduction of additional exposure dose (%)	Contribution of physical attenuation (%)	Contribution of decontamination effect (%)
0.99 or higher	about 73	about 40	about 33
0.80 to below 0.99	about 64		about 24
0.61 to below 0.80	about 63		about 23
0.42 to below 0.61	about 60		about 20
0.23 to below 0.42	about 55		about 15

Figure 5-6 Reduction rate of additional exposure dose for each air dose range (the general public).

Air dose rate (μSv/h)	Reduction of additional exposure dose (%)	Contribution of physical attenuation (%)	Contribution of decontamination effect (%)
0.99 or higher	about 74	about 40	about 34
0.80 to below 0.99	about 67		about 27
0.61 to below 0.80	about 67		about 27
0.42 to below 0.61	about 63		about 23
0.23 to below 0.42	about 58		about 18

Figure 5-7 Reduction rate of additional exposure dose for each air dose rate range (children).

5.2. Overview on the Decontamination Effects

The "Decontamination effects (air dose rate) in the decontamination work implemented by the National Government and local municipalities" (prepared by the MOE, Decontamination Team, December 2013) reviewed the decontamination effects (air dose rate) in the decontamination work to date, focusing on to what extent the air dose rate (at the height of 1 m) could be reduced by decontamination, from the viewpoint of evaluating the exposure dose to the general public.

5.2.1. Data for Evaluation

The report reviewed about 250,000 data (two measured values before and after decontamination per one measurement point) of the air dose rate (measured at the heights of 1 m and 50 cm; unit, μSv/h), roughly between March 2012 and October 2013 in the decontamination work implemented in JFY 2012 onward (in 10 municipalities under the National Government jurisdiction and in 90 municipalities in 8 prefectures under local jurisdiction).

The evaluation was limited to the data collected at the time of evaluation. Decontamination methods and decontamination target places include various types depending on the situations. In residential areas, for example, the evaluation of air dose rate was based on the results from various complex effects of gardens with soil, paved surfaces, roofs, walls, etc. The following data were excluded from the evaluation.

- The air dose rate data below 0.23μSv/h before decontamination.
- Top 1% and bottom 1% of the reduction rate data (Outlier data, unsuitable for grasping the overall trend).

Classification work	Land- use Classification	Air dose rate(1m)	Air dose rate(0.5m)
National Government	Public facilities *2	approx. 12,000	-
	Residential area	approx. 54,000	
	Road	approx. 28,000	-
	Farm land	approx. 11,000	-
	Forest	approx. 10,000	-
	Sum	approx.116,000	-
Local municipalities	Public facilities *2	approx. 36,000	-
	Residential area	approx. 37,000	-
	Road	approx. 6,000	-
	Farm land	approx. 10,000	-
	Forest	approx. 3,000	-
	Children's living environment *3	-	approx.40,000
	Sum	approx.92,000	approx.40,000
Total		approx.208,000	approx.40,000

Note: There is a case in which the total does not match due to rounding off the fractional.
*1：Less than 0.23μSv/h of decontamination data before, data of upper reduction rate 1% and lower reduction rate 1% are excluded and calculated.
*2：Public facilities include school, park or large facility.
*3：Children's living environment include elementary school, kindergarten and park.

Figure 5-8 Data for evaluation[135].

5.2.2. Summary of the Results

- In terms of typical distribution ranges of air dose rate (the range here refers to rates between the 25th percentile value and the 75th percentile value), the air dose rate before decontamination was 0.36 to 0.93 μSv/h, and it was reduced to 0.25 to 0.57 μSv/h after

[135]Source: Ministry of the Environment (MOE), Decontamination Team, "Decontamination effects (air dose rate) implemented by the National Government and local municipalities," December 2013 (Figure 5-9 to Figure 5-14 have the same source.)

decontamination. As a whole, the air dose rate was reduced and at the same time, its distribution range became narrower after decontamination. This indicates the reduction rate of air dose rate by decontamination in the higher air dose rate areas is larger and the reduction rate in lower air dose rate areas is smaller.

- The air dose rate was reduced by decontamination by about 30 to 50% on average in all dose rate ranges (below 1μSv/h, 1 to 3.8μSv/h and above 3.8μSv/h, respectively, before decontamination). This indicates the higher the dose rates before decontamination, the larger the decontamination effects and the air dose rate reduction.
- In the current review, the evaluation was done by air dose rates (μSv/h) from the viewpoint of evaluating exposure dose of the general public. Regarding the difference of decontamination effects (reduction rates) depending on the target place and the decontamination methods, the evaluation results by surface contamination densities (cpm) were made public in January 2013, in which the decontamination effect by removing radiocesium from the decontamination targets had been confirmed.
- The air dose rate reduction features varied subject to influences from the surrounding area, depending on the characteristics of decontamination site, type of land-use and others.
- Concerning the relation between the type of land-use and decontamination effects, the decontamination effects were relatively high in the residential areas and relatively low in the forests. It should be noted that the data for forests do not directly indicate the effects on the neighboring living environment such as residential areas because the data for forests included a considerable number of data collected inside the forests.

(Note) The forests were decontaminated by removing accumulated leaf litter and woody materials. The decontamination guidelines were revised based on the new knowledge obtained for more effective decontamination, by, for example, adding the removed accumulated organic materials to targets for the decontamination methods, and also by considering the migration of radiocesium over time.

- Regarding the living environment for children such as schools, parks, etc., there were some data measured at different heights. Therefore, the data were reviewed separately in individual cases. As the result, the reduction rate was roughly 50% to 80%, tending to be higher compared with that of the whole area (air dose rate at 1 m in height).

Air dose rate *1,2 (measurement hight 1m)	**Before decontamination : 0.36 to 0.93μSv/h** ⇩ **After decontamination : 0.25 to 0.57μSv/h**		
Reduction rate of air dose rate (average) *2,3	Before decontamination less than 1μSv/h	Before decontamination 1~3.8μSv/h	Before decontamination 3.8μSv/h or more
	32%	**43%**	**51%**
ex) Reduction rate of surface contamination density *4	Asphalt pavement of parking lot: washing is aprox.50 to 70% High-pressure washing is approx.30 to 70% Soil ground: stripping of surface soil is approx..80 to 90%		

＊1.Band of value of 25 percentile and 75 percentile of air dose rate.
＊2.Data at measurement height 0.5m is not included in the data of living environment for children on school etc..
＊3.Average data of reduction rate of air dose rate at each decontamination classification before.
(reduction rate(%) =(1-air dose rate before decontamination/ air dose rate before decontamination)×100)
＊4.Announcement “effect of decontamination method in the work by National Government and local municipalities" has been Press released on 18.Jan.2013.

Figure 5-9 Decontamination effects in the decontamination work implemented by the National Government and local municipalities (main results).

5.3. Decontamination Effects in Five Areas: Public Facilities, Residential Areas, Roads, Farmland and Forests

The "Decontamination effects (air dose rate) in the decontamination work implemented by the National Government and local municipalities" (prepared by the MOE, Decontamination Team, December 2013) reviewed the decontamination effects also by land-use classification (five categories consisting of: public facilities and the like; residential areas; roads; farmland; and forests) in addition to the review as a whole.

5.3.1. Public Facilities

- The data of public facilities and the like included various data such as those of ground surfaces of bare soil, asphalt paved surfaces, gravel, etc.
- About 70% of the data were from the facilities with the air dose rate below 1 μSv/h before decontamination and the average reduction rate for all public facilities was about 34%.
- In the areas with the air dose rate was below 1 μSv/h before decontamination, the average reduction rate was about 29% and the air dose rate after decontamination was 0.38μSv/h or less at half of the measurement points. The reduction rate was higher in the areas with higher air dose rate before decontamination and the average air dose rate at the points of 1 μSv/h before decontamination was about 0.6 μSv/h (a reduction rate of about 40%).
- In the areas with the air dose rate ranges of 1 to 3.8 μSv/h and 3.8 μSv/h or higher before decontamination, the reduction rates were higher in the areas with higher air dose rate as compared with those in the areas with the rate of less than 1 μSv/h, and the average reduction rate in the areas with the rate of more than 3.8 μSv/h before decontamination was about 53%.
- Most of the data with high air dose rate were data obtained by decontamination of a public facility as a single target. For this reason, the air dose rate of public facilities after decontamination tended to be higher when compared with the air dose rate of residences which were decontaminated zone-wise including the surroundings. However, the air dose rate of public facilities is expected to be reduced through decontamination of their surroundings.

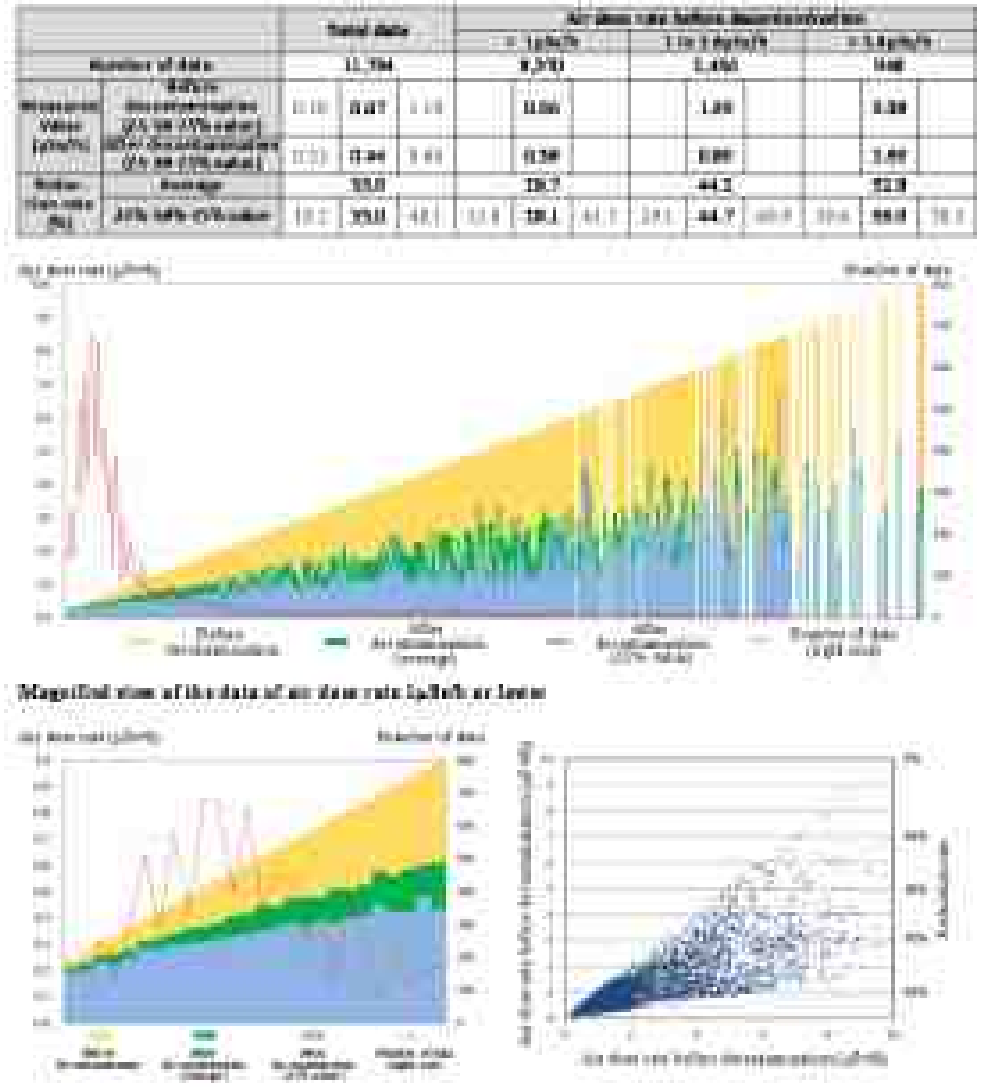

Figure 5-10 Air dose rate (at 1m) in the National Government work (public facilities).

5.3.2. Residential Areas

- The number of data measured in residential areas was about 50,000, about half of the data were from the work by the National Government, which included a wide variety of data such as bare soil, gardens, grass fields, gravel, concrete paved surfaces, etc.
- About 70% of the data were from the zones with the air dose rate below 1 μSv/h before decontamination and the average reduction rate for all residential areas was about 43%, which was relatively higher than for all decontamination work.
- In the zones with the air dose rate below 1 μSv/h before decontamination, the average reduction rate was about 40% and the air dose rate after decontamination was 0.33μSv/h or less at half of the measurement points. The reduction rate was higher in the zones with higher air dose rate before decontamination and the average air dose rate at the points of 1 μSv/h before decontamination was about 0.5 μSv/h after decontamination (a reduction rate of about 50%).
- In the zones with the air dose rate ranges of 1 to 3.8 μSv/h and 3.8 μSv/h or higher before decontamination, the reduction rates were higher in the areas with higher air dose rate as compared with those in the zones with the air dose rate of less than 1 μSv/h, and the average reduction rate in the zones with the air dose rate of more than 3.8 μSv/h before decontamination was about 57%.

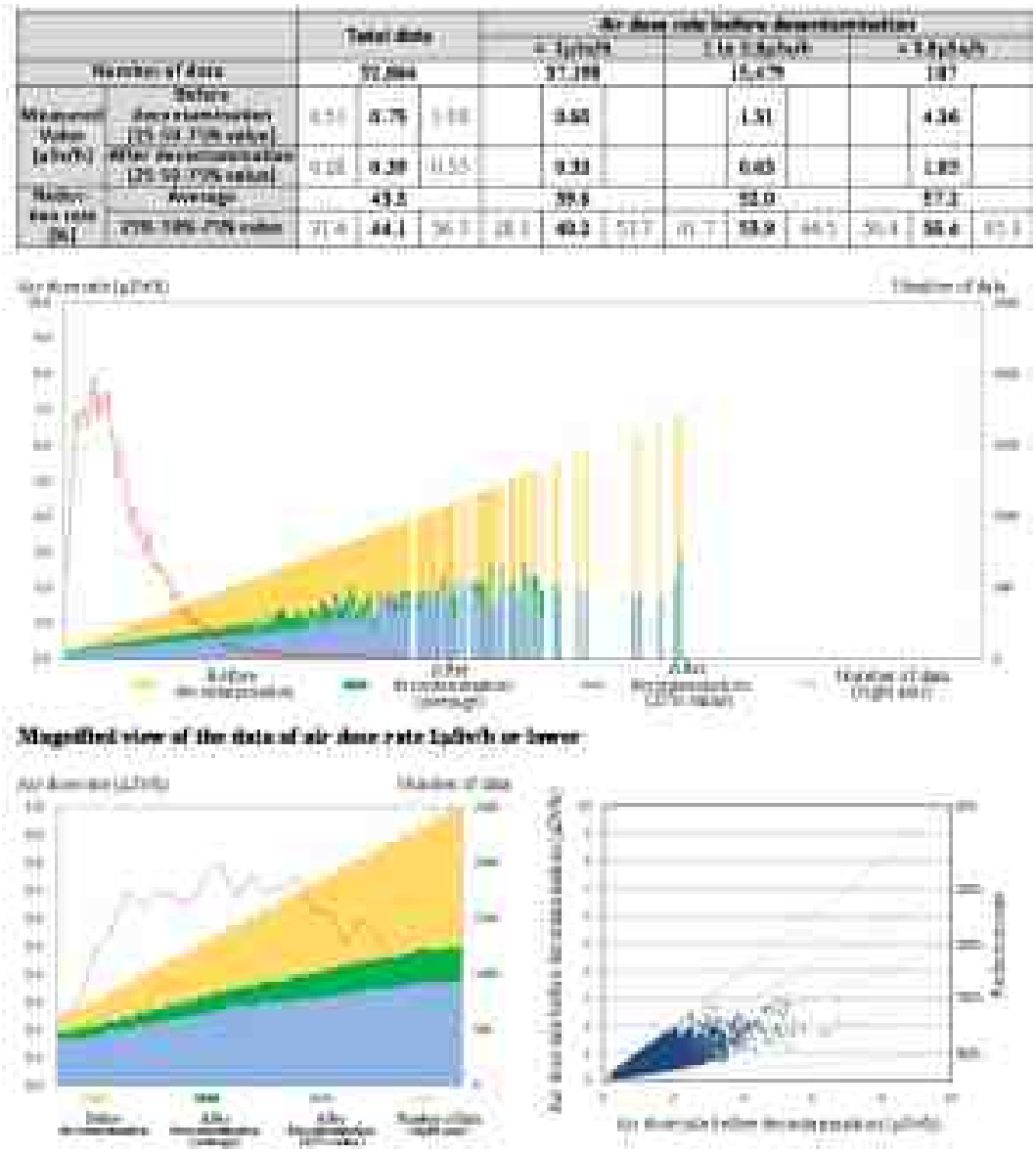

Figure 5-11 Air dose rate (at 1 m) in the National Government work (residential areas).

5.3.3. Roads

- The data for roads included those of paved roads, gravel and crushed stone roads, etc.
- About 70% of the data were from the roads with the air dose rate below 1 μSv/h before decontamination and the average reduction rate for all roads was about 33%.
- On the roads with the air dose rate below 1 μSv/h before decontamination, the average reduction rate was about 29% and the air dose rate after decontamination was 0.40μSv/h or less at half of the measurement points. The reduction rate was higher on the roads with higher air dose rate before decontamination and the average air dose rate at the points of 1 μSv/h before decontamination was about 0.6 μSv/h after decontamination (a reduction rate of about 40%).
- On roads with the air dose rate ranges of 1 to 3.8 μSv/h and 3.8 μSv/h or higher before decontamination, the reduction rates were higher on roads with higher air dose rate as compared with that on the roads with the air dose rate of less than 1 μSv/h, and the average reduction rate on the roads with the air dose rate of more than 3.8 μSv/h before decontamination was about 53%.

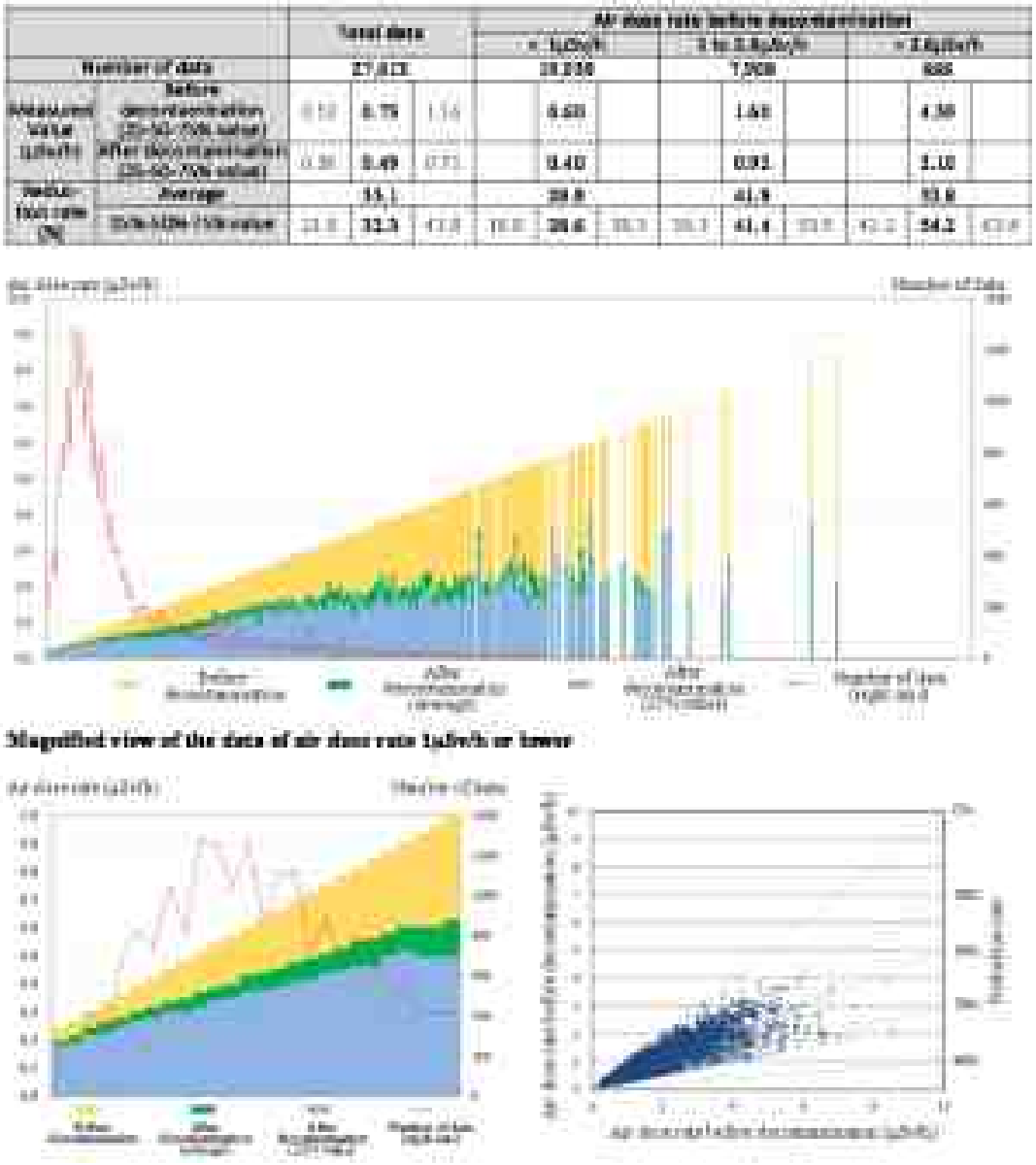

Figure 5-12 Air dose rate (at 1m) in the National Government work (roads).

5.3.4. Farmland

- The data on farmland included those on orchards and pasture land, but most of them were data on plowed land (deep plowing, top soil scraping). Most of the data on farmland with the air dose rates exceeding about 2μSv/h before decontamination were obtained from the farmland where decontamination was done by topsoil scraping.
- About 70% of the data were from farmland with the air dose rate below 1 μSv/h before decontamination and the average reduction rate for all farmland was about 34%.
- On farmland with the air dose rate below 1μSv/h before decontamination, the average reduction rate was about 28% and the air dose rate after decontamination was 0.44μSv/h or less at half of the measurement points. The reduction rate was higher on the farmland with the higher air dose rate before decontamination and the average air dose rate at the points of 1 μSv/h before decontamination was about 0.6 μSv/h (a reduction rate about 40%).
- On farmland with the air dose rate ranges of 1 to 3.8 μSv/h and 3.8 μSv/h or higher before decontamination, the reduction rates were higher on farmland with higher air

dose rate as compared with those on farmland with the air dose rate of less than 1 μSv/h. On farmland with the air dose rate exceeding about 2 μSv/h before decontamination, the air dose rate was reduced to about 1 μSv/h, regardless of the air dose rate before decontamination, because the decontamination was mostly by topsoil scraping.

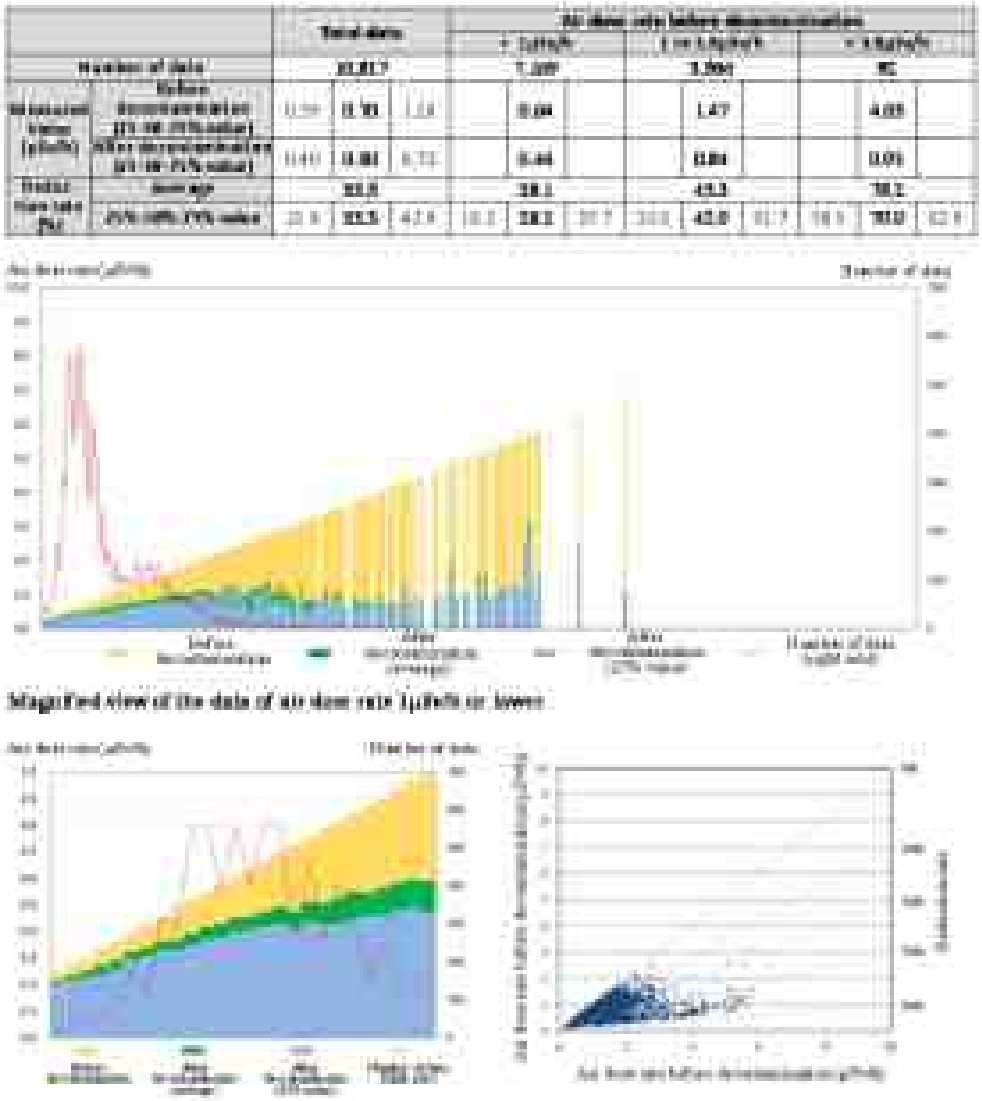

Figure 5-13 Air dose rate (at 1m) in the National Government work (farmland).

5.3.5. Forests

- Most data of forests were those obtained by removing organic matter such as fallen leaves and woody materials.
- About 60% of the data were from forests with the air dose rate of below 1 μSv/h before decontamination, lower in proportion of the data than in other land-use categories. The average reduction rate for all forests was about 22%, lower than for all decontamination work.
- For forests with the air dose rate below 1 μSv/h before decontamination, the average reduction rate was about 18% and the air dose rate after decontamination was 0.57μSv/h or less at half of the measurement points. The reduction rate was higher for forests with the higher air dose rate before decontamination and the average air dose

rate at the points of 1 μSv/h before decontamination was about 0.75 μSv/h (a reduction rate of about 25%).

- For forests with the air dose rate of 1 μSv/h or higher before decontamination, the reduction rate was slightly higher than that for the forests with the air dose rate of less than 1 μSv/h before decontamination, and the average reduction rate for the forests with the air dose rate of 1 to 3.8 μSv/h before decontamination was about 27%.
- It should be noted that the data for forests do not directly indicate the effects on the neighboring living environments such as residential areas because the data for forests included a considerable number of data collected inside the forests.

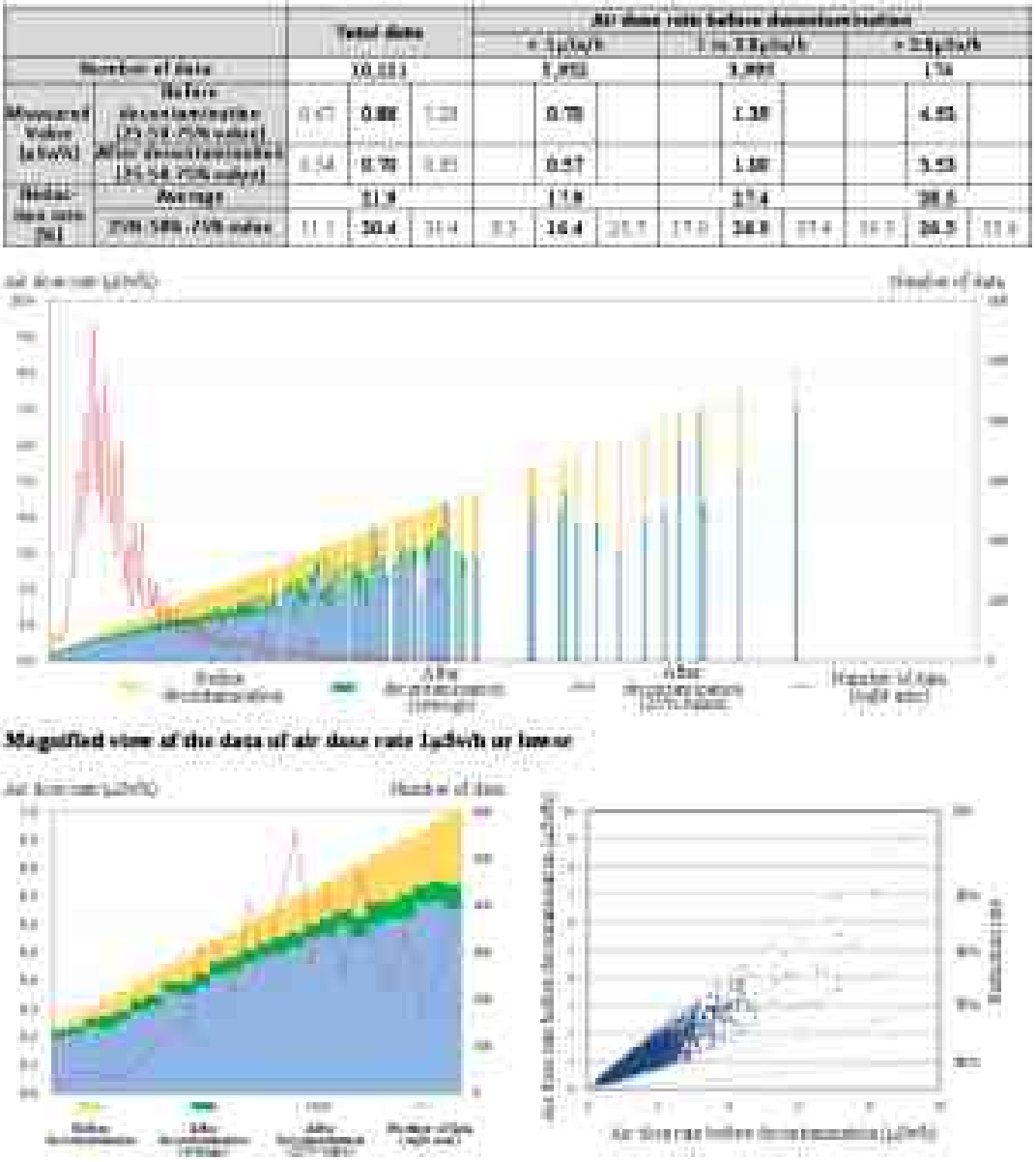

Figure 5-14 Air dose rate (at 1m) in the National Government work (forest).

5.4. Effects at Each Target Decontamination Place

The "Effectiveness of decontamination methods in the decontamination work implemented to date by the National Government and local municipalities" (prepared by the MOE, Decontamination Team, January 2013) reviewed the results of decontamination work in the early stage (mainly in JFY 2011) implemented by the National Government and local

municipalities mostly in the area with comparatively high dose areas in Fukushima Prefecture, focusing on to what extent the radioactive materials could have been reduced by decontamination work.

5.4.1. Outline

- The data collected mainly in the neighboring areas of residential areas such as buildings and structures, roads, etc. were reviewed, which had been obtained in the decontamination work at the first stage. (Data one plowed land and forests were excluded from the review because the numbers of data points were insufficient.)
- The effectiveness of decontamination methods was evaluated in terms of reduction rates of surface contamination densities because the review purpose was to evaluate the effectiveness of each decontamination method.
- The data to be reviewed were limited to those with surface contamination densities before decontamination of higher than 2,000 cpm, in order to reduce data deviations due to the influences from objects other than the target object.

Object	Number of Data (2,000cpm or more)	Number of Data (whole data)	Decontamination method for analysis
Rainwater gutter	343	772	High-pressure washing, Swabbing after removal of sediments
Rainwater basin	85	214	High-pressure washing after removal of sediments
Side ditch	132	306	Removal of sediments, High-pressure washing after removal of sediments
Roof	464	751	Wiping, Washing, High-pressure washing
Outer wall	64	997	Wiping, Washing, High-pressure washing
Garden ground	446	628	Grass mowing, Stripping of top soil, Soil replacement, Peeling off of lawn
Pavement surface of parking lots	601	781	Washing, High-pressure washing, Scraping off
Ground (soil)	271	343	Stripping of top soil
Road (surface of asphalt pavement)	506	539	Washing, Pressure washing, Scraping off
Total	2,912	5,331	

Figure 5-15 Target objects of decontamination, numbers of data and decontamination methods[136].

[136]Source: Ministry of the Environment (MOE), Decontamination Team, “Effectiveness of decontamination methods in the decontamination work implemented to date by the national government and local municipalities", January 2013 (Figure 5-16 to Figure 5-29 have the same source.)

5.4.2. Effectiveness of Decontamination Methods for Each Target Decontamination Place

（1） Buildings and structures

1）Rainwater gutters and street drains

a.) Rainwater gutters

- The reduction rate of surface contamination densities was around 60 to 80% by wiping after sediment removal and around 40 to 80% by high-pressure water washing after sediment removal. Higher reduction rate by wiping after sediment removal was achieved than by high-pressure water cleaning.
- Substantial amounts of radioactive materials were accumulated in the sediments in rainwater gutters. It should be noted that sediment removal is an effective approach for decontamination.

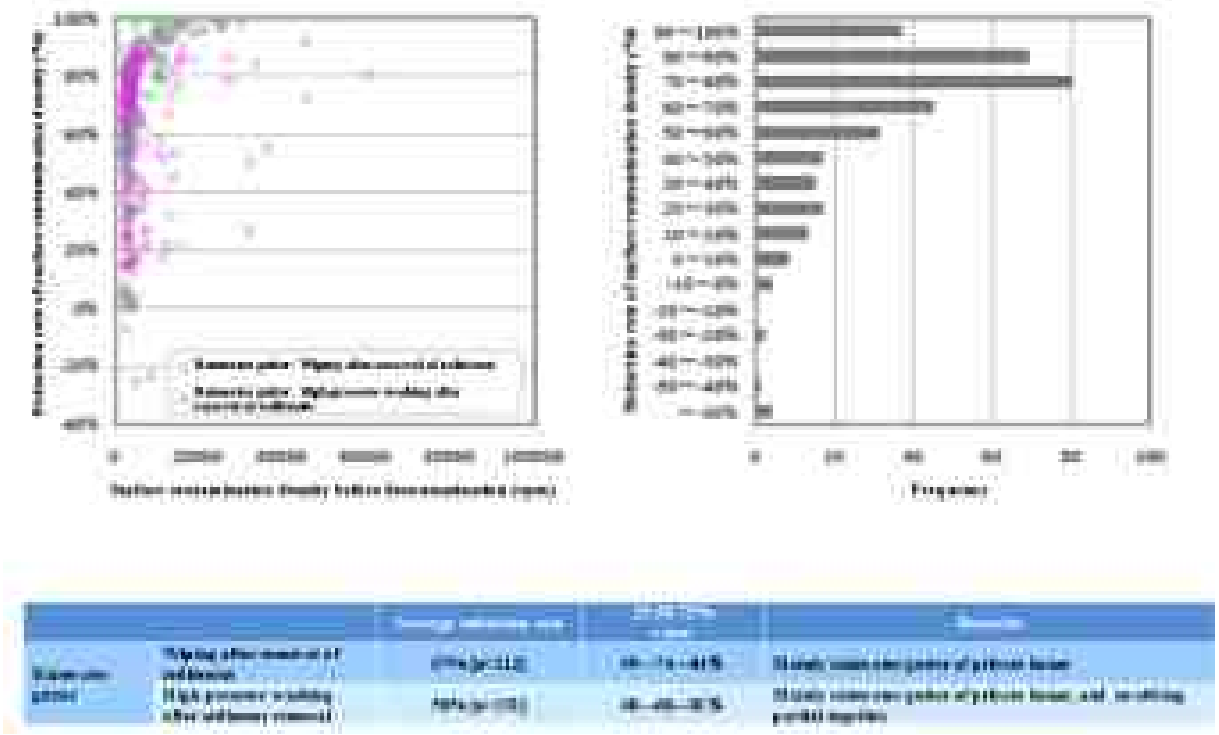

Figure 5-16 Decontamination effect for a target decontamination place (rainwater gutters).

b.) Rainwater cisterns

- The reduction rate of surface contamination densities was around 60 to 90% by high-pressure water washing after sediment removal.
- The effect by sediment removal was considered large, too.
- It should be noted in data interpretation that radioactive materials sunk into seams or cracks in high concentrations from rainfall in the early stage after the nuclear power plant accident and lowered the reduction rate.
- It is a point of careful attention in decontamination that soil and other objects in the surrounding area might be contaminated in case the rainwater cisterns are damaged and leaking.

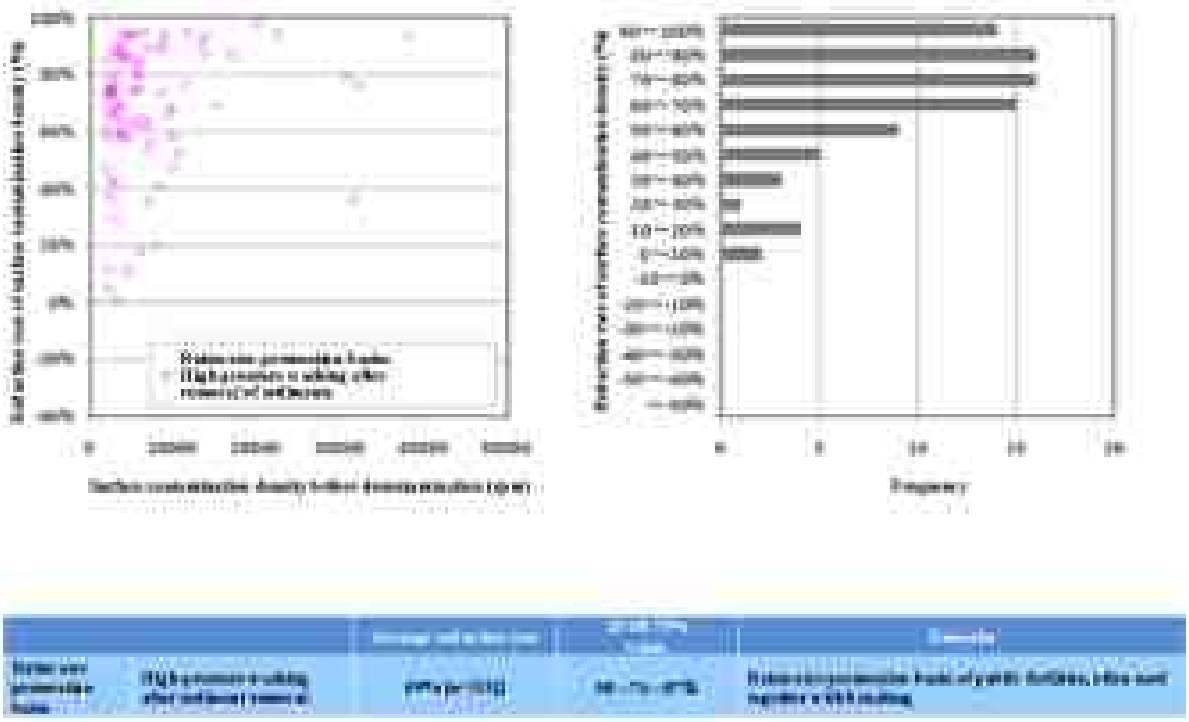

Figure 5-17 Decontamination effect for a target decontamination place (rainwater cisterns).

c.) Street drains

- The reduction rate of surface contamination densities was around 70 to 90% by sediment removal and around 60 to 90% by high-pressure water washing after sediment removal.
- Substantial amounts of radioactive materials were accumulated in street drains. It is a point of careful attention in decontamination that simple removal of sediments can be effective enough and that the possibility should be considered for contamination of the soil and other objects in the surrounding area in case the street drains are damaged and leaking.

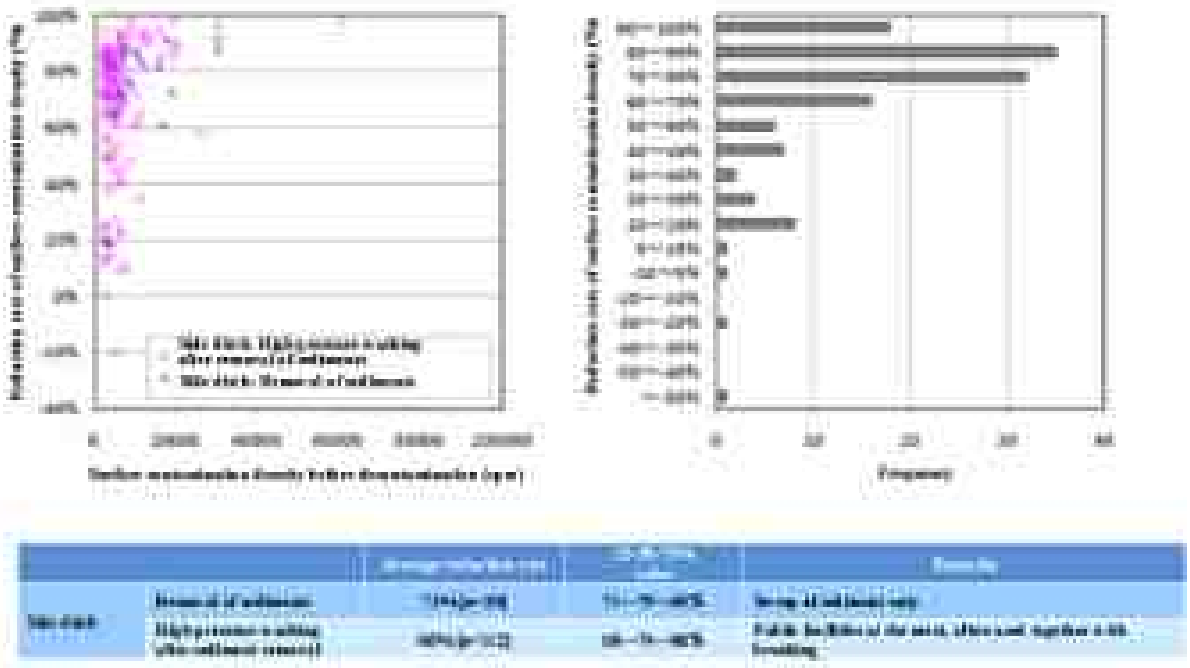

Figure 5-18 Decontamination effect for a target decontamination place (street drains).

2）Roofs and other house structures

- The reduction rate of surface contamination density on the roofs was around 0 to 20% (*) by wiping, around 20 to 60% by water washing, and 40 to 80% by high-pressure water washing. (* The reduction rate was improved to 20 to 50% using a better way of wiping in the decontamination of roofs of private houses implemented in the autumn of 2012.)
- The reduction rate for rooftops was around 60 to 90% by high-pressure water washing. The rooftop shapes are generally not very complicated and therefore the high-pressure water washing is effective.
- The reduction rate for verandas and similar structures was around 20 to 50% by high-pressure water washing. But the available data were limited. If the high-pressure water washing was done after the sediments were removed, the reduction rate reached around 60 to 90%.
- Points of attention in data interpretation are:

  ✓ Data for roofs had deviations depending on their shapes or surface materials.
  ✓ Data deviations occurred in high-pressure water washing, since contaminated wastewater was left.
  ✓ Low reduction rates were experienced in some cases of water washing and wiping of roofs even with high surface contamination densities before decontamination. These cases were for cement tiles, unglazed clay tiles and painted steel plates. The cause of the low reduction rate is considered to have come from the influence of rust or the roof materials themselves.

- Points of attention in decontamination are:

  ✓ Measures should be taken to prevent wastewater from spreading when decontaminating using water.
  ✓ If rust is present, it should be removed by wiping and other means before high-pressure water washing, because its presence lowers the effect.
  ✓ A possibility should be considered in high-pressure water washing of damaging the structures, for instance, peeling off their surface materials.

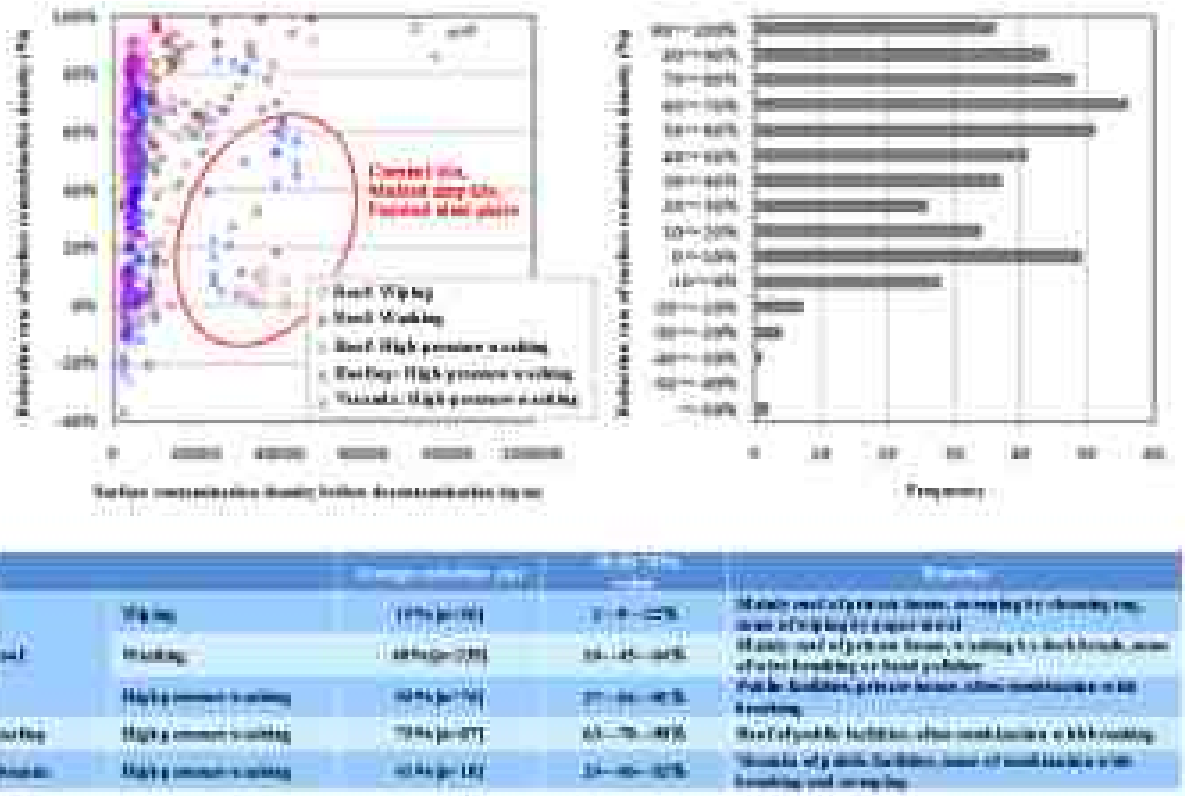

Figure 5-19 Decontamination effect for a target decontamination place (roofs and others).

3) Exterior walls

a.) Concrete walls

- The reduction rates of surface contamination densities were around 10 to 30% by wiping and around 20 to 80% by high-pressure water washing. However, the data of wiping were limited.
- Many data were available for low surface contamination densities (less than 2,000 cpm) before decontamination. This is likely because the amount of radioactive materials attached was small or the radioactive materials had been washed away to some extent by rainfall.
- It is a point of attention in data interpretation that contamination of exterior walls was generally low, since rain, dust and other things were less likely to be attached on the walls than on the roofs, rainwater gutters, etc.
- Points of attention in decontamination are:
  - ✓ The need for decontamination should be assessed by comparing the background radiation levels and the contaminated situation of the objects.
  - ✓ A possibility should be considered in high-pressure water washing of damaging the structures, for instance, peeling off wall surface materials.

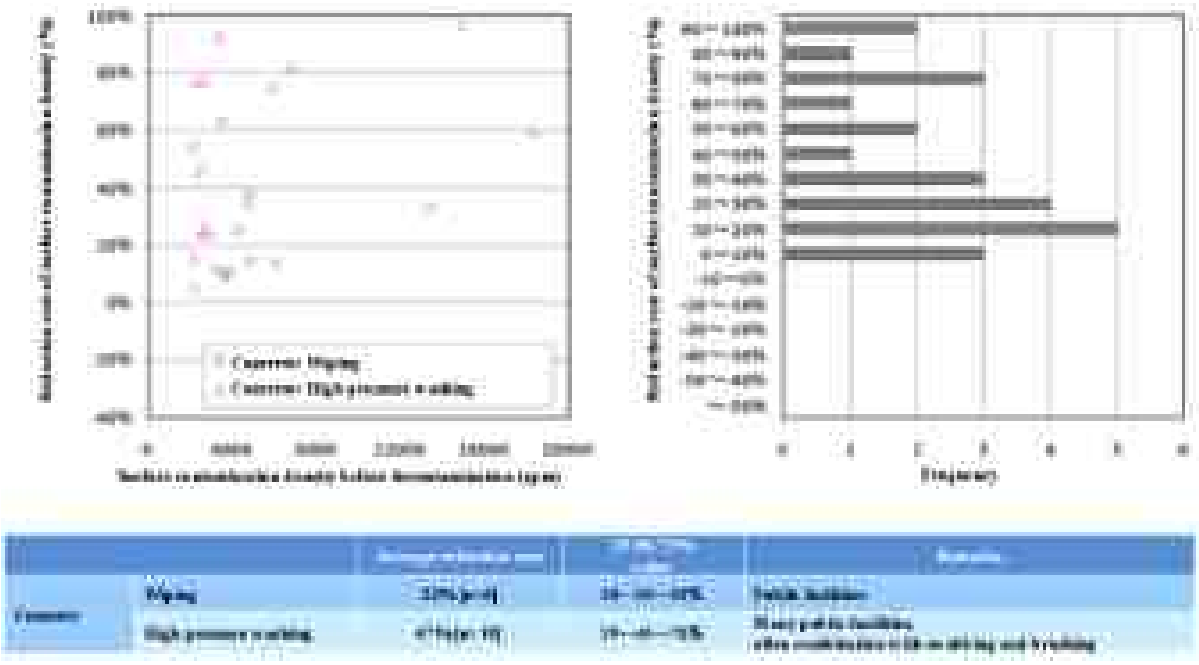

Figure 5-20 Decontamination effect for a target decontamination place (concrete).

b.) Metal walls, windows, doors and shutters, etc.

- Few data were available for metal walls, windows, doors and shutters, etc.
- For metal walls, the reduction rate was around 40 to 70% by cleaning and around 40 to 90% by high-pressure water washing.
- For windows, doors and shutters, the reduction rate was around 70 to 80% by wiping, around 20 to 70% by water washing, and around 50 to 90% by high-pressure water washing.
- Many data were available for low surface contamination densities (less than 2,000 cpm) before decontamination. This is likely because the amount of radioactive materials attached was small or radioactive materials had been washed away by rainfall.
- It is a point of attention in data interpretation that the contamination of windows, doors and shutters is generally low, since rain, dust and other things are less likely to be attached on these surfaces than on the roofs, rainwater gutters, etc.
- It is a point of attention for decontamination that the need should be assessed by comparing the background radiation levels and the contaminated situation of the objects.

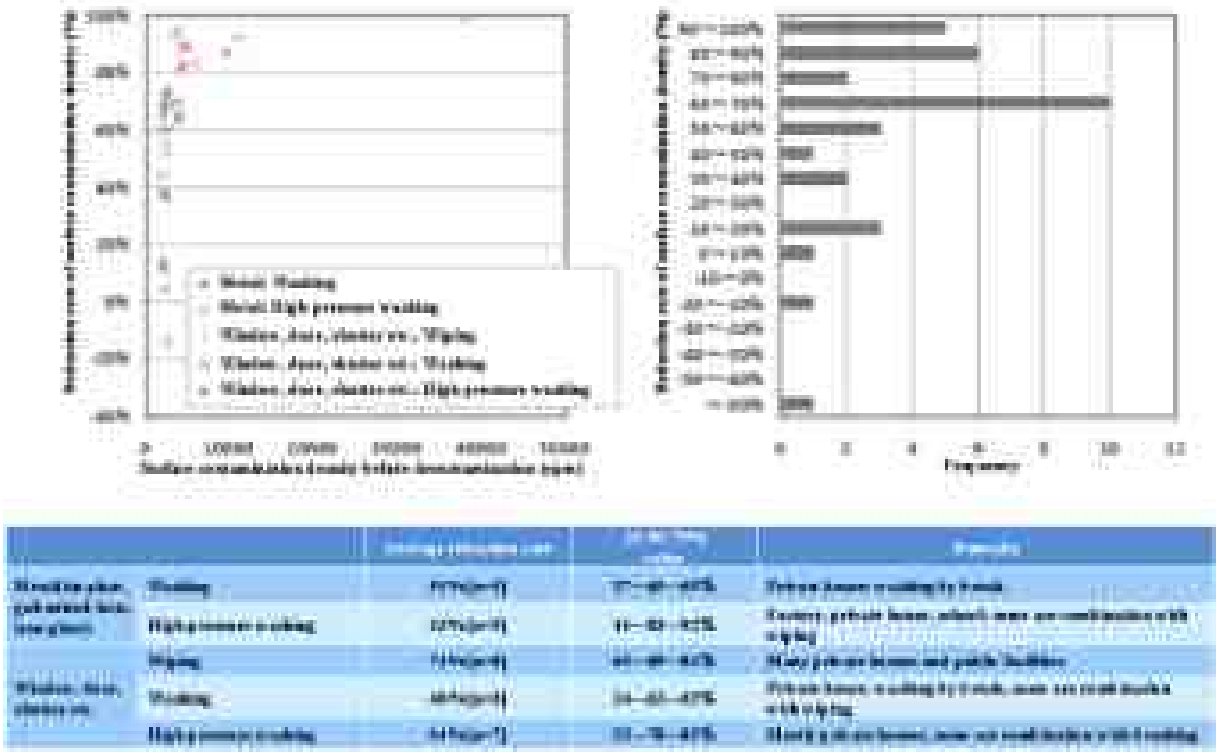

Figure 5-21 Decontamination effect for a target decontamination place (metal walls, windows, doors and shutters, etc.).

c.) Tiles and sidings

- The reduction rate of surface contamination densities was around 60 to 70% by high-pressure water washing. But the data were limited.
- The reduction rate by high-pressure water washing of tiles and sidings was higher than that of concrete walls.
- Many data were available for low surface contamination densities (less than 2,000 cpm) before decontamination. This is likely because the amount of radioactive materials attached was small or the radioactive materials had been washed away by rainfall.
- It is a point of attention in data interpretation that the contamination of tiles and sidings is generally low, since rain, dust and other things are less likely to be attached on the tiles and sidings than on the roofs, rainwater gutters, etc.
- It is a point of attention for decontamination that the need should be assessed by comparing the background radiation levels and the contaminated situation of the objects.

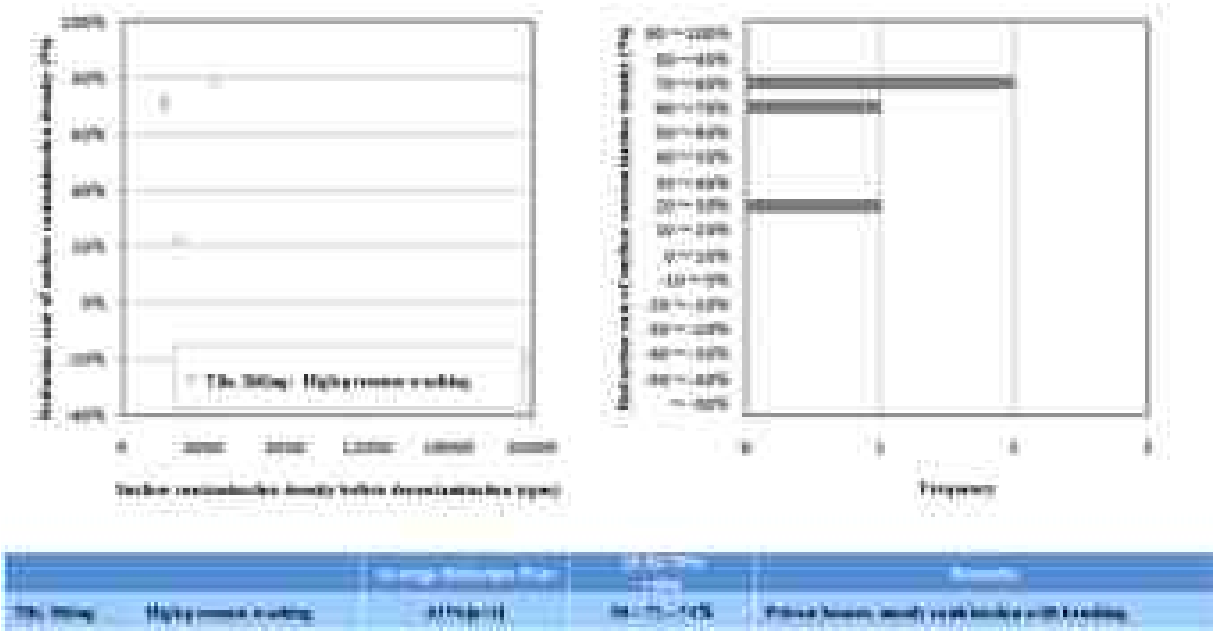

Figure 5-22 Decontamination effect for a target decontamination place (tiles and sidings).

4) Ground surfaces such as gardens

a.) Bare soil and grassland

- The reduction rate of surface contamination densities was around 0 to 60% by grass mowing, around 40 to 80% by topsoil scraping, and around 70 to 100% by soil replacement.
- Soil replacement was applied in cases where the surface contamination density was relatively high before decontamination.
- The points of attention in data interpretation are:
  - ✓ Topsoil scraping of gardens may lower the certainties of decontamination work because of the presence of vegetation or more unevenness than on other types of ground surfaces.
  - ✓ The effect of decontamination by grass mowing may possibly change because the attachment of radioactive materials to the grass changes with time and also as grass grows uptake of radioactive materials may occur.
  - ✓ In some cases, the reduction rate becomes lower due to decrease of shielding effects of beta rays by grass as a result of mowing.

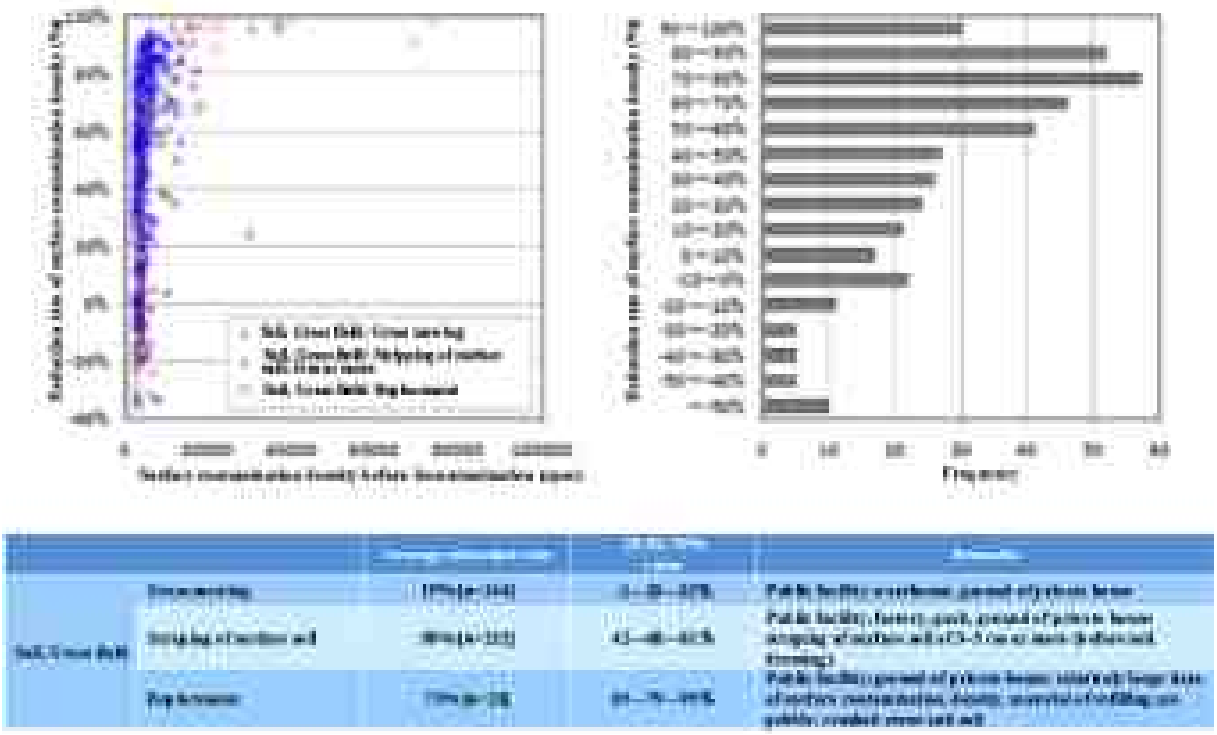

Figure 5-23 Decontamination effect for a target decontamination place (bare soil, grassland)

b.) Lawns

- The reduction rate of surface contamination densities was high; 70 to 90% by peeling off of lawns and about 90% by soil replacement (coverage with crushed stones after removal of lawns).
- It is a point of attention in decontamination that it is necessary to consider “close mowing combined with topsoil removal(*),” for which a certain effect of dose reduction has been confirmed, from the viewpoint of controlling the amount of removed soil generated as well as regeneration of the lawns.
  (*) Close mowing combined with topsoil removal: a method to remove the topsoil including the root layer of dead lawns and other grasses depending on the situation of radioactive materials.

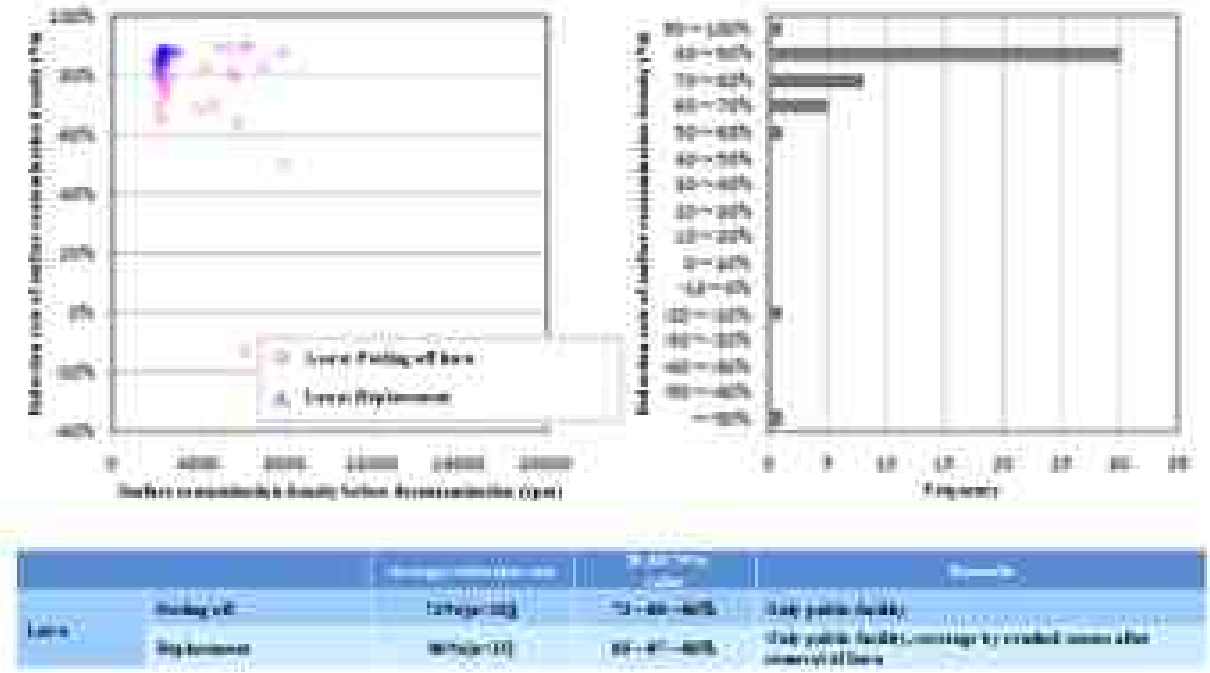

Figure 5-24 Decontamination effect for a target decontamination place (lawns).

5) Paved surfaces such as parking lots

a.) Asphalt paved surfaces

- The reduction rate of surface contamination densities was around 50 to 70% by cleaning, around 30 to 70% by high-pressure water washing, and around 70 to 90% by surface scraping.
- In high-pressure water washing, the reduction rate had large deviations irrespective of surface contamination densities before decontamination.
- A point of attention in data interpretation is that the decontamination effects may have large deviations because of variations in decontamination conditions of high-pressure water washing at each decontamination place (nozzle elevations above ground surface, work time per unit area, and other conditions) and the size of the area to be decontaminated like parking lots or the different conditions of paved surfaces (permeability or drainage capability).
- Points of attention in decontamination are:
  - ✓ Measures should be taken to prevent wastewater from spreading when decontaminating using water.
  - ✓ The possibility that radioactive materials may have deposited into cracks should be considered.

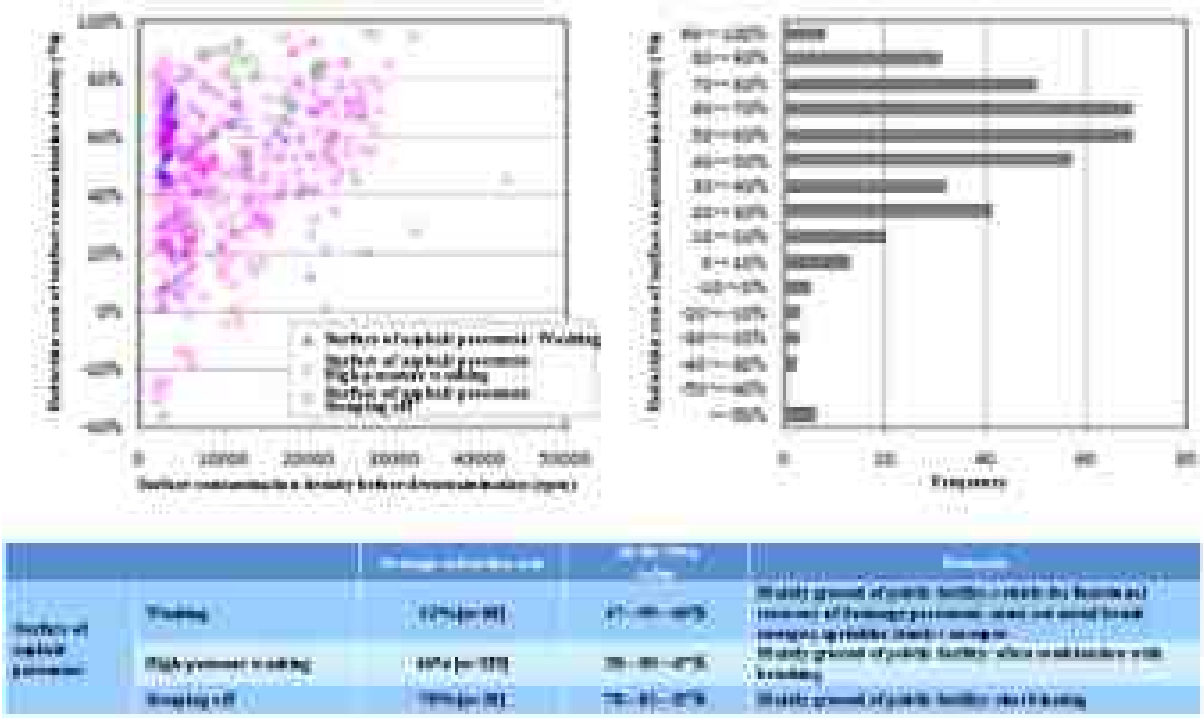

Figure 5-25 Decontamination effect for a target decontamination place (asphalt paved surfaces).

b.) Concrete paved surfaces

- The reduction rate of surface contamination densities was around 40 to 70% by high-pressure water washing and around 60 to 90% by surface scraping.
- The reduction rate varies depending on the work method of surface scraping.
- A point of attention in data interpretation is that the decontamination effects may have large deviations because of variations in decontamination conditions of high-pressure water washing at each decontamination place (nozzle elevations above ground surface, work time per unit area, and other conditions) and the size of the area to be decontaminated like parking lots or the different conditions of paved surfaces (permeability or drainage capability).
- Points of attention in decontamination are:
  - ✓ Relatively high reduction rates are obtained on the concrete surfaces because of less unevenness, but contamination tends to be concentrated around moss-covered spots.
  - ✓ Measures should be taken to prevent wastewater from spreading when decontaminating using water.

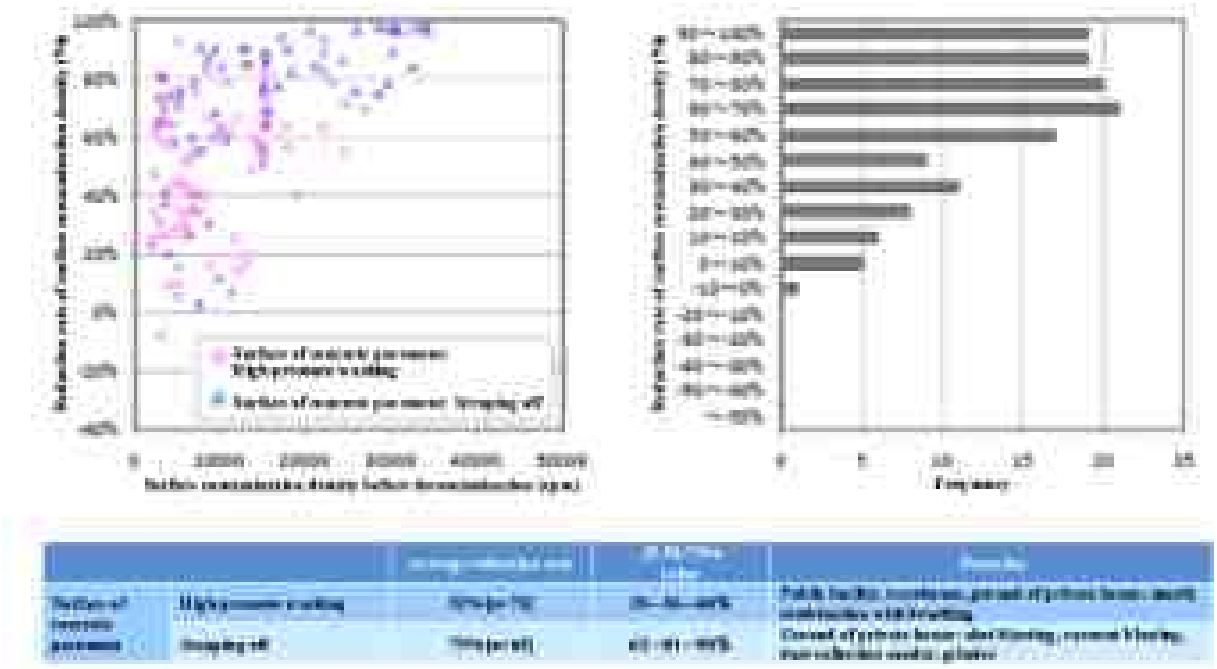

Figure 5-26 Decontamination effect for a target decontamination place (concrete paved surfaces).

c.) Interlocking block surfaces

- The reduction rate of surface contamination densities was around 50 to 80% by high-pressure water washing and around 40 to 70% by scraping.
- Points of attention in data interpretation are:
  - ✓ The reduction rate can be lowered in scraping if scraped chips and radioactive materials are left in the gaps between the interlocking blocks.
  - ✓ The reduction rate by scraping (abrasive material blasting and concrete surface planing) of interlocking blocks is lower than that by scraping of asphalt paved or concrete paved surfaces. The scraped chips left in the gaps of interlocking are likely one reason for this.

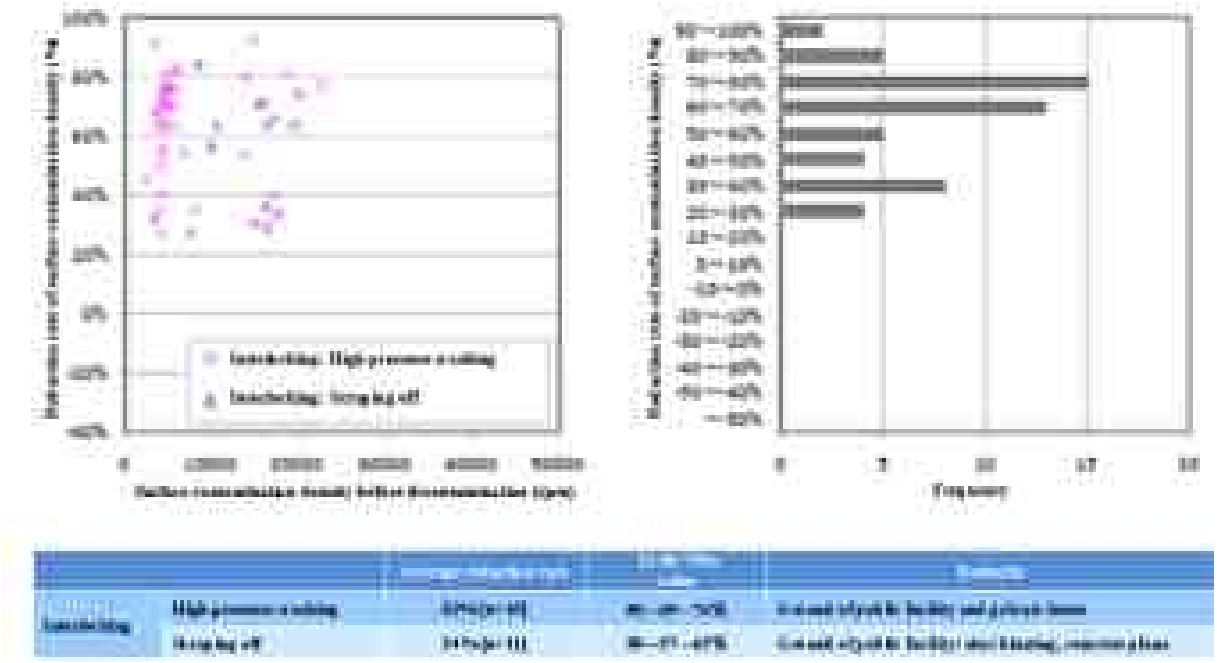

Figure 5-27 Decontamination effect for a target decontamination place (interlocking blocks).

6) Ground surfaces and the like (soil)

- High reduction rates of around 80 to 90% were achieved by topsoil scraping.
- Stable reduction rates seem to have been obtained, since the grounds have limited unevenness.
- It is a point of attention in decontamination that it is necessary to check the depth of contamination from the surface layer in advance and determine the optimum thickness of scraping.

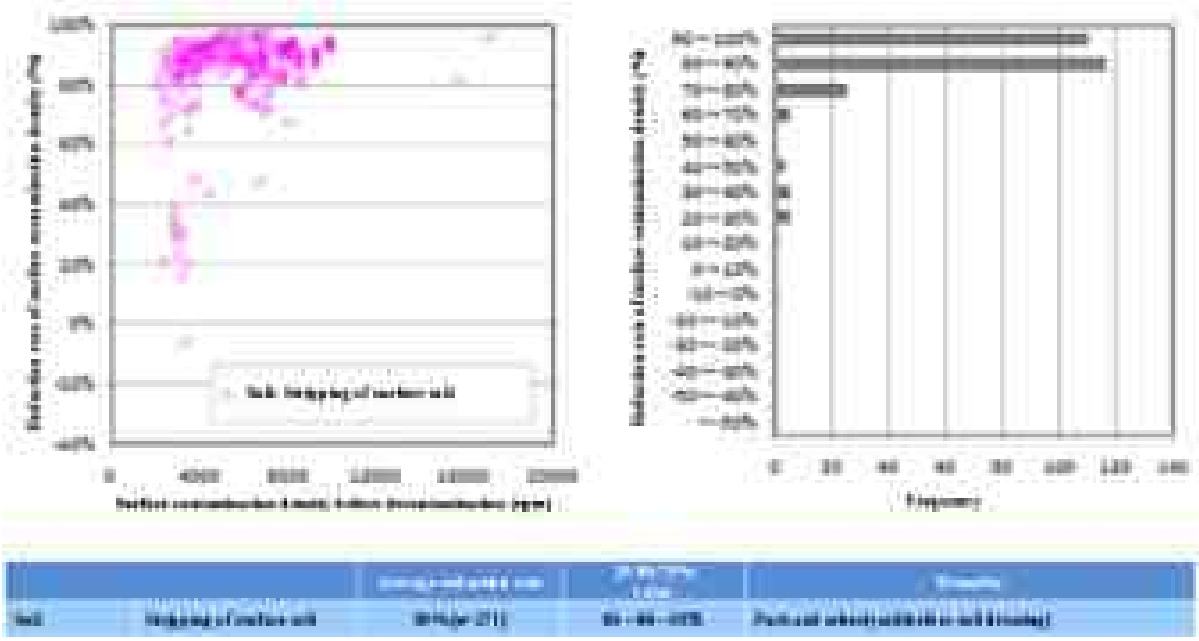

Figure 5-28 Decontamination effect for a target decontamination place (ground surfaces and the like (soil)).

(2) Roads (asphalt paved surfaces)

- Most data are from decontamination by cleaning and the reduction rate was around 0 to 50%. Large deviations were seen in the reduction rate because most data were obtained from decontamination by special cleaning vehicles that restore permeable pavement.
- The reduction rate by high-pressure water washing was around 10 to 50%. However, the data were limited.
- The reduction rate by scraping was around 10 to 70% (* the reduction rate is currently being improved by better collection of scraped chips.)
- The reduction rates of the asphalt-paved roads by any decontamination methods of cleaning, high-pressure water washing, or scraping were in many cases lower than those of asphalt-paved surfaces in parking lots of structures such as buildings.
- Points of attention in data interpretation are:

  ✓ The decontamination effect may have large deviations because of deviations in decontamination conditions of high-pressure water washing at each decontamination place (nozzle elevations above ground surface, work time length per unit area and other conditions) and the size of the area to be decontaminated like parking lots or the different conditions of paved surfaces (permeability or drainage capability).

  ✓ The reduction rate tends to be low when vehicles to restore permeable pavements are used with low water pressure and recirculated wastewater. Also, the cleaning and wastewater collection performance are downgraded on the road surfaces distorted or damaged by the earthquake and other reasons.

Measures should be taken to prevent wastewater from spreading, when decontaminating using water.

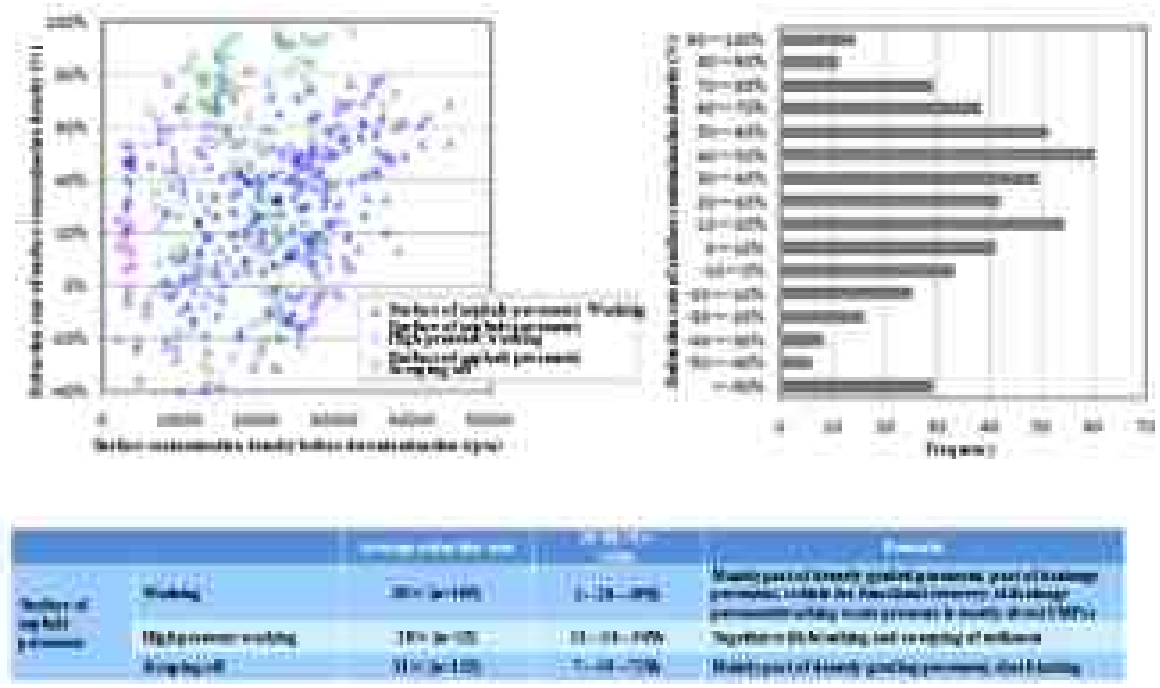

Figure 5-29 Decontamination effect for a target decontamination place (asphalt paved surfaces).