April 4th, 2011

Interim Report on Radiation Survey in Iitate Village area conducted on March 28th and 29th

Iitate Village Area Radioactive Contamination Investigation Team

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Following the Fukushima Daiichi nuclear power plant accident on March 11th 2011, the Village of Iitate located 25 - 45 km northwest from the plant is found with radioactive contamination and suspected as a Hot Spot, where the contamination is greater than other parts of Fukushima Prefecture (Attachment 1). Given the urgency of the situation of residents living in the region and in order to grasp the extent and spread of Hot Spot, radiation survey activities have been carried out with the cooperation of Iitate Village and related authorities on March 28th and 29th.

Survey Participants

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Research Methods

With radiation detectors brought into a van provided by Iitate Village office, the radiation dose rate inside the vehicle was measured as it travelled within the village. The detectors used were ALOKA Co. pocket survey meter PDR-101(CsI detector) and ALOKA Co. Ionization Chamber Survey Meter ICS-313. On the first day of March 28th upon arriving in the early evening, the general condition of contamination was surveyed with an hour of driving within the village. This confirmed that the contamination was noticeable in the southern part of the village. On the second day, 92 points were surveyed in the morning largely in the north where relatively low contamination was found, while in the afternoon 38 points were surveyed in the south, totaling 130 points. The survey was conducted in and outside the vehicle at several locations, and this confirmed the shielding effect of the vehicle. In general, the survey was conducted above the paved road, and in addition soil samples were obtained at 5 locations for the propose of the radionuclide analysis, and later with Ge semiconductor detector, gamma ray radionuclide analysis was conducted at Hiroshima University.

Summary of Findings

◎ Air Dose Rate Measurement

Figure 1 shows radiation dose measurement points recorded with GPS. Figure 2 shows contours of radiation dose based on measurement results.

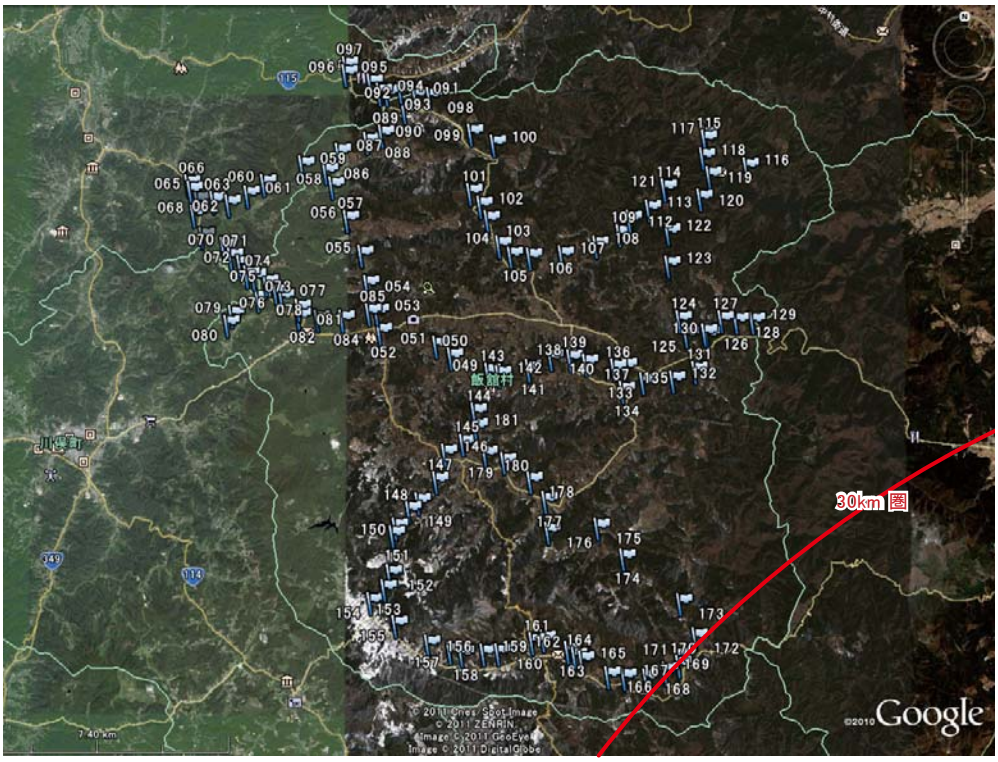


Figure 1. Dosimetry points

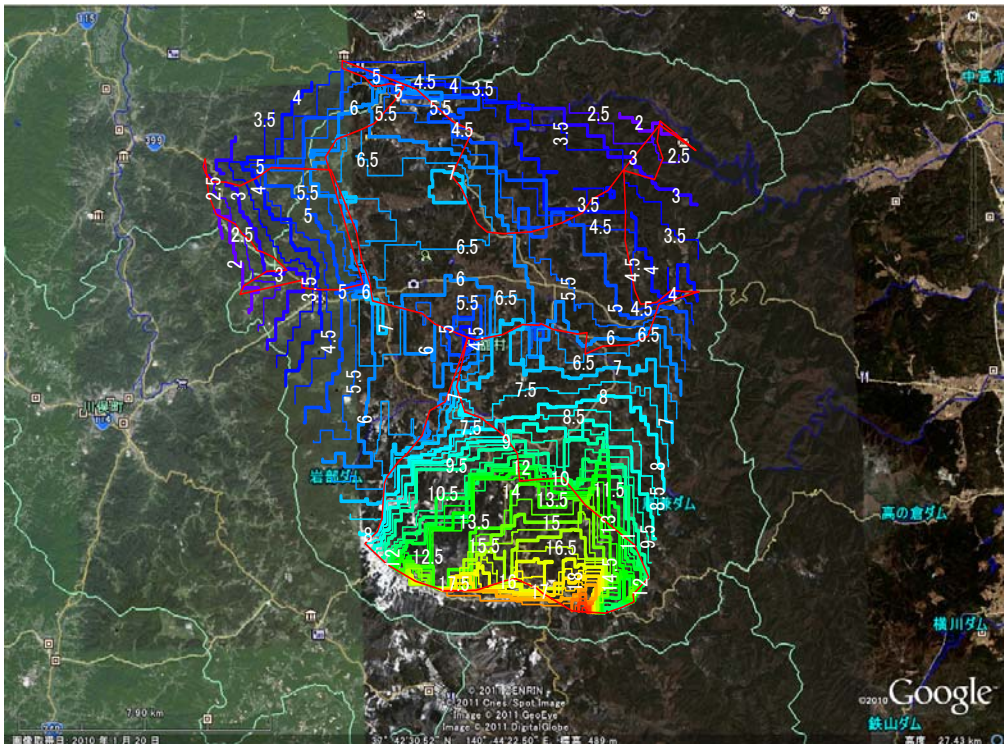


Figure 2. Dose rate contours

The contours shown in Figure 2 are prepared by the simple linear interpolation (data points for each measurement are shown in Attachment 2). The statistical method must be considered for the interpolation in the end, however, due to time constraints Figure 2 shows the preliminary result. Thin red lines show the measurement paths, while thick rectangular lines shows the contour. From blue to red in the contour, it refrects transitions to a higher radiation dose rate (the values shown are dose rates measured inside the vehicle.) Furthest southern point in red measured 18 − 20 micro-sievert per hour.

Radiation levels around the northwestern part of the village including the Town Hall are measured 5 − 7 micro-sievert per hour, while crossing the ridge toward the City of Date the measurement reduced to 2 − 3 micro-sievert per hour. In the northeastern part of the village, the measurement was 4 − 5 micro-sievert per hour near the Iitate Ranch, and approaching Ookura it decreased to 2 − 3 micro-sievert per hour.

In the southern part of the village, higher radiation levels were observed in contrast to the north, and along Hiso River from Shimo-Hiso to Warabi-daira the levels were more than 10 micro-sievert per hour. The largest value observed inside the vehicle was 20 micro-sievert per hour. The measurement outside the vehicle 1 meter above the paved road was 24 micro-sievert per hour and at the adjacent farmland, the measurement was 30 micro-sievert per hour. The shielding effect of vehicles and building structures, etc. (transmission coefficient of radiation dose rate) was estimated to be approximately 0.8 inside a vehicle, approximately 0.4 inside wooden houses, and approximately 0.1 inside concrete structures.

◎ Gamma ray radionuclide analysis of soil samples

The soil samples of 5cm deep were obtained at # 49, # 53, # 88, # 98, # 165 as shown in Figure 1. The soils were divided into 40g subsamples and with Ge semiconductor detector, gamma ray radionuclide analysis was conducted in the Radiation Laboratory, the Graduate School of Engineering, Hiroshima University, First an example of gamma ray spectrum measurement is shown in Figure 3.

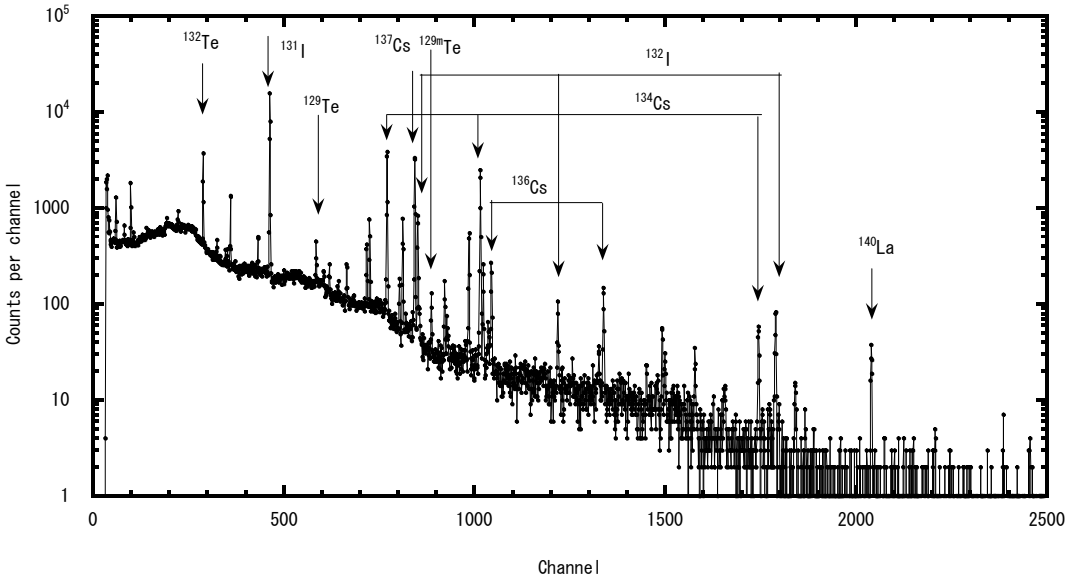


Figure 3. γ-ray Spectrum measured from soil samples collected at #53

From Figure 3, radionuclides such as 132Te, 131I, 129Te, 129mTe, 137Cs, 134Cs, 136Cs and 140La were identified. Though additional measurements are needed, peaks 99Mo, 99mTe, 140Ba were also recognized. Based on these count rates, radionuclide concentration levels of these pollutants were determined, and with 5.5cm × 7.5cm collecting surface area of an oval bottom sampler with 32.4cm2 area the converted densities per unit area of contamination were obtained (Table 1). Air dose rate measurements at the soil sample locations were 24 micro-sievert per hour at #165 (Magata), and approximately 10 micro-sievert per hour at 4 other locations. In addition, in order to evaluate their variation within a small area, contamination densities were similarly measured from 5 soil samples obtained within the 50cm x 60cm area of the flowerbed of Iitate Village office. The results were shown in Table 2. According to Table 2, the variation of contamination density of soil sample points is considered around 15%, although it is expected to vary with differing conditions.

Table 1. Soil Contamination Levels at # 49, # 53, # 88, # 98, # 165 (Time of Measurement: March 31st)

	Usuishi	Sasu	Yamstsumi shrine	Village office	Magata
	contamination (kBq/m2)				
Te-129m	13.1 ± 2.9	21.6 ± 3.2	13.0 ± 2.3	15.8 ± 1.5	50.2 ± 3.9
Te-129	17.9 ± 3.8	24.8 ± 4.2	18.6 ± 3.0	20.7 ± 2.0	55.7 ± 5.4
I-131	1947.4 ± 12.7	1788.3 ± 13.2	1265.6 ± 9.3	1168.8 ± 5.7	3243.5 ± 14.1
Te-132	195.8 ± 4.8	209.2 ± 5.0	176.9 ± 3.9	158.7 ± 2.4	518.1 ± 6.2
I-132	126.1 ± 6.0	133.5 ± 6.2	111.5 ± 5.0	110.1 ± 3.1	338.2 ± 8.1
Cs-134	796.7 ± 10.4	651.1 ± 10.1	507.1 ± 7.3	580.5 ± 5.1	1873.4 ± 13.4
Cs-136	66.4 ± 4.2	22.7 ± 3.2	29.8 ± 3.1	35.5 ± 2.1	145.9 ± 5.7
Cs-137	956.1 ± 12.7	774.2 ± 12.2	588.2 ± 8.8	671.9 ± 6.0	2188.2 ± 16.3
$^{131}I/^{132}I$	15.4 ± 0.74	13.40 ± 0.63	11.35 ± 0.51	10.62 ± 1.04	9.59 ± 0.95
$^{131}I/^{137}Cs$	2.0 ± 0.0	2.3 ± 0.04	2.15 ± 0.04	1.74 ± 0.02	1.48 ± 0.01
$^{132}I/^{132}Te$	0.64 ± 0.04	0.64 ± 0.04	0.63 ± 0.04	0.69 ± 0.07	0.65 ± 0.07
$^{137}Cs/^{136}Cs$	14.39 ± 0.93	34.08 ± 4.81	19.77 ± 2.11	18.91 ± 1.15	14.99 ± 0.60
$^{137}Cs/^{134}Cs$	1.20 ± 0.02	1.19 ± 0.03	1.16 ± 0.02	1.16 ± 0.01	1.17 ± 0.01

Table 2. Variation of Contamination Density in a given point (at flowerbed in Iitate Village Office)

	Village office#1	Village office#2	Village office#3	Village office#4	Village office#5	Average	Std	%
	contamination (kBq/m2)							
Te-129m	20.3 ± 2.5	15.4 ± 1.7	22.7 ± 2.3	17.5 ± 1.8	18.2 ± 1.7	18.8	2.8	15%
Te-129	22.5 ± 3.3	18.1 ± 2.3	24.3 ± 2.9	19.5 ± 2.4	19.1 ± 2.4	20.7	2.6	13%
I-131	1488.0 ± 9.2	1329.9 ± 6.8	1532.2 ± 8.6	1294.1 ± 6.9	1141.3 ± 6.4	1357.1	157.4	12%
Te-132	196.7 ± 3.9	166.8 ± 2.9	201.3 ± 3.5	172.6 ± 2.8	162.8 ± 2.7	180.0	17.7	10%
I-132	123.3 ± 4.9	109.1 ± 3.6	118.9 ± 4.5	112.3 ± 3.7	105.2 ± 3.5	113.7	7.3	6%
Cs-134	694.2 ± 8.1	599.4 ± 5.8	694.2 ± 7.4	638.0 ± 6.1	622.3 ± 6.0	649.6	42.9	7%
Cs-136	57.5 ± 3.5	40.3 ± 2.5	60.7 ± 3.2	51.5 ± 2.5	50.6 ± 2.5	52.1	7.8	15%
Cs-137	813.7 ± 9.8	682.4 ± 6.9	807.4 ± 9.0	736.9 ± 7.3	704.1 ± 7.1	748.9	59.5	8%
$^{131}I/^{132}I$	12.1 ± 0.49	12.19 ± 1.90	12.89 ± 0.49	11.52 ± 1.47	10.85 ± 1.38			
$^{131}I/^{137}Cs$	1.8 ± 0.0	1.9 ± 0.02	1.90 ± 0.02	1.76 ± 0.02	1.62 ± 0.02			
$^{137}Cs/^{134}Cs$	1.17 ± 0.02	1.14 ± 0.02	1.16 ± 0.02	1.16 ± 0.02	1.13 ± 0.02			

The average density of 134Cs and 137Cs of #1 - #5 soil samples in Table 2 were 17 Bq/g and 21Bq/g respectively, and according to “The enactment on quantity of radiation-emitting isotope ” of “Laws Concerning the Prevention from Radiation Hazards due to Radioisotopes and Others”, these numbers are above 10Bq/g set as a density equivalent of “radioactive materials” for these radionuclides.

Estimation of Exposure

The time variation of air dose rate was calculated by using the contamination density obtained from the flowerbed samples. To calculate this, a conversion factor from the contamination density to radiation dose rate at 1 m above the surface (Beck, BNL-378, 1980) was used, and the time variation of radiation dose rate was derived since the time of radioactive deposition of March 15th, 2011, considering the diminishing factor of a half-life of each radioactivity. The results are shown in Figure 4. For comparison, the monitoring post air rate dose measurements (MP) were plotted with the multiplication factor of 9.6/6.5 based on air dose rate ratio of the soil samples obtained at the flowerbed to that of MP. The calculated and measured air dose rates roughly coincided, and this indicated that this evaluation was valid.

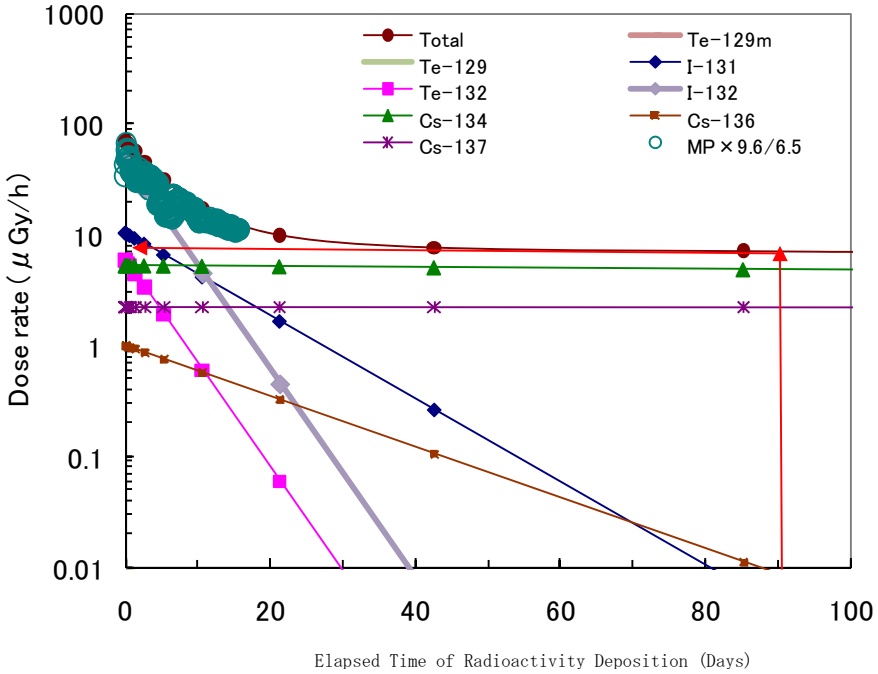


Figure 4. Variation of Air Radiation Dose Rate in Iitate Village Office (Above Soil). 7 μ Gy/h after approximately 3 months (micro-gray per hour.) ("Micro-gray and micro-sievert are considered the same " in Iitate Village contamination.)

For reference, using the soil contamination data from Table 1, radiation dose rate was calculated at Magata settlement where highest radiation dose rate was measured. This dose rate being approximately 200 micro-Sv per hour on March 15th, 2011 indicates the expected exposure of about 5 mSv per DAY. Figure 5 shows the increase in cumulative exposure in Iitate Village office and Magata settlement obtained by integrating the radiation dose rates shown in Figure 4.

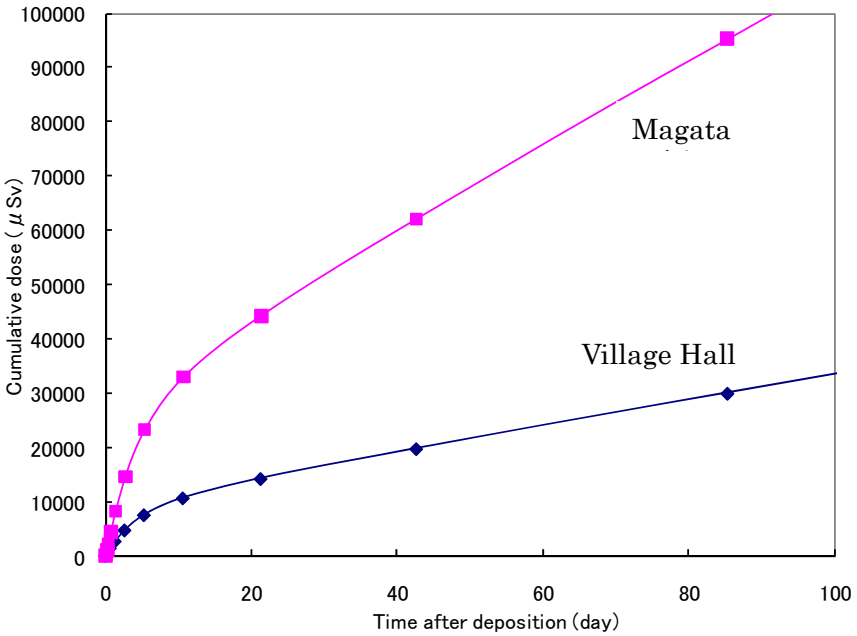


Figure 5. Cumulative Dose at Iitate Village Office and Magata (Microsievert)

Following from Figure 5, the estimated accumulative exposure to radiation over 90 days beginning from the March 15 low is 95mSv for Magata and 30mSv for the Iitate Village Hall. These figures apply to the soil of pasture land and are slightly reduced depending on where one is. For example, riding in a car results in 2/3 the exposure, being inside of a wooden framed house is 1/2, and being inside of a concrete building is 1/10.

According to the “Indoor Evacuation and Mandatory Evacuation Index” as described by the Nuclear Power Safety Committee’s “Measures to Prevent Disasters at Nuclear Power Plants”, given the amount of radioactive contamination and time of exposure, 10 to 50mSv requires that shelter be taken indoors, and levels above 50mSv require that shelter be taken in a concrete building or to evacuate. There is no doubt that radioactive contamination in Iitate Village is a critical issue.

□The Range and Time of Radioactive Contamination

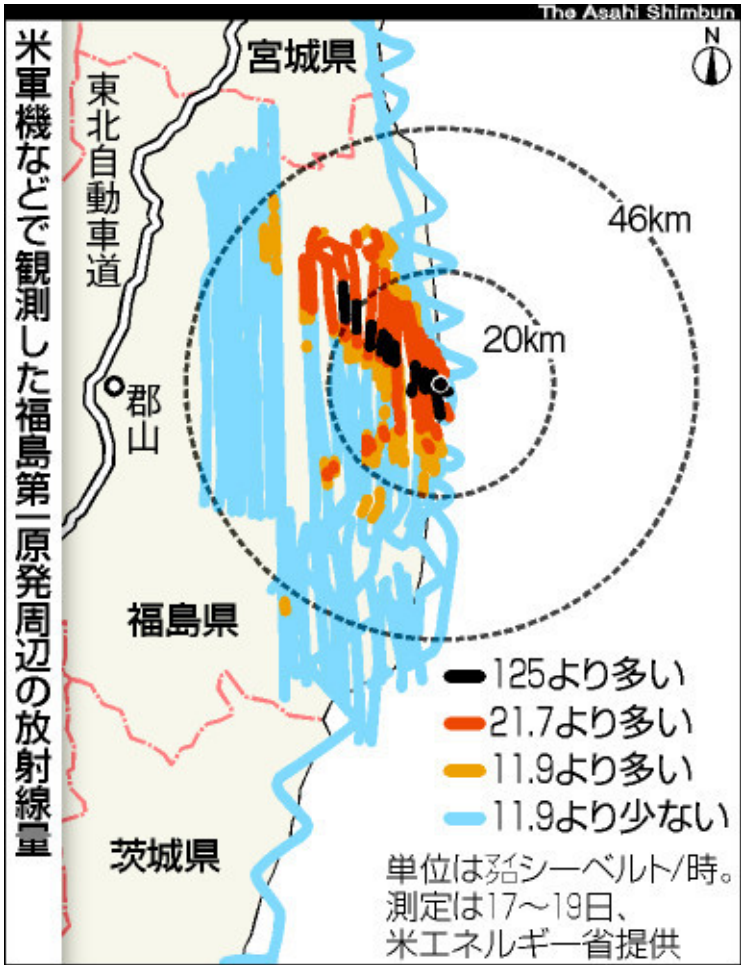
Judging from the results of the Iitate Village Radiation Survey, radioactive contamination stretches beyond Iitate Village. Accordingly, diverse information since the March 15 explosion has been investigated.

□Radiation Survey Conducted by the US Military

Below is a link to an article in Asahi Newspaper on March 24th, which describes the results of a US military survey of atmospheric radiation.

http://www.asahi.com/special/10005/TKY201103240214.html

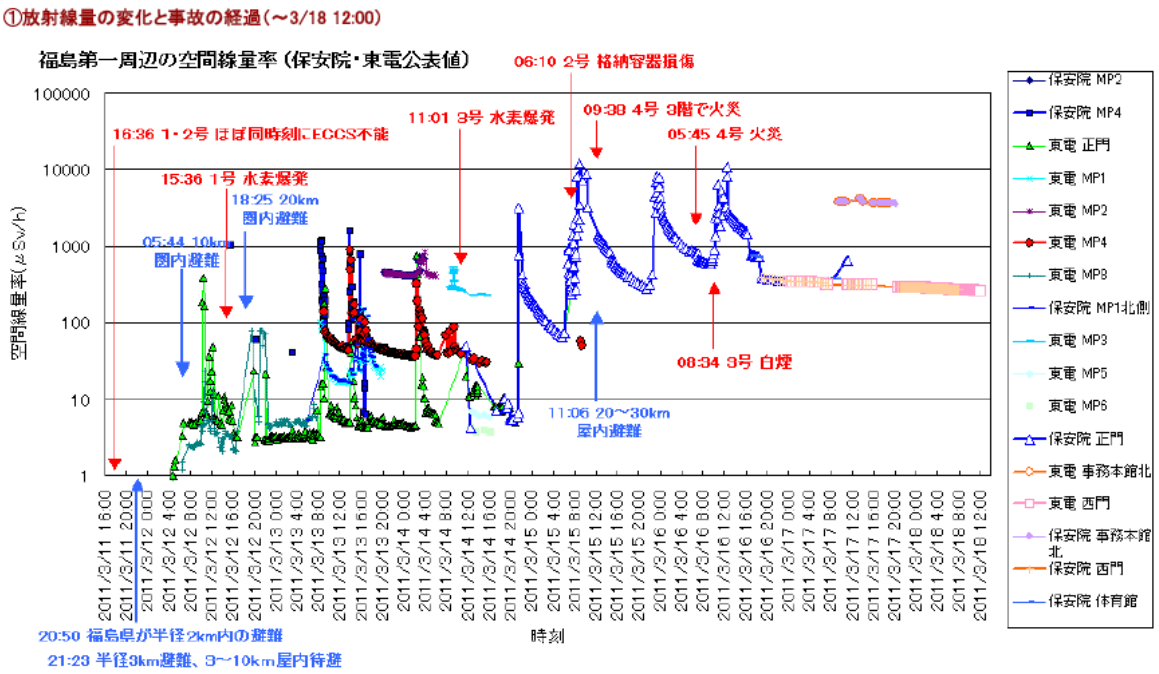
The results show a high concentration of radiation from the Fukushima Daiichi Nuclear Power Plant towards the northwest, in the direction of Iitate Village.



Mihamanokai's Analysis of Radioactive Emissions

Below are the results of Mihamanokai's radioactive emission analysis.

http://www.jca.apc.org/mihama/fukushima/monitoring/fukushima_monitoring.htm



According the above figure, on the morning of March 15 there was a large emission of radioactivity due to the destruction of the second reactor's containment vessel and the fire in the fourth reactor's spent fuel pool. It can be considered that this radioactive pollution traveled northwest and left a trail of highly radioactive contamination. Due to the amount of radioactive iodine found, it is believed that the destruction of the second reactor's containment vessel at 6:10 on March 15 emitted a large quantity of radiation towards the northwest.

According the data of attachment 1, the maximum radiation dose rate of 44.7μSv/h occurred at 18:20 on March 15th. The right chart is the record of meteorological condition in Iiitate village of March 15.

It is considered that the destruction of the second reactor's containment vessel at 6:10 on March 15 induced a nuclear cloud which took 12 hours to reach and hover over the area of Iitate Village. (On the chart to the right, "///" signifies that no data is available.)

The above results and discussion of the Iitate Village Area Radiation Survey demonstrate the severity of the situation.

Lastly, we would like to thank Mayor Norio Sugano and all of the residents of Iitate Village for their cooperation.

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飯舘 2011年3月15日 (1時間ごとの値) 一覧

時	降水量(mm)	気温(℃)	風向・風速(m/s)		日照時間(h)	雪(cm)	
			風速	風向		降雪	積雪
1	///	///	///	///	///	///	///
2	///	///	///	///	///	///	///
3	///	///	///	///	///	///	///
4	///	///	///	///	///	///	///
5	///	///	///	///	///	///	///
6	///	///	///	///	///	///	///
7	///	///	///	///	///	///	///
8	///	///	///	///	///	///	///
9	///	///	///	///	///	///	///
10	///	///	///	///	///	///	///
11	///	///	///	///	///	///	///
12	0.0	2.6	1.1	東南東	0.0	///	///
13	0.0	2.3	1.6	東	0.0	///	///
14	0.0	2.2	1.2	東南東	0.0	///	///
15	0.0)	2.1	0.9	東	0.0)	///	///
16	0.0	2.1	1.1	東南東	0.0	///	///
17	0.5	1.9	0.8	東南東	0.0	///	///
18	0.0	1.7	0.8	東	0.0	///	///
19	0.5	1.3	0.1	静穏		///	///
20	0.5	0.8	0.4	東		///	///
21	1.0	0.5	0.1	静穏		///	///
22	1.5	0.3	0.0	静穏		///	///
23	1.5	0.3	0.0	静穏		///	///
24	1.5	0.1	///	///		///	///

<Revised 17:50, Aril 5, 2011>

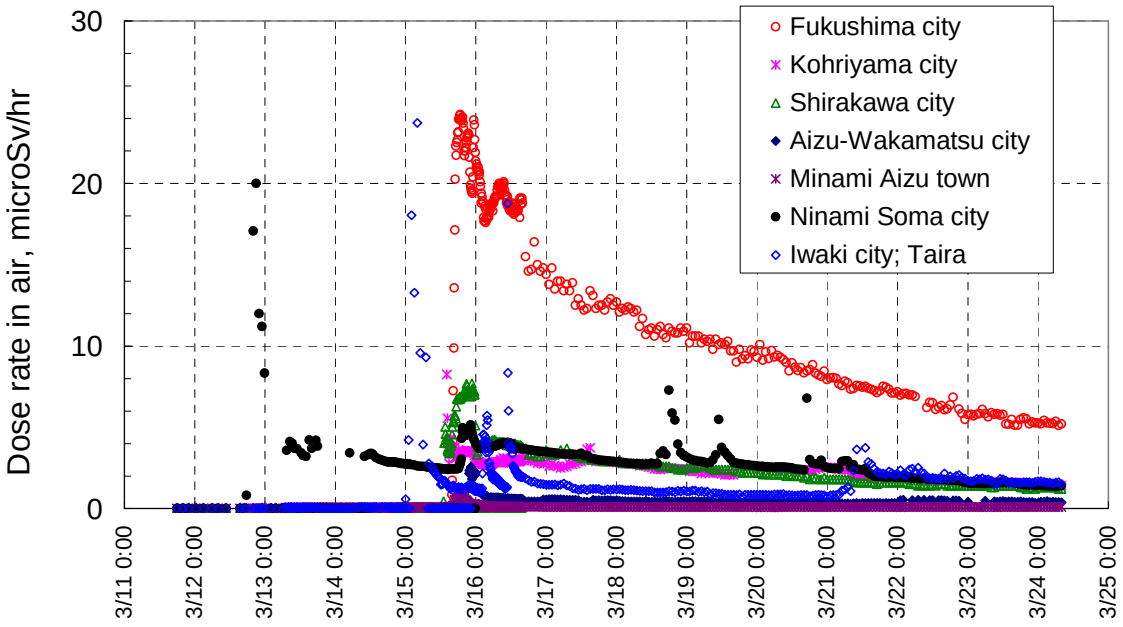
Note; English version was prepared on April, 12, 2011 with helps from FoE Japan and Prof Itonaga and his colleagues.

Appendix-1

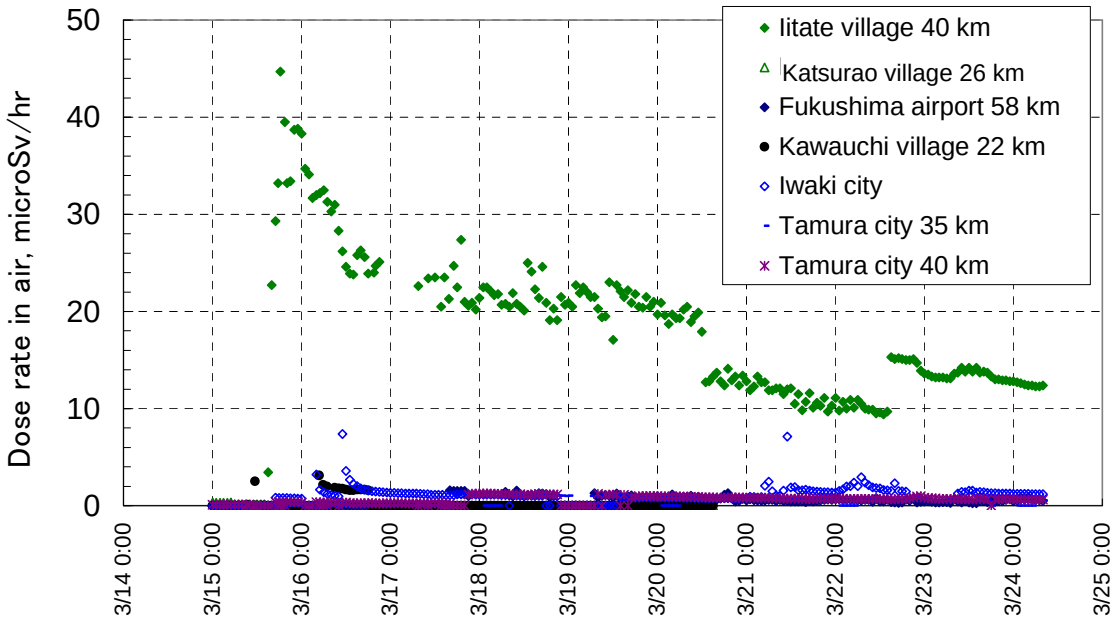
March 25, 2011. Imanaka T.

Radiation dose rate at various places in Fukushima prefecture

One of my friends sent me e-mail with radiation dose data measured at various places in Fukushima prefecture. He got these data from the Internet released from the prefecture headquarter for the disaster. The followings indicate temporal change of radiation dose rate in the environment. Locations are in the next maps.



Change of radiation dose rate (1): March 11 -



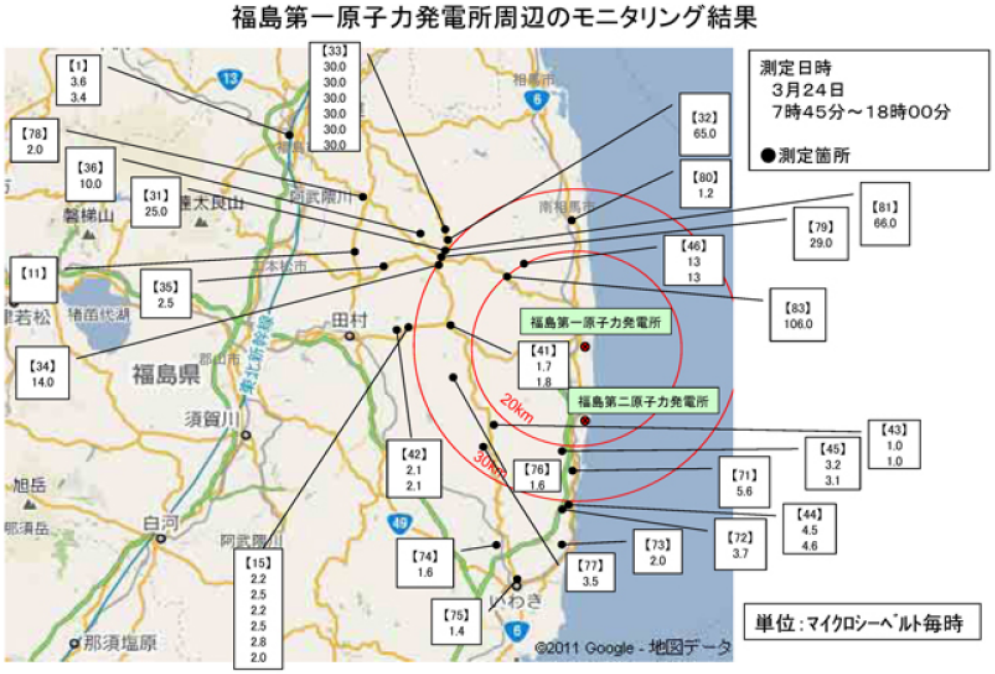
Change of radiation dose rate (2): March 15 -

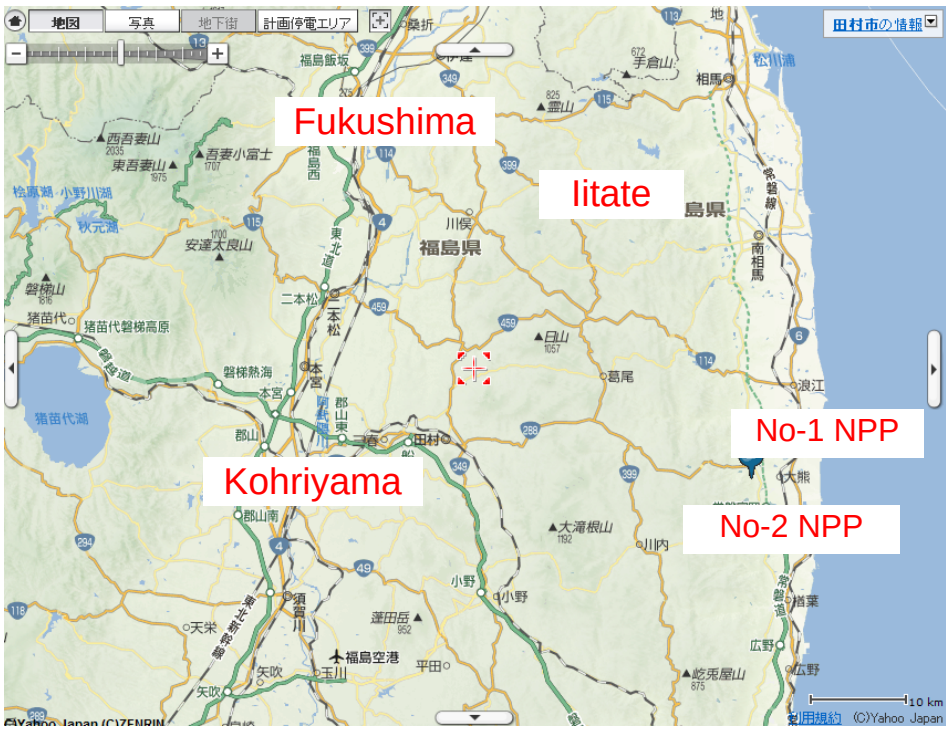
Appendix-1

Location of monitoring points and Fukushima No-1 NPP

文部科学省のモニタリングカーを用いた福島第1発電所及び第2発電所周辺の空間線量率の測定結果（地図）（再掲）

飲用水（水道水）環境放射能測定結果（暫定値）（PDF：104KB）（※福島県ホームページへリンク）





Appendix-2: measured dose rate

No	Time	Location	Dise rate (μSv/h) Inside car PDR	Dose rate (μSv/h) Outside car	Dose rate (μSv/h) Ionizing chamber
49	9:15	iitatemurayakuba	3.5		-
50	10:15	itamizawakousater	6		6.4
51	11:15	matuzuka	5.3		-
52	12:15	usuisi	7.5		-
53	13:15		6.6		-
54	14:15	hosokawabokujyou	7		
55	15:15	sugata	6		
56	16:15	maeta	6.1		
57	17:15	tyokubaisyomae	7.1	10.5	
58	18:15	datesakai	6.4		
60	19:15	tukidatesenkitanos	5.6		
61	20:15	sakatocyu	4.1		
62	21:15	sakatocyu	3.1		
63	22:15	sakatocyu	3		
64	23:15	datesisannsaro	2.3		
65	0:15	kanijyousuijyouwa	2.4		
66	1:15	kanijyousuijyouwa	2.4		
67	2:15	kanijyousuijyousita	2.6		
68	3:15	kokudou399	2.4		
69	4:15	cyoujyuyamairiguti	1.9		
70	5:15	noboritocyu	2.7		
71	6:15	noboritocyu	2.5		
72	7:15	noboritocyu	2.7		
73	8:15	toogetemae	2.8		
74	9:15	iitatemurasakai	3.1		
75	10:15	toogesaki	3.3		
76	11:15	toogesaki	3.4		
77	12:15	nimaibasimotomat	2.9		
78	13:15	sugaya	3.1		
79	14:15	sugaya	2.2		
80	15:15	kendouiriguti	1.5		
81	16:15	nimaibasitocyu	2.8		
82	17:15	399kousaten	2.9		
83	18:15		4.2		
84	19:15	saitounnyukougyo	4.8		
85	20:15	usuisikousaten	4.1		
86	21:15	maetakousaten	5.9		
87	22:15	houei	6.6		
88	23:15	yamatumijinnjya	6.5	11.5	12
89	0:15	yamatumijinnjyasa	5.7		
90	1:15		5.2		
91	2:15	kousaten	5		
92	3:15	resutoran	4.3		
93	4:15	toogetemae	6.8		
94	5:15	tooge	6		
95	6:15	toogekudari	5.6		
96	7:15	ryouzentemae	5		
97	8:15	kousatentemae	4.4		
98	9:15		6.7		
99	10:15	sasunamerikousat	4.1		
100	11:15	maenorikousaten	4.5		
101	12:15	sannsaro	7.2		
102	13:15	namiesentocyu	7.7		
103	14:15	namiesentocyu	6.9		
104	15:15	hasegawadennkim	7		
105	16:15		6.6		
106	17:15	miyautikousaten	6.2		
107	18:15	miyautisyuukaijyor	4.9		
108	19:15	sinkoukousyairigut	5.1		
109	20:15	ookuratouge	4.1		
112	21:15	ookuratouge	3.2		
113	22:15	totinoki	4.1		
114	23:15	kotogikousaten	3.5		
115	0:15	ookurakousaten	2.4		
116	1:15	matugataira	2.5		
117	2:15	hasinoue	1.6		
118	3:15	sakatocyu	2.4		
119	4:15	sakatocyu	2.4		

No	Time	Location	Dise rate (μSv/h) Inside car PDR	Dose rate (μSv/h) Outside car PDR	Dose rate (μSv/h) Ionizing chamber
120	12:16	kotogitemae	2.9		
121	12:18	kotogisansaro	3.2		
122	12:20	kaitekidoutocyu	4		
123	12:21	kaitekidoutocyu	4.8		
124	12:23	kaitekidoutocyu	4.4		
125	12:24	kyudoukousaten	4.2		
126	12:25	nukazukabasutei	4.1		
127	12:26		3.4		
128	12:27		4.4		
129	12:32	minamisoumasak	3.8		
130	12:35	kamiyagisawa	4.9		
131	12:38		6.6		
132	12:39		6.2		
133	12:40	komiyatocyu	6.4		
134	12:41	iitoigawabasi	6.2		
135	12:43	asiharasannsaro	5.7		
136	12:44	sionomititouge	5.6		
137	12:45	sekisawasyukaijyo	6.6		
138	12:46	kousaten	5.8		
139	12:47		4.2		
140	12:48	sekisawanozawa	7.1		
141	12:49		7.3		
142	12:50	cyugakkoumae	4.7		
143	12:51		2.5		
144	14:15	iitatemurayakuba	6.2		
145	14:18	ootairakousaten	5.7		
146	14:20	iitoikousaten	6		
147	14:20	iitoisyoumae	5.6		
148	14:22	tokorokubo	7.3		
149	14:23		7.2		
150	14:25	sakatocyu	6.9		
151	14:28	tougetocyu	6.3		
152	14:30		7.5		
153	14:30	sansaro	7.7		
154	14:32	hisotouge	8.3		
155	14:33	kanahiso	10.5		
156	14:35	simohiso	18.2		
157	14:36	keisya	13.8		13
158	14:39	keisyasita	19.6		18.8
159	14:41	keisyasita	over		19.2
160	14:43	hiso,nagadoro	17.8		17.4
161	14:45	nagadorojyumonji	15.9		14
162	14:48	nagadorottonsyo	17.8		16.3
163	14:50	magatatemae	17.9		15.9
164	14:52	magata	15.7		14.2
165	14:54	magata	18.6		15
166	15:13	magata	over	24	20
167	15:17	namiebunki	over	22	
168	15:29	warabitaira	10.5		9
169	15:30	warabitaira	8.6		7
170	15:32		13.2		10.5
171	15:35	warabitairasyukaij	15.5		12.5
172	15:38	kidokousaten	9.8		7.8
173	15:40	warabitairatocyu	10.4		9.5
174	15:44	makibakousaten	15.3		12
175	15:46	kayakariniwakous	9.7		9
176	15:49	touge	13.9		11.5
177	15:52		10.7		7.5
178	15:53	yamabezawakous	8.3		7.2
179	15:55	oohasi	7.4		
180	15:58		8.5		
181	16:01	kousaten	7.3		
49	16:30	yakubamae	3.5		
182		Iisaka Onsen		1.2	
184		Azumi interchange		3	
185		Kami-kawachi	0.12	0.19	
186		by Hanyu bridge	0.11		
186		on Hanyu bridge	0.08		