

Radiocesium contamination of wild mushrooms collected from the University of Tokyo Forests over a six-year period (2011-2016) after the Fukushima nuclear accident

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東京大学演習林における福島第一原子力発電所事故後6年間（2011～2016）の
野生キノコの放射性セシウムの測定結果

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1. Introduction

Radioactivity emitted from the Fukushima Dai-ichi nuclear power plant (F1-NPP) accident in March 2011 spread over a wide area of East Japan. Mushrooms are known to accumulate radiocesium (Sugiyama *et al.* 1990, 1994), and thus wild mushrooms often contain a high level of radiocesium, even in low contaminated areas (Muramatsu & Yoshida 1997, Muramatsu *et al.* 1997, Yoshida & Muramatsu 1996). The University of Tokyo has seven research forests located in East Japan (250-660 km from F1-NPP), and in the spring of 2012 the gamma ray air dose rate was 0.019-0.114 $\mu\text{Sv/h}$ at 1 m above ground (Yamada 2013, Yamada *et al.* 2013). Radiocesium contamination of wild mushrooms in the University of Tokyo Forests (UTokyo Forests) 6 months after the Fukushima accident was previously reported (Yamada 2013, Yamada *et al.* 2013); a part of the radiocesium detected, namely ^{137}Cs , would have originated from the Chernobyl nuclear accident in 1986 and atmospheric nuclear weapons testing that occurred between 1952-1981. No radiocesium from the Fukushima nuclear accident was detected in UTHF (Hokkaido) and ERI

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(Aichi) (Table 1). Herein, we report the results of a 6-year survey (2011-2016) of radiocesium contamination of wild mushrooms and their presumptive substrates (litter, soil or wood debris) to better understand the dynamics of radiocesium in the forest ecosystem.

2. Materials and Methods

2.1. Sampling sites and sample collection

Mushrooms and their presumptive substrates were collected each autumn between 2011 and 2016. The presumptive substrates were the O horizon (organic litter layer, referred to as the A₀ horizon in Japan), the A horizon (mineral layer and accumulated organic matter), and the Ch horizon (mineral layer with organic matter, which is not affected by pedogenic processes); mushrooms were also collected from logs. The number of UTokyo forests where mushrooms were collected and the year of sampling were 6, 5 and 4 in 2011, 2012 and 2013-2016, respectively (Table 1). One to several mushrooms were collected from each site depending on their size and number of collectable mushrooms.

Table 1. University of Tokyo Forests where samples were collected

University Forest	Abbreviation	Distance from Fukushima Daiichi nuclear power plant	Years of sample collection
The University of Tokyo Hokkaido Forest	Hokkaido, UTHF	660 km	2011 - 2016
The University of Tokyo Chichibu Forest	Chichibu, UTCF	250 km	2011 - 2016
The University of Tokyo Chiba Forest	Chiba, UTCBF	260 km	2011 - 2016
Fuji Iyashinomori Woodland Study Center (formerly Forest Therapy Research Institute, FTRI)	Fuji, FIWSC	300 km	2011 - 2016
Arboricultural Research Institute	Izu, ARI	360 km	2011
Ecohydrology Research Institute	Aichi, ERI	420 km	2011 - 2012

2.2. Measurements

After measuring the fresh weight (FW) of samples, each was dried at 105 °C for 24 h or to equivalent extent of drying, then the dry weight (DW) was determined. Moisture content (MC) was calculated as follows: MC (%) = 100 (FW-DW)/FW. Samples were placed in a 100 mL U8 type polystyrene container and concentrations of ¹³⁴Cs, ¹³⁷Cs and ⁴⁰K were determined using a germanium semiconductor detector (GEM-type, ORTEC, SEIKO EG&G, Tokyo, Japan). The gamma ray energies used to measure ¹³⁴Cs, ¹³⁷Cs and ⁴⁰K activities were 604.7, 661.6 and 1460.8 keV, respectively. These results are presented in Table 2.

Gamma ray air dose rates (μSv/h) were measured at 0.1 m and 1.0 m above ground level at the sampling sites located in Hokkaido, Chichibu, Fuji and Chiba using a dose rate meter (TC100S, Techno AP Co. Ltd., Japan) with a CsI (Tl) scintillation detector. These results are shown in Table 3.

References

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Table 2. Radiocesium activity in wild mushrooms and their substrates

Sampling site		2011							Radioactivity concentration		
University	Forest	Forest compartment / Experimental field (Area)	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)	(Bq / kg DW)		
									¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K
Hokkaido	7		Oshiroishimeji	Mushroom	21-Oct	353.8	33.5	90.5	ND	62	1,320
			<i>Leucocybe connata</i>	O horizon	21-Oct	44.8	16.0	64.2	ND	ND	ND
				A horizon	21-Oct	126.7	92.8	26.7	ND	9	648
	74		Hanaiguchi	Mushroom	12-Oct	456.9	21.5	95.3	ND	31	1,420
			<i>Suillus grevillei</i>	O horizon	12-Oct	24.0	10.0	58.3	ND	ND	ND
				A horizon	12-Oct	126.0	90.2	28.5	ND	ND	607
Chichibu	27 (Tochimoto)		Dokubenitake	Mushroom							
			<i>Russula emetica</i>	O horizon							
				A horizon							
	27 (Tochimoto)		Oomiyamatobimai	Mushroom	28-Oct	78.5	16.3	79.2	102	154	604
			<i>Bondarzewia berkeleyi</i>	Wood							
				O horizon	28-Oct	5.7	5.0	11.4	1,730	2,230	ND
			A horizon	28-Oct	113.5	80.3	29.3	24	56	689	
	27 (Tochimoto)		Fuusentakake (Genus)	Mushroom							
			<i>Cortinarius</i> sp.	O horizon							
				A horizon							
	27 (Tochimoto)		Kotengutakemodoki	Mushroom							
			<i>Amanita pseudoporphyria</i>	O horizon							
				A horizon							
	27 (Tochimoto)		Oofukurotake	Mushroom							
			<i>Volvopluteus gloiocephalus</i>								
	27 (Tochimoto)		Dokubenitake	Mushroom							
			<i>Russula emetica</i>								
	20 (Tochimoto)		Yamabushitake	Mushroom							
			<i>Hericium erinaceus</i>	Wood							
	19 (Tochimoto)		Mukitake	Mushroom	15-Nov	208.0	28.7	86.2	492	706	572
<i>Sarcomyxa edulis</i>			Bark					Included in wood sample			
			Wood						61	51	ND
			O horizon	15-Nov	7.5	6.9	8.3	1,780	2,480	ND	
			A horizon	15-Nov	113.0	80.9	28.4	58	95	568	
Kuroishi		Mineshimeji	Mushroom	28-Oct	164.8	35.6	78.4	162	233	1,010	
		<i>Tricholoma saponaceum</i>	O horizon	28-Oct	24.3	14.4	40.8	1,200	1,640	ND	
			A horizon	28-Oct	112.9	90.4	20.0	ND	ND	330	
Kuroishi		Tengutake	Mushroom								
		<i>Amanita pantherina</i>	O horizon								
			A horizon								
1 (Oochigawa)		Kawaratake	Mushroom	18-Nov	16.3	14.2	13.0	67	89	ND	
		<i>Trametes versicolor</i>	Bark					Included in wood sample			
			Wood	18-Nov	-	18.7	-	ND	44	ND	
			O horizon	18-Nov	9.4	7.3	22.3	1,020	1,440	ND	
			A horizon	18-Nov	124.9	71.8	42.6	116	198	476	
1 (Oochigawa)		Amatake	Mushroom								
		<i>Gymnopus confluens</i>	O horizon								
		A horizon									
1 (Oochigawa)		Tuchisugitake	Mushroom								
		<i>Pholiota terrestris</i>									
Chiba	47 (Kiyosumi)		Oomomitake	Mushroom							
			<i>Catathelasma imperiale</i>	O horizon							
				A horizon							
	27 (Fudago)		Oomomitake	Mushroom	7-Oct	175.7	39.0	77.8	ND	ND	802
			<i>Catathelasma imperiale</i>	O horizon	7-Oct	41.6	25.3	39.2	261	377	ND
				A horizon	7-Oct	108.9	79.5	27.0	ND	19	276
8 (Godai)		Oomomitake	Mushroom	4-Oct	158.0	32.2	79.6	ND	77	860	
		<i>Catathelasma imperiale</i>	O horizon	4-Oct	31.7	24.0	24.2	280	398	ND	
			A horizon	4-Oct	85.8	65.2	24.0	46	126	229	

ND, not detected

Table 2. Radiocesium activity in wild mushrooms and their substrates (continued)

Sampling site		2011									
University Forest	Forest compartment / Experimental field (Area)	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)	Radioactivity concentration (Bq / kg DW)			
								¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K	
Fuji	I	Tamagotake	Mushroom								
		<i>Amanita caesareoides</i>									
		Honshimeji	Mushroom								
		<i>Lyophyllum shimeji</i>									
			O horizon								
			Ch horizon								
	I		Naratake	Mushroom							
		<i>Armillaria mellea</i>									
			Bark								
			Wood								
		Shiitake	Mushroom								
		<i>Lentinula edodes</i>									
		Nameko	Mushroom								
		<i>Pholiota microspora</i>									
		Hiratake	Mushroom	23-Oct	339.0	17.5	94.8	ND	ND	708	
		<i>Pleurotus ostreatus</i>									
			Bark	28-Nov	44.0	22.8	48.2	ND	34	ND	
			Wood	28-Nov	36.0	20.7	42.5	ND	ND	ND	
			O horizon								
			Ch horizon								
	I		Hanaiguchi	Mushroom	23-Oct	180.0	8.5	95.3	137	714	2,040
		<i>Suillus grevillei</i>									
			O horizon	28-Nov	33.0	9.8	70.3	281	340	ND	
		Ch horizon	28-Nov	72.0	51.0	29.2	ND	21	215		
I		Kuritake	Mushroom								
	<i>Hypholoma lateritium</i>										
		Bark									
		Wood									
II, lakeside		Numeriguchi	Mushroom								
	<i>Suillus luteus</i>										
	Hatsutake	Mushroom									
	<i>Lactarius lividatus</i>										
		O horizon									
		Ch horizon									
II, lakeside		Kugitake	Mushroom								
	<i>Chroogomphus rutilus</i>										
		O horizon									
		Ch horizon									
II		Chanametsumutake	Mushroom	1-Nov	266.0	24.4	90.8	1,070	1,630	878	
	<i>Pholiota lubrica</i>										
		O horizon									
		Ch horizon									
	Shironumeriguchi	Mushroom									
	<i>Suillus viscidus</i>										
	Hanaiguchi	Mushroom	23-Oct	36.0	1.7	95.3	183	737	1,470		
	<i>Suillus grevillei</i>										
		O horizon	28-Nov	39.0	10.7	72.6	146	237	389		
		Ch horizon	28-Nov	75.0	47.3	36.9	ND	44	295		
III		Chanametsumutake	Mushroom	7-Nov	53.0	3.1	94.2	1,840	2,440	ND	
	<i>Pholiota lubrica</i>										
	Akamomitake	Mushroom									
	<i>Lactarius laeticolor</i>										
		O horizon	28-Nov	34.0	9.4	72.4	168	267	ND		
		Ch horizon	28-Nov	83.0	20.5	75.3	ND	59	603		
ARI	2 (Aono)	Shiitake	Mushroom	9-Nov	189.6	19.1	89.9	ND	68	1,140	
	<i>Lentinula edodes</i>										
		Bark	9-Nov	45.3	33.4	26.4	ND	ND	ND		
		Wood	9-Nov	32.8	19.2	41.2	ND	ND	ND		
	2 (Aono)	Shiitake	Mushroom	9-Nov	276.7	14.5	94.8	53	78	1,150	
	<i>Lentinula edodes</i>										
ERI	61 (Akazu)	Naratake	Mushroom	27-Oct	105.5	10.3	90.2	ND	ND	1,870	
	<i>Armillaria mellea</i>										
		Bark	27-Oct	48.2	21.5	55.3	ND	ND	ND		
		Wood	27-Oct	47.6	12.2	74.4	ND	ND	ND		
		O horizon	27-Oct	42.8	20.2	52.8	ND	ND	977		
		A horizon	27-Oct	127.0	93.7	26.2	ND	9	1,060		
	24 (Inuyama)	Karakasatake	Mushroom	27-Oct	33.3	8.7	73.8	ND	ND	783	
	<i>Macrolepiota procera</i>										
		O horizon	27-Oct	12.9	10.2	20.6	ND	ND	90		
		A horizon	27-Oct	117.7	102.5	12.9	ND	ND	934		

ND, not detected

Table 2. Radiocesium activity in wild mushrooms and their substrates (continued)

Sampling site			2012						Radioactivity concentration		
University	Forest compartment / Forest	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)	(Bq / kg DW)			
								¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K	
Hokkaido	7	Oshiroishimeji <i>Leucocybe connata</i>	Mushroom	15-Oct	547.0	34.0	93.8	ND	35	1,460	
			O horizon	15-Oct	67.4	23.0	65.9	ND	ND	ND	
			A horizon	15-Oct	123.5	91.0	26.3	ND	ND	616	
	74	Hanaiguchi <i>Suillus grevillei</i>	Mushroom	15-Oct	587.0	27.0	95.4	ND	20	1,400	
			O horizon	15-Oct	25.8	14.0	45.8	ND	ND	ND	
			A horizon	15-Oct	134.4	98.0	27.1	ND	ND	510	
Chichibu	27 (Tochimoto)	Dokubenitake <i>Russula emetica</i>	Mushroom								
			O horizon								
			A horizon								
	27 (Tochimoto)	Oomiyamatobimai <i>Bondarzewia berkeleyi</i>	Mushroom								
			Wood								
			O horizon								
	27 (Tochimoto)	Fuusentakake (Genus) <i>Cortinarius</i> sp.	Mushroom								
			O horizon								
			A horizon								
	27 (Tochimoto)	Kotengutakemodoki <i>Amanita pseudoporphyria</i>	Mushroom								
			O horizon								
			A horizon								
	27 (Tochimoto)	Oofukurotake <i>Volvopluteus gloiocephalus</i>	Mushroom								
			O horizon								
			A horizon								
	27 (Tochimoto)	Dokubenitake <i>Russula emetica</i>	Mushroom								
			O horizon								
			A horizon								
20 (Tochimoto)	Yamabushitake <i>Hericum erinaceus</i>	Mushroom									
		Wood									
		O horizon									
19 (Tochimoto)	Mukitake <i>Sarcomyxa edulis</i>	Mushroom									
		Bark									
		Wood									
		O horizon									
Kuroishi	Mineshimeji <i>Tricholoma saponaceum</i>	Mushroom	30-Oct	190.8	21.7	88.6	32	74	1,377		
		O horizon	30-Oct	33.0	16.9	48.7	685	1,254	248		
		A horizon	30-Oct	124.6	105.1	15.7	9	22	374		
Kuroishi	Tengutake <i>Amanita pantherina</i>	Mushroom									
		O horizon									
		A horizon									
1 (Oochigawa)	Kawaratake <i>Trametes versicolor</i>	Mushroom	30-Oct	3.3	1.0	69.2	ND	249	ND		
		Bark	30-Oct	21.5	11.0	48.6	347	645	ND		
		Wood	30-Oct	18.0	4.3	76.3	ND	ND	ND		
		O horizon									
1 (Oochigawa)	Amatake <i>Gymnopus confluens</i>	Mushroom									
		O horizon									
		A horizon									
1 (Oochigawa)	Tuchisugitake <i>Pholiota terrestris</i>	Mushroom									
		O horizon									
Chiba	47 (Kiyosumi)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom	9-Oct	362.8	26.9	92.6	ND	23	1,450	
			O horizon	9-Oct	46.3	23.5	49.2	51	110	ND	
			A horizon	9-Oct	85.0	48.8	42.6	125	264	492	
	27 (Fudago)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom	9-Oct	353.2	33.5	90.5	ND	32	905	
			O horizon	9-Oct	63.7	28.4	55.4	142	255	ND	
			A horizon	9-Oct	95.7	48.9	48.9	99	207	247	
	8 (Godai)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom	9-Oct	450.9	34.1	92.4	22	108	1,190	
			O horizon	9-Oct	54.0	26.3	51.3	102	195	ND	
			A horizon	9-Oct	93.0	48.7	47.6	126	312	306	

ND, not detected

Table 2. Radiocesium activity in wild mushrooms and their substrates (continued)

Sampling site		2012									
University	Forest compartment / Experimental field (Area)	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)	Radioactivity concentration (Bq / kg DW)			
								¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K	
Fuji	I	Tamagotake	Mushroom								
		<i>Amanita caesareoides</i>									
		Honshimeji	Mushroom								
		<i>Lyophyllum shimeji</i>									
				O horizon							
				Ch horizon							
	I	Naratake	Mushroom	6-Oct	145.0	9.0	93.8	289	554	2,620	
			<i>Armillaria mellea</i>								
			Bark	28-Nov	28.0	13.0	53.6	ND	49	ND	
			Wood	28-Nov	37.0	12.0	67.6	ND	ND	ND	
			Shiitake	Mushroom	6-Oct	295.0	28.0	90.5	ND	49	570
			<i>Lentinula edodes</i>								
			Nameko	Mushroom	20-Oct	316.0	16.0	94.9	ND	77	1,010
			<i>Pholiota microspora</i>								
			Hiratake	Mushroom	5-Nov	202.0	16.0	92.1	ND	74	979
			<i>Pleurotus ostreatus</i>								
				Bark	28-Nov	25.0	12.0	52.0	485	990	ND
				Wood	28-Nov	32.0	12.0	62.5	ND	ND	ND
			O horizon	28-Nov	38.0	10.0	73.7	134	224	ND	
			Ch horizon	28-Nov	116.0	89.0	23.3	ND	14	203	
	I	Hanaiguchi	Mushroom	8-Oct	263.0	14.0	94.7	239	1,008	ND	
			<i>Suillus grevillei</i>								
			O horizon	28-Nov	48.0	14.0	70.8	193	336	ND	
			Ch horizon	28-Nov	91.0	65.0	28.6	ND	18	219	
I	Kuritake	Mushroom	20-Oct	75.0	4.0	94.7	297	561	1,630		
		<i>Hypholoma lateritium</i>									
		Bark	28-Nov	55.0	21.0	61.8	80	139	ND		
		Wood	28-Nov	28.0	12.0	57.1	ND	ND	ND		
II, lakeside	Numeriiguchi	Mushroom									
		<i>Suillus luteus</i>									
	Hatsutake	Mushroom									
	<i>Lactarius lividatus</i>										
			O horizon								
			Ch horizon								
II, lakeside	Kugitake	Mushroom									
		<i>Chroogomphus rutilus</i>									
		O horizon									
			Ch horizon								
II	Chanametsumutake	Mushroom	29-Oct	117.0	5.0	95.7	625	929	2,490		
		<i>Pholiota lubrica</i>									
		O horizon	28-Nov	62.0	24.0	61.3	94	220	203		
		Ch horizon	28-Nov	100.0	69.0	31.0	ND	29	171		
		Shironumeriiguchi	Mushroom								
	<i>Suillus viscidus</i>										
		Hanaiguchi	Mushroom	29-Oct	131.0	6.0	95.4	ND	477	1,570	
	<i>Suillus grevillei</i>										
		O horizon	28-Nov	42.0	16.0	61.9	120	220	ND		
		Ch horizon	28-Nov	89.0	69.0	22.5	ND	23	153		
III	Chanametsumutake	Mushroom	5-Nov	34.0	2.0	94.1	2,066	3,769	3,340		
		<i>Pholiota lubrica</i>									
	Akamomitake	Mushroom									
	<i>Lactarius laeticolor</i>										
		O horizon	28-Nov	73.0	25.0	65.8	65	124	ND		
	Ch horizon	28-Nov	84.0	56.0	33.3	ND	32	264			
ARI	2 (Aono)	Shiitake	Mushroom								
		<i>Lentinula edodes</i>									
		Bark									
		Wood									
2 (Aono)	Shiitake	Mushroom									
		<i>Lentinula edodes</i>									
ERI	61 (Akazu)	Naratake	Mushroom	9-Oct	267.8	32.9	87.7	ND	ND	882	
		<i>Armillaria mellea</i>									
		Bark	9-Oct	100.6	47.7	52.6	ND	ND	ND		
		Wood	9-Oct	251.7	53.8	78.6	ND	ND	ND		
		O horizon									
		A horizon									
24 (Inuyama)	Karakasatake	Mushroom									
		<i>Macrolepiota procera</i>									
		O horizon									
	A horizon										

ND, not detected

Table 2. Radiocesium activity in wild mushrooms and their substrates (continued)

Sampling site		2013								Radioactivity concentration (Bq / kg DW)		
University	Forest Forest	Forest Experimental field (Area)	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)				
									¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K	
Hokkaido	7		Oshiroishimeji	Mushroom	9-Oct	385.7	44.6	88.4	ND	69	1,290	
			<i>Leucocybe connata</i>	O horizon	9-Oct	55.5	29.3	47.2	ND	ND	382	
				A horizon	9-Oct	140.0	111.9	20.1	ND	ND	664	
	74		Hanaiguchi	Mushroom	15-Oct	672.9	36.8	94.5	ND	15	899	
			<i>Suillus grevillei</i>	O horizon	15-Oct	77.2	51.2	33.7	ND	ND	324	
				A horizon	15-Oct	147.2	122.4	16.8	ND	ND	445	
Chichibu	27 (Tochimoto)		Dokubenitake	Mushroom	24-Oct	72.8	1.6	97.8	9,011	23,361	ND	
			<i>Russula emetica</i>	O horizon	24-Oct	12.0	3.7	69.1	1,614	3,877	528	
				A horizon	24-Oct	74.0	29.8	59.7	159	478	ND	
	27 (Tochimoto)		Omiyamatonbimai	Mushroom								
			<i>Bondarzewia berkeleyi</i>	Wood								
				O horizon								
	27 (Tochimoto)		Fuusentakake (Genus)	Mushroom								
			<i>Cortinarius</i> sp.	O horizon								
				A horizon								
	27 (Tochimoto)		Kotengutakemodoki	Mushroom								
			<i>Amanita pseudoporphyria</i>	O horizon								
				A horizon								
	27 (Tochimoto)		Oofukurotake	Mushroom								
			<i>Volvopluteus gloiocephalus</i>									
	27 (Tochimoto)		Dokubenitake	Mushroom								
			<i>Russula emetica</i>									
	20 (Tochimoto)		Yamabushitake	Mushroom								
			<i>Hericium erinaceus</i>	Wood								
	19 (Tochimoto)		Mukitake	Mushroom	25-Oct	242.3	13.6	94.4	52	156	1,060	
			<i>Sarcomyxa edulis</i>	Bark	25-Oct	28.0	18.9	32.6	ND	82	ND	
				Wood	25-Oct	15.8	10.3	34.9	ND	ND	ND	
O horizon												
			A horizon									
Kuroishi		Mineshimeji	Mushroom	6-Nov	150.4	13.3	91.2	ND	ND	1,600		
		<i>Tricholoma saponaceum</i>	O horizon	6-Nov	33.4	13.4	59.9	372	922	ND		
			A horizon	6-Nov	101.5	78.1	23.0	47	122	338		
Kuroishi		Tengutake	Mushroom									
		<i>Amanita pantherina</i>	O horizon									
			A horizon									
1 (Oochigawa)		Kawaratake	Mushroom	31-Oct	11.5	6.6	42.7	ND	193	ND		
		<i>Trametes versicolor</i>	Bark	31-Oct	18.3	11.7	36.0	281	921	ND		
			Wood	31-Oct	27.7	5.7	79.4	ND	ND	ND		
			O horizon									
			A horizon									
1 (Oochigawa)		Amatake	Mushroom									
		<i>Gymnopus confluens</i>	O horizon									
			A horizon									
1 (Oochigawa)		Tuchisugitake	Mushroom									
		<i>Pholiota terrestris</i>										
Chiba	47 (Kiyosumi)		Oomomitake	Mushroom								
			<i>Catathelasma imperiale</i>	O horizon								
				A horizon								
	27 (Fudago)		Oomomitake	Mushroom	8-Oct	343.9	26.9	92.2	ND	ND	1,330	
			<i>Catathelasma imperiale</i>	O horizon	8-Oct	68.2	34.1	50.0	56	157	163	
				A horizon	8-Oct	106.4	77.3	27.3	31	90	394	
	8 (Godai)		Oomomitake	Mushroom	8-Oct	282.4	28.5	89.9	ND	ND	881	
<i>Catathelasma imperiale</i>			O horizon	8-Oct	91.5	30.8	66.4	233	605	ND		
			A horizon	8-Oct	103.0	65.4	36.6	16	83	240		

ND, not detected

Table 2. Radiocesium activity in wild mushrooms and their substrates (continued)

Sampling site			2013							Radioactivity concentration		
University	Forest compartment / Experimental field (Area)	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)	(Bq / kg DW)				
								¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K		
Fuji	I	Tamagotake	Mushroom	24-Sep	215.0	20.0	90.7	210	1,057	1,530		
		<i>Amanita caesareoides</i>										
		Honshimeji	Mushroom	30-Sep	41.0	6.1	85.1	449	3,051	1,530		
		<i>Lyophyllum shimeji</i>										
		O horizon	12-Nov	36.0	12.0	66.7	114	330	ND			
		Ch horizon	12-Nov	67.0	50.0	25.4	ND	51	ND			
		I	Naratake	Mushroom	2-Oct	102.0	6.3	93.8	177	544	2,090	
			<i>Armillaria mellea</i>									
			Bark				Common with following 3 mushroom species					
			Wood				Common with following 3 mushroom species					
			Shiitake	Mushroom	30-Sep	82.0	9.6	88.3	ND	38	ND	
			<i>Lentinula edodes</i>									
			Nameko	Mushroom	7-Oct	136.0	9.0	93.4	ND	90	ND	
			<i>Pholiota microspora</i>									
			Hiratake	Mushroom	30-Oct	174.0	10.5	94.0	ND	54	1,210	
			<i>Pleurotus ostreatus</i>									
			Bark	12-Nov	34.0	13.0	61.8	ND	45	ND		
			Wood	12-Nov	32.0	7.2	77.5	ND	ND	ND		
			O horizon									
			Ch horizon									
I		Hanaiguchi	Mushroom	2-Oct	180.0	10.5	94.2	149	705	1,290		
		<i>Suillus grevillei</i>										
		O horizon	12-Nov	30.0	7.8	74.0	ND	280	ND			
		Ch horizon	12-Nov	73.0	54.0	26.0	ND	26	180			
I		Kuritake	Mushroom									
		<i>Hypholoma lateritium</i>										
		Bark										
		Wood										
II, lakeside		Numeriiguchi	Mushroom	24-Sep	201.0	20.6	89.8	61	353	914		
		<i>Suillus luteus</i>										
		Hatsutake	Mushroom	24-Sep	155.0	17.9	88.5	721	1,853	752		
		<i>Lactarius lividatus</i>										
		O horizon	12-Nov	41.0	21.0	48.8	42	183	ND			
		Ch horizon	12-Nov	66.0	42.0	36.4	ND	17	179			
II, lakeside		Kugitake	Mushroom	24-Sep	181.0	23.8	86.9	41	185	1,080		
		<i>Chroogomphus rutilus</i>										
		O horizon	12-Nov	32.0	10.2	68.1	ND	279	ND			
		Ch horizon	12-Nov	58.0	42.0	27.6	ND	59	ND			
II		Chanametsumutake	Mushroom	17-Oct	76.0	5.1	93.3	470	1,148	ND		
		<i>Pholiota lubrica</i>										
		O horizon			Common with following 2 mushroom species							
		Ch horizon			Common with following 2 mushroom species							
		Shironumeriiguchi	Mushroom	3-Oct	165.0	8.0	95.2	ND	188	1,200		
		<i>Suillus viscidus</i>										
		Hanaiguchi	Mushroom	3-Oct	252.0	16.0	93.7	ND	100	1,570		
		<i>Suillus grevillei</i>										
		O horizon	12-Nov	35.0	12.0	65.7	52	154	ND			
		Ch horizon	12-Nov	61.0	37.0	39.3	ND	74	141			
III		Chanametsumutake	Mushroom	24-Oct	92.0	4.7	94.9	792	1,923	1,490		
		<i>Pholiota lubrica</i>										
		Akamomitake	Mushroom	17-Oct	57.0	4.6	91.9	378	1,420	ND		
		<i>Lactarius laeticolor</i>										
		O horizon	13-Nov	43.0	15.0	65.1	ND	189	ND			
		Ch horizon	13-Nov	76.0	53.0	30.3	ND	20	136			
ARI	2 (Aono)	Shiitake	Mushroom									
		<i>Lentinula edodes</i>										
		Bark										
		Wood										
	2 (Aono)	Shiitake	Mushroom									
		<i>Lentinula edodes</i>										
ERI	61 (Akazu)	Naratake	Mushroom									
		<i>Armillaria mellea</i>										
		Bark										
		Wood										
		O horizon										
		A horizon										
24 (Inuyama)	Karakasatake		Mushroom									
		<i>Macrolepiota procera</i>										
		O horizon										
		A horizon										

ND, not detected

Table 2. Radiocesium activity in wild mushrooms and their substrates (continued)

Sampling site		2014								
University	Forest compartment / Experimental field (Area)	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)	Radioactivity concentration (Bq / kg DW)		
								¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K
Hokkaido	7	Oshiroishimeji <i>Leucocybe connata</i>	Mushroom	1-Oct	483.5	32.7	93.2	ND	13	1,230
			O horizon	1-Oct	73.0	25.2	65.5	ND	12	222
			A horizon	1-Oct	120.1	91.4	23.9	ND	8	602
	74	Hanaiguchi <i>Suillus grevillei</i>	Mushroom	1-Oct	389.2	30.9	92.1	ND	13	1,080
			O horizon	1-Oct	50.8	20.9	58.9	ND	5	267
			A horizon	1-Oct	112.7	103.6	8.1	ND	6	470
Chichibu	27 (Tochimoto)	Dokubenitake <i>Russula emetica</i>	Mushroom							
			O horizon							
			A horizon							
	27 (Tochimoto)	Oomiyamatonbimai <i>Bondarzewia berkeleyi</i>	Mushroom							
			Wood							
			O horizon							
	27 (Tochimoto)	Fuusentakake (Genus) <i>Cortinarius</i> sp.	Mushroom							
			O horizon							
			A horizon							
	27 (Tochimoto)	Kotengutakemodoki <i>Amanita pseudoporphyria</i>	Mushroom							
			O horizon							
			A horizon							
	27 (Tochimoto)	Oofukurotake <i>Volvolpluteus gloiocephalus</i>	Mushroom							
	27 (Tochimoto)	Dokubenitake <i>Russula emetica</i>	Mushroom							
20 (Tochimoto)	Yamabushitake <i>Hericium erinaceus</i>	Mushroom								
		Wood								
19 (Tochimoto)	Mukitake <i>Sarcomyxa edulis</i>	Mushroom	16-Oct	121.7	7.8	93.6	ND	166	1,250	
		Bark		Included in wood sample						
		Wood	16-Oct	27.7	6.2	77.6	ND	ND	ND	
		O horizon								
		A horizon								
Kuroishi	Mineshimeji <i>Tricholoma saponaceum</i>	Mushroom	30-Oct	94.2	8.1	91.4	ND	64	2,000	
		O horizon	30-Oct	42.3	21.7	48.7	181	769	288	
		A horizon	30-Oct	87.6	59.7	31.8	93	384	431	
Kuroishi	Tengutake <i>Amanita pantherina</i>	Mushroom								
		O horizon								
		A horizon								
1 (Oochigawa)	Kawaratake <i>Trametes versicolor</i>	Mushroom	30-Oct	12.3	7.0	43.3	79	204	ND	
		Bark		Included in wood sample						
		Wood	30-Oct	18.6	8.9	52.1	ND	58	ND	
		O horizon								
		A horizon								
1 (Oochigawa)	Amatake <i>Gymnopus confluens</i>	Mushroom								
		O horizon								
		A horizon								
1 (Oochigawa)	Tuchisugitake <i>Pholiota terrestris</i>	Mushroom								
Chiba	47 (Kiyosumi)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom							
			O horizon							
			A horizon							
	27 (Fudago)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom	18-Sep	251.3	26.8	89.3	ND	32	1,040
			O horizon	18-Sep	52.1	29.5	43.3	27	137	ND
			A horizon	18-Sep	99.9	78.1	21.8	12	59	308
8 (Godai)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom	18-Sep	236.7	36.5	84.6	ND	113	875	
		O horizon	18-Sep	56.2	23.3	58.5	32	206	ND	
		A horizon	18-Sep	102.1	70.7	30.8	20	89	215	

ND, not detected

Table 2. Radiocesium activity in wild mushrooms and their substrates (continued)

Sampling site		2014										
University Forest	Forest compartment / Experimental field (Area)	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)	Radioactivity concentration (Bq / kg DW)				
								¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K		
Fuji	I	Tamagotake <i>Amanita caesareoides</i>	Mushroom	18-Sep	32.0	2.0	93.8	297	1,396	ND		
		Honshimeji <i>Lyophyllum shimeji</i>	Mushroom									
			O horizon	18-Sep	40.0	13.0	67.5	64	272	ND		
			Ch horizon	18-Sep	56.0	40.0	28.6	ND	33	130		
		I	Naratake <i>Armillaria mellea</i>	Mushroom	27-Sep	104.0	7.0	93.3	ND	410	1,210	
				Bark		Common with following 3 mushroom species						
			Shiitake <i>Lentinula edodes</i>	Mushroom	3-Oct	106.0	7.0	93.4	ND	133	1,600	
			Nameko <i>Pholiota microspora</i>	Mushroom	14-Oct	104.0	6.0	94.2	ND	598	1,290	
			Hiratake <i>Pleurotus ostreatus</i>	Mushroom	25-Oct	141.0	8.0	94.3	ND	52	962	
				Bark	14-Oct	29.0	13.0	55.2	ND	13	ND	
				Wood	14-Oct	26.0	5.0	80.8	ND	13	ND	
				O horizon								
				Ch horizon								
		I	Hanaiguchi <i>Suillus grevillei</i>	Mushroom	27-Sep	213.0	10.0	95.3	86	457	1,570	
				O horizon	27-Sep	26.0	8.0	69.2	ND	324	ND	
				Ch horizon	27-Sep	69.0	52.0	24.6	ND	39	117	
		I	Kuritake <i>Hypholoma lateritium</i>	Mushroom								
				Bark								
				Wood								
		II, lakeside	Numeriiguchi <i>Suillus luteus</i>	Mushroom	16, 27-Sep	107.0	7.0	93.5	338	1,254	1,410	
			Hatsutake <i>Lactarius lividatus</i>	Mushroom	16-Sep	231.0	21.0	90.9	691	2,395	845	
				O horizon	16-Sep	39.0	18.0	53.8	52	225	ND	
				Ch horizon	16-Sep	72.0	59.0	18.1	ND	8	180	
	II, lakeside	Kugitake <i>Chroogomphus rutilus</i>	Mushroom	27-Sep	107.0	9.0	91.6	68	253	1,230		
			O horizon	27-Sep	27.0	8.0	70.4	ND	275	ND		
			Ch horizon	27-Sep	60.0	38.0	36.7	ND	68	241		
	II	Chanametsumutake <i>Pholiota lubrica</i>	Mushroom	9-Oct	35.0	2.0	94.3	ND	582	ND		
			O horizon		Common with following 2 mushroom species							
			Ch horizon		Common with following 2 mushroom species							
			Shironumeriiguchi <i>Suillus viscidus</i>	Mushroom	14-Oct	36.0	2.0	94.4	504	2,558	1,420	
			Hanaiguchi <i>Suillus grevillei</i>	Mushroom	27-Sep	160.0	6.0	96.3	214	1,814	1,450	
				O horizon	9-Oct	45.0	14.0	68.9	ND	94	ND	
				Ch horizon	9-Oct	92.0	51.0	44.6	12	58	189	
		III	Chanametsumutake <i>Pholiota lubrica</i>	Mushroom	14-Oct	23.0	1.0	95.7	515	2,650	ND	
				Akamomitake <i>Lactarius laeticolor</i>	Mushroom	27-Sep	51.0	4.0	92.2	272	1,468	ND
					O horizon	27-Sep	45.0	7.0	84.4	124	460	ND
				Ch horizon	27-Sep	63.0	38.0	39.7	ND	45	198	
ARI	2 (Aono)	Shiitake <i>Lentinula edodes</i>	Mushroom									
			Bark									
			Wood									
	2 (Aono)	Shiitake <i>Lentinula edodes</i>	Mushroom									
ERI	61 (Akazu)	Naratake <i>Armillaria mellea</i>	Mushroom									
			Bark									
			Wood									
			O horizon									
	24 (Inuyama)	Karakasatake <i>Macrolepiota procera</i>	Mushroom									
			O horizon									
			A horizon									

ND, not detected

Table 2. Radiocesium activity in wild mushrooms and their substrates (continued)

Sampling site		2015								
University	Forest compartment / Experimental field (Area)	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)	Radioactivity concentration (Bq / kg DW)		
								¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K
Hokkaido	7	Oshiroishimeji <i>Leucocybe connata</i>	Mushroom	1-Oct	600.0	38.0	93.7	ND	55	101
			O horizon	1-Oct	75.0	20.0	73.3	ND	8	103
			A horizon	1-Oct	133.9	98.0	26.8	ND	6	480
	74	Hanaiguchi <i>Suillus grevillei</i>	Mushroom	1-Oct	555.0	30.0	94.6	ND	11	1,230
			O horizon	1-Oct	50.5	19.0	62.4	ND	ND	ND
			A horizon	1-Oct	135.9	104.0	23.5	ND	3	506
Chichibu	27 (Tochimoto)	Dokubenitake <i>Russula emetica</i>	Mushroom	16-Sep	84.5	7.8	90.8	2,033	8,720	1,270
			O horizon	16-Sep	90.0	28.6	68.2	162	688	ND
			A horizon	16-Sep	114.3	38.4	66.4	96	430	ND
	27 (Tochimoto)	Oomiyamatonbimai <i>Bondarzewia berkeleyi</i>	Mushroom	7-Oct	333.3	44.3	86.7	ND	25	ND
			Wood	7-Oct	398.5	99.8	75.0	ND	8	ND
			O horizon							
	27 (Tochimoto)	Fuusentakake (Genus) <i>Cortinarius</i> sp.	Mushroom	7-Oct	148.4	14.9	90.0	40	65	1,060
			O horizon	7-Oct	334.1	79.6	76.2	ND	20	ND
			A horizon	27-Oct	298.0	219.8	26.2	11	47	236
	27 (Tochimoto)	Kotengutakemodoki <i>Amanita pseudoporphyria</i>	Mushroom							
			O horizon							
			A horizon							
	27 (Tochimoto)	Oofukurotake <i>Volvopluteus gloiocephalus</i>	Mushroom							
	27 (Tochimoto)	Dokubenitake <i>Russula emetica</i>	Mushroom							
	20 (Tochimoto)	Yamabushitake <i>Hericium erinaceus</i>	Mushroom	7-Oct	662.2	105.5	84.1	ND	13	309
			Wood	7-Oct	236.5	49.0	79.3	ND	3	ND
	19 (Tochimoto)	Mukitake <i>Sarcomyxa edulis</i>	Mushroom							
			Bark							
			Wood							
			O horizon							
			A horizon							
	Kuroishi	Mineshimeji <i>Tricholoma saponaceum</i>	Mushroom	22-Oct	222.0	22.2	90.0	27	133	1,350
O horizon			22-Oct	175.7	98.9	43.7	17	64	ND	
A horizon			22-Oct	364.6	291.4	20.1	3	15	102	
Kuroishi	Tengutake <i>Amanita pantherina</i>	Mushroom								
		O horizon								
		A horizon								
1 (Oochigawa)	Kawaratake <i>Trametes versicolor</i>	Mushroom	8-Oct	40.4	31.5	21.9	ND	39	ND	
		Bark	8-Oct	78.2	49.7	36.4	ND	30	ND	
		Wood	8-Oct	109.5	51.9	52.6	ND	3	18	
		O horizon								
1 (Oochigawa)	Amatake <i>Gymnopus confluens</i>	Mushroom								
		O horizon								
		A horizon								
1 (Oochigawa)	Tuchisugitake <i>Pholiota terrestris</i>	Mushroom								
Chiiba	47 (Kiyosumi)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom							
			O horizon							
			A horizon							
	27 (Fudago)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom	16-Sep	457.3	38.0	91.7	ND	17	904
			O horizon	16-Sep	51.6	31.0	40.0	36	184	195
			A horizon	16-Sep	103.3	79.0	23.5	11	54	306
	8 (Godai)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom	16-Sep	359.0	40.0	88.9	15	110	728
			O horizon	16-Sep	48.1	24.0	50.1	44	178	88
			A horizon	16-Sep	90.1	63.0	30.1	16	116	214

ND, not detected

Table 2. Radiocesium activity in wild mushrooms and their substrates (continued)

Sampling site			2015								
University Forest	Forest compartment / Experimental field (Area)	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)	Radioactivity concentration (Bq / kg DW)			
								¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K	
Fuji	I	Tamagotake <i>Amanita caesareoides</i>	Mushroom	20, 25-Sep	21.0	1.0	95.2	ND	1,052	3,500	
			Honshimeji <i>Lyophyllum shimeji</i>	Mushroom							
		O horizon		20, 25-Sep	30.0	10.0	66.7	46	323	ND	
		Ch horizon	20, 25-Sep	61.0	43.0	29.5	ND	49	95		
		Naratake <i>Armillaria mellea</i>	Mushroom	28-Sep	78.0	5.0	93.6	130	490	1,610	
			Bark		Common with following 3 mushroom species						
			Wood		Common with following 3 mushroom species						
			Shiitake	Mushroom	28-Sep	97.0	5.0	94.8	ND	64	985
			<i>Lentinula edodes</i>								
			Nameko	Mushroom	15-Oct	120.0	9.0	92.5	ND	106	903
			<i>Pholiota microspora</i>								
			Hiratake	Mushroom	28-Sep	103.0	7.0	93.2	ND	34	725
			<i>Pleurotus ostreatus</i>								
			Bark	15-Oct	29.0	20.0	31.0	ND	6	ND	
		Wood	15-Oct	39.0	3.0	92.3					
		O horizon									
		Ch horizon									
		I	Hanaiguchi <i>Suillus grevillei</i>	Mushroom	25-Sep	115.0	6.0	94.8	ND	318	1,470
				O horizon	25-Sep	36.0	13.0	63.9	34	222	376
				Ch horizon	25-Sep	72.0	58.0	19.4	ND	35	116
I	Kuritake <i>Hypholoma lateritium</i>	Mushroom									
		Bark									
		Wood									
II, lakeside	Numeriiguchi <i>Suillus luteus</i>	Mushroom	26-Sep	117.0	5.0	95.7	155	999	1,120		
		Hatsutake	Mushroom	20-Sep	108.0	7.0	93.5	383	1,619	1,130	
		<i>Lactarius lividatus</i>									
		O horizon	20-Sep	28.0	11.0	60.7	ND	143	ND		
Ch horizon	20-Sep	78.0	57.0	26.9	ND	20	118				
II, lakeside	Kugitake <i>Chroogomphus rutilus</i>	Mushroom	6-Oct	91.0	9.0	90.1	ND	217	982		
		O horizon	6-Oct	27.0	9.0	66.7	55	193	ND		
		Ch horizon	6-Oct	59.0	46.0	22.0	ND	32	158		
II	Chanametsumutake <i>Pholiota lubrica</i>	Mushroom	14-Oct	77.0	5.0	93.5	ND	274	880		
		O horizon		Common with following 2 mushroom species							
		Ch horizon		Common with following 2 mushroom species							
		Shironumeriiguchi	Mushroom	26-Sep	45.0	2.0	95.6	291	1,487	977	
		<i>Suillus viscidus</i>									
		Hanaiguchi	Mushroom	26-Sep	77.0	3.0	96.1	ND	1,022	2,000	
		<i>Suillus grevillei</i>									
		O horizon	14-Oct	28.0	10.0	64.3	ND	63	240		
		Ch horizon	14-Oct	70.0	44.0	37.1	ND	44	152		
		III	Chanametsumutake <i>Pholiota lubrica</i>	Mushroom	15-Oct	86.0	7.0	91.9	116	845	767
Akamomitake	Mushroom			8, 15-Oct	39.0	7.0	82.1	406	2,023	675	
<i>Lactarius laeticolor</i>											
O horizon	15-Oct			31.0	10.0	67.7	ND	194	ND		
Ch horizon	15-Oct	75.0	52.0	30.7	ND	22	192				
ARI	2 (Aono)	Shiitake	Mushroom								
		<i>Lentinula edodes</i>	Bark								
2 (Aono)	Shiitake <i>Lentinula edodes</i>	Wood									
		Mushroom									
ERI	61 (Akazu)	Naratake <i>Armillaria mellea</i>	Mushroom								
			Bark								
			Wood								
			O horizon								
A horizon											
24 (Inuyama)	Karakasatake <i>Macrolepiota procera</i>	Mushroom									
		O horizon									
		A horizon									

ND, not detected

Table 2. Radiocesium activity in wild mushrooms and their substrates (continued)

Sampling site			2016					Radioactivity concentration		
University	Forest compartment / Forest	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)	(Bq / kg DW)		
								¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K
Hokkaido	7	Oshiroishimeji <i>Leucocybe connata</i>	Mushroom	12-Oct	745.4	51.0	93.2	ND	30	2,410
			O horizon	12-Oct	94.7	27.0	71.5	ND	ND	ND
			A horizon	12-Oct	108.0	54.0	50.0	ND	ND	794
	74	Hanaiguchi <i>Suillus grevillei</i>	Mushroom	12-Oct	653.0	26.0	96.0	ND	19	3,000
			O horizon	12-Oct	73.3	24.0	67.3	ND	ND	536
			A horizon	12-Oct	118.4	68.0	42.6	ND	9	921
Chichibu	27 (Tochimoto)	Dokubenitake <i>Russula emetica</i>	Mushroom	11-Oct	5.8	0.4	93.6	ND	243	ND
			O horizon	11-Oct	39.0	16.7	57.2	36	334	ND
			A horizon	11-Oct	55.1	26.5	52.0	53	444	780
	27 (Tochimoto)	Oomiyamatobimai <i>Bondarzewia berkeleyi</i>	Mushroom							
			Wood							
			O horizon							
	27 (Tochimoto)	Fuusentakake (Genus) <i>Cortinarius sp.</i>	Mushroom							
			O horizon							
			A horizon							
	27 (Tochimoto)	Kotegutakemodoki <i>Amanita pseudoporphyria</i>	Mushroom	17-Oct	154.8	12.2	92.2	121	1,302	2,420
			O horizon	17-Oct	41.7	14.0	66.4	125	954	ND
			A horizon	17-Oct	138.8	60.6	56.4	ND	67	635
	27 (Tochimoto)	Oofukurotake <i>Volvopluteus gloiocephalus</i>	Mushroom	17-Oct	214.4	10.2	95.3	33	399	4,120
	27 (Tochimoto)	Dokubenitake <i>Russula emetica</i>	Mushroom	17-Oct	16.4	1.0	94.1	122	1,166	1,640
	20 (Tochimoto)	Yamabushitake <i>Hericium erinaceus</i>	Mushroom							
			Wood							
	19 (Tochimoto)	Mukitake <i>Sarcomyxa edulis</i>	Mushroom							
			Bark							
			Wood							
			O horizon							
			A horizon							
	Kuroishi	Mineshimeji <i>Tricholoma saponaceum</i>	Mushroom							
O horizon										
A horizon										
Kuroishi	Tengutake <i>Amanita pantherina</i>	Mushroom	13-Oct	135.3	10.5	92.2	36	302	3,300	
		O horizon	13-Oct	57.3	21.2	63.0	31	213	ND	
		A horizon	13-Oct	115.6	79.9	30.8	8	91	503	
1 (Oochigawa)	Kawaratake <i>Trametes versicolor</i>	Mushroom	13-Oct	17.8	12.0	32.8	ND	ND	ND	
		Bark								
		Wood	13-Oct	29.1	16.0	44.9	ND	168	ND	
		O horizon								
1 (Oochigawa)	Amatake <i>Gymnopus confluens</i>	Mushroom	13-Oct	28.8	3.1	89.1	ND	72	1,680	
		O horizon	13-Oct	43.8	11.9	72.9	10	101	ND	
		A horizon	13-Oct	119.5	72.2	39.5	ND	79	1,040	
1 (Oochigawa)	Tuchisugitake <i>Pholiota terrestris</i>	Mushroom	13-Oct	38.1	3.3	91.4	ND	51	2,760	
Chiba	47 (Kiyosumi)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom							
			O horizon							
			A horizon							
	27 (Fudago)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom	3-Oct	-	9.4	-	ND	34	2,520
			O horizon	3-Oct	-	31.8	-	10	68	ND
			A horizon	3-Oct	-	81.2	-	ND	44	727
	8 (Godai)	Oomomitake <i>Catathelasma imperiale</i>	Mushroom	3-Oct	-	19.9	-	6	126	2,150
			O horizon	3-Oct	-	23.9	-	13	43	ND
			A horizon	3-Oct	-	66.1	-	13	119	372

ND, not detected

Table 2. Radiocesium activity in wild mushrooms and their substrates (continued)

Sampling site			2016								
University	Forest compartment / Experimental field (Area)	Collected Mushroom Japanese & Scientific name	Sample	Sampling date	Fresh weight, FW (g)	Dry weight, DW (g)	Moisture content (%)	Radioactivity concentration (Bq / kg DW)			
								¹³⁴ Cs	¹³⁷ Cs	⁴⁰ K	
Fuji	I	Tamagotake	Mushroom	8-Sep	67.0	3.0	95.5	48	841	3,290	
		<i>Amanita caesareoides</i>									
		Honshimeji	Mushroom								
		<i>Lyophyllum shimeji</i>									
				O horizon	7-Nov	31.0	13.0	58.1	33	338	ND
				Ch horizon	7-Nov	59.0	42.0	28.8	ND	43	ND
	I	Naratake	Mushroom	5-Oct	95.0	6.0	93.7	32	349	3,550	
			<i>Armillaria mellea</i>								
				Bark			Common with following 3 mushroom species				
				Wood			Common with following 3 mushroom species				
			Shiitake	Mushroom	26-Oct	167.0	11.0	93.4	ND	53	2,100
			<i>Lentinula edodes</i>								
			Nameko	Mushroom	31-Oct	114.0	6.0	94.7	ND	74	1,670
			<i>Pholiota microspora</i>								
			Hiratake	Mushroom	31-Oct	126.0	7.0	94.4	ND	34	1,750
			<i>Pleurotus ostreatus</i>								
				Bark	7-Nov	19.0	14.0	26.3	ND	7	ND
				Wood	7-Nov	29.0	11.0	62.1	ND	ND	ND
			O horizon								
			Ch horizon								
I	Hanaiguchi	Mushroom	5-Oct	83.0	4.0	95.2	62	776	3,260		
		<i>Suillus grevillei</i>									
		O horizon	7-Nov	33.0	16.0	51.5	19	184	163		
		Ch horizon	7-Nov	66.0	51.0	22.7	ND	17	302		
I	Kuritake	Mushroom									
		<i>Hypholoma lateritium</i>									
		Bark									
		Wood									
II, lakeside	Numeriiguchi	Mushroom	26, 28-Sep	94.0	6.0	93.6	54	578	2,480		
		<i>Suillus luteus</i>									
		Hatsutake	Mushroom	26-Sep	66.0	5.0	92.4	88	945	2,390	
		<i>Lactarius lividatus</i>									
		O horizon	7-Nov	51.0	40.0	21.6	ND	31	304		
		Ch horizon	7-Nov	83.0	70.0	15.7	ND	6	364		
II, lakeside	Kugitake	Mushroom	16, 26-Oct	70.0	7.0	90.0	8	125	1,900		
		<i>Chroogomphus rutilus</i>									
		O horizon	7-Nov	27.0	9.0	66.7	54	410	ND		
		Ch horizon	7-Nov	72.0	57.0	20.8	ND	25	345		
II	Chanametsumutake	Mushroom	31-Oct	167.0	8.0	95.2	34	253	3,000		
		<i>Pholiota lubrica</i>									
			O horizon			Common with following 2 mushroom species					
			Ch horizon			Common with following 2 mushroom species					
		Shironumeriiguchi	Mushroom	5-Oct	89.0	5.0	94.4	89	1,363	2,190	
		<i>Suillus viscidus</i>									
		Hanaiguchi	Mushroom	1-Oct	81.0	4.0	95.1	50	1,292	2,900	
		<i>Suillus grevillei</i>									
			O horizon	7-Nov	38.0	18.0	52.6	ND	75	335	
			Ch horizon	7-Nov	70.0	50.0	28.6	ND	29	410	
III	Chanametsumutake	Mushroom	31-Oct	91.0	4.0	95.6	62	775	3,550		
		<i>Pholiota lubrica</i>									
		Akamomitake	Mushroom	6, 16-Oct	102.0	9.0	91.2	145	1,757	1,250	
		<i>Lactarius laeticolor</i>									
			O horizon	7-Nov	39.0	14.0	64.1	24	226	194	
		Ch horizon	7-Nov	72.0	49.0	31.9	ND	25	423		
ARI	2 (Aono)	Shiitake	Mushroom								
		<i>Lentinula edodes</i>									
		Bark									
		Wood									
2 (Aono)	Shiitake	Mushroom									
		<i>Lentinula edodes</i>									
ERI	61 (Akazu)	Naratake	Mushroom								
		<i>Armillaria mellea</i>									
		Bark									
			Wood								
			O horizon								
		A horizon									
24 (Inuyama)	Karakasatake	Mushroom									
		<i>Macrolepiota procera</i>									
		O horizon									
		A horizon									

ND, not detected

Table 3. Gamma-ray air dose rate of the mushroom collection sites

Sampling site	Gamma ray air dose rate (0.1m)	2012 Spring		2012 Autumn		2013		2014		2015		2016	
		Measuring date	Dose rate ($\mu\text{Sv/h}$)	Measuring date	Dose rate ($\mu\text{Sv/h}$)	Measuring date	Dose rate ($\mu\text{Sv/h}$)	Measuring date	Dose rate ($\mu\text{Sv/h}$)	Measuring date	Dose rate ($\mu\text{Sv/h}$)	Measuring date	Dose rate ($\mu\text{Sv/h}$)
Hokkaido													
University compartment / Forest	Collected mushroom												
Forest field (Area)													
74	<i>Leucocybe connata</i>	21-Jun	0.061	15-Oct	0.06	9-Oct	0.043	1-Oct	0.049	1-Oct	0.036	12-Oct	0.043
	<i>Suillus grevillei</i>	21-Jun	0.047	15-Oct	0.062	15-Oct	0.034	1-Oct	0.041	1-Oct	0.03	12-Oct	0.033
Chichibu													
27 (Tochimoto)	<i>Bondarzewia berkeleyi</i> , <i>Cortinarius sp.</i>	17-Feb	0.109			18-Nov	0.03			27-Oct	0.05	27-Oct	0.022
	<i>Russula emetica</i>												
Kuroishi	<i>Tricholoma saponaceum</i> , <i>Amanita pantherina</i>	17-Feb	0.064			18-Nov	0.04	30-Oct	0.049	22-Oct	0.044	22-Oct	0.041
19 (Tochimoto)	<i>Sarcomyxa edulis</i>	17-Feb	0.11			18-Nov	0.079	30-Oct	0.062				
1 (Oochigawa)	<i>Trametes versicolor</i> , <i>Pholiota terrestris</i> , <i>Gymnopus confluens</i>	17-Feb	0.083			18-Nov	0.067	30-Oct	0.058	8-Oct	0.061	8-Oct	0.044
Chiba													
8 (Godai)	<i>Catathelasma imperiale</i>	23-Apr	0.042			18-Jan-14	0.023	18-Sep	0.016	16-Sep	0.023	5-Jan-17	0.018
27 (Fudago)	<i>Catathelasma imperiale</i>	30-Jan	0.04			18-Jan-14	0.026	18-Sep	0.023	16-Sep	0.021	6-Jan-17	0.019
Fuji													
I	<i>Suillus grevillei</i>	14-May	0.022	5-Nov	0.021	2-Dec	0.017	9-Dec	0.014	24-Nov	0.024	7-Nov	0.014
I	<i>Pleurotus ostreatus</i> , <i>Lentinula edodes</i> , <i>Pholiota microspora</i> , <i>Armillaria mellea</i>	14-May	0.03	5-Nov	0.019	2-Dec	0.016	9-Dec	0.013	24-Nov	0.018	7-Nov	0.02
I	<i>Amanita caesareoides</i> , <i>Lyophyllum shimeji</i> , <i>Hypholoma lateritium</i>			5-Nov	0.022	2-Dec	0.016	9-Dec	0.008	24-Nov	0.02	7-Nov	0.02
II, lakeside	<i>Suillus luteus</i> , <i>Lactarius lividatus</i>					2-Dec	0.011	9-Dec	0.015	24-Nov	0.017	7-Nov	0.02
II, lakeside	<i>Chroogomphus rutilus</i>					2-Dec	0.019	9-Dec	0.021	24-Nov	0.015	7-Nov	0.018
II	<i>Pholiota lubrica</i> , <i>Suillus viscidus</i> , <i>S. grevillei</i>	14-May	0.022	5-Nov	0.027	2-Dec	0.008	9-Dec	0.022	24-Nov	0.014	7-Nov	0.028
III	<i>Pholiota lubrica</i> , <i>Lactarius laeticolor</i>	14-May	0.031	5-Nov	0.014	2-Dec	0.015	9-Dec	0.02	24-Nov	0.013	7-Nov	0.016

Japanese names of mushrooms are shown in Table 2.
2012S, collected in the spring of 2012.

Table 3. Gamma-ray air dose rate of the mushroom collection sites (continued)

Gamma ray air dose rate (1.0m)		2012 Spring		2012 Autumn		2013		2014		2015		2016	
Sampling site	Forest	Measuring date	Dose rate ($\mu\text{Sv/h}$)	Measuring date	Dose rate ($\mu\text{Sv/h}$)	Measuring date	Dose rate ($\mu\text{Sv/h}$)	Measuring date	Dose rate ($\mu\text{Sv/h}$)	Measuring date	Dose rate ($\mu\text{Sv/h}$)	Measuring date	Dose rate ($\mu\text{Sv/h}$)
Hokkaido	7	21-Jun	0.053	15-Oct	0.049	9-Oct	0.047	1-Oct	0.033	1-Oct	0.04	12-Oct	0.034
		21-Jun	0.035	15-Oct	0.043	15-Oct	0.038	1-Oct	0.034	1-Oct	0.038	12-Oct	0.03
Chichibu	27 (Tochimoto)	17-Feb	0.082							7-Oct	0.057	27-Oct	0.042
						18-Nov	0.029						
		17-Feb	0.05			18-Nov	0.047	30-Oct	0.044	22-Oct	0.036	22-Oct	0.032
		17-Feb	0.114			18-Nov	0.081	30-Oct	0.058				
		17-Feb	0.09			18-Nov	0.075	30-Oct	0.051	8-Oct	0.058	8-Oct	0.038
Chiba	8 (Godai)	23-Apr	0.033			18-Jan-14	0.021	18-Sep	0.016	16-Sep	0.023	5-Jan-17	0.019
		30-Jan	0.032			18-Jan-14	0.023	18-Sep	0.025	16-Sep	0.022	6-Jan-17	0.02
Fuji	I	14-May	0.024	5-Nov	0.017	2-Dec	0.015	9-Dec	0.015	24-Nov	0.027	7-Nov	0.007
		14-May	0.019	5-Nov	0.017	2-Dec	0.016	9-Dec	0.013	24-Nov	0.016	7-Nov	0.014
				5-Nov	0.027	2-Dec	0.018	9-Dec	0.009	24-Nov	0.024	7-Nov	0.018
II, lakeside						2-Dec	0.012	9-Dec	0.016	24-Nov	0.015	7-Nov	0.013
II, lakeside						2-Dec	0.016	9-Dec	0.022	24-Nov	0.017	7-Nov	0.014
II		14-May	0.029	5-Nov	0.025	2-Dec	0.009	9-Dec	0.023	24-Nov	0.014	7-Nov	0.014
III		14-May	0.022	5-Nov	0.021	2-Dec	0.009	9-Dec	0.018	24-Nov	0.016	7-Nov	0.017

Japanese names of mushrooms are shown in Table 2.
2012S, collected in the spring of 2012.