Extensive investigation to make contamination maps and understanding of radiation risk for recovery

Tokushi Shibata
Japan Radioisotope Association

1. The time sequence of events
2. Measured quantity and aria
3. Method of soil sampling and car survey
4. Cooperative organization and cooperator
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6. Lifetime exposure in Fukushima and risk
7. Risk in everyday life
8. Summary

Points of the investigation:

- Short life of ^{131}I (8 days).
- An enormous number of soil samples had to be collected.
- All samples should be measured by Ge detectors.
- Many people and organizations had to be involved.

Points for recovery

- Estimation of lifetime exposure and risk
- Risk in everyday life
- Understanding of risk by people in Fukushima

1. The time sequence of events

2011

11 March: Tokyo Electric Power Company Fukushima Daiichi Nuclear Power Plant Accident

16 March: Discussion meeting on supports for the Fukushima accident was held at RCNP(Research Center for Nuclear Physics), Osaka Univ.

4 April: SCJ (Science Council of Japan) released the 2nd emergency recommendation regarding the response to the Great East Japan Earthquake "Regarding the necessity of the investigation of radiation levels after the accident of the Fukushima Daiichi Nuclear Power Plant"

20 April: Joint meeting of Environmental Nuclear Physics and Geoscience on the investigation of soil contamination was held at Univ. of Tokyo

7~8 May: Pilot study(10km×10km mesh) to check the method

26 May: MEXT (Ministry of Education, Culture, Sport, Science and Technology) held the 1st meeting of Review Committee on Preparing the Map of Radiation Dose Rate and Radionuclide Concentration.

6 June～14 June: The first sampling of soil (2 km mesh inside 80 km and 10km mesh from 80 km to 100 km from Nuclear Power Plant)

6 June～13 June: Radiation dose rate survey using car-survey system (KURAMA) which was developed at Research Reactor Institute, Kyoto Univ.

6 June: Gamma-ray measurements started (total ～6600 samples by Universities and Research institutes and ～4400 by Japan Chemical Analysis Center)

27 June～7 July: The second sampling of soil (2 km mesh inside 80 km and 10km mesh from 80 km to 100 km from Nuclear Power Plant)

2 August～31 October: MEXT released air dose rate map, Cs, I, Pu, Sr, Te and Ag deposition map

2. Measured quantity and aria

Sampling

Container of soil sample: U8 container(8 cm ϕ × 5 cm)
Container for depth distribution: Iron pipe(5 cm ϕ ×30 cm)
Number of samples at each mesh point: 5 samples
Mesh size: 2 km × 2 km mesh within 80 km from Fukushima Daiichi Nuclear Power Plant,
10 km × 10 km mesh from 80 km to 100 km
Number of total samples: ～11,000

Measurement

Measurement of dose rate
Radiation dose rate at each mesh point: 1m above at each mesh point by survey meter(μSv/h)
Radiation dose rate by car-survey: Survey meter(KURAMA) (μSv/h)

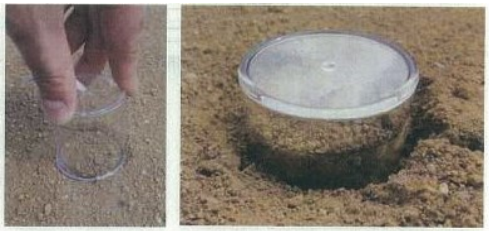
Measurement of soil samples
Measurement method: Gamma-ray spectrum by Ge detector
Measured quantity: Activity concentration(Bq/cm^2)

3. Method of soil sampling and car survey

Method of sampling

Radionuclide distribution in soil was known by a pilot study to be high concentration at the soil surface and decreasing with depth.

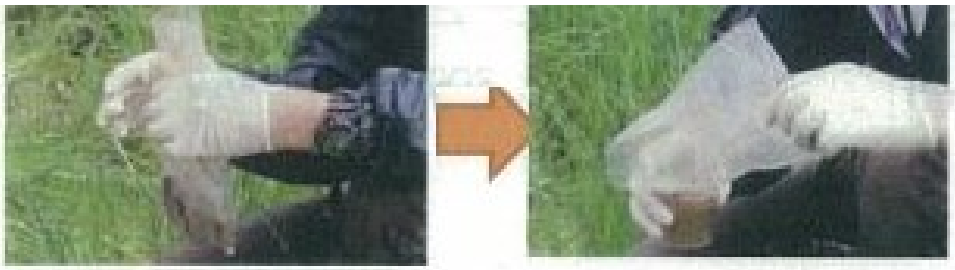
Since calibration source was a volume type uniform source by IAEA, the uniformity of sample was important.



Insert the U8 container into soil

Dig out the U8 container with soil by a shovel

Slice of excess soil from the container



Mix well soil in a plastic bag,
then put soil back into
the U8 container

Wipe out soil attached the U8 container,
then put into a plastic bag

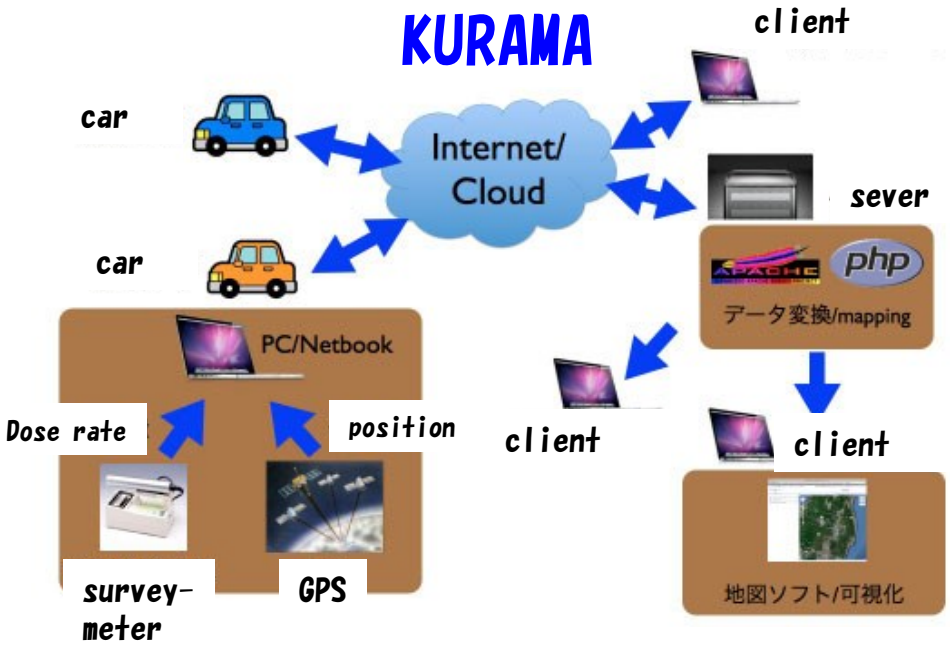
Soil sampling:

First sampling: June 4, 2011 ~ June 14, 2011
(4 and 5 June were trial)
Fukushima, Yamagata, Tochigi Pref.

Second sampling: June 27 ~ June 29
Miyagi, Fukushima(Aizu) Pref.
June 28 ~ July 8
Fukushima(Iwaki), Ibaraki Pref.

Measurement of air-dose rate by car survey

A car survey system (KURAMA) developed by Research Reactor Institute, Kyoto Univ.



The KURAMA system records the air dose rate and position measured by each car.

The distant client can see the measured values and its distribution on a map

Measurement of air-dose rate by car survey

June 4 ～ June 14

Fukushima, Yamagata, Miyagi, Ibaraki Pref.

4. Cooperative organization and cooperator

Participating organization for soil sampling and number of participants

	Organization	No.		Organization	No.
1	青山学院大学	4	21	京都女子大学	1
2	秋田大学	1	22	京都大学	6
3	茨城県立医療大学	4	23	群馬県立県民健康科学大学	1
4	医療法人大雄会総合大雄会病院	2	24	群馬大学	2
5	医療法人名古屋放射線診療財団	1	25	高エネルギー加速器研究機構	16
6	医療法人明倫会今市病院	1	26	高知大学	1
7	宇都宮大学	1	27	甲南大学	6
8	愛媛大学	1	28	神戸市立工業専門学校	1
9	大阪市立大学	1	29	神戸常磐大学	1
10	大阪大学	31	30	国際福祉医療大学	3
11	岡山大学	2	31	国立環境研究所	1
12	岡山理科大学大学院	2	32	国立がん研究センター	1
13	海洋研究開発機構	3	33	国立極地研究所	1
14	金沢医科大学	2	34	国立天文台	1
15	金沢大学	11	35	国際基督教大学	1
16	亀田総合病院	1	36	国立病院機構	3
17	関西学院大学	3	37	埼玉医科大学	1
18	九州シンクロトロン光研究センター	1	38	財団法人高輝度光科学研究センター	1
19	九州大学	6	39	産業技術総合研究所	2
20	京都教育大学	5	40	滋賀医科大学	1

	Organization	No.		Organization	No.		Organization	No.
41	渋川総合病院	1	61	東北公益文科大学	1	81	北海道大学	9
42	首都大学東京	3	62	東北大学	15	82	武蔵大学	1
43	純真学園大学	6	63	獨協大学	1	83	三重大学	1
44	順天堂大学	1	64	名古屋市立大学	1	84	宮城教育大学	1
45	昭和薬科大学	1	65	名古屋大学	8	85	宮崎大学	1
46	信州大学	3	66	新潟大学	14	86	山形大学	4
47	聖マリアンナ大学	1	67	日本原子力研究開発機構	73	87	横浜国立大学	1
48	千葉大学	2	68	日本大学	3	88	リアルタイム地震情報利用協議会	2
49	中部大学	1	69	日本分析センター	20	89	理化学研究所	9
50	筑波大学	9	70	沼津工業高等専門学校	1	90	立教大学	5
51	帝京大学	1	71	兵庫県立粒子線医療センタ	1	91	立正大学	3
52	東海大学	2	72	広島国際大学	2	92	立命館大学	1
53	東京医科歯科大学	2	73	広島大学	5	93	琉球大学	3
54	東京工業大学	1	74	福井大学	6	94	早稲田大学	1
55	東京慈恵医大	1	75	福島県立医科大学	3	95	荏原製作所	1
56	東京大学	14	76	福島大学	9	96	(株)日本環境調査研究所	1
57	東京都市大学	2	77	藤田保健衛生大学	1	97	電気事業連合会(現地支援チーム)	31
58	東京理科大学	3	78	防災科学技術研究所	1		(電力会社10社及び日本原燃(株))	
59	東邦大学	3	79	放射線医学総合研究所	3	98	富士フィルムRIファーマ株式会社	3
60	東北学院大学	2	80	北部地区医師会病院	1			

Number of participants : 440
Number of universities and research Institutes : 94
Corporation : 4

Organization an people participated for gamma-ray measurement

	Organization	No.		Organization	No.
1	大阪大学	84	12	東京工業大学	21
2	大阪電気通信大学	11	13	東京大学	16
3	金沢大学	24	14	東北大学	29
4	九州大学	10	15	徳島大学	7
5	京都大学	11	16	新潟大学	11
6	高エネルギー加速器研究機構	5	17	日本大学	5
7	甲南大学	6	18	日本分析センター	7
8	佐賀大学	1	19	宮崎大学	5
9	首都大学東京	21	20	理化学研究所	30
10	信州大学	1	21	立教大学	34
11	筑波大学	1			

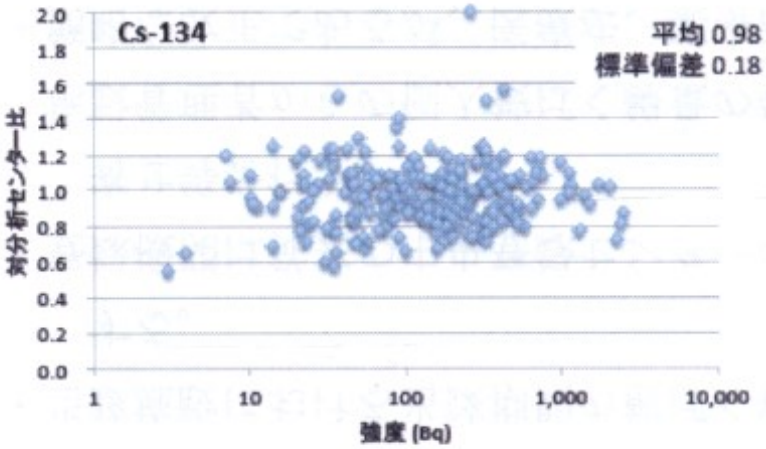
Number of participants : 340
Number of organizations participated : 21

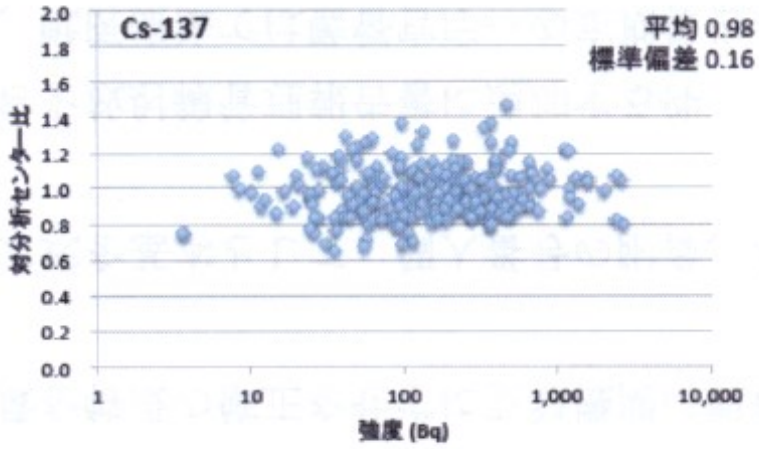
5. Map of distribution of dose rate and radionuclide

Released maps

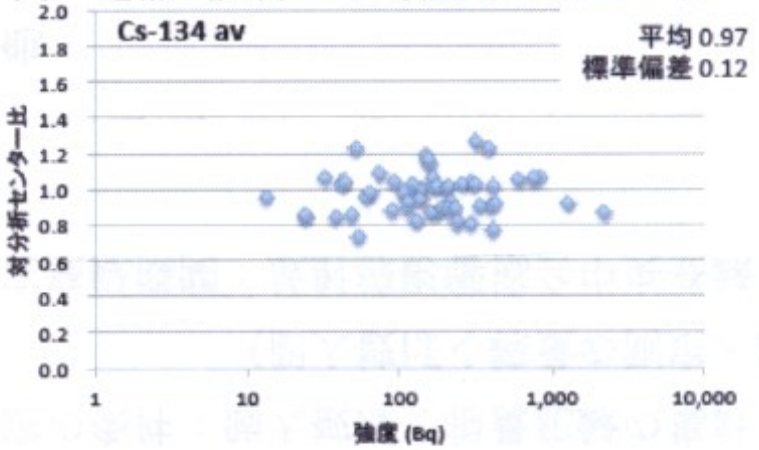
- Air dose rate measured by car survey
- Air dose rate at 1 m above mesh points
- Distribution of ^{134}Cs
- Distribution of ^{137}Cs
- Distribution of ^{131}I
- Ratio of ^{131}I to ^{137}Cs
- Distribution of ^{238}Pu and $^{239+240}Pu$
- Distribution of $^{89,90}Sr$
- Distribution of ^{129m}Te
- Distribution of ^{110m}Ag
- Correlation of concentration of ^{134}Cs + ^{137}Cs to air dose rate
- Dynamics of radionuclide in environment

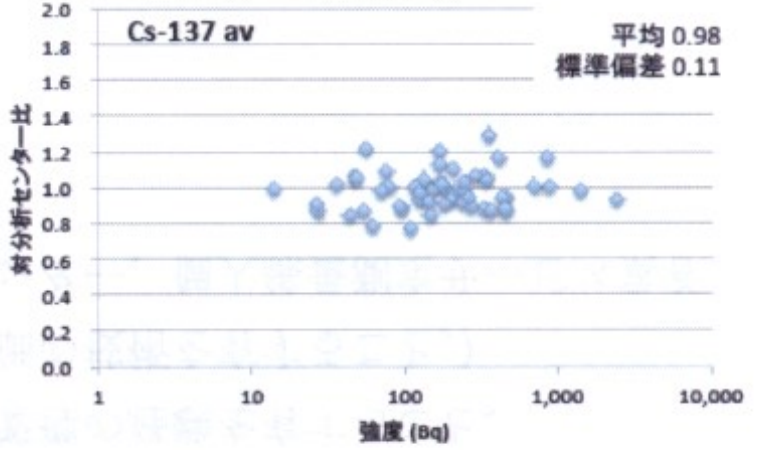
Comparison of measured data by universities etc. and data measured by Japan Chemical Analysis Center



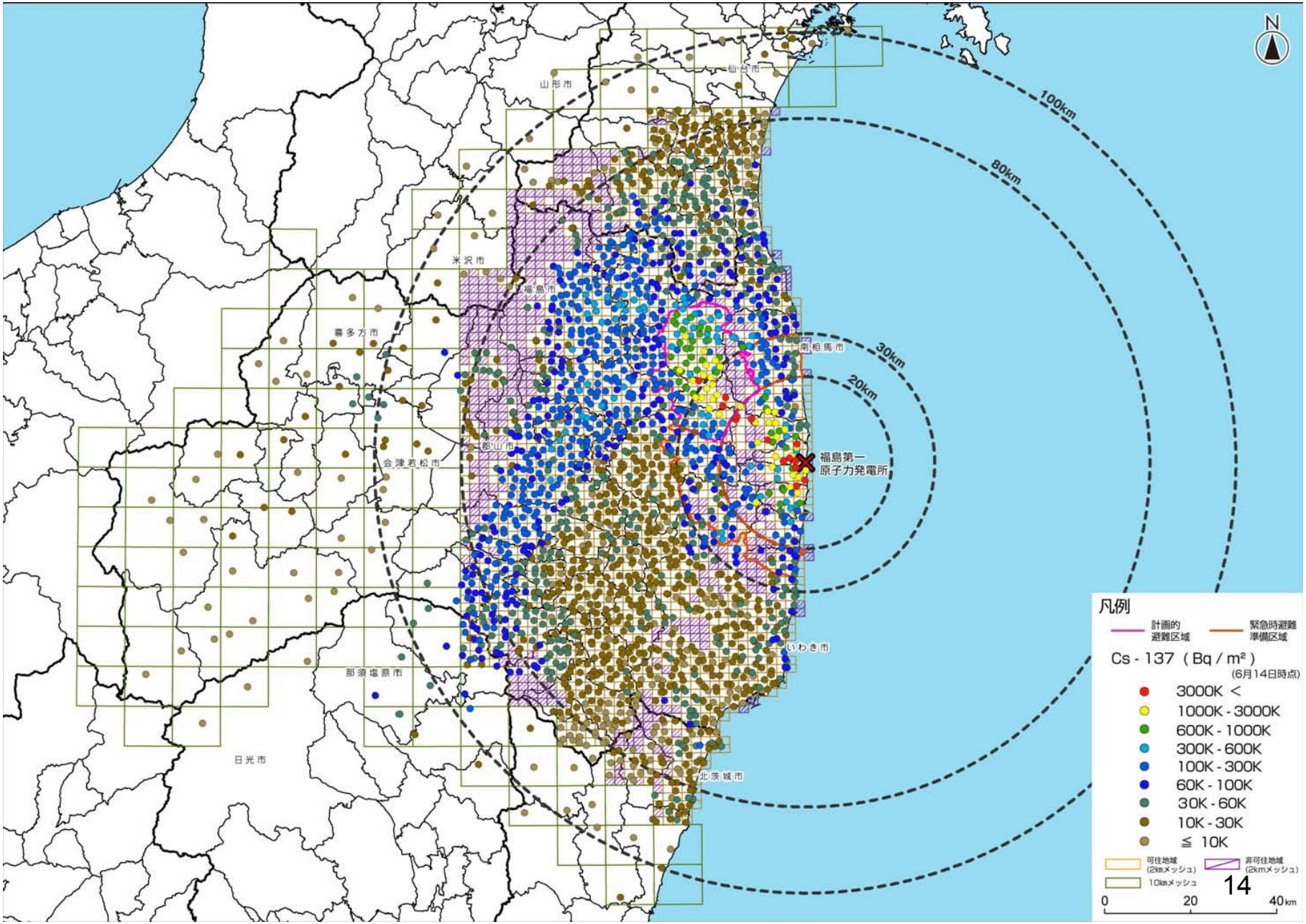


同一地点5試料の平均値間の相互比較





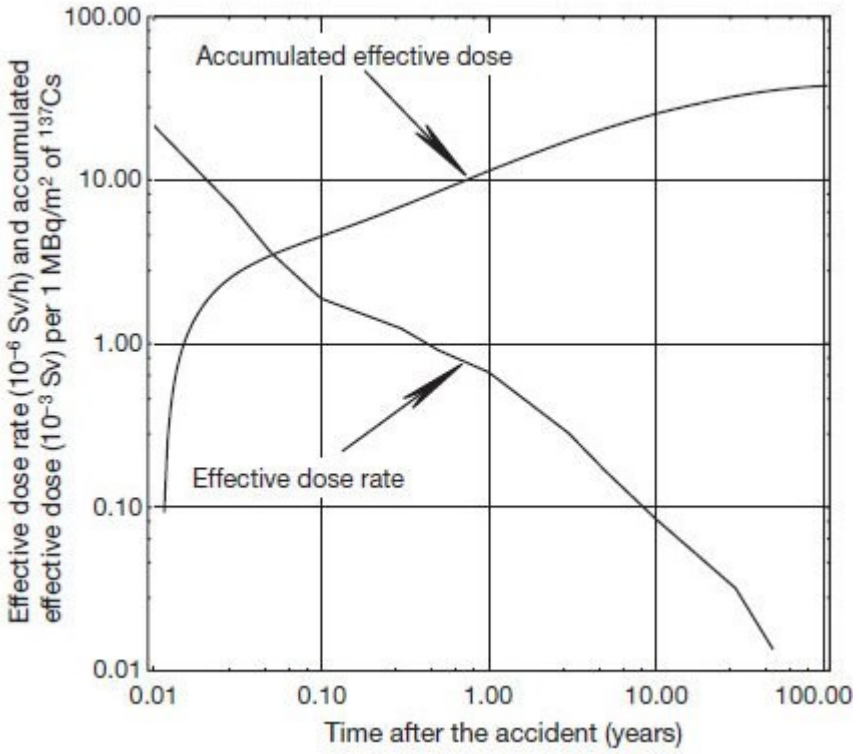
Distribution of ^{137}Cs



6. Lifetime exposure in Fukushima and risk

The measured results of external and internal exposure for Fukushima people show the internal exposure is much lower than the external exposure.

The lifetime exposure in Fukushima can be estimated using the method used to estimate for the Chernobyl accident.



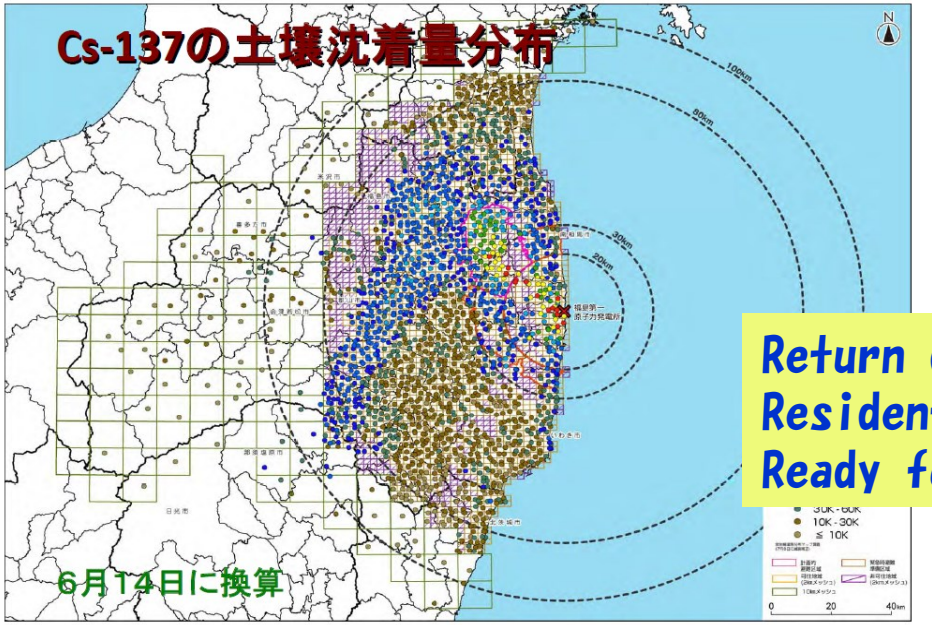
Model prediction of the time dependence of the external effective gamma dose rate and the accumulated external effective dose to the urban population of the Bryansk region of the Russian Federation normalized to 1 MBq/m^2 of ^{137}Cs

AVERAGE NORMALIZED EFFECTIVE EXTERNAL DOSE TO THE ADULT POPULATION IN THE INTERMEDIATE (100 km < DISTANCE < 1000 km) ZONE OF CHERNOBYL CONTAMINATION

	Population	E/σ_{137} ($\mu Sv \cdot kBq^{-1} \cdot m^2$ of ^{137}Cs)				
		1986	1987–1995	1996–2005	2006–2056	1986–2056
Russian Federation	Rural	14	25	10	19	68
	Urban	9	14	5	9	37
Ukraine	Rural	24	36	13	14	88
	Urban	17	25	9	10	61

Accumulated effective dose for 70 years for 1 $kBq \cdot m^{-2}$ of ^{137}Cs

Russian federation :Rural 68 μSv Urban 37 μSv
Ukraine :Rural 88 μSv Urban 61 μSv

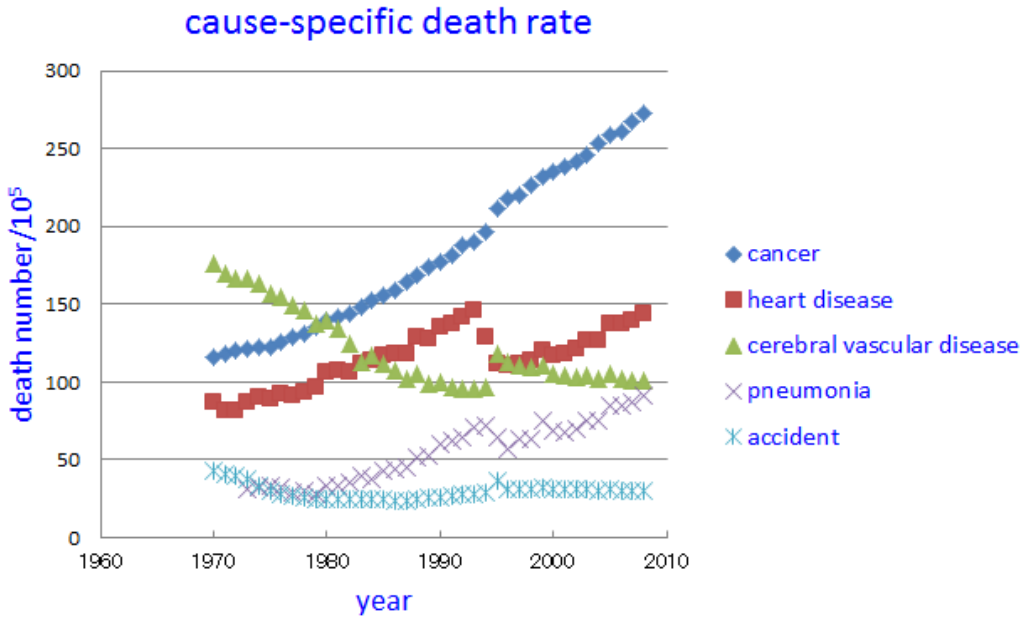


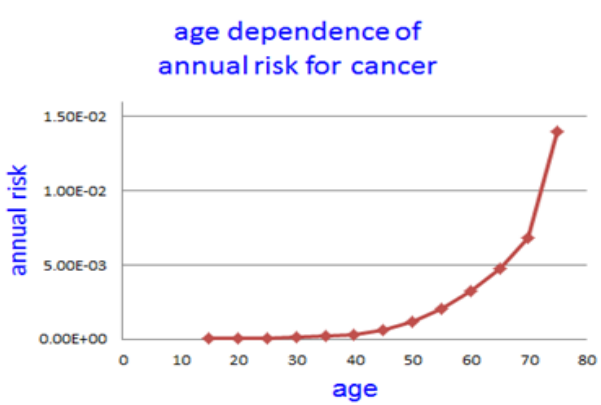
Return difficult >50mSv/y
Resident restricted 50～20mSv/y
Ready for return <20mSv/y

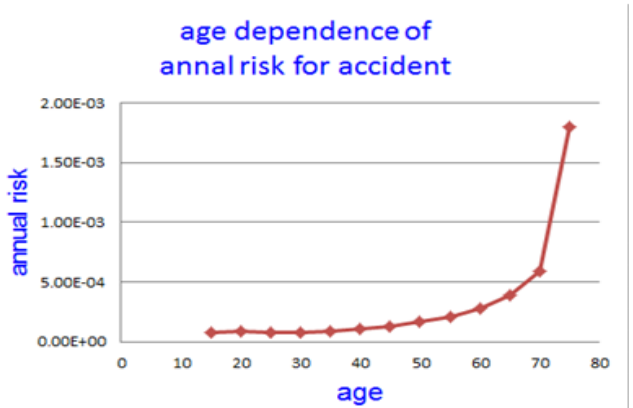
mark	concentration	dose rate	dose rate	exposure during 70y	risk in 70y	anuual risk
	Bq/m^2	μSv/h	mSv/y	mSv for 70y		
	3000K-15000	10-52	88-460	260-1300	1.4×10^{-2}-7.1×10^{-2}	2.0×10^{-4}-1.0×10^{-3}
	1000k-3000k	3.5-10	31-88	88-260	4.8×10^{-3}-1.4×10^{-2}	6.9×10^{-5}-2.0×10^{-4}
	600k-1000k	2.1-3.5	18-31	53-88	2.9×10^{-3}-4.8×10^{-3}	4.1×10^{-5}-6.9×10^{-5}
	300k-600k	1.0-2.1	8.8-18	26-53	1.4×10^{-3}-2.9×10^{-3}	2.0×10^{-5}-4.1×10^{-5}
	100k-300k	0.35-1.0	3.1-8.8	8.8-26	4.8×10^{-4}-1.4×10^{-3}	6.9×10^{-6}-2.0×10^{-5}
	60k-100k	0.21-0.35	1.8-3.1	5.3-8.8	2.9×10^{-4}-4.8×10^{-4}	4.1×10^{-6}-6.9×10^{-6}
	30k-60k	0.10-0.21	0.88-1.8	2.6-5.3	1.4×10^{-4}-2.9×10^{-4}	2.0×10^{-6}-4.1×10^{-6}
	10k-30k	0.035~0.10	0.31-0.88	0.88-2.6	4.8×10^{-5}-1.4×10^{-4}	6.9×10^{-7}-2.0×10^{-6}
	<10k	<0.035	<0.31	<0.88	$<4.8\times10^{-5}$	$<6.9\times10^{-7}$

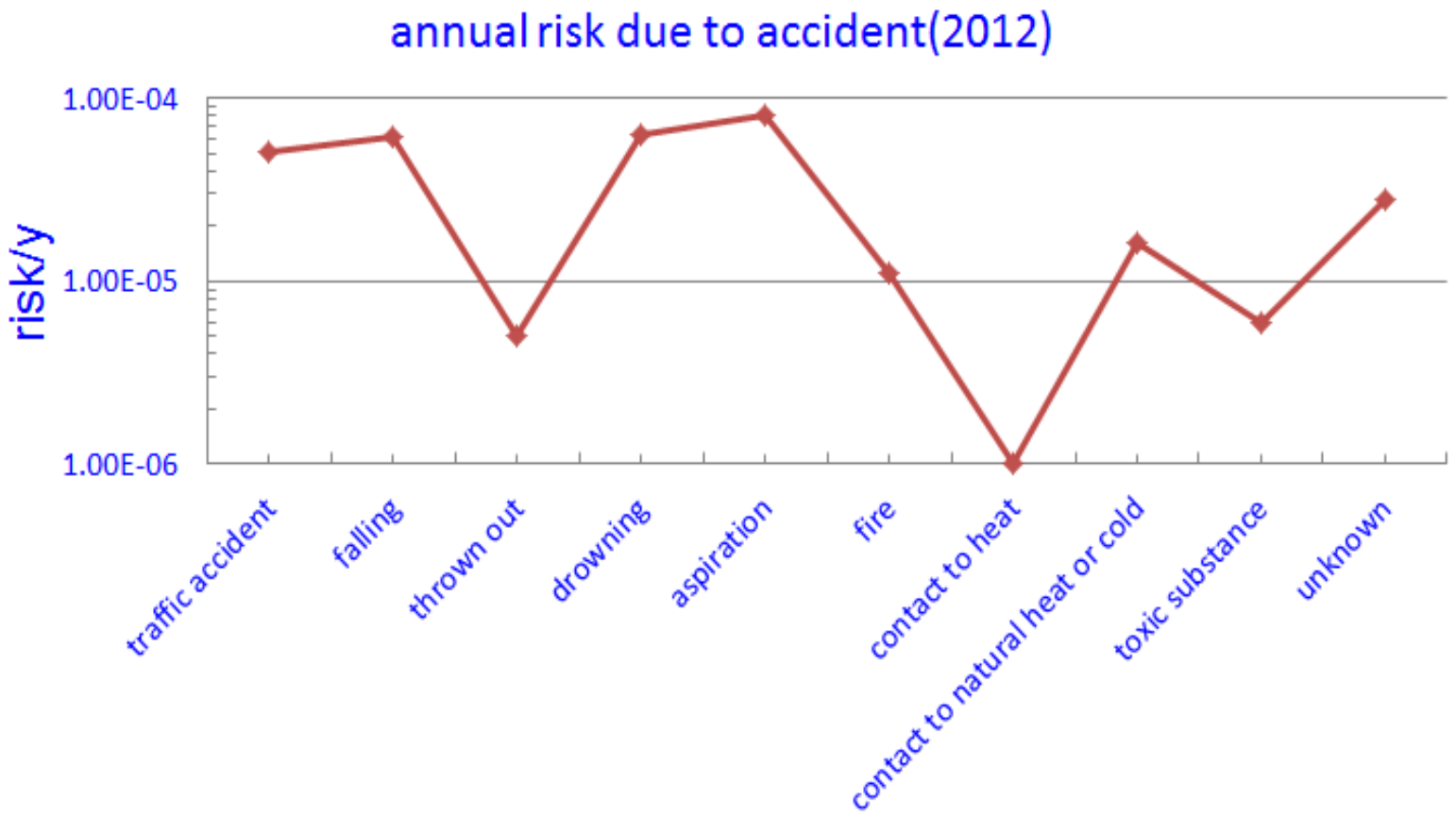
Risk is calculated using 5.5% for 1Sv (ICRP recommendation)

7. Risk in everyday life

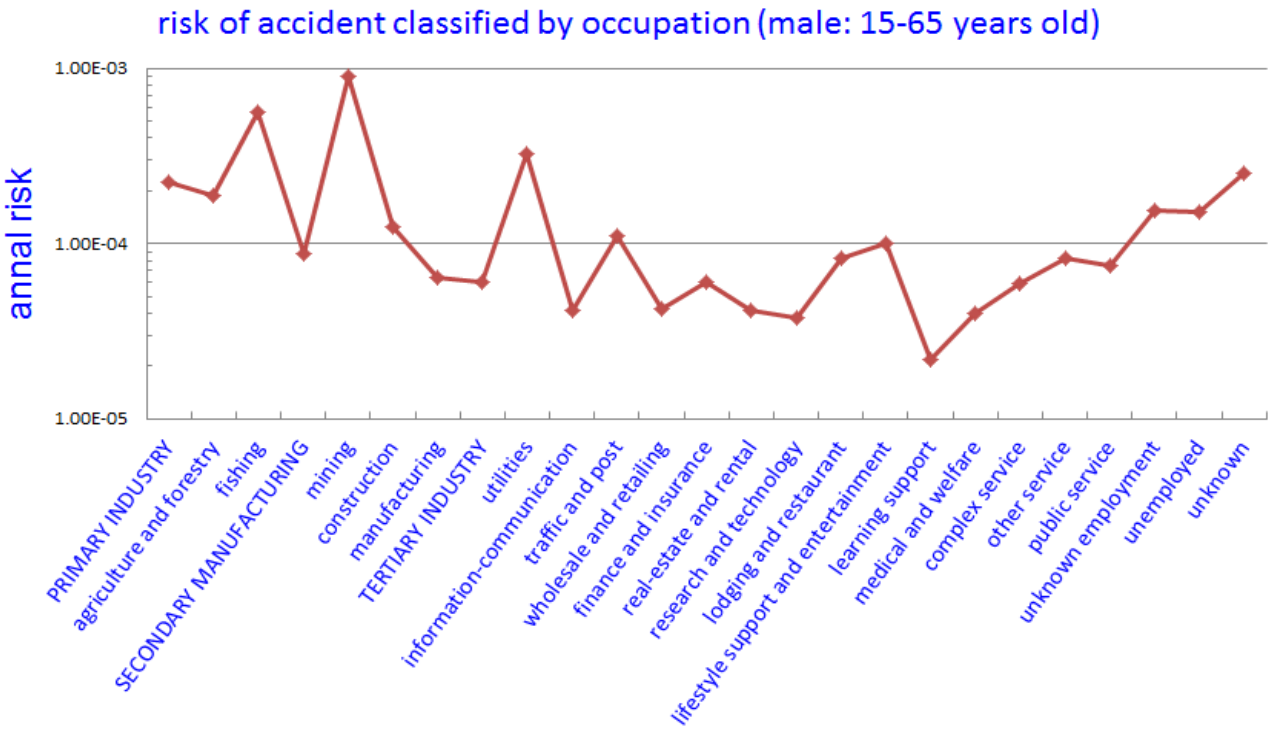




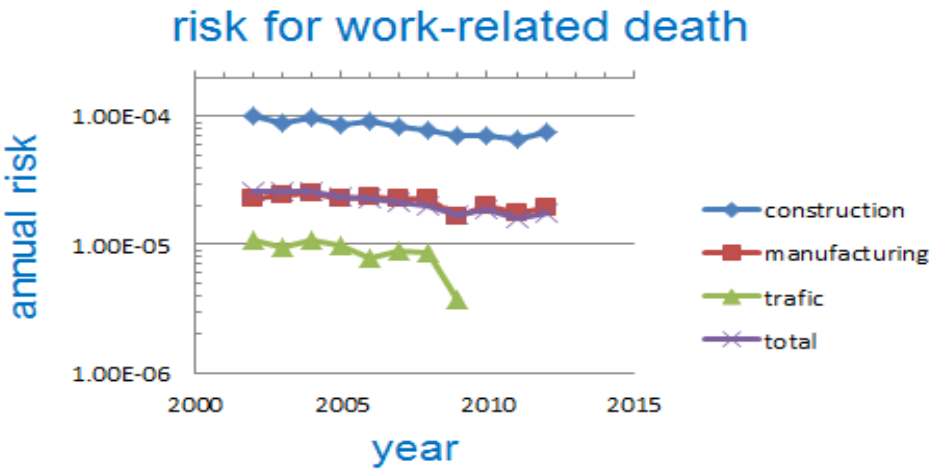



annual risk due to accident(2012)
risk/y
1.00E-04
1.00E-05
1.00E-06
traffic accident
falling
thrown out
drowning
aspiration
fire
contact to heat
contact to natural heat or cold
toxic substance
unknown

2012



2010



2002~2012

8. Summary

- Many researchers and organizations fully cooperated with the MEXT project, resulted in completion of detailed contamination map.
  It was a great job to be praised.

- The annual risk in everyday life of $1\sim2\times10^{-5}$/y looks safe.

- Radiation rate in Fukushima for $1\sim2\times10^{-5}$/y risk is about 5~9mSv/y.

- Return of evacuees will take long time, if one sticks strongly to 1 mSv/y.

END