Fukushima fallout of ^{131}I, ^{137}Cs, ^{134}Cs at Milano, Italy

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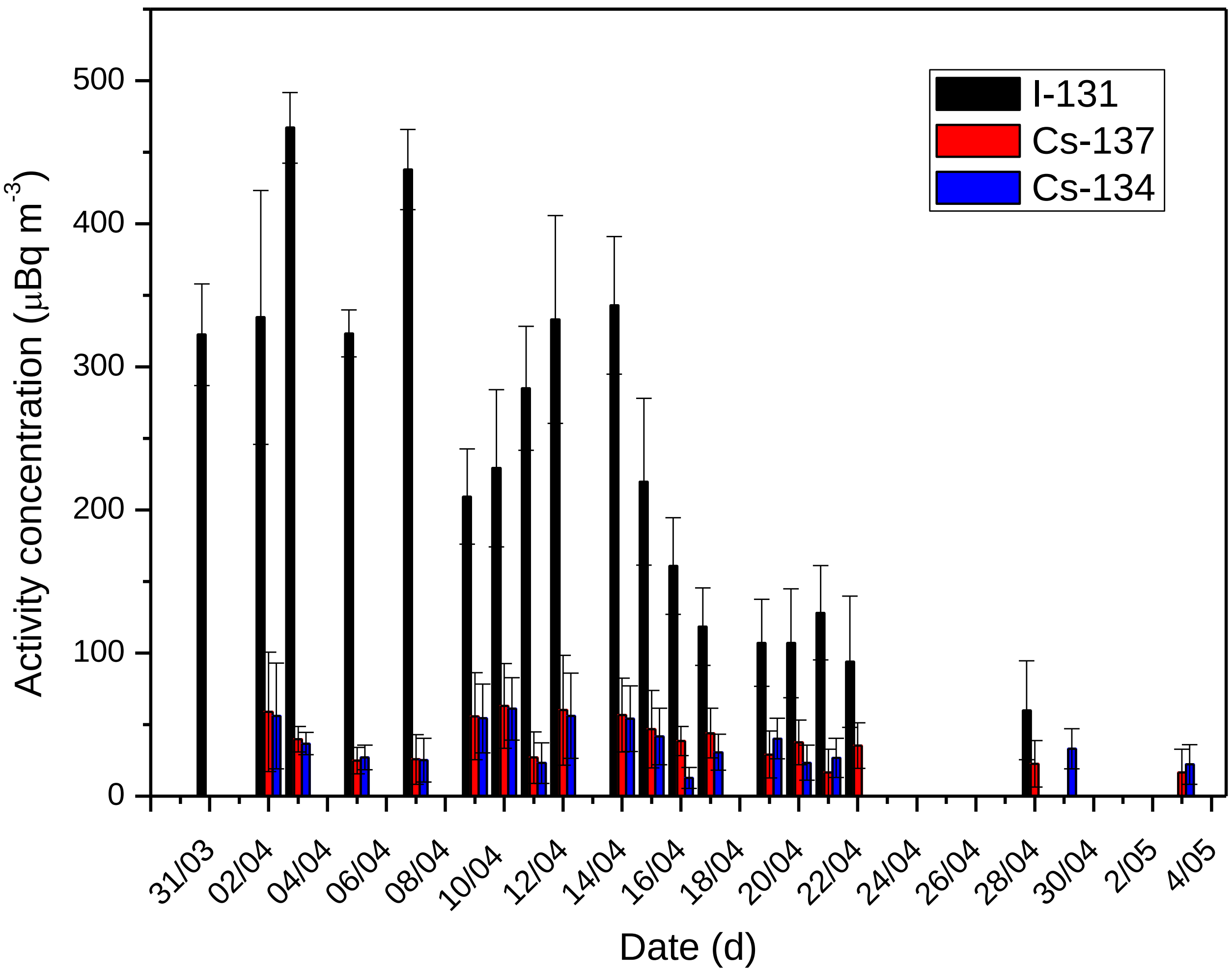
Activity concentrations of ^{131}I, ^{137}Cs and ^{134}Cs in air

23 h sampling period

2400 m^3

Activity concentrations of ^{131}I, ^{137}Cs and ^{134}Cs in air



Activity concentrations of ^{131}I, ^{137}Cs and ^{134}Cs in air

Date of sampling	Fallout isotopes in surface air				
	^{131}I μBq m^{-3}	^{137}Cs μBq m^{-3}	^{134}Cs μBq m^{-3}	ratio $^{134}Cs/^{137}Cs$	ratio $^{131}I/^{137}Cs$
31/03/11	322±35	< 29[a]	< 26[a]	-	-
02/04/11	335±89	59±42	56±37	0.95	5.7
03/04/11	467±25	40±9	37±8	0.92	11.7
05/04/11	323±16	25±9	27±9	1.09	12.9
07/04/11	438±28	26±17	25±15	0.98	16.8
09/09/11	209±33	56±30	54±24	0.97	3.7
10/04/11	229±55	63±30	61±22	0.97	3.6
11/04/11	285±43	[b]27±18	[b]23±14	0.90	10.6
12/04/11	333±73	60±38	56±30	0.94	5.6
14/04/11	343±48	57±26	54±23	0.95	6.0
15/04/11	220±58	47±27	42±20	0.89	4.7
16/04/11	161±34	39±10	[b]13±7	0.33	4.1
17/04/11	118±27	44±17	31±13	0.69	2.7
19/04/11	107±30	29±16	40±14	1.38	3.7
20/04/11	107±38	38±16	23±12	0.62	2.8
21/04/11	128±33	[b]17±16	27±14	1.59	7.5
22/04/11	94±46	35±16	< 11[a]	-	2.7
28/04/11	[b]60±35	[b]23±16	< 12[a]	-	2.6
29/04/11	< 41[a]	< 11	33±14	-	-
30/04/11	< 19[a]	< 16[a]	< 12[a]	-	-
3/05/11	< 9[a]	17±16	22±14	1.34	-

[a] MDA
[b] Critical Level

$^{134}Cs/^{137}Cs = 1$

$^{131}I/^{137}Cs$ decrease with time.

The radioactive cloud was first more rich in ^{131}I, as iodine is a more volatile element than caesium

Activity concentrations of ^{131}I, ^{137}Cs and ^{134}Cs in rainwater

Fallout isotopes in rainwater samples

Site	Date of Sampling	Volume	Surface area m^2	^{131}I mBq L^{-1} (*Bq m^{-2}*)	^{137}Cs mBq L^{-1} (*Bq m^{-2}*)	^{134}Cs mBq L^{-1} (*Bq m^{-2}*)
Segrate	28/03/11	0.685	0.1739	891±115 *(3.51±0.45)*	[b]122±89 *(0.48±0.35)*	< 58[a] *(<0.23)*
Senago	28/03/11	0.500	0.1739	725±133 *(2.08±0.38)*	< 11[a] *(<0.03)*	< 86[a] *(<0.25)*
Segrate	12/04/11	0.016	0.5217	<36[a] *(<0.011)*	859±435 *(0.271±0.137)*	<308[a] *(<0.097)*
Segrate	15/04/11	0.925	0.5217	291±87 *(0.52±0.15)*	45±32 *(0.08±.0.06)*	57±26 *(0.10±.0.05)*

[a] MDA
[b] Critical Level

^{131}I < 1Bq L^{-1}

The Food and Drug Administration (FDA) fixed intervention level for ^{131}I in drinking water and infant milk, to 170 Bq L^{-1} while in Japan, the ^{131}I limit for consumption of tap water is 100 Bq L^{-1} for infants, and 300 Bq L^{-1} for adults (RIKEN, 2011).

Dry deposition of ^{131}I, ^{137}Cs and ^{134}Cs

Date of Sampling	Fallout isotopes in dry deposition samples			
	^{131}I Bq m^{-2}	^{137}Cs Bq m^{-2}	^{134}Cs Bq m^{-2}	ratio ^{134}Cs/^{137}Cs
06/04/11	0.40±016	0.24±0.11	< 0.05[a]	-

Dry Deposition:

^{131}I: 11% of wet

^{137}Cs: 50% of wet

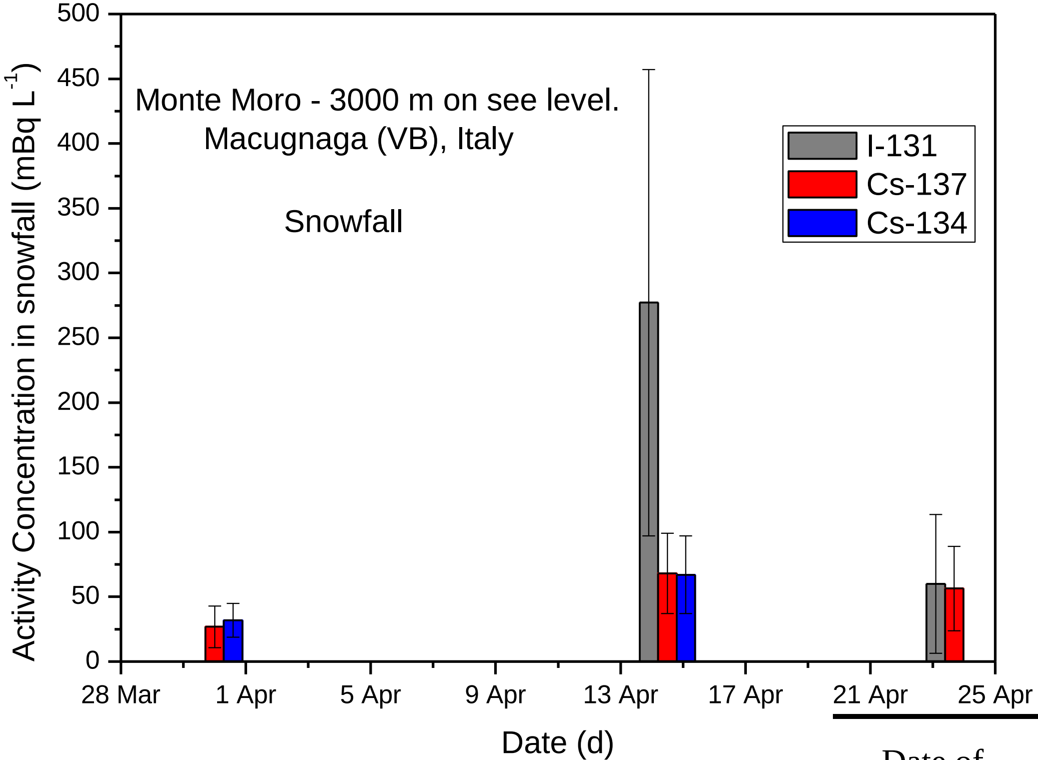
- If these data are compared with the ones obtained by rainwater, it is clear that the dry deposition of ^{137}Cs and ^{134}Cs is greater than that of ^{131}I.
- This can be explained because, contrary to the iodine mainly found in gaseous form, caesium is rapidly bound to aerosols and thus highly subject to dry deposition.

Activity concentrations of ^{131}I, ^{137}Cs and ^{134}Cs in snow

Samples collected at 3000 m s.l.m.

Monte Moro - Macugnaga (VB), Italy

Activity concentrations of ^{131}I, ^{137}Cs and ^{134}Cs in snow



Date of Sampling	Fallout isotopes in snowfall samples			
	^{131}I mBq L^{-1}	^{137}Cs mBq L^{-1}	^{134}Cs mBq L^{-1}	ratio $^{134}Cs/^{137}Cs$
28/03/11	< 12.04[a]	< 8.98[a]	< 6.92[a]	-
31/03/11	< 20.88[a]	27±16	[b]32 ±13	1.19
14/04/11	277±180	68±31	67±30	0.98
23/04/11	[b]60±53	56±33	< 29[a]	

Activity concentrations of ^{131}I, ^{137}Cs and ^{134}Cs in grass

Total surface: 1 m^2

Total mass: 0,35-0.45 kg

Date of Sampling	Fallout isotopes in grass samples			
	^{131}I mBq kg^{-1}	^{137}Cs mBq kg^{-1}	^{134}Cs mBq kg^{-1}	ratio $^{134}Cs/^{137}Cs$
30/03/11	66±24	47±19	<18[a]	-
06/04/11	[b]37±33	60±20	[b]21±17	0.3
13/04/11	<51[a]	[b]41±35	<30[a]	-
20/04/11	[b]135±119	89±32	<21[a]	-

Surface deposition

^{131}I: 0.016-0.029 Bq m^{-2}

^{137}Cs: 0.014-0.026 Bq m^{-2}

Dry Deposition:

^{131}I: 0.40 Bq m^{-2}

^{137}Cs: 0.24 Bq m^{-2}

Activity concentrations of ^{131}I, ^{137}Cs and ^{134}Cs in soil

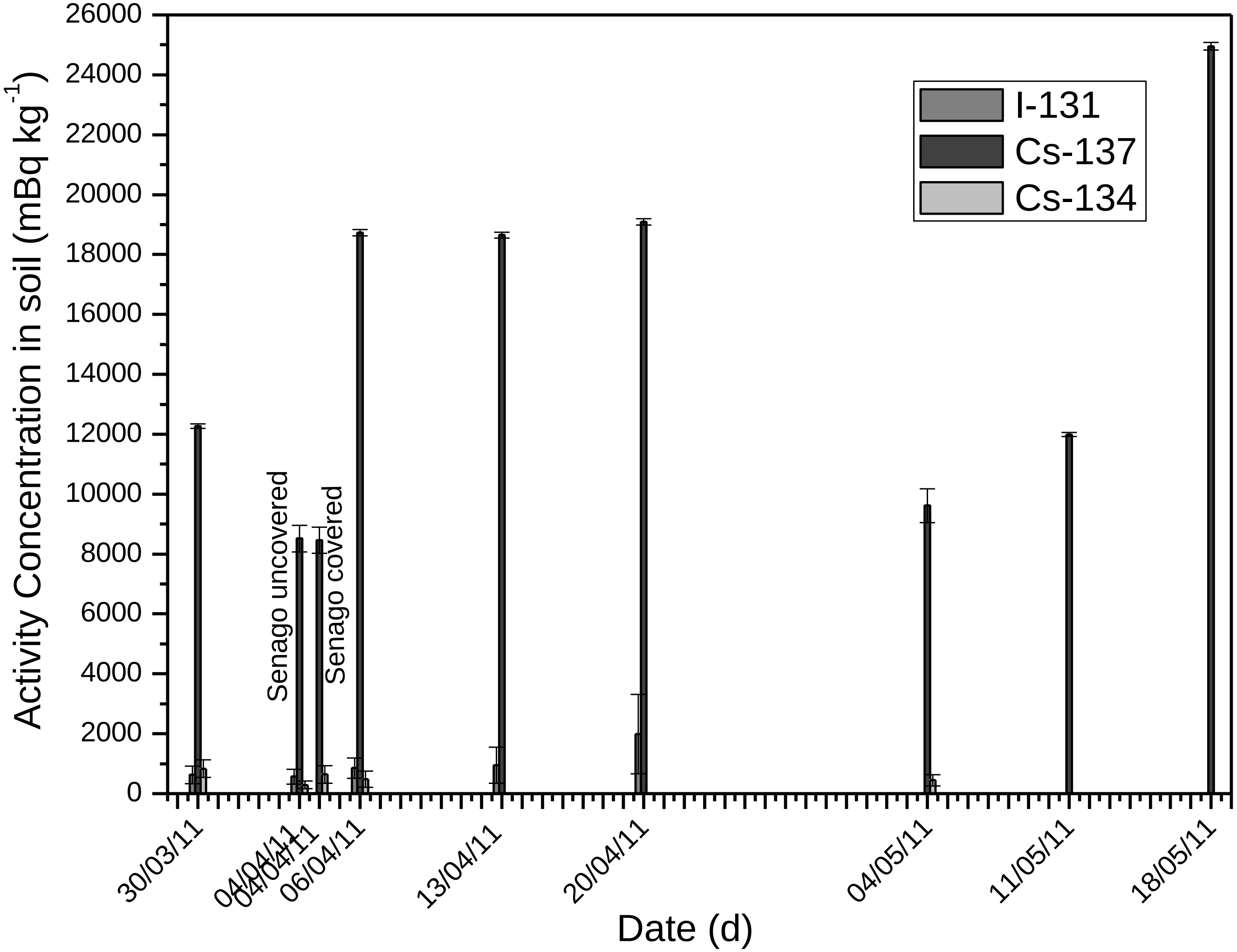
Site	Date of Sampling	Fallout isotopes in soil samples			
		^{131}I Bq kg^{-1}	^{137}Cs Bq kg^{-1}	^{134}Cs Bq kg^{-1}	ratio $^{137}Cs/^{134}Cs$
Segrate	30/03/11	0.63±0.29	12.26±0.70	0.83±0.30	0.07
Senago uncovered	04/04/11	0.57±0.25	85.17±4.40	0.29±0.13	0.0034
Senago covered	04/04/11	<0.15[a]	84.65±4.40	0.47±0.28	0.01
Segrate[b]	06/04/11	0.85±0.34	18.73±1.02	[c]0.48±0.27	0.03
Segrate	13/04/11	0.95±0.60	18.65±1.04	< 0.21[a]	-
Segrate	20/04/11	1.99±1.32	19.08±1.05	< 0.19[a]	
Segrate	04/05/11	< 0.24[a]	9.62±0.56	0.45±0.19	0.05
Segrate	11/05/11	< 0.21[a]	11.99±0.63	< 0.06	
Segrate	18/05/11	< 0.48[a]	24.95±1.30	< 0.07	

[a] MDA
[b] Sample taken in an unplowed area
[c] Critical Level

Dry Deposition:

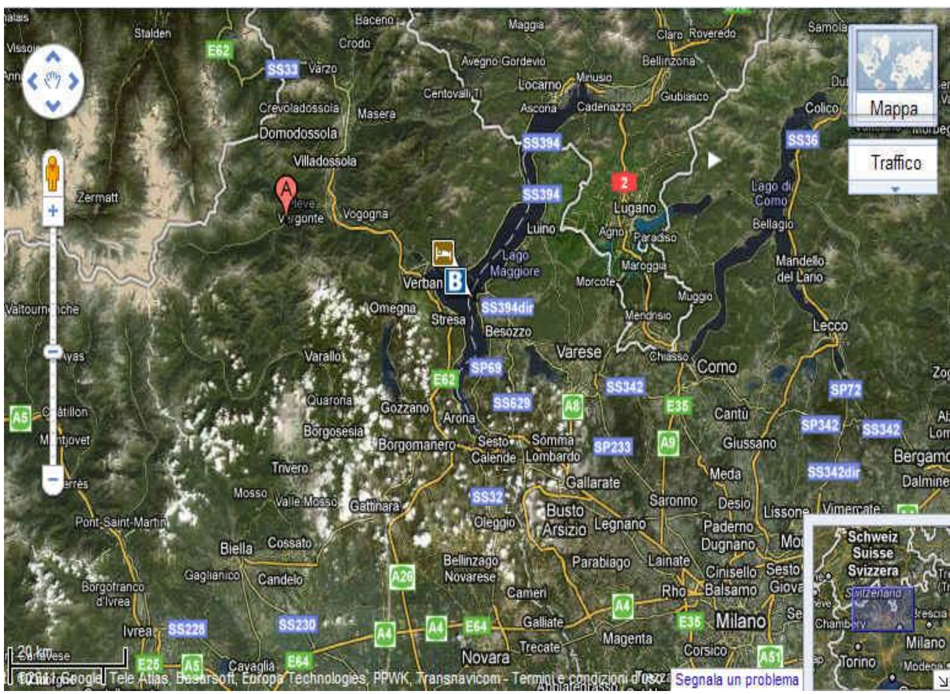
^{131}I: 0.70 Bq m^{-2}

Activity concentrations of ^{131}I, ^{137}Cs and ^{134}Cs in soil



Activity concentrations of ^{131}I, ^{137}Cs and ^{134}Cs in milk

Samples of sheeps and cows milk
collected in Val Anzasca (VB), Italy at 400 m s.l.m.



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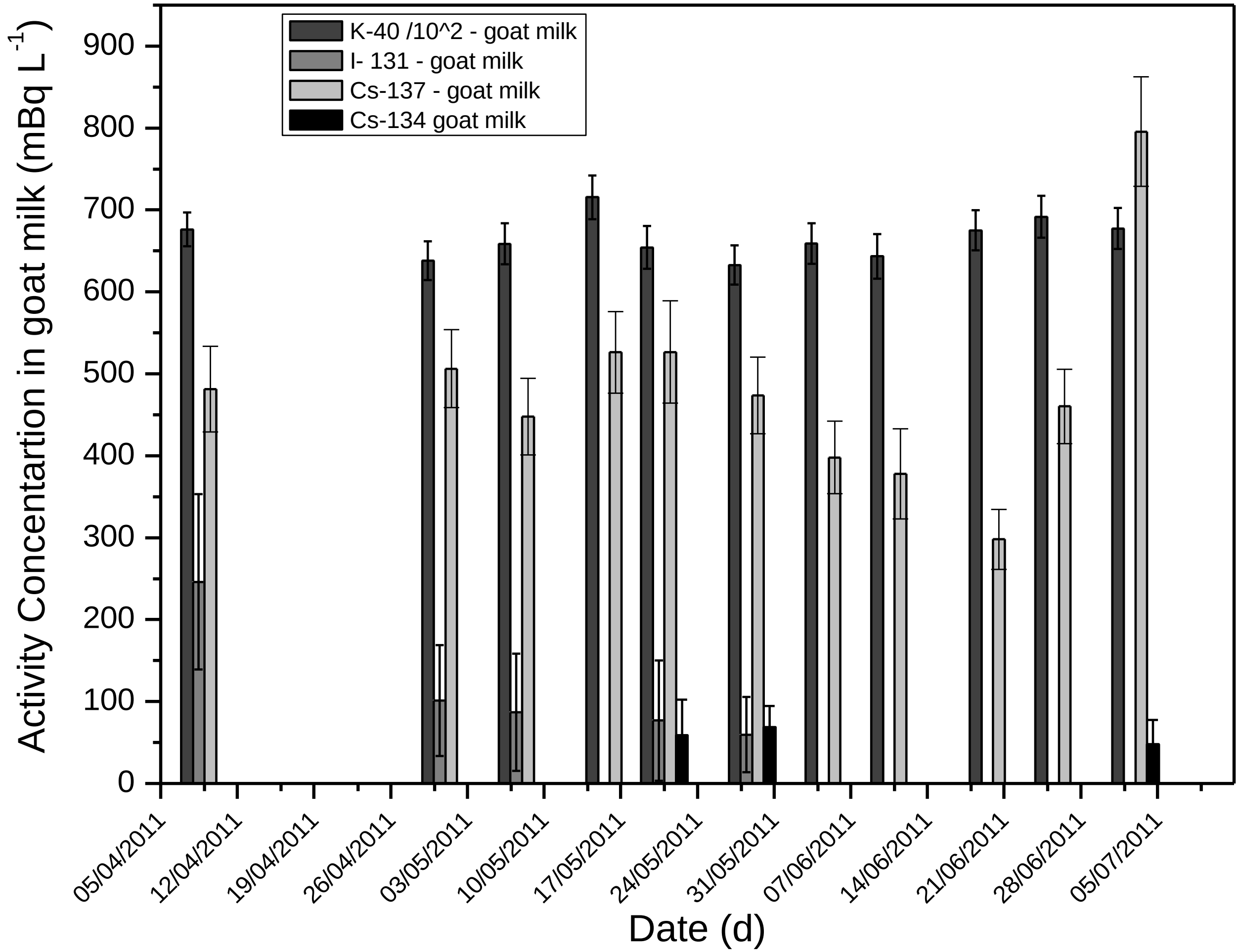
Activity concentrations of ^{131}I, ^{137}Cs and ^{134}Cs in milk

Fallout isotopes in milk samples

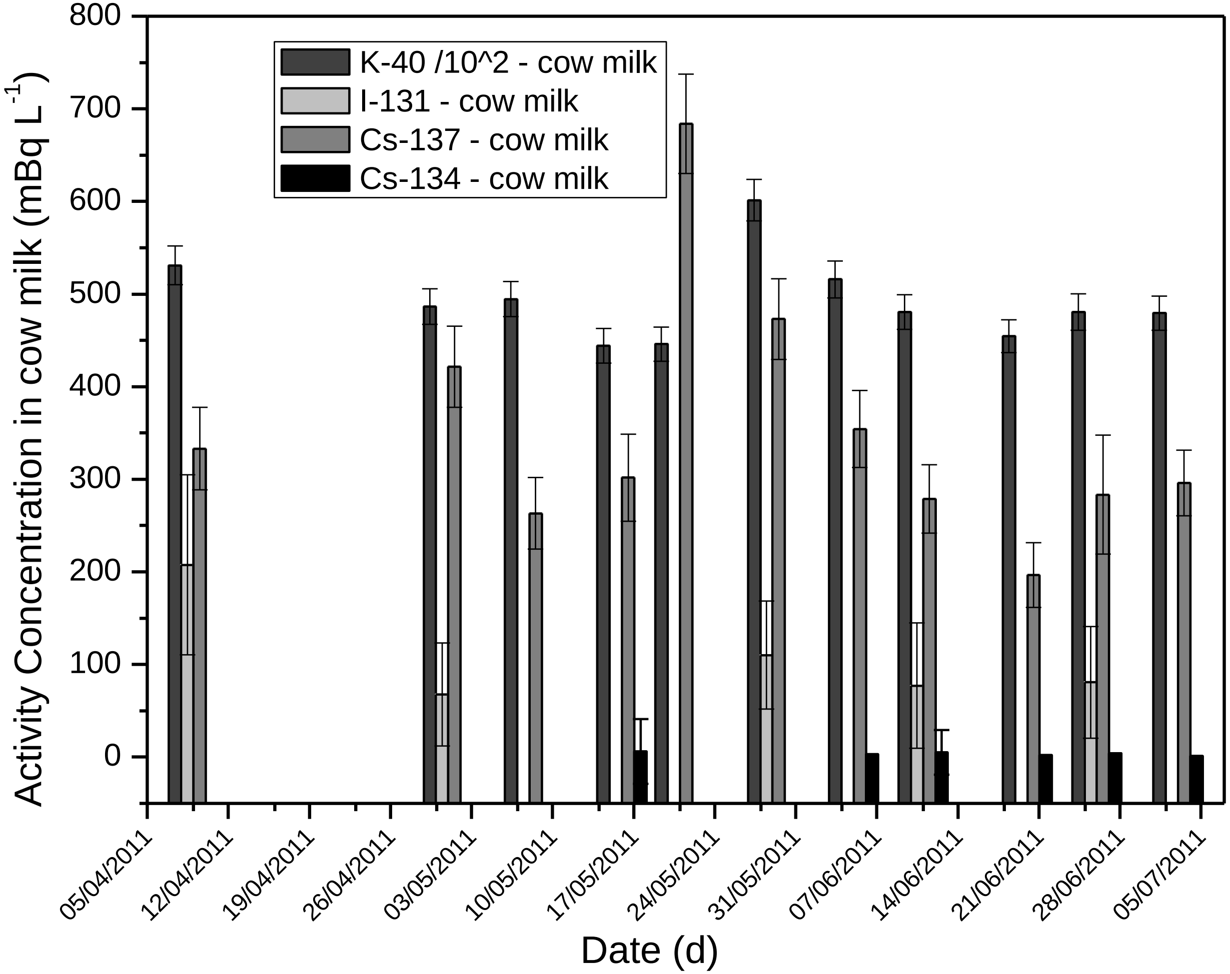
Date of Sampling	Goat Milk				Cow Milk			
	^{131}I mBq L^{-1}	^{137}Cs mBq L^{-1}	^{134}Cs mBq L^{-1}	Ratio $^{134}Cs/^{137}Cs$	^{131}I mBq L^{-1}	^{137}Cs mBq L^{-1}	^{134}Cs mBq L^{-1}	Ratio $^{134}Cs/^{137}Cs$
9/04/11	246±107	481±52	< 33[a]	-	208± 97	333±44	< 31[a]	
1/05/11	101±68	506±48	< 26[a]		[b]68±67	421±44	< 31[a]	
8/05/11	87±72	448±47	< 26[a]		< 40[a]	263±39	< 26[a]	
16/05/11	< 24[a]	526 ±50	< 30[a]		< 38[a]	302±47	67±35	0.22
21/05/11	[b]77±73	527±63	[b]59±44	0.11	< 53[a]	684±54	< 28[a]	
29/05/11	60 ±46	474±47	69 ±26	0.15	110±58	473±44	< 27[a]	
05/06/11	< 25[a]	398±44	< 33[a]		< 34	354±41	< 27[a]	
11/06/11	< 68[a]	378±55	< 34[a]		77±68	279±37	41±24	0.15
20/06/11	< 32[a]	298±37	< 22[a]		< 28[a]	197 ±35	< 22[a]	
26/06/11	< 29[a]	460±45	< 25[a]		81±60	283±64	< 34[a]	
03/07/11	< 28	796±67	[b]48±30		< 32 [A)]	296±36	< 0.23	

a. MDA
b. Critical level

Activity concentrations of ^{131}I and ^{134,137}Cs in goat milk at Monte Rosa mountain, after the Fukushima nuclear accident.



Activity concentrations of ^{131}I and $^{134,137}Cs$ in cow milk at Monte Rosa, Italy after the Fukushima nuclear accident.



Dose assessment

The limit of the effective dose for the population is fixed for the Italian Low of Radioprotection in 1 mSv y^{-1} (Italian Government Legislative Decree, 1995).

The evaluation of the effective dose is done by the relation:

[illegible]

where, E_{est} is the effective dose for exposure;
$Jj,_{ing}$ and $Jj,_{inh}$ are the intake activity (Bq) by ingestion and by inhalation of radionuclide *j*, respectively*;*
$h(g)_{j,\ ing,}$ $h(g)_{j,\ inh}$ (Sv Bq^{-1}) are the coefficients of committed dose for unit of intake by ingestion and/or by inhalation for the population of age group *g*, due to radionuclide *j*.

Dose assessment

Coefficients of committed dose for unit of intake by ingestion and/or by inhalation for the population of age group *g*, for the radionuclides of interest, per unit of intake – Sv Bq^{-1}

Nuclide	age < 1 a $h(g)_{ing}$	age > 17 a $h(g)_{ing}$	*age < 1 a*(*) $h(g)_{inh}$	age > 17 a**(*)** $h(g)_{inh}$
I-131	$1{,}8\ 10^{-7}$	$2{,}2\ 10^{-8}$	$7{,}2\ 10^{-8}$	$7{,}4\ 10^{-9}$
Cs-137	$2{,}1\ 10^{-8}$	$1{,}3\ 10^{-8}$	$8{,}8\ 10^{-9}$	$4{,}6\ 10^{-9}$
Cs-134	$2{,}6\ 10^{-8}$	$1{,}9\ 10^{-8}$	$1{,}1\ 10^{-8}$	$6{,}6\ 10^{-9}$

(*) Fast Type of Absorption

Annual individual usage factors for external exposure, inhalation and consumption of foods. reported in NCRP-123 publication

Pathways - External *and* Inhalation	**Unit**	**Exposure**
Inhalation	$m^3\ a^{-1}$	8 000
Pathways - Ingestion	**Unit**	**Intake**
Water and beverages	$L\ a^{-1}$	800
Milk	$L\ a^{-1}$	300

Dose assessment

The evaluation of the Effective Dose was done using the highest concentration value for ^{131}I, ^{134}Cs and ^{137}Cs measured (Tables 1, 2, 7), and are taken into account only the h(g) coefficients for population of age less than 1 year old and greater than 17 a.

Effective doses due to different pathways

Pathways	***age < 1 a***	**age > 17 a**
Air	[illegible]	[illegible]
Water	[illegible]	[illegible]
Goat Milk	[illegible]	[illegible]
Cow Milk	[illegible]	[illegible]

< 1mSv y^{-1}

Fukushima accident, 11 March 2011

NISA

13 March 2011 First environmental radiation monitoring conducted.

NNSA

30 March – 3 April, 2011 Airborne measurements of external dose rates performed by the Americn National Nuclear Security Adimistration and published on the U.S. DOE's website.

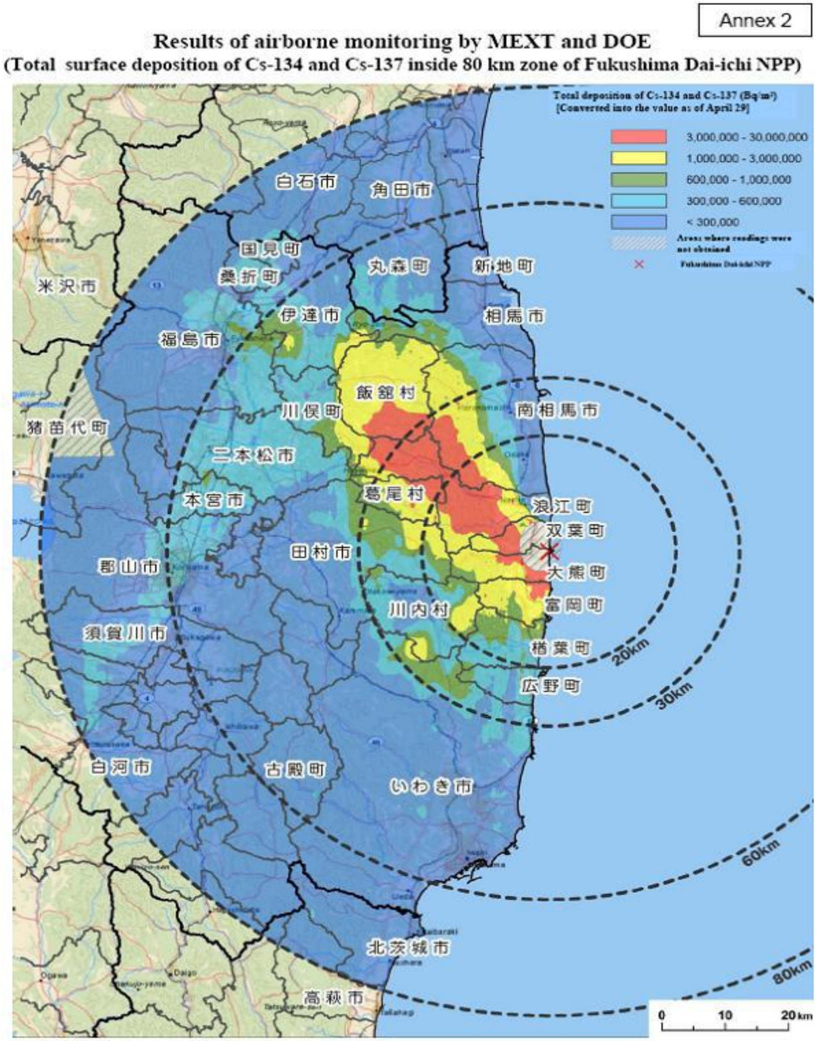
IRSN

8 April, 2011 (Institut de Radioprotection et de Sûreté Nucléaire, France) published the first map of the dose might to be received by the population.

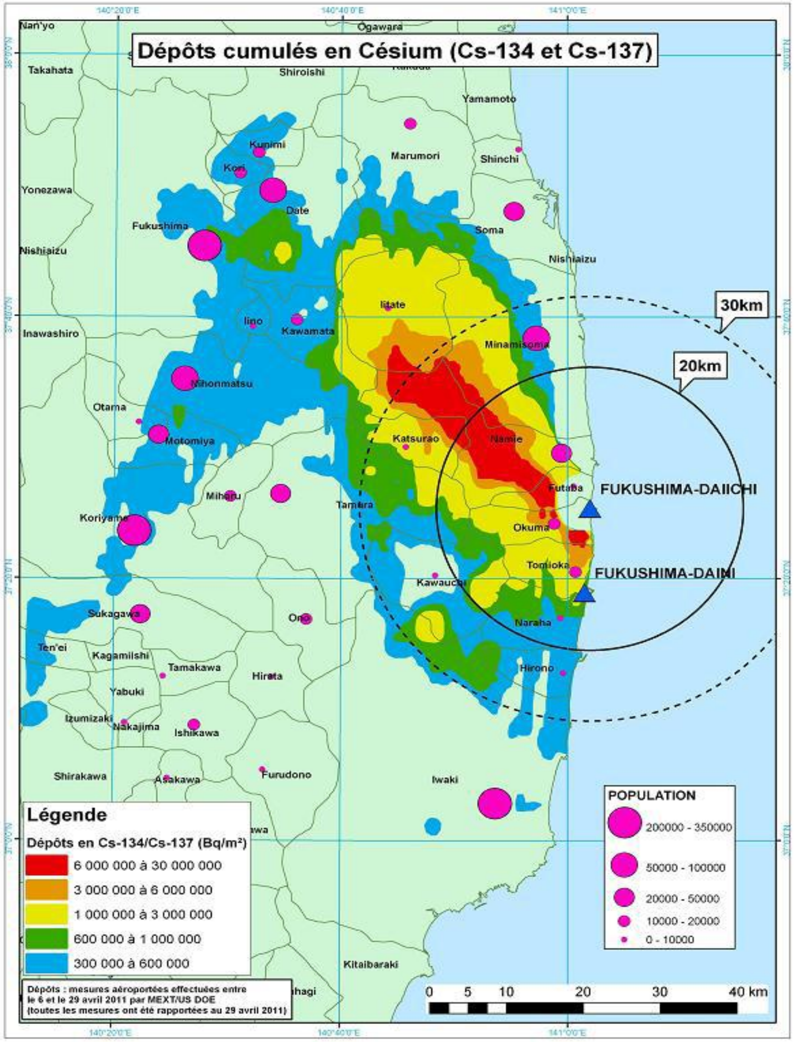
MEXT

26 April 2011 published a map of dose rates in the northwest zone ranging from 1-50 μSv h^{-1}.

- On the 56th day after the acciden, MEXT published the first maps of Caesium deposition
- They revealed high values comparable with the most contaminated areas of Chernobyl, even beyond the initial 20km-radius evacuation zone around the Fukushima plant
- The estimated projected doses reach particularly significant values, some of them even above 200 mSv (20-100 mSv recommended by ICRP emergency situation), which are no longer in the range of “low doses” according to UNSCEAR definitions.
- The level of projected external doses in upcoming years – up to 4 Sv lifetime dose in the most contaminated areas (30 million Bq m^{-2} of $^{137,134}Cs$) – requires the implementation of protective actions such as evacuation of population.
- The Japanese authorities have taken even more protective reference level, 10 mSv for the 1st year.



MEXT and DoE map of deposits on the ground surface (Bqm^{-2}) of ^{137}Cs and ^{134}Cs (map established from airborne measurements collected between April 6 and April 29, 2011)



IRSN map, shown the MEXT data of cumulative deposits of ^{137}Cs and ^{134}Cs rom **0.3 to 30 MBq m^{-2}**

Dose Assessment

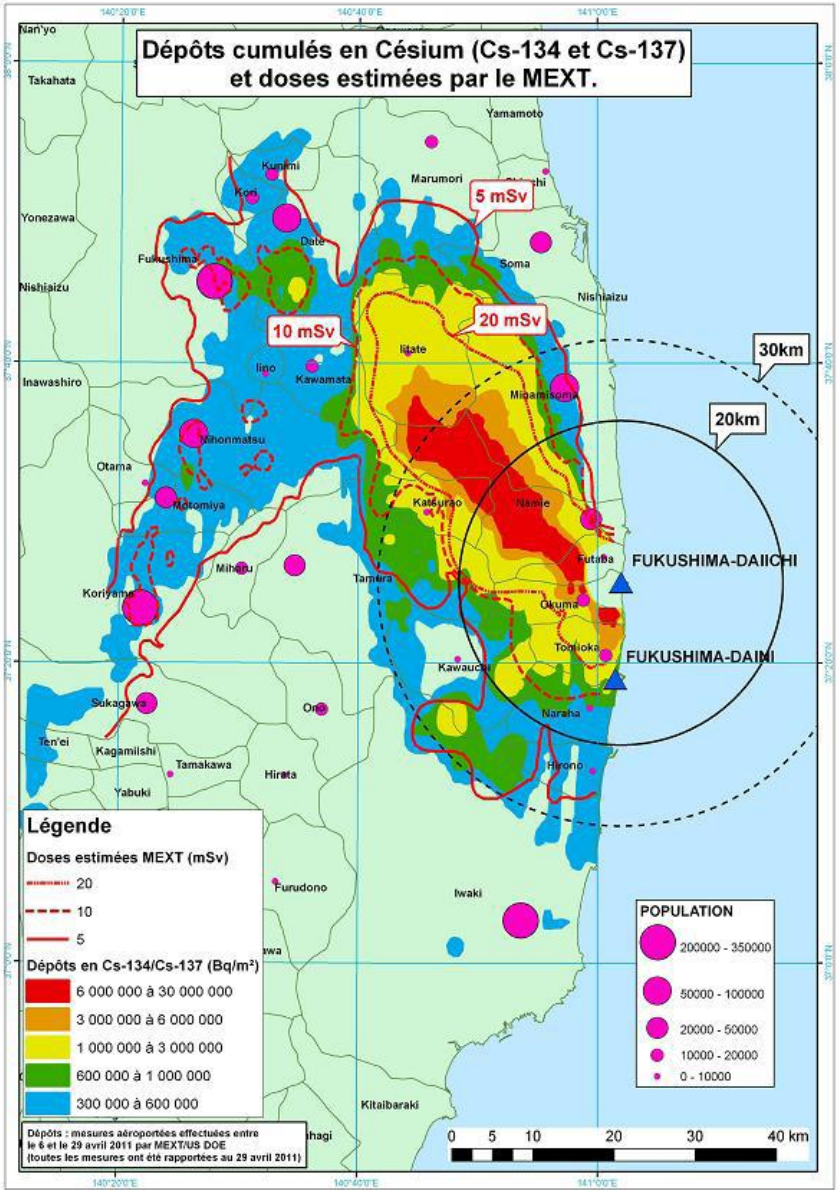
- The conversion factor form surface activity ($Bq\ m^{-2}$) to dose rate ($\mu Sv\ h^{-1}$) is around 300,000.

  300,000 $Bq\ m^{-2}$ correspond to 1 $\mu Sv\ h^{-1}$

- The conversion factor from dose rate ($\mu Sv\ h^{-1}$) to the annual dose (mSv) is a factor of 5.

  20 mSv annual dose correspond to 1 $\mu Sv\ h^{-1}$ dose rate

Dose Assessment



Cumulative deposits of ^{137,134}Cs and doses estimated by MEXT

16.6 mSv/year per MBq m^{-2}

up to 500 mSv/year (30 MBq m^{-2})

ICRP suggested reference levels in terms of effective dose in a range from 20-100 mSv received in one year for radiation emergency situations.

Dose Assessment

NISA now estimates that the total amount of radiation released into the atmosphere in the first week of the crisis was 770,000 TBq, the agency previously estimated that about 370,000 TBq were released, that is still 10% of the radiation released from hernobyl accident.

At Fukushima city, 60 km far from nuclear power plant, the levels of radioactivity if 4 regions are highe than 10.000 Bq kg-1, up to 46.500 Bq kg-1. in 3 regions were between 16.290 – 19 22 Bq kg-1.

Higher than the levels at Chernobyl evacuated regions.

CONCLUSIONS

- The Fukushima plume was detected in Milano, Italy
- The max ^{131}I concentration in surface air was 467 µBq m^{-3}, on April 3-4, 2011
- The presence of more than one peaks of ^{131}I and $^{137,134}Cs$ showed that air continuously transferred from Fukushima, Japan to Italy till May 3, 2011
- The dry deposition of Cs isotopes is greater than that of ^{131}I
- The relative high concentrations of ^{137}Cs in grass, soil and fresh milk samples, correspond to Chernobyl fallout contribution rather than Fukushima accident
- ^{131}I and $^{137,134}Cs$ isotopes were found above their detection limits in all environmental samples but very far below levels of concern