Radiation Exposure to the Population in Japan After the Earthquake

Marco Kaltofen, MS, PE (Civil, MA)
Department of Civil and Environmental Engineering
Worcester Polytechnic Institute
Worcester, MA
kaltofen@wpi.edu

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Hypothesis

- Dust contaminated with fallout from the Fukushima accidents is a source of human exposure to radiation.

Radioisotopes in dusts released by Fukushima Daiichi units

- Radioiodine
- Cesium-134 and-137
- Cobalt-60
- Fission wastes and neutron activation products
- Uranium and plutonium fuels and transuranics such as americium and neptunium

How are people exposed to radioactive particulates?

- Inhalation of airborne particles
- Inhalation of resuspended dusts
- Ingestion of contaminated food

  (seaweed, shellfish, beef, milk, spinach, eggs, tea and finfish including pollock and cod)
- Ingestion of soils and dusts (pica)
- Dermal contact

Common materials that retain radioactive particulate matter

- Car air filters, ~ 650 M^3_{air}/mo., qualitative
- 37 mm air filters, 30 M^3_{air} / d., quantitative
- Home air filters
- Shoes
- Settled dusts
- Surface soils
- Food and plants

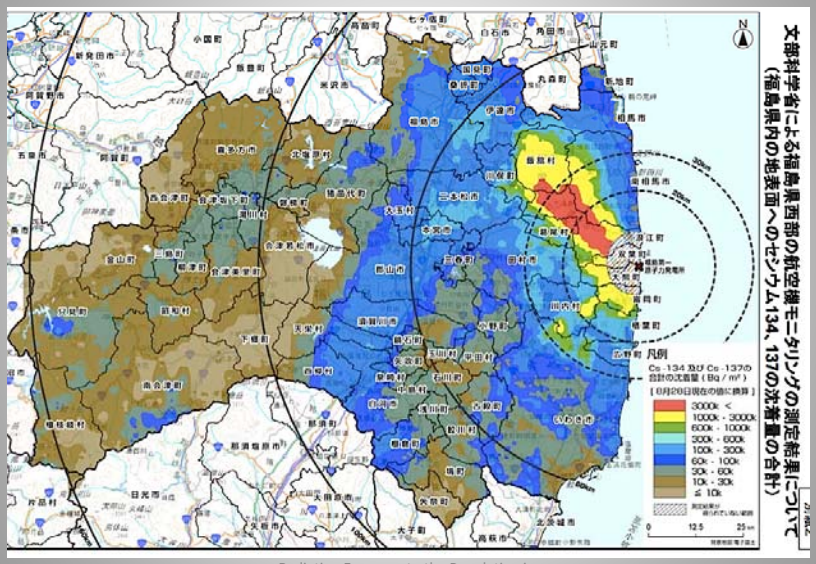
Air sampling stations

Primary radioisotopes detected

- Cesium-134 and cesium-137
- Iodine-131 (short lived)
- Cobalt-60
- Fission products

Detected as elements by SEM/EDS and as isotopes by gamma spectrometry, with total α & β counts.

Cs-137 Distribution – Fukushima Prefecture NMEXT and US DOE Data



Permissible doses in Fukushima Prefecture, 2011

- Raised from 1 mSv yr^{-1} to 20 mSv yr^{-1}
  (100 mRem yr^{-1} to 2000 mRem yr^{-1})
- US general public limits:
  10 mRem yr^{-1} EPA and 100 mRem yr^{-1} NRC

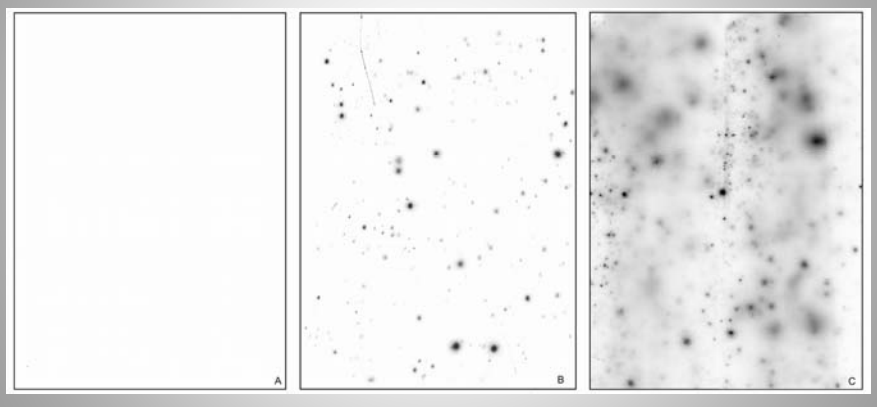
Collecting samples from Japan

- Sampling team includes university scientists, bloggers and farmers, all with varied technical training
- Requires education on safety and sample care
- Must be cognizant of cultural issues
- Requires safe and legal shipping methods, despite involving common everyday items, especially for biologically active soils

Autoradiographs – car air filters

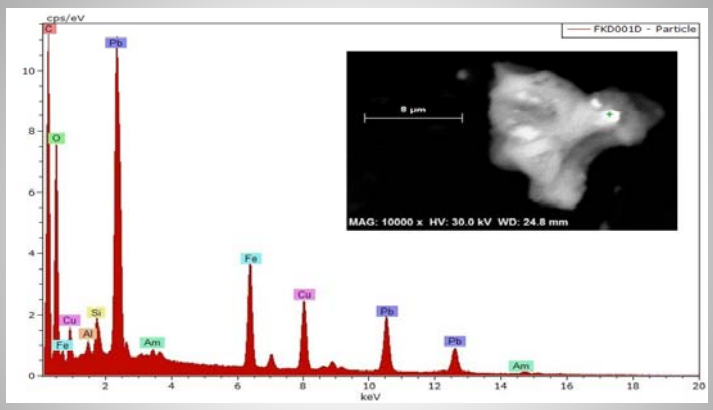
X-ray film image with surface activity in uR/hr., (blank = 11.2)

Seattle m=11.7 Tokyo m=18.9 Fukushima City m=199



Examining individual radioactive particles

Ibaraki dust sample, collected 4/4/2011,



High z particles, (Eu, Y, Zr, Th, Ce, Sr, Ce), in 1 to 15 um size range
Analyzed by SEM/EDS and gamma spectrometry

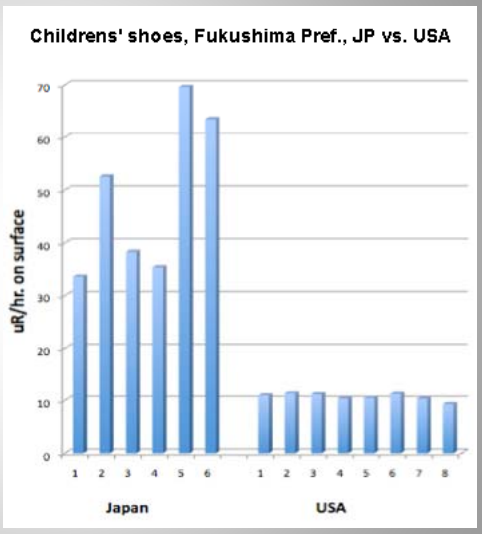
Radiation on children's shoes

Fukushima, Pref.
48.8 uR/hr. σ = 15.4,
USA mean
10.6 uR/hr. σ = 0.68

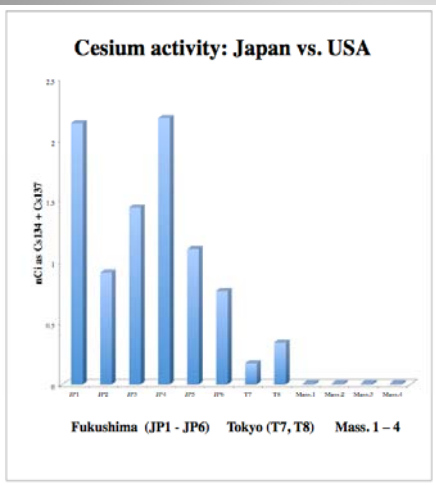
Elementary schools soils,
Fukushima Pref., mean,
(vs. 12.7 uR/hr. US)

260 to 359 uR/hr.
2.6-3.5 uSv/hr.

I^{131}+ Cs^{137}+ Cs^{134} MEXT data



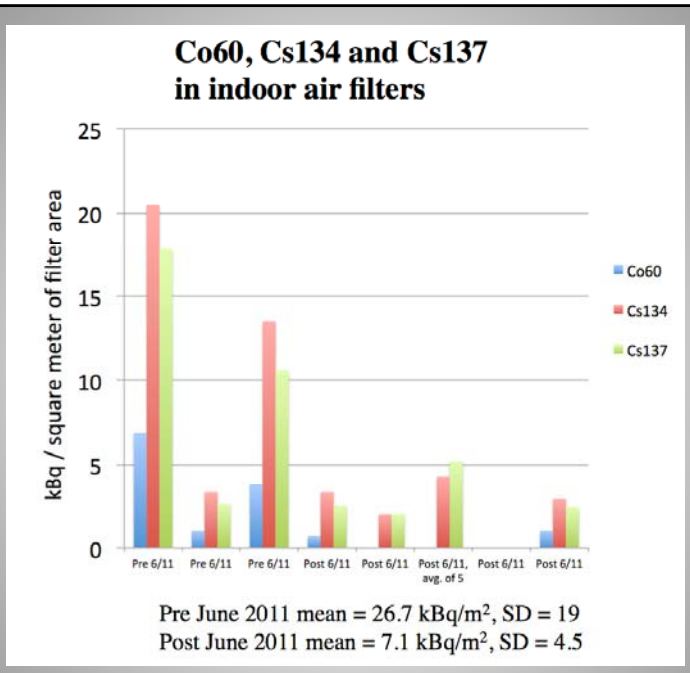
Cs134 + Cs137 on children's shoes



Japan average pCi = 1,180, SD = 790
USA average pCi = < 10 pCi, SD = NA

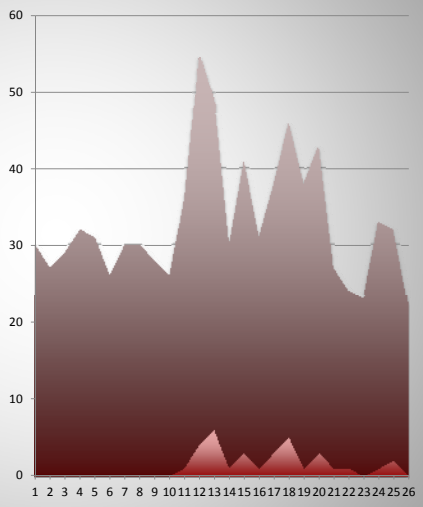
Environmental fate of radioactive dust

- Airborne levels have dropped, soil levels remain high, while food chain radiation can increase.
- Radiation is not uniform. Some areas are much higher than average, forming "hot spots" with up to 2.92 nCi/ft^2 radiocesium in surface dust.
- Cleaned areas can become recontaminated by dusts from "hot spots." Sept. 2011 Noda City house filters: 0.23 nCi radiocesium despite generally lower air levels.



Long distance dust transport

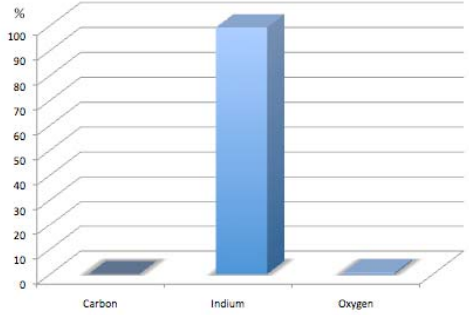
- Boston air filters had slightly elevated total α and β counts during April and May 2011.
- Seattle and Boston air filters had positive autoradiographic results during April 2011. All other USA filters were negative.



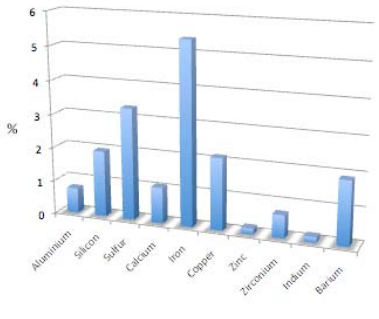
Bruker AXS Microanalysis GmbH, Germany 4/27/2011
Metals in air samples, collected: Natick, MA

Sample date:21 April 2011 to 24 April 2011
Results NAT #18 - Particle
Date: 4/27/2011 91 cubic meters on 045 um filter

Element	AN	orm. wt.-%]	orm. at.-%]	Error in %
Carbon	6	0.0	0.0	0.0
Indium	49	99.9	99.3	3.2
Oxygen	8	0.1	0.7	1.0
		100	100	



Element	AN	orm. wt.-%]	orm. at.-%]	Error in %
Aluminium	13	0.9	0.7	0.1
Silicon	14	2.4	2.0	0.2
Sulfur	16	4.7	3.3	0.3
Calcium	20	1.9	1.1	0.1
Iron	26	13.4	5.4	0.4
Copper	29	6.0	2.1	0.2
Zinc	30	0.5	0.2	0.0
Zirconium	40	2.8	0.7	0.2
Indium	49	0.8	0.2	0.1
Barium	56	11.6	1.9	0.4



EPA RadNet Precipitation Concentration Measurement Data

Issued: 4/4/2011

State	City	Date	Radionuclide (pCi/l)								
			Cs-134	Cs-136	Cs-137	I-131	I-132	I-133	Te-129	Te-129m	Te-132
AL	Montgomery	3/21/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
AL	Montgomery	3/24/2011	ND	ND	ND	16.7	ND	ND	ND	ND	ND
CA	Richmond	3/15/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
CA	Richmond	3/22/2011	ND	ND	ND	138	ND	ND	ND	ND	5.96
CT	Hartford	3/18/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
CT	Hartford	3/25/2011	ND	ND	ND	26.0	ND	ND	ND	ND	ND
GA	Atlanta	3/17/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
ID	Boise	3/22/2011	11.2	ND	11.6	242	ND	ND	ND	ND	ND
KS	Kansas City	3/21/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
MA	Boston	3/18/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
MN	St. Paul	3/22/2011	ND	ND	ND	32.3	ND	ND	ND	ND	ND
MN	Welch	3/17/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
NY	Albany	3/16/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
NY	Albany	3/23/2011	ND	ND	ND	30.0	ND	ND	ND	ND	ND
OH	Painesville	3/15/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
OH	Painesville	3/25/2011	ND	ND	ND	46.8	ND	ND	ND	ND	ND
OR	Portland	3/25/2011	ND	ND	ND	86.8	ND	ND	ND	ND	ND
TN	Oak Ridge/K	3/17/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
TN	Oak Ridge/K	3/24/2011	ND	ND	ND	17.7	ND	ND	ND	ND	ND
TN	Oak Ridge/M	3/17/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
TN	Oak Ridge/M	3/24/2011	ND	ND	ND	18.3	ND	ND	ND	ND	ND
TN	Oak Ridge/Y	3/17/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
TN	Oak Ridge/Y	3/24/2011	ND	ND	ND	13.4	ND	ND	ND	ND	ND
WA	Olympia	3/17/2011	ND	ND	ND	ND	ND	ND	ND	ND	ND
WA	Olympia	3/24/2011	ND	ND	ND	125	ND	ND	ND	ND	ND

(ND = No Detect)

Conclusion

- Circular evacuation zones were not protective; some evacuees moved to greater contamination.
- Air now cleaner, but dusts remobilize cesium.
- Cs-134 and Cs-137 nearly ubiquitous in Fukushima Prefecture and detectable throughout Tokyo; Co-60 found in dusts from northern Japan.
- US samples had only two isolated Cs-134 and Cs-137 detections in soil; Am-241 found offsite only in one Tokyo-area dust sample; I-131 has decayed.