

Radiation Exposure to the Population in Japan After the Earthquake

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

Air sampling stations



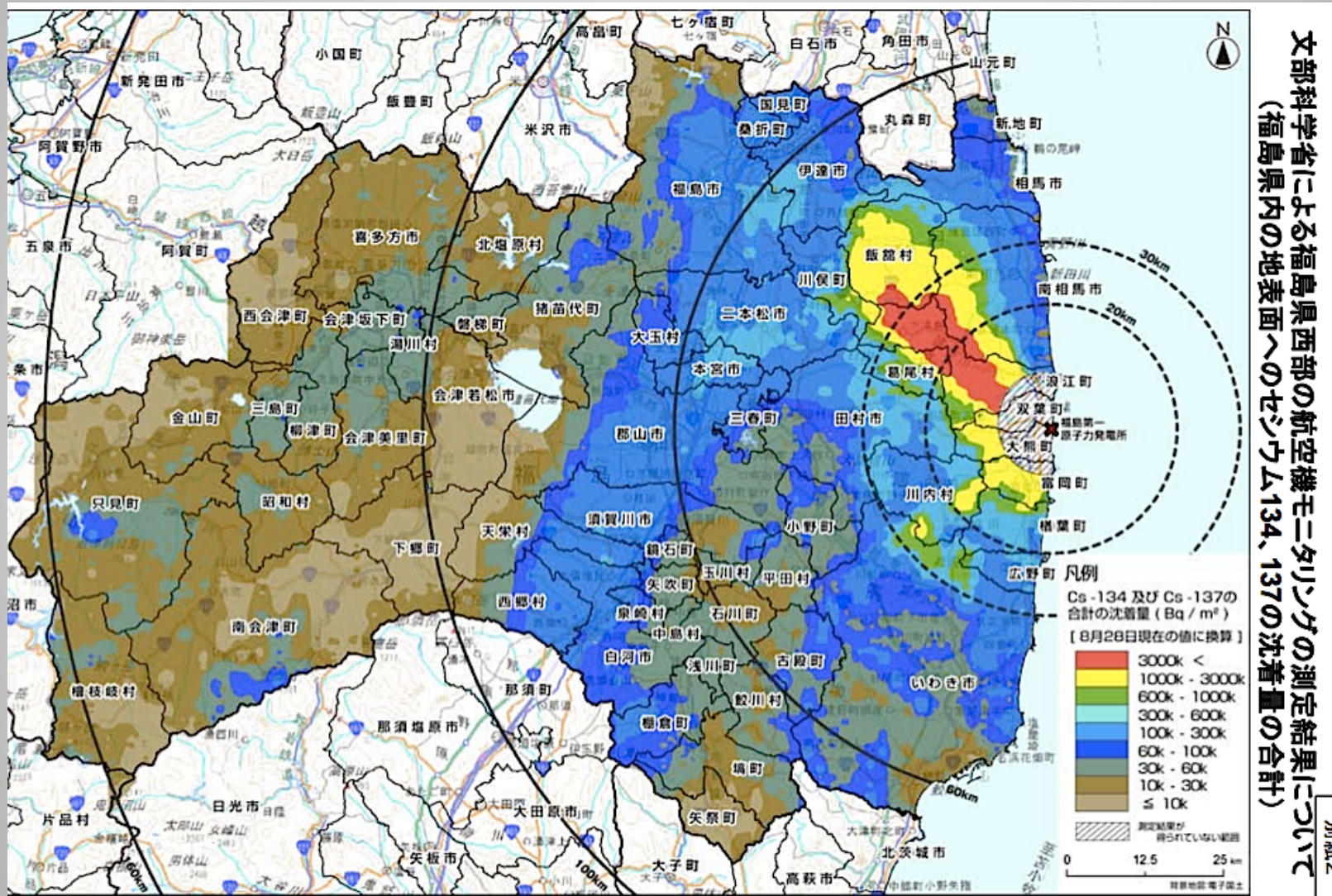
Primary radioisotopes detected

- 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 $2000 \text{ mRem yr}^{-1}$)
- 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

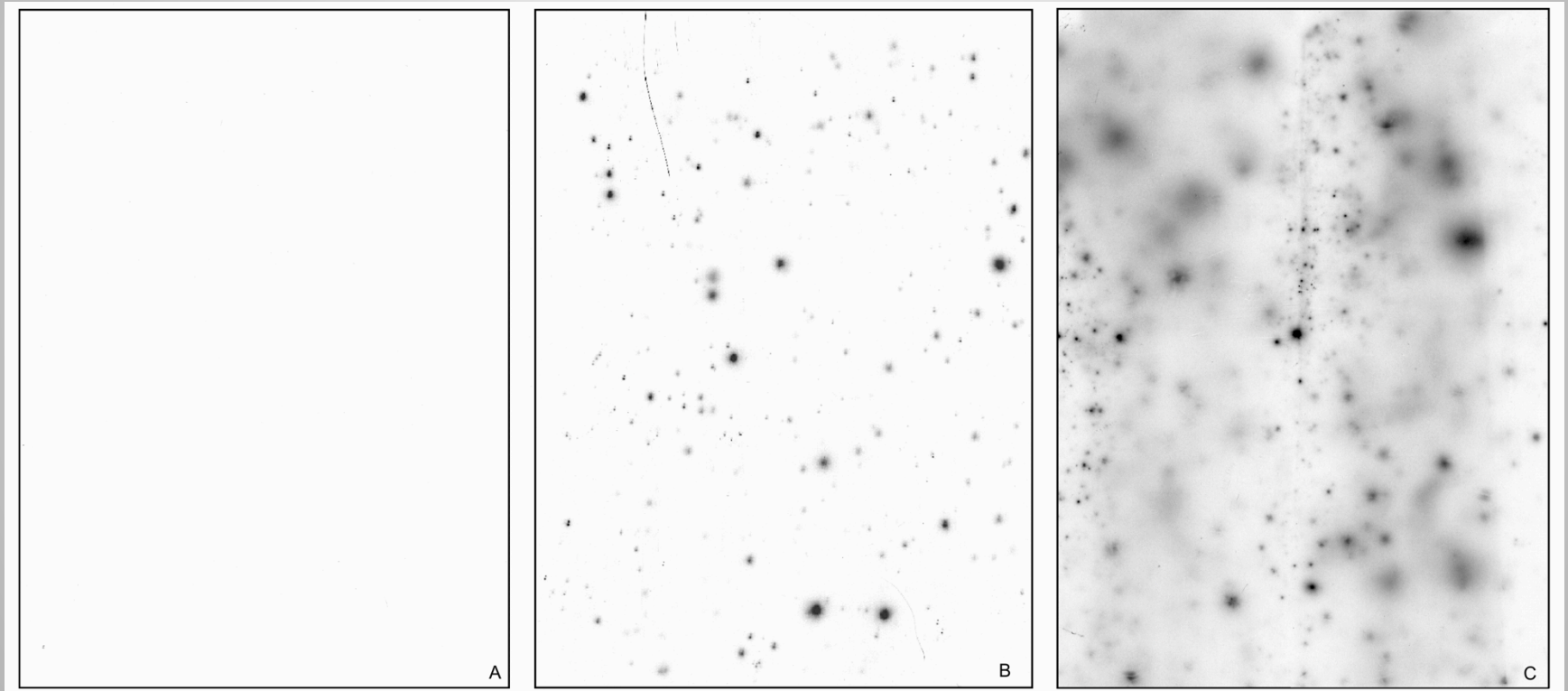
Autoradiographs – car air filters

April 2011, X-ray film image and uR/hr.

Seattle $m=11.7$

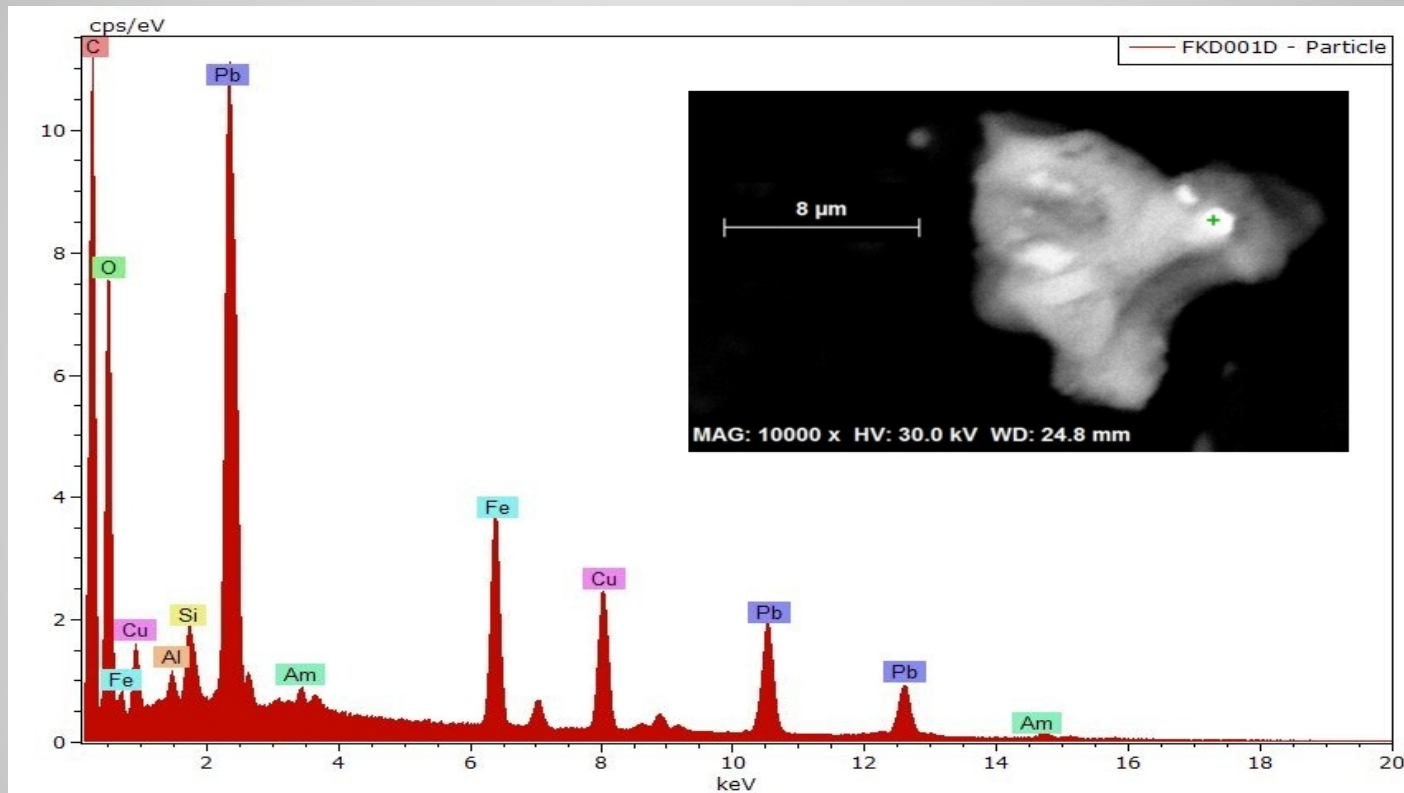
Tokyo $m=18.9$

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 μm size range
Analyzed by SEM/EDS and gamma spectrometry

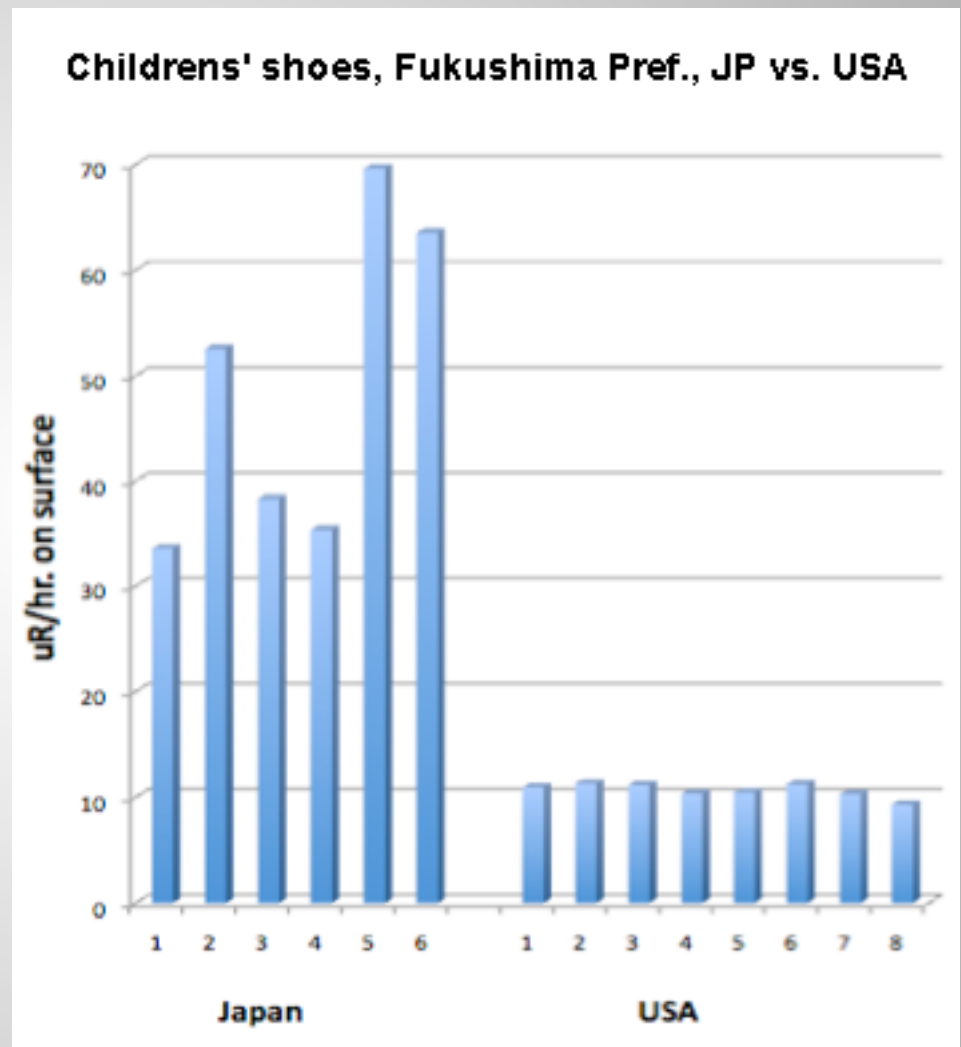
Radiation on children's shoes

Fukushima, Pref.
48.8 $\mu\text{R/hr}$. $\sigma = 15.4$,
USA mean
10.6 $\mu\text{R/hr}$. $\sigma = 0.68$

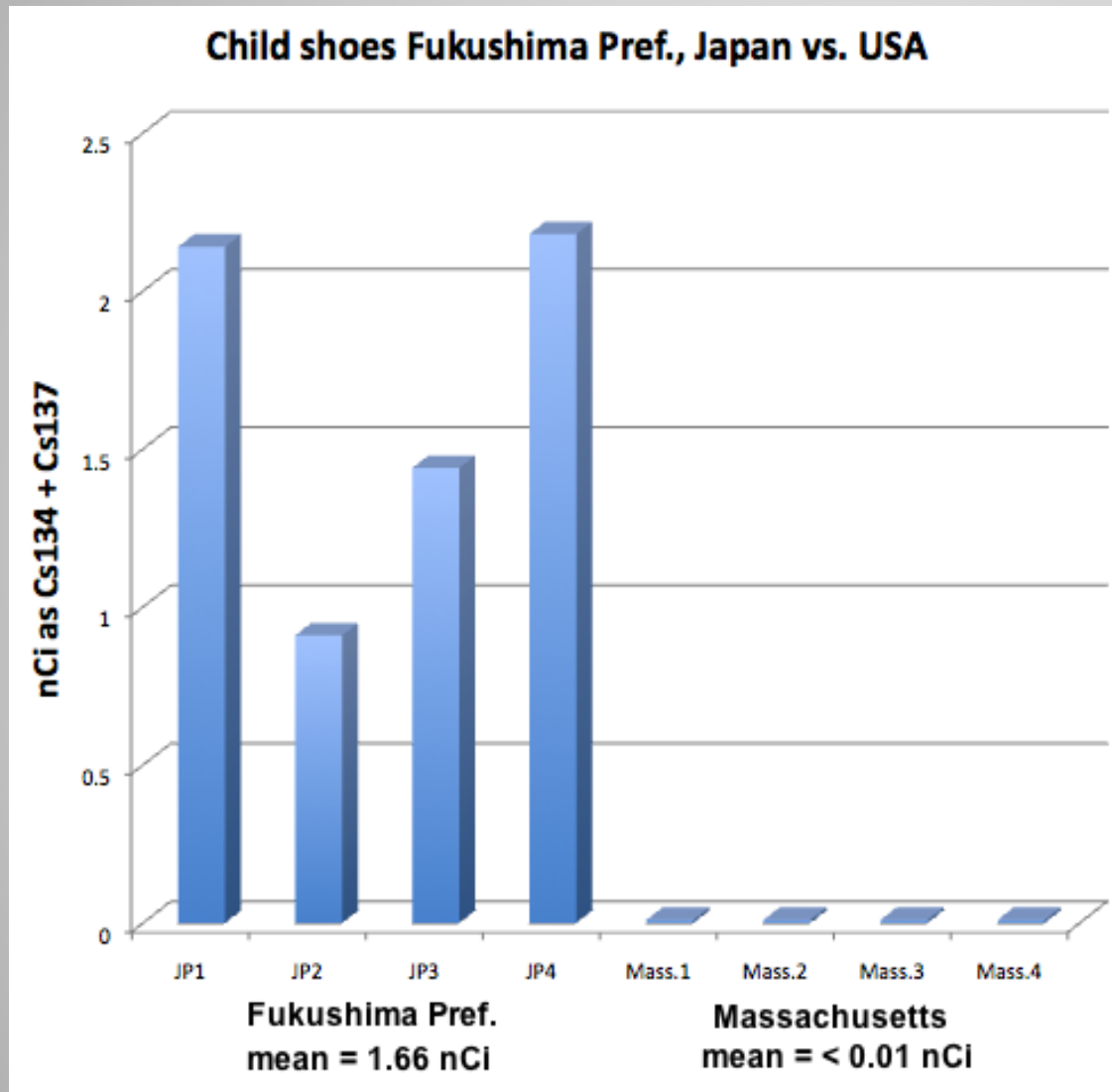
Elementary schools soils,
Fukushima Pref., mean,
(vs. 12.7 $\mu\text{R/hr}$. US)

260 to 359 $\mu\text{R/hr}$.
2.6-3.5 $\mu\text{Sv/hr}$.

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



Cs134 + Cs 137 on children's shoes

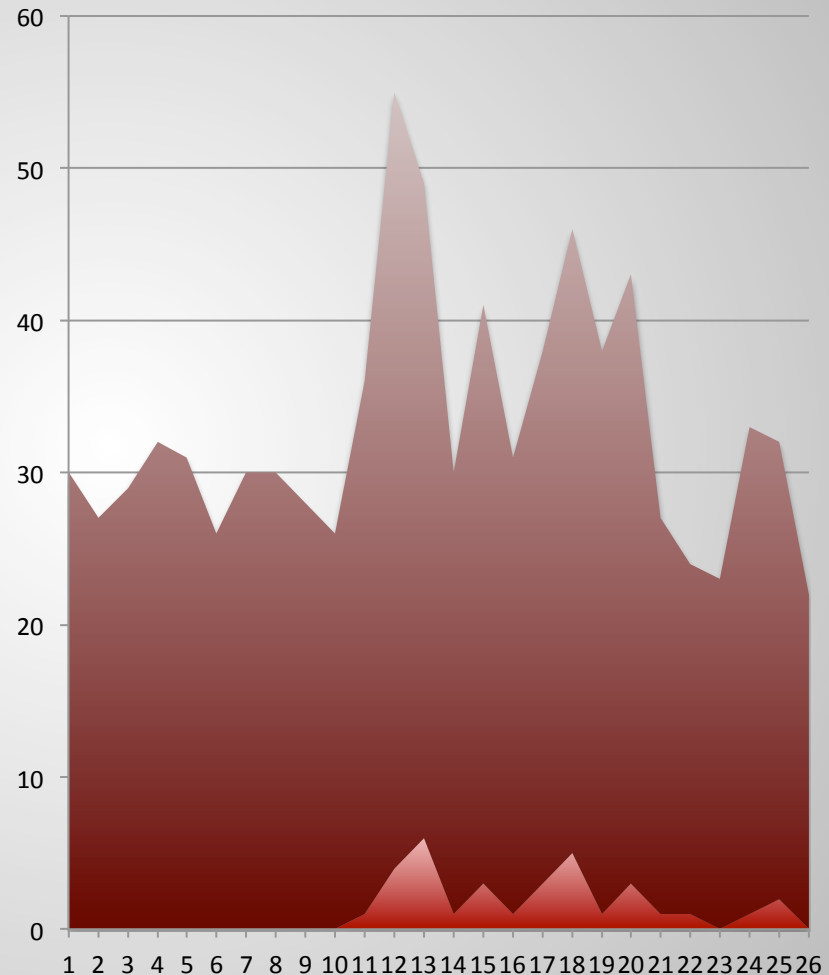


Environmental fate of radioactive dust

- 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/ft² 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.



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.

The 12 mile Japanese evacuation zone appears inadequate to protect the public health. Is it time to reexamine the US Nuclear Regulatory Commission 10 mile planning zone for airborne accidental nuclear releases?