

Depth-Dependent Measurement of Radioactive Cesium Activity Concentration in a 30 cm Soil Core from Fukushima

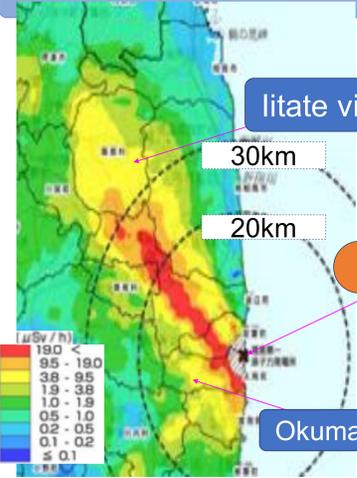
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Abstract

Radioactive materials released by the Fukushima Daiichi Nuclear Power Plant accident were dispersed by rain and wind, settling on land across various regions. We collected soil samples contaminated by this fallout and measured their radioactivity concentrations. The results revealed diverse patterns, suggesting that the concentration of ^{137}Cs in soil does not necessarily decrease exponentially with depth. Our investigation examined how decontamination work, site-specific characteristics, and activities by animals and humans alter the depth distribution and shift it away from an exponential decrease.

Introduction

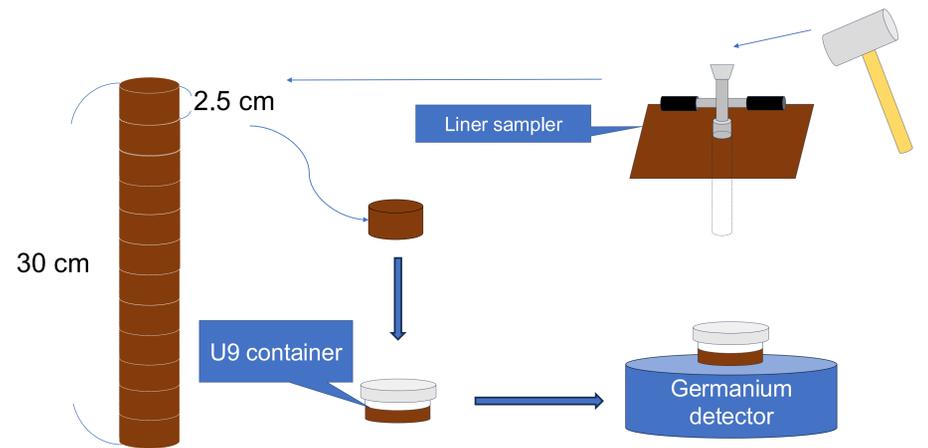


The map on the left shows the air dose rates in December 2011 following the Fukushima Daiichi Nuclear Power Plant accident. Radioactive materials did not disperse in concentric circles from the plant but spread in bands along the prevailing wind direction at the time of the accident. Consequently, radioactive contamination occurred even in the relatively distant village of litate. Decontamination work is still ongoing in various locations. This work involves removing the top 10 cm of contaminated soil and replacing it with imported new soil.

Okuma Town is the municipality where the Fukushima Daiichi Nuclear Power Plant is located, while litate Village is located about 30 km away from the plant.

It is generally known that the concentration of ^{137}Cs in soil decreases exponentially with depth. To confirm this, we started to measure the depth distribution of radioactive concentrations in soil samples from Okuma Town and litate Village in Fukushima Prefecture.

Method



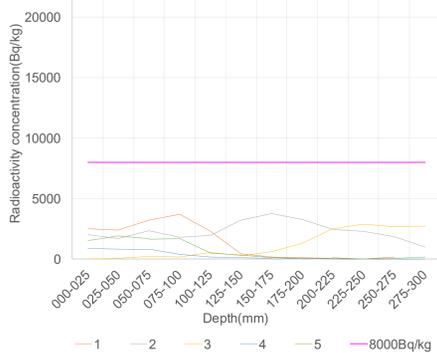
Soil samples were collected from the surface to a depth of 30 cm using a liner sampler. The collected 30 cm soil core was divided into 2.5 cm intervals. Each divided sample was thoroughly mixed and packed into U9 containers. The weight and height of the sample in each container were measured. The radioactivity concentration of ^{137}Cs was measured for each sample using a germanium semiconductor detector.

Result

The depth distribution of ^{137}Cs in soil cores collected from litate Village and Okuma Town is shown below. The dark pink line indicates 8000 Bq/kg. 8000 Bq/kg is the standard value for the safe disposal of waste.

Ichizawa garden (litate vilage)

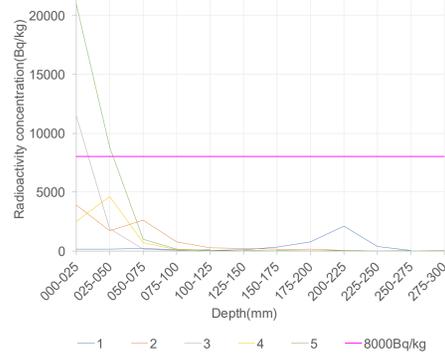
- This area was used as a blueberry farm even before the earthquake.
- After the earthquake, decontamination work was carried out, and the blueberries grown here are now being sold.



- All samples showed values below 8000 Bq/kg, confirming effective decontamination.
- As the land is cultivated as a blueberry field, the radioactive concentration is considered nearly uniform regardless of depth.

Ichizawa house's forest (litate vilage)

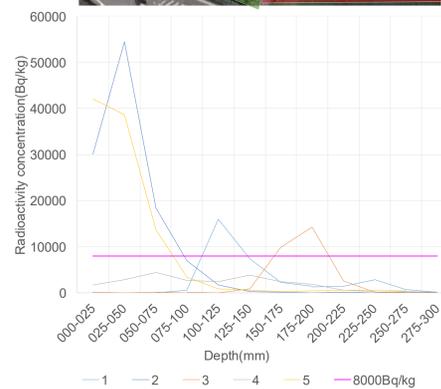
- This area is outside of Mr. Ichizawa's house and fields.
- While residential areas are decontaminated, mountains and such are not, so the back mountain remains undecontaminated.



- At locations 3 and 5, a clear exponential decrease was observed, indicating that decontamination has not been performed.
- Locations 2 and 4 are areas that have not been decontaminated, yet their levels are below 8000 Bq/kg. This is thought to be partly because the amount of radioactive material that fell on litate Village was relatively low.
- Location 1 is a residential area. The fact that levels are below 8000 Bq/kg indicates that effective decontamination was carried out.

KITAMUKAI (Okuma Town)

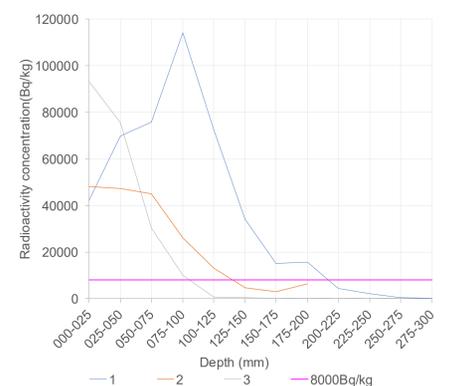
- This area was previously used as rice paddies.
- The green areas are decontaminated zones, while the red areas are zones where decontamination has not been performed.



- At locations 2 and 5, while the radioactivity concentration is slightly lower at the top layer, it decreases exponentially with increasing depth.
- Radioactivity concentrations at locations 1 and 3 exceeded 8000 Bq/kg at depths greater than 10 cm in some locations. This indicates that soil exceeding 8000 Bq/kg remained at depths deeper than the topsoil removed during decontamination work.
- Radioactivity levels at location 4 remained below 8,000 Bq/kg from the surface down to a depth of 30 cm.

OTTOZAWA (Okuma Town)

- This is an untouched area.
- This area was used as rice paddies.



- Radioactivity concentrations at location 1 showed exponential decrease in sections deeper than 7.5 cm, while concentrations were lower in sections shallower than 7.5 cm. This is thought to be caused by sediment influx from surrounding areas into the surface layer.
- Radioactivity concentrations at locations 2 and 3 decreased more gradually compared to other areas. This may be attributed to soil characteristics, animal activity (such as wild boars), or heavy rainfall.

Summary

- While some areas showed an exponential decrease in the depth distribution of ^{137}Cs radioactivity concentration in soil, others exhibited low surface concentrations or a gradual decrease. Animal activity and natural environmental factors are considered possible causes.
- In decontaminated areas, concentrations fell below 8000 Bq/kg, indicating effective decontamination in some locations. However, in other areas, even after removing the top layer, soil with concentrations around 15000 Bq/kg remained.

References

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Future Possibilities

- For areas where radioactive concentration is not decreasing exponentially, we want to examine the soil's constituent materials and particle size to investigate their relationship with Cs adsorption rates.
- This time, we collected samples from various locations to identify trends, but we want to collect more samples from a single location for a more detailed investigation.

Acknowledgements

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