2016.1.20
ISARD2016
@KEK, Tsukuba, Japan

Challenge for Remediation of Agricultural land Contaminated by Radiocesium in Iitate Village, Fukushima

東京大学 THE UNIVERSITY OF TOKYO

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2 NPO:Resurrection of Fukushima

1

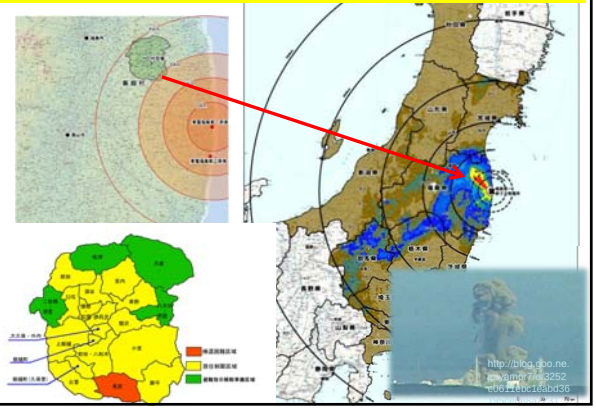
Agricultural engineering for Reconstruction

- Prof. Hidesaburo Ueno
  - Owner of Hachiko dog
  - Professor at Univ. of Tokyo
    - Law of Land consolidation(1900)
    - Lecture of Land consolidation (1905)
- Agricultural engineering
  - Infrastructure of food production
  - Barren land to fertile farmland
  - Land reclamation
  - Irrigation and drainage
  - Farmland decontamination
- Land use after decontamination
  - Rural plan after villagers return

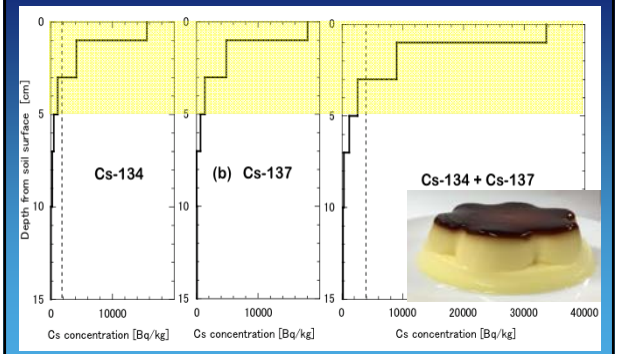
(2015.3.8)

2

Iitate Village in Fukushima Prefecture



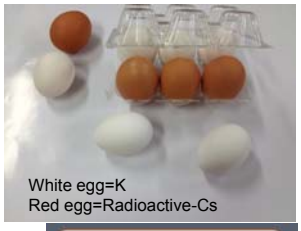
Vertical distribution of Cs in soil (24/5/2011)



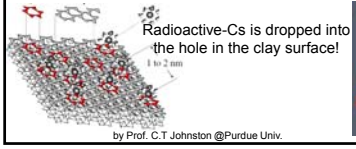
Shiozawa et al. (2011): Vertical concentration profiles of radioactive cesium and convective velocity in soil in a paddy field in Fukushima. Radioisotopes 60 : 323-328

Radioactive-Cs is replaced with K and fixed to the clay particles

Egg pack = a pair of clay sheets

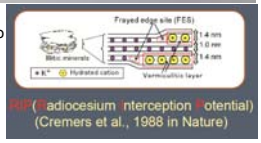


White egg=K
Red egg=Radioactive-Cs



Radioactive-Cs is dropped into the hole in the clay surface!

by Prof. C.T Johnston @Purdue Univ.



RIP (Radiocesium Interception Potential)
(Cremers et al., 1988 in Nature)

Measurement of radiation dose on a slope near the Iitate Village office (2011.6.25; Mizoguchi and Noborio)

Radiation dose was higher at the bottom of the slope than at the top of the slope

Stripping topsoil method

農林水産省

Official decontamination methods by Government

MAFF

Ministry of Agriculture, Forestry and Fisheries

From August, 2012

Soil puddling method

Deep plowing method

Current status of paddies in Iitate

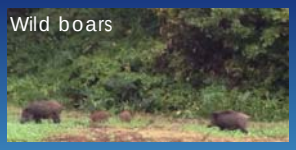
Decontamination work (2014.10)

"Temporal-temporal" storage space in a paddy

Soil dressing of farmland by sand (2015.3)

http://www.keinishikori.com/

Reality of narrow agricultural field



Need to develop a feasible decontamination method that farmers can conduct by themselves

2013.10.30
PAWEES2013
@Korea

Development of decontamination method farmers can do by themselves in paddy contaminated by radiocesium in Fukushima

Prof. Masaru *Mizo*guchi
Dept. of Global Agricultural Science
Univ. of Tokyo
東京大学

Practices utilizing the properties of cesium and clay

decontamination method by stripping frozen soil (2012.1.8)

Rotary weeder method (2012.4.1)

Made-method-1 (Komiya method)
Soil puddling + Deep plowing method

(2013.5.18)

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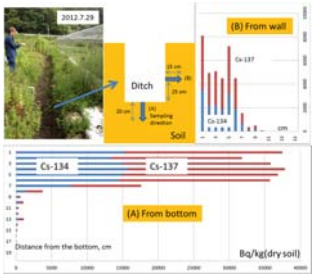
Pour contaminated muddy water into the drain



A result of the radioactivity measured at each depth by sampling the soil of the bottom and sides of the groove after a dried-up Cesium is not expected to immersion in the soil!

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Why all right? – Soil Filtration function!

Fresh water comes out when muddy water is poured in the sand. When this operation is repeated, fresh water becomes slow to comes out. Clay particles with radioactive cesium are also trapped in the sand by this principle.

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Made-method-1 (Sasu method)
Stripping topsoil + Deep plowing method

Burial of contaminated soil

Compaction of soil

2012.12.1

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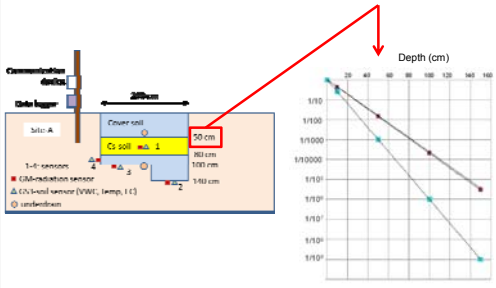
Contaminated soil should be buried in the bare hole!

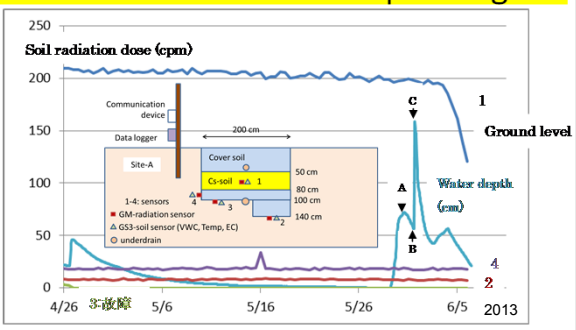
Radiation dose is 1/100 to 1/1000 just bury 50cm deep!



Question-1

- Does radioceasium leak from the buried contaminated soil?
- How can we check it?

Changes in the groundwater level and soil radiation after rice planting



Radiocaesium is not moved even if water penetrates!

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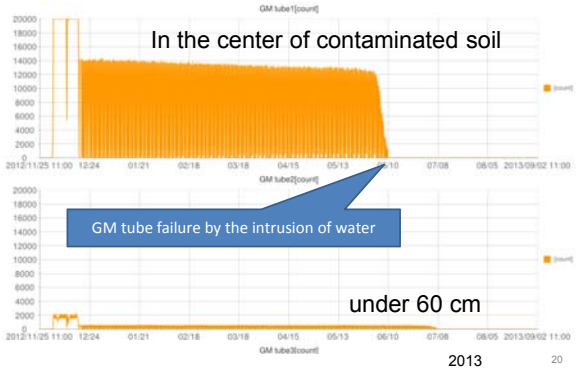
Long-term (?) monitoring of soil radiation



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Method

Experimatal Site:
Sasu, Iitate village, Fukushima

PVC pipes in inner diameter 10cm and 200cm long is installed at the depth of 150cm to the height of 50cm over the ground for the measurement of soil radiation

Buried construction of contaminated soil (2014.5.18)

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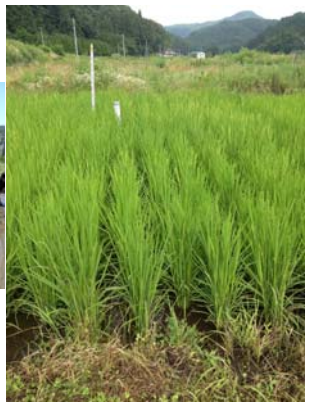
Plant rice in 2014



Rice planting by NPO (2014.6.1)

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Instrument to measure soil radiation

- Easy to measure soil radiation in a well
- 1 m long, 3 cm in diameter
- with 10 pieces of GM tube arranged at 10cm intervals
- Only 3 min to measure

MISAO Network

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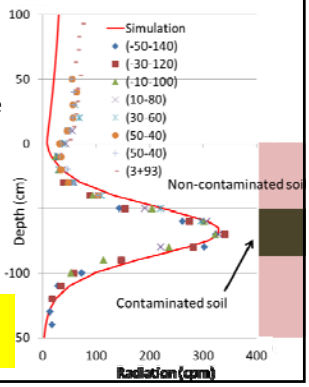
Result: Radiation dose in soil (cpm)

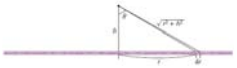
- has Gaussian distribution with a peak at around the depth of 70cm
- Is lower in the soil under the buried contaminated soil than in the topsoil.
  - No movement of cesium
- Is larger in air than in soil
  - Affected by forest around paddy

The distribution shape can be simulated with the model that takes into account the attenuation of the radiation by the soil.



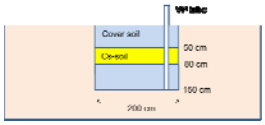
A model of soil radiation

$$I(h) = \int_a^b \frac{pe^{-\mu\sqrt{x^2+(y-h)^2}}}{4\pi\{x^2+(y-h)^2\}} 2\pi x dx$$



Relationship between a measuring point and radioactive matter on the ground

x: horizontal radius from the center of PVC pipe (cm)
y: height of measurement (cm)
h: height of GM tube (cm)
μ: attenuation coefficient of radiation (1/100 for 50 cm soil thickness)
p: concentration of cesium of soil
a: radius of PVC pipe (5cm)
b: radius of buried contaminated soil (cm)



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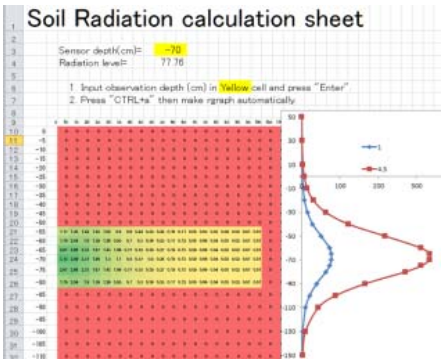
Approximate calculation by EXCEL sheet



demo

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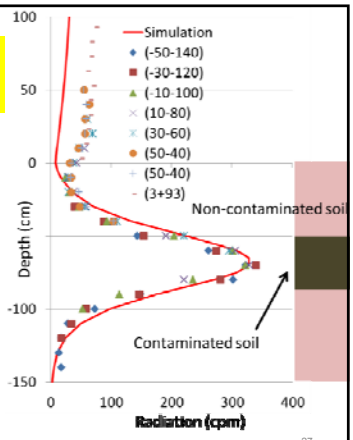
Simulation result

The distribution shape was reproduced in the model that takes into account the attenuation of the radiation by the soil.



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Amswers to Question-1

1. The local buried method is effective for remediation of farmland contaminated by radiocesium.
2. Gaussian distribution of the soil radiation was observed in paddy soil layer in which contaminated topsoil is buried at the depth of 50-80cm.
3. The observed result was simulated by a model that takes into account the radiation attenuation by soil.
4. Radiocesium may not leak from the buried-contaminated soil even if rice is grown normally under the flood condition in paddy field.
5. We need long-term monitoring and prediction of radiocesium movement in soil.

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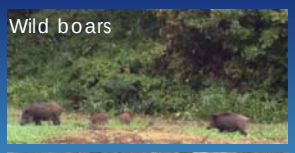
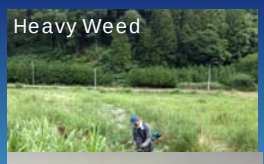
Question-2

- How should we estimate the thickness of contaminated soil in-site?
- How should we evaluate performance of decontamination before/after construction?

Situation of agricultural field after 4 years from the accident





Must measure vertical distribution and spatial distribution of Cs for decontamination

DOJYO-kun (Soil radiation meter)

Measurement Time: 3 min

GM tube: LND712
(LND, Inc.)

How to use the in-situ device “DOJYO-kun”

Paddy field in Sasu, Fukushima

(1) Experimental area
Iitate Village, Fukushima, Japan. (19, 27/7/2014)

(2) Measurement Points
3×4 Points before and after decontamination

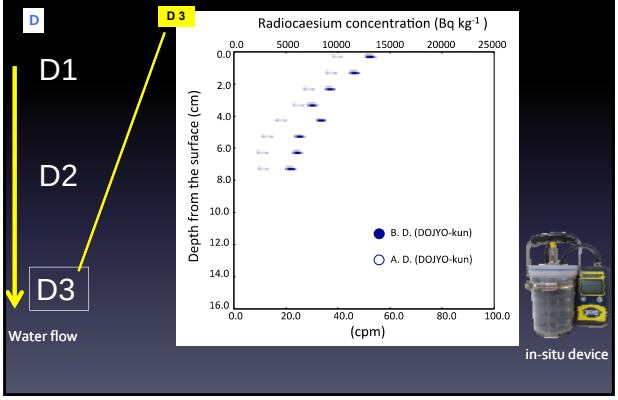
(3) Measurement data
○ Cs concentration;
・Soil sampling: 0～16 cm,
・Device: 0～8 cm

Methods

Decontamination with tennis court brush

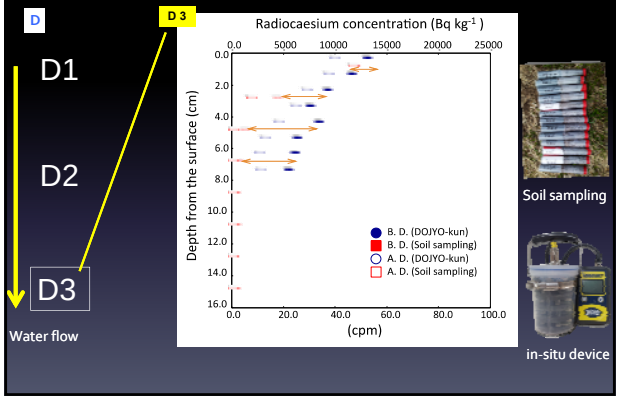
Results

Vertical distribution of Cs in the field before and after decontamination (D3)



Results

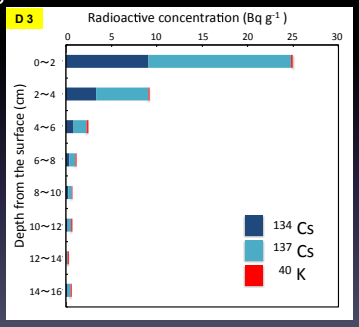
Vertical distribution of Cs in the field before and after decontamination (D3)



Results

Radioactive concentration of ^{134}Cs, ^{137}Cs, ^{40}K in each depth

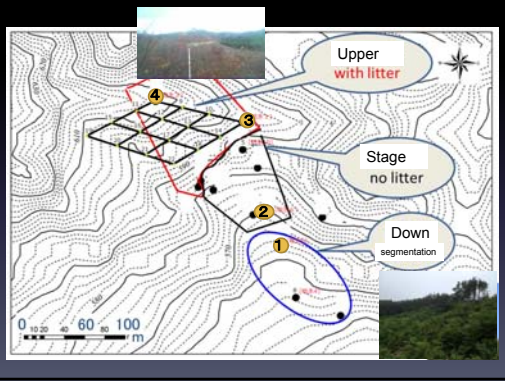
Using Ge scintillation detector



○ Rate of ^{40}K

0.6%
1.5%
6.7%
10.6%
15.3%
19.5%
47.0%
21.6%

DOJYO-kun in forest area



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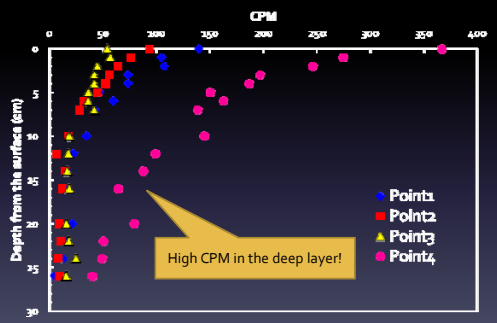
DOJYO-kun data



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Cs concentration

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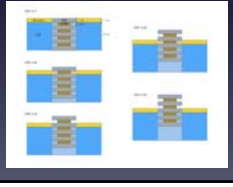
CPM → Cs concentration

How to estimate

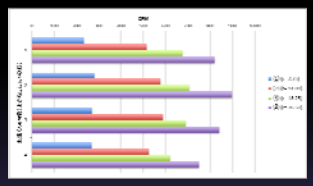
Partially contaminated experiment

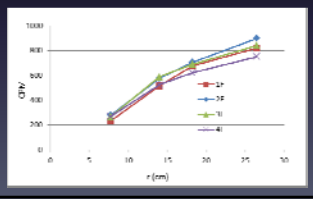
- Effect of radius
  - 7.75, 14.0, 18.25, 26.5 cm
- Only top soil coontaminated

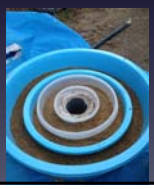
Contaminated soil (151,471 Bq kg⁻¹)
Non-contaminated sand (842 Bq kg-1)



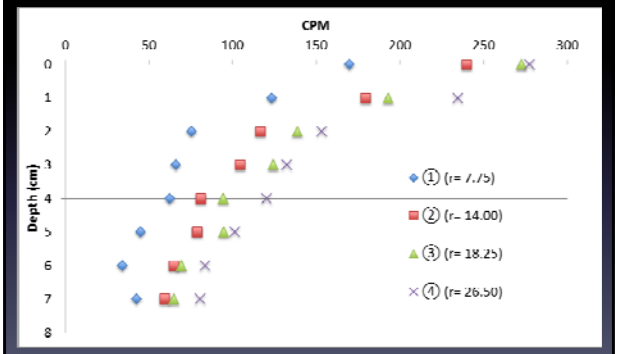
Effect of radius



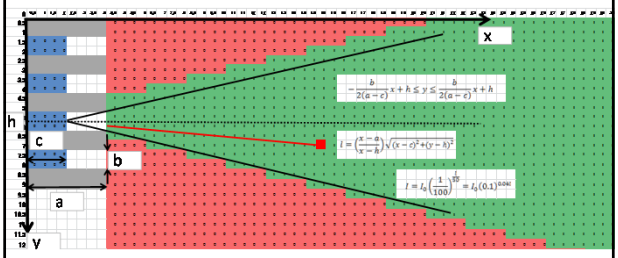




CPM distribution

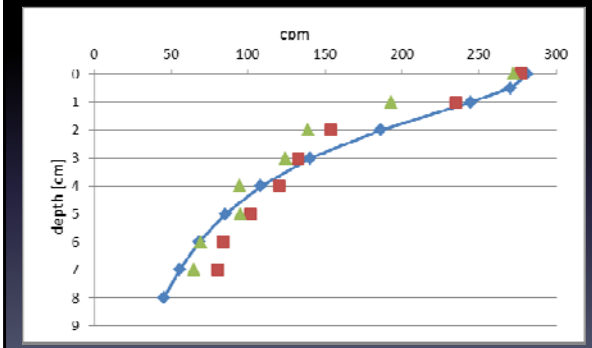


EXCEL Simulation by a simple model

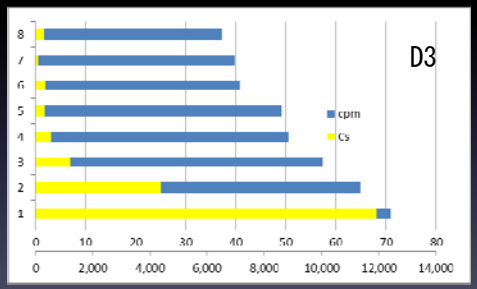


http://www.iai.ga.a.u-tokyo.ac.jp/mizo/edrp/fukushima/141115rad/

Results



Difference between CPM and Cs concentration



Compton scattering? Lead? Beta ray?

Answers to Question-2

- I did NOT succeed to estimate Cs concentration in soil from CPM results.
- I cannot understand the reason why the simple model succeeded to simulate the observation result.
- I would like to discuss the attenuation process of the radiation in soil.

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Current status of our activities in Iitate Village

東京大学 THE UNIVERSITY OF TOKYO

New challenges for the agriculture resurrection

Collaboration among farmers, NPO and university


農地再生 ともに一歩
除染後 利用法探る
専門家の助力で地力回復
協定締結へ
NPO
大学

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Tasks for returning to village

- Ready to return to village in April in2017
  - Village office will return in July, 2016
- Radiation monitoring by villagers themselves
  - User-friendly tools for radiation monitoring

Need help of KEK !

- Revival of infrastructure for life
  - Industries including agriculture

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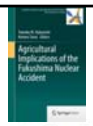
Thank you for your attention

Acknowledgments

Mr. Muneo Kanno, Agriculture Committee in Iitate village
Members of NPO "Resurrection of Fukushima"
Agricultural engineering team for reconstruction Fukushima at University of Tok

Activity report can be seen on my homepage



Collection of Mizo's works on Fukushima (in English)

Movie: http://www.iai.ga.a.u-tokyo.ac.jp/mizo/edrp/fukushima/Fukushima_articles.html

1. (2015.3.3) The Rebirth of Fukushima (D, H, S)
2. (2013.9.19)Frozen soil shuts water flow
3. (2012.11.20)Filtration of muddy water using sand
   Fresh water comes out when muddy water is poured in the sand. When this operation is repeated, fresh water becomes slow to comes out. Clay particles with radioactive cesium are also trapped in the sand by this principle.

TV

1. (2013.12.19) Decontaminating Fukushima: Cleaning up Farms(NHK WORLD)
2. (2013.12.09) Decontamination: Challenge of the Villagers(NHK-WORLD,TOMORROW)
3. (2012.03.09)Japan tsunami: Battling Fukushima radiation one year on(BBC, UK)

Article:

1. (2013.12.12) FUKUSHIMA NEDFRYSNING SOM SKAPAR FRAGETECKEN
2. (2013.10.31)How Engineers Use Ground Freezing to Build Bigger, Safer, and Deeper(NOVA next, USA)

Academic meeting:

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