

Sustainable Technologies for Environmental Management  
Supported by World Class Professor 2023 Program

# Agricultural Land Remediation in Radioactive Contaminated Area

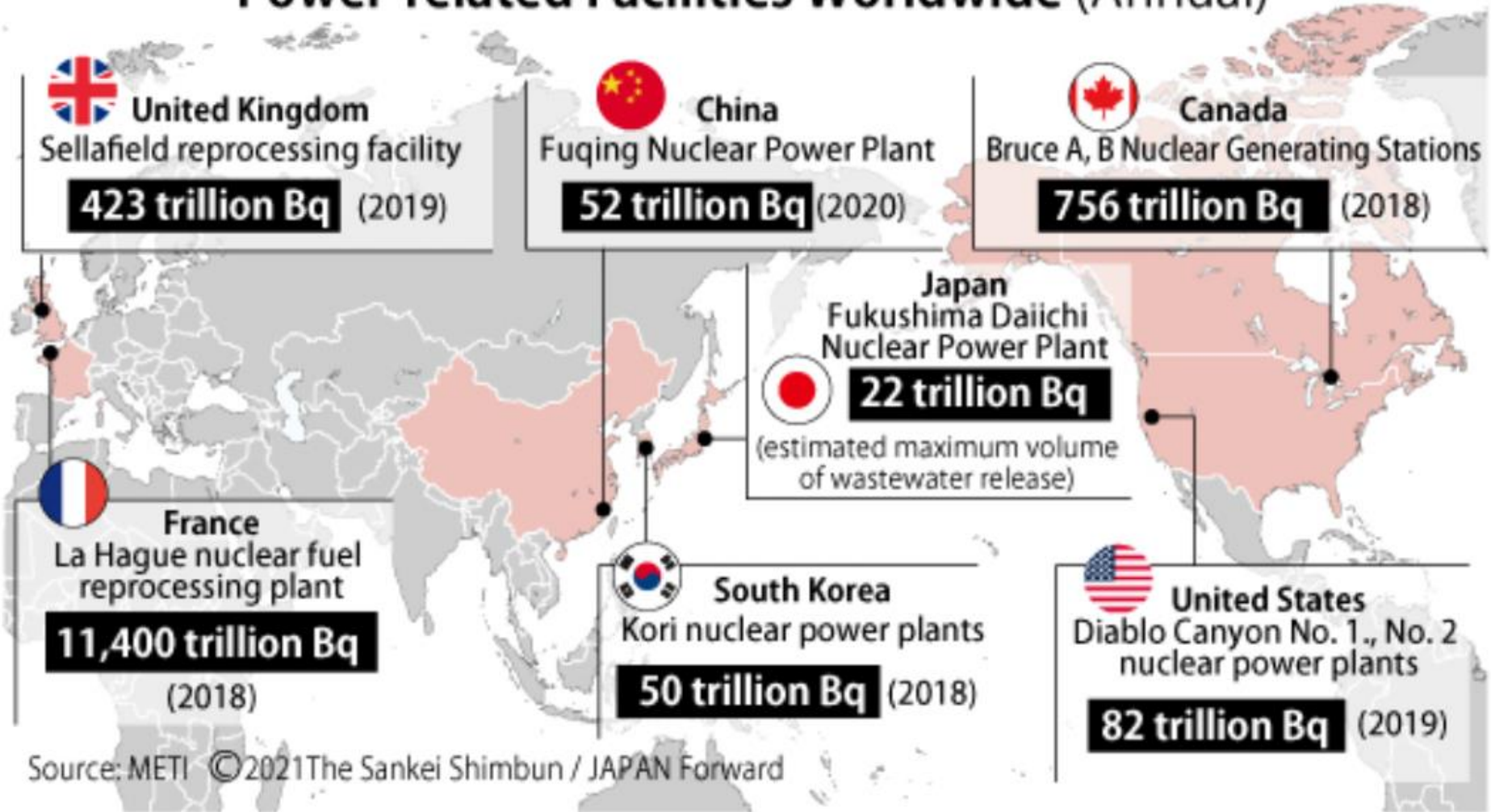


Masaru **MIZOGUCHI**



Graduate school of Agricultural and Life Sciences

# Volume of Tritium Discharge in Liquid Form for Major Nuclear Power-related Facilities Worldwide (Annual)

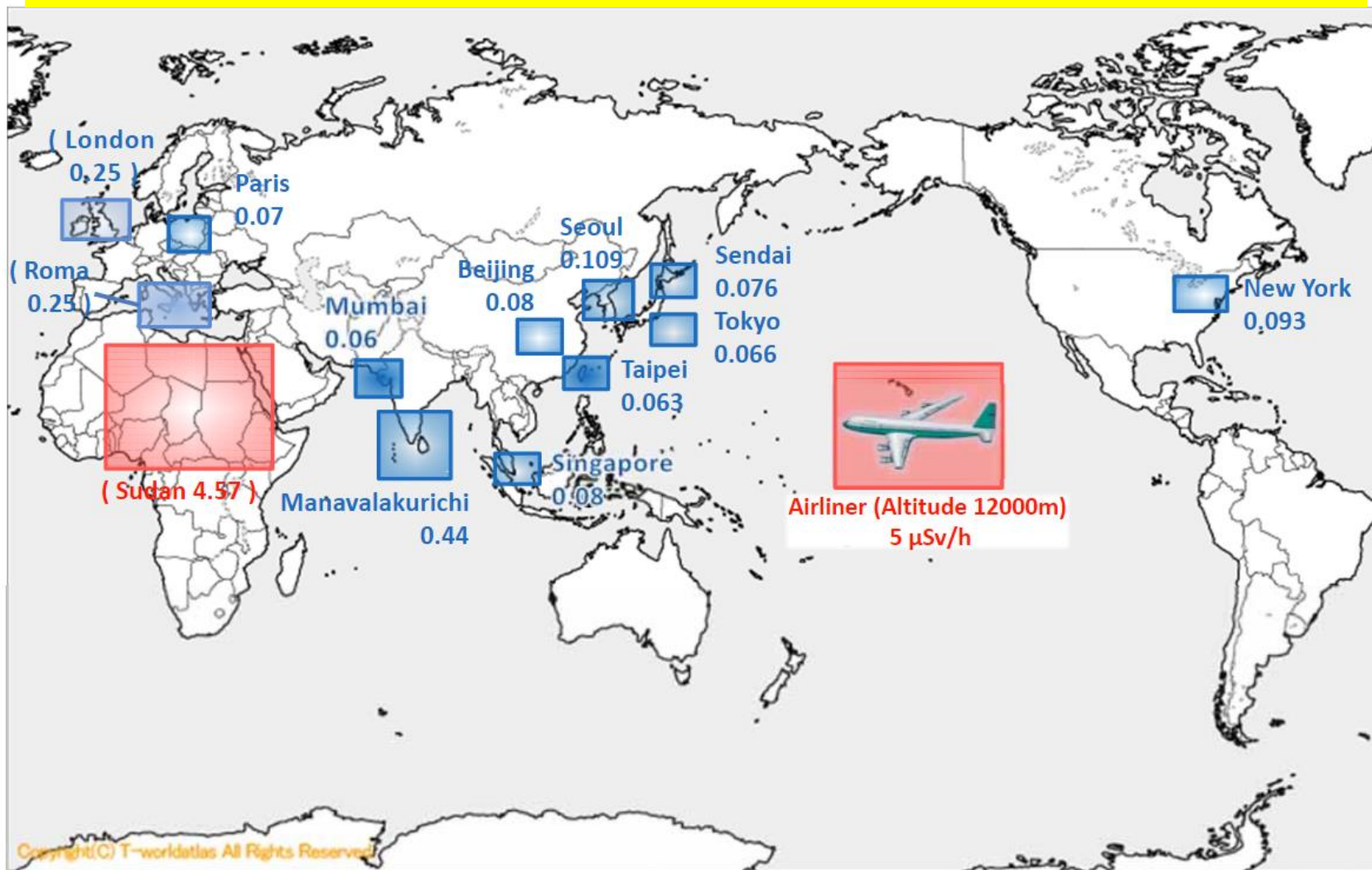


Source: METI ©2021The Sankei Shimbun / JAPAN Forward

<https://japan-forward.com/china-and-south-korea-too-release-nuclear-plant-wastewater-into-the-oceans/>

# Radiation dose in the world ( $\mu\text{Sv/h}$ )

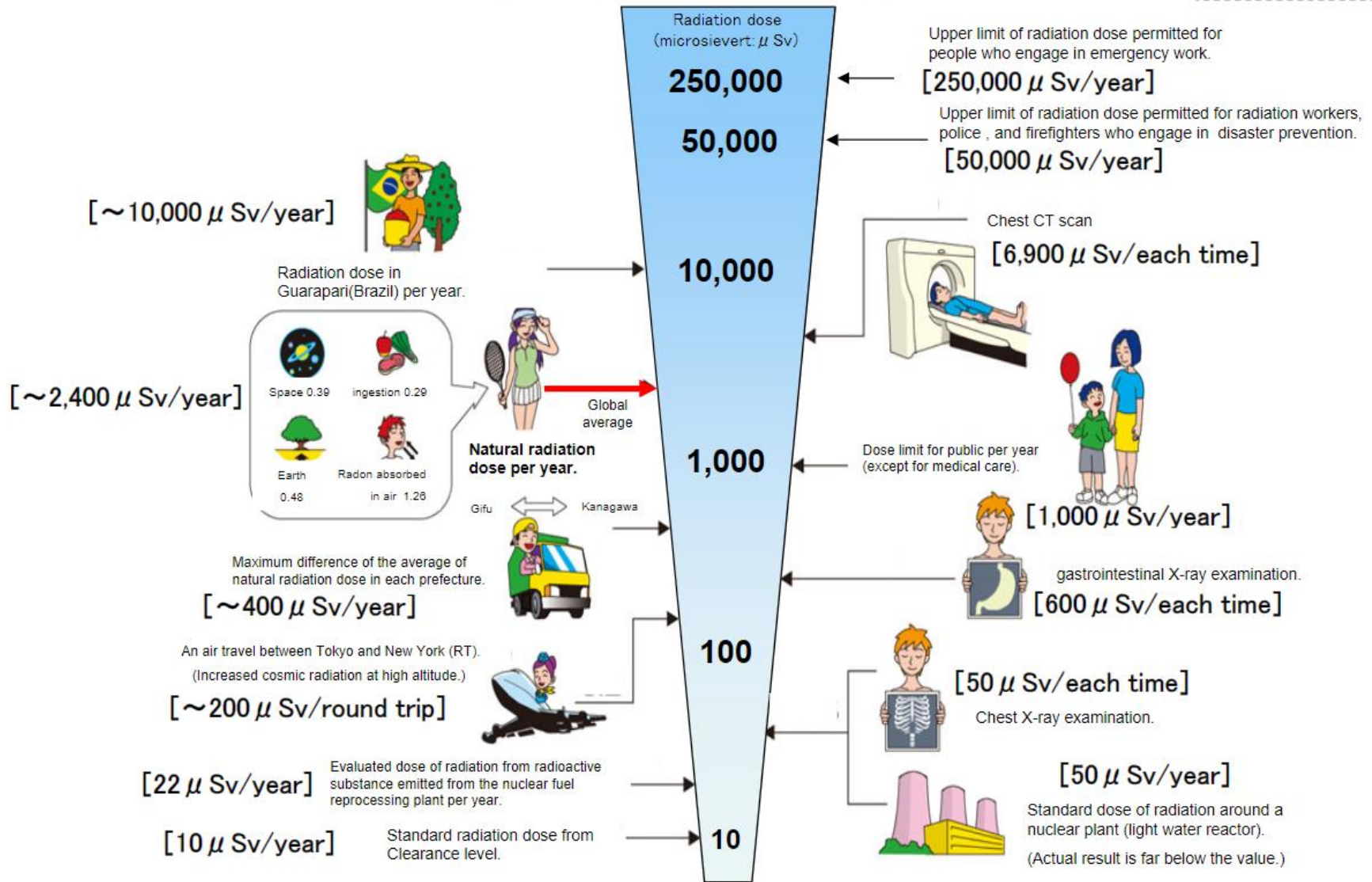
May 2011



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# Radiation in Daily-life

※Unit :  $\mu\text{Sv}$



(Ref) Average dose rate at the monitoring post of Tokyo (3/17 9:00~3/18 9:00, March) :  $0.050 \mu\text{Sv}/\text{h} = 438 \mu\text{Sv}/\text{y}$

# Agriculture and Rural Area

## Agricultural Infrastructure

public works

Soil, Water, Rural Areas, Information



Supporting agricultural production

A behind-the-scenes role

March 2011

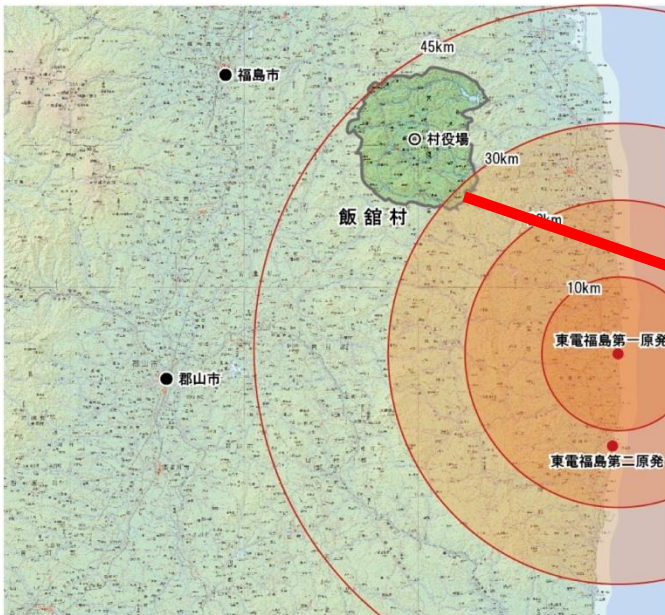
Nuclear power plant accident

1 水を貯める

2 水を運ぶ



# Iitate Village in Fukushima Prefecture

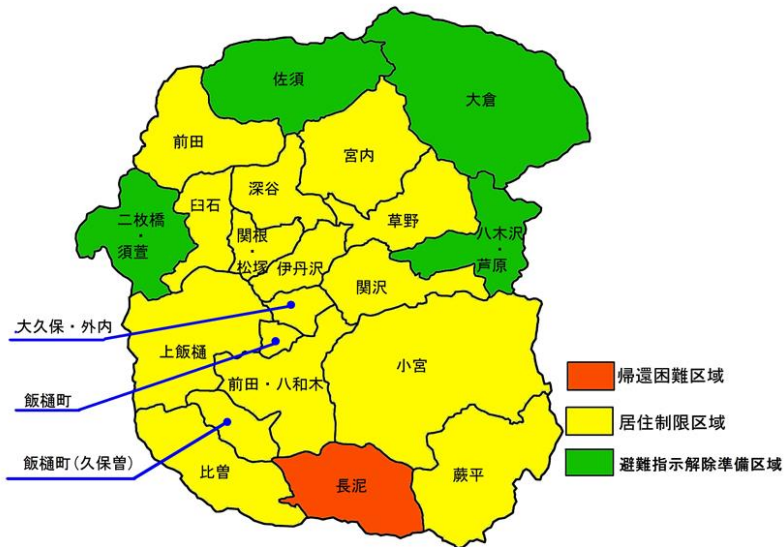
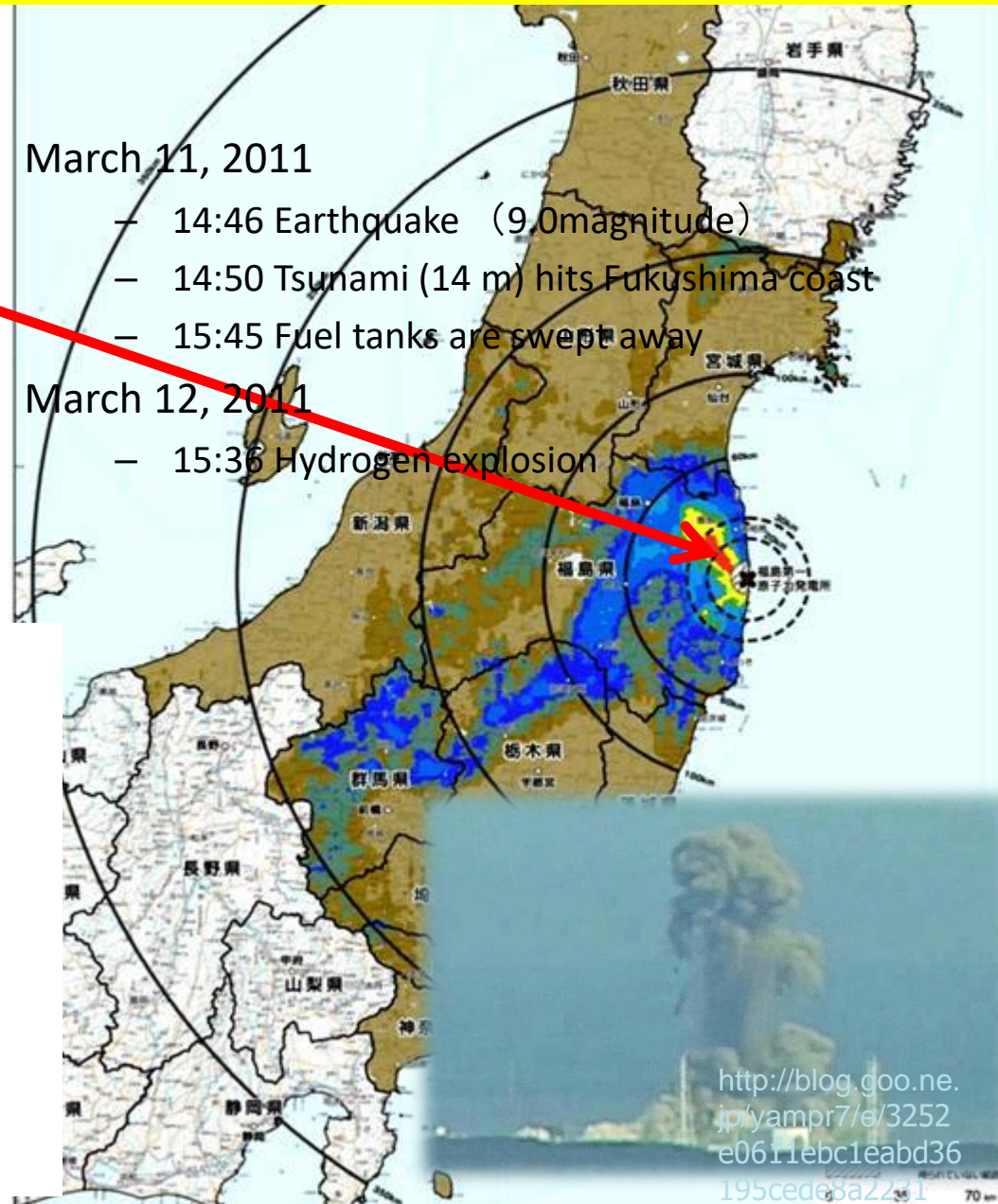


March 11, 2011

- 14:46 Earthquake (9.0 magnitude)
- 14:50 Tsunami (14 m) hits Fukushima coast
- 15:45 Fuel tanks are swept away

March 12, 2011

- 15:36 Hydrogen explosion



<http://blog.goo.ne.jp/yampr7/e/3252e0611ebc1eabd36195ced68a2231>

# How did I act immediately after the nuclear accident?

(2011.3.11) **The Great East Japan Earthquake**

(2011.3.15) Establishment of the University of Tokyo's Fukushima Reconstruction Agricultural Engineering Council (UT-FRAE)

(2011.5.30) Seminar on Radioactive Cesium on Clay Surface

(2011.6.25) First visit to Iitate Village

(2011.7.10) Symposium talk: the "soil" of Iitate Village

(2011.8.30) Encounter with NPO: "RESURRECTION OF FUKUSHIMA"

(2011.9.4) UT-FRAE first Field Survey of Iitate Village



How do we act  
for the afflicted area  
after Fukushima nuclear accident?  
The respective trajectories of experts and sufferers

原発事故後、  
いかに行動したか  
専門家と被災者の軌跡

# History of development of farmland decontamination methods and agricultural revitalization

- (2012.1.8) Frost Stripping Method
- (2012.4.1) Mud Sweeping Method with a weeder machine
- (2012.10.6) Student Tour of the Faculty of Agriculture, University of Tokyo
- (2012.12.1) The burial method  
(contaminated soil burial method)
- (2013.5.15) The Muddy Waters Forced Drainage method
- (2013.6.6) Waterlogging Experiment in a Paddy Field
- (2015.6.26) Drainage Survey of Farmland Soil after Decontamination
- (2016.6.24) Decontamination experiment in forest  
(contaminated soil burial method)
- (2017.3.21) Iitate flowerbed
- (2017.3.31) Lifting the Evacuation Order
- (2018.3.5 ) Collaboration Agreement  
between Iitate Village and the University of Tokyo
- (2018.5.1) The birth of the sake “Like a Phoenix”
- (2019.6 )Nominated for Cannes Lions
- (2019.8) Buckwheat Cultivation by Todai Murajuku



Please visit the following URL for the contents and photos of each item.  
<http://www.iai.ga.a.u-tokyo.ac.jp/mizo/edrp/fukushima/201017.html>





**小宮の大久保さん方**

**東大院生ら協力 飯館村の形の  
花壇が完成**

東京電力福島第一原発事故に伴い避難指示が三十日に解除された飯館村小宮の大久保さん方（ご近所）の有志二十日、村の形をした花壇の整備作業と、活動する大久保さん方の活動を東大の大学院生が撮影した。

大久保さん（前列左から2人目）方では花壇を整備した東大大学院の学生ら。前列左端が佐藤さん

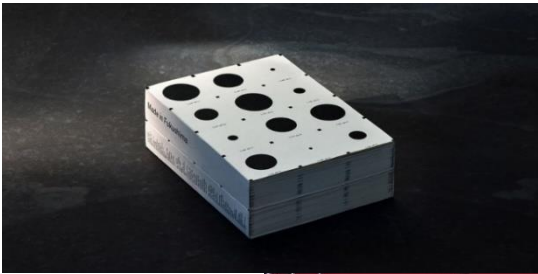
大久保さん（前列左から2人目）方では花壇を整備した東大大学院の学生ら。前列左端が佐藤さん

二三日の間に土壌改良剤を撒き始め、野菜を植える準備が整った。花壇の形は、大久保さん方の村の形に似せようとする。村の形は、大久保さん方の村の形に似せようとする。村の形は、大久保さん方の村の形に似せようとする。

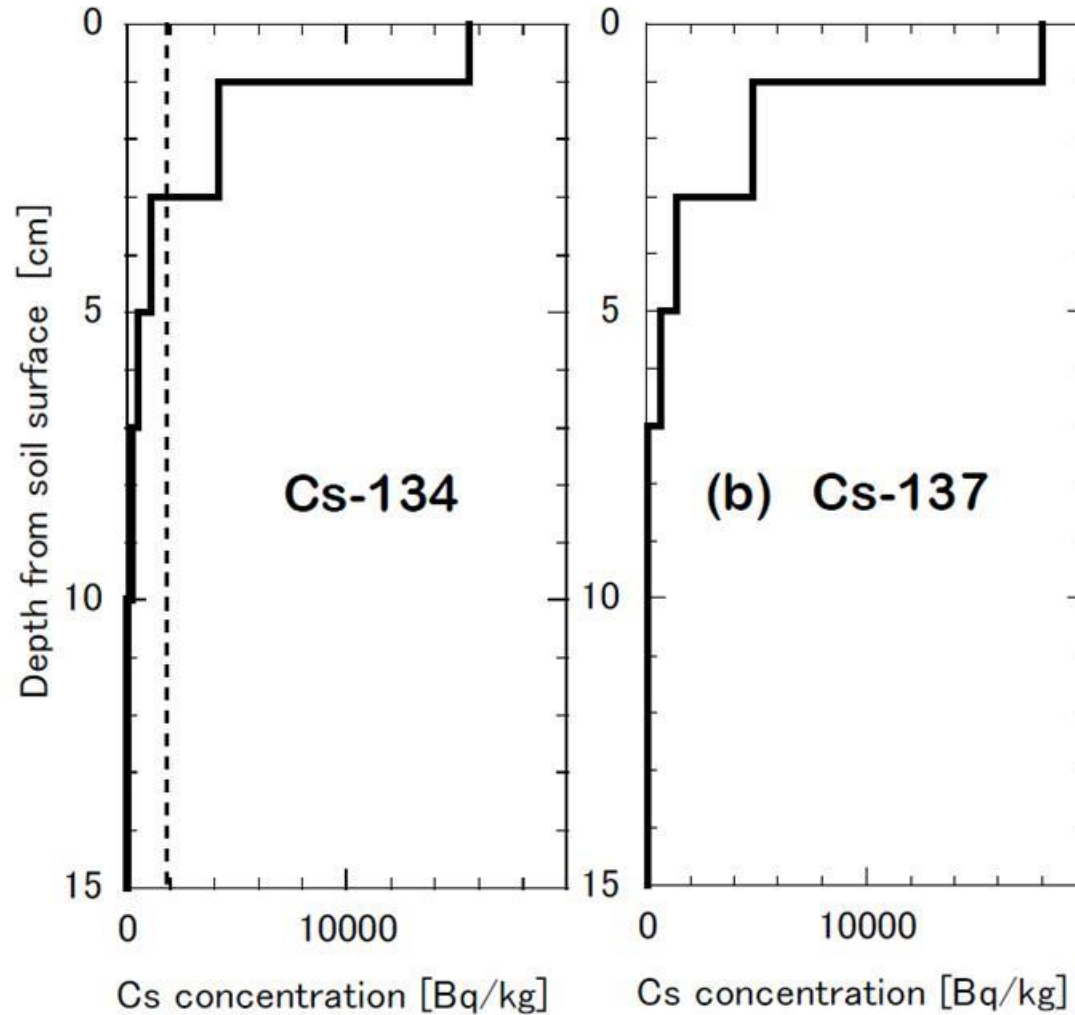
大久保さん方の村の形に似せようとする。村の形は、大久保さん方の村の形に似せようとする。村の形は、大久保さん方の村の形に似せようとする。



**飯館村が東大と連携協定**



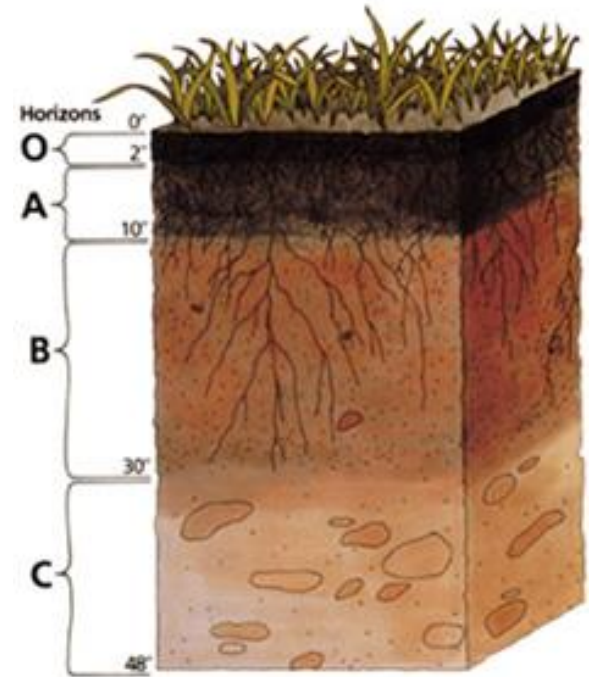
# Vertical distribution of Cs in soil (24/5/2011)



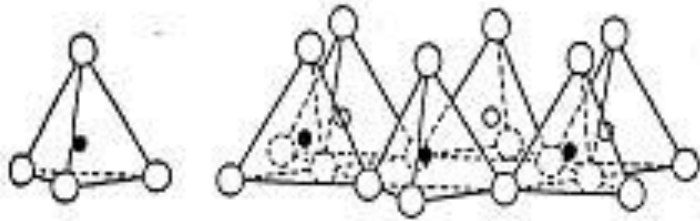
Shiozawa et al. (2011): Vertical concentration profiles of radioactive cesium and convective velocity in soil in a paddy field in Fukushima. *Radioisotopes* 60 : 323-328

# What is Soil?

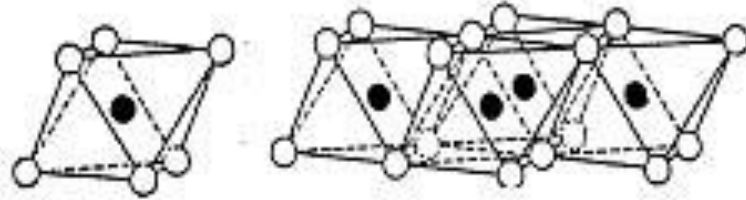
- What is soil composed of?
  - Soil particles, Water, Air
- Classification of Soil Particles
  - Classified by size
  - sand, silt, clay
- Properties of **Clay**
  - Hard to sink in water
  - Sludgy when it contains water
  - When it dries, it is stiff.



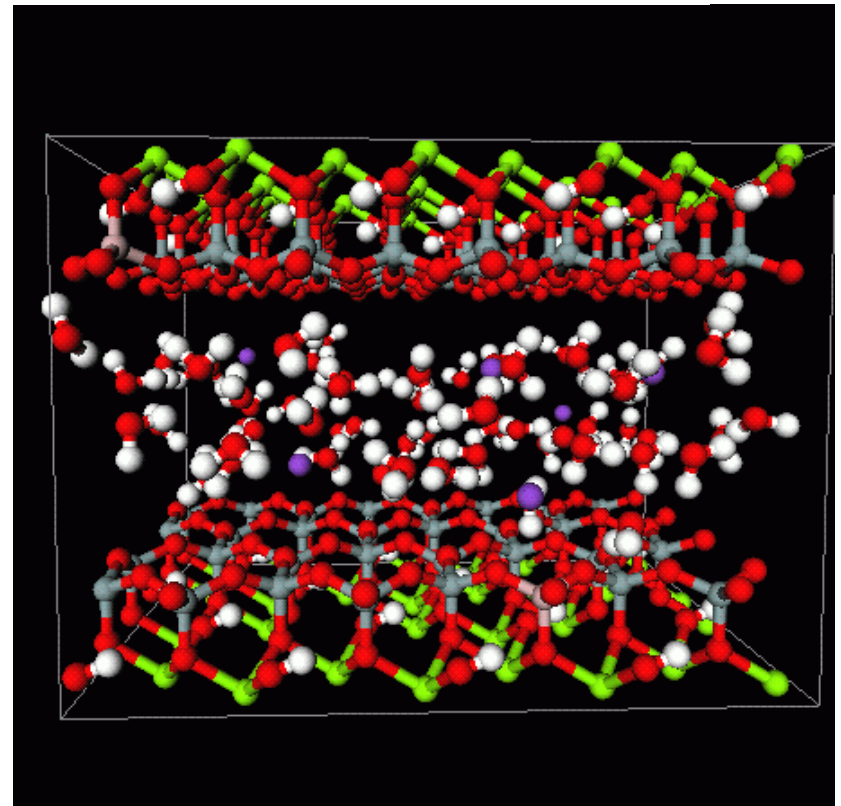
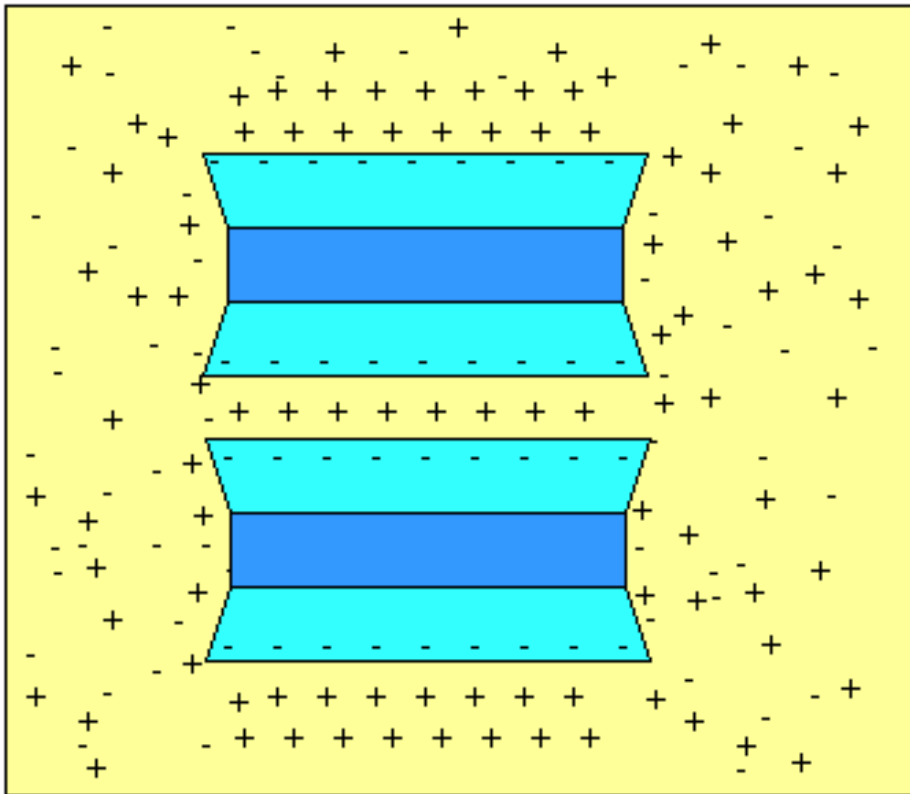
# 粘土の化学ーモンモリロナイト



○酸素原子  
●Si 原子



○酸素原子  
●M<sup>n+</sup> : Mg<sup>2+</sup>, Al<sup>3+</sup>, etc.



# Exchangeable cations

1 <b>H</b> 1.0079																	18 <b>He</b> 4.0026
3 <b>Li</b> 6.941	4 <b>Be</b> 9.0122											5 <b>B</b> 10.811	6 <b>C</b> 12.011	7 <b>N</b> 14.007	8 <b>O</b> 15.999	9 <b>F</b> 18.998	10 <b>Ne</b> 20.180
11 <b>Na</b> 22.990	12 <b>Mg</b> 24.305											13 <b>Al</b> 26.982	14 <b>Si</b> 28.086	15 <b>P</b> 30.974	16 <b>S</b> 32.065	17 <b>Cl</b> 35.453	18 <b>Ar</b> 39.948
19 <b>K</b> 39.098	20 <b>Ca</b> 40.078	21 <b>Sc</b> 44.956	22 <b>Ti</b> 47.867	23 <b>V</b> 50.942	24 <b>Cr</b> 51.996	25 <b>Mn</b> 54.938	26 <b>Fe</b> 55.845	27 <b>Co</b> 58.933	28 <b>Ni</b> 58.693	29 <b>Cu</b> 63.546	30 <b>Zn</b> 65.409	31 <b>Ga</b> 69.723	32 <b>Ge</b> 72.64	33 <b>As</b> 74.922	34 <b>Se</b> 78.96	35 <b>Br</b> 79.904	36 <b>Kr</b> 83.798
37 <b>Rb</b> 85.468	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.906	40 <b>Zr</b> 91.224	41 <b>Nb</b> 92.906	42 <b>Mo</b> 95.94	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.41	49 <b>In</b> 114.82	50 <b>Sn</b> 118.71	51 <b>Sb</b> 121.76	52 <b>Te</b> 127.60	53 <b>I</b> 126.90	54 <b>Xe</b> 131.29
55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.33	57-71 *	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.84	75 <b>Re</b> 186.21	76 <b>Os</b> 190.23	77 <b>Ir</b> 192.22	78 <b>Pt</b> 195.08	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.38	82 <b>Pb</b> 207.2	83 <b>Bi</b> 208.98	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)
87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89-103 #	104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (266)	107 <b>Bh</b> (264)	108 <b>Hs</b> (277)	109 <b>Mt</b> (268)	110 <b>Ds</b> (281)	111 <b>Rg</b> (272)	112 <b>Uub</b> (285)	113 <b>Uut</b> (284)	114 <b>Uuq</b> (289)	115 <b>Uup</b> (288)	116 <b>Uuh</b> (291)	118 <b>Uuo</b> (294)	

\* Lanthanide series

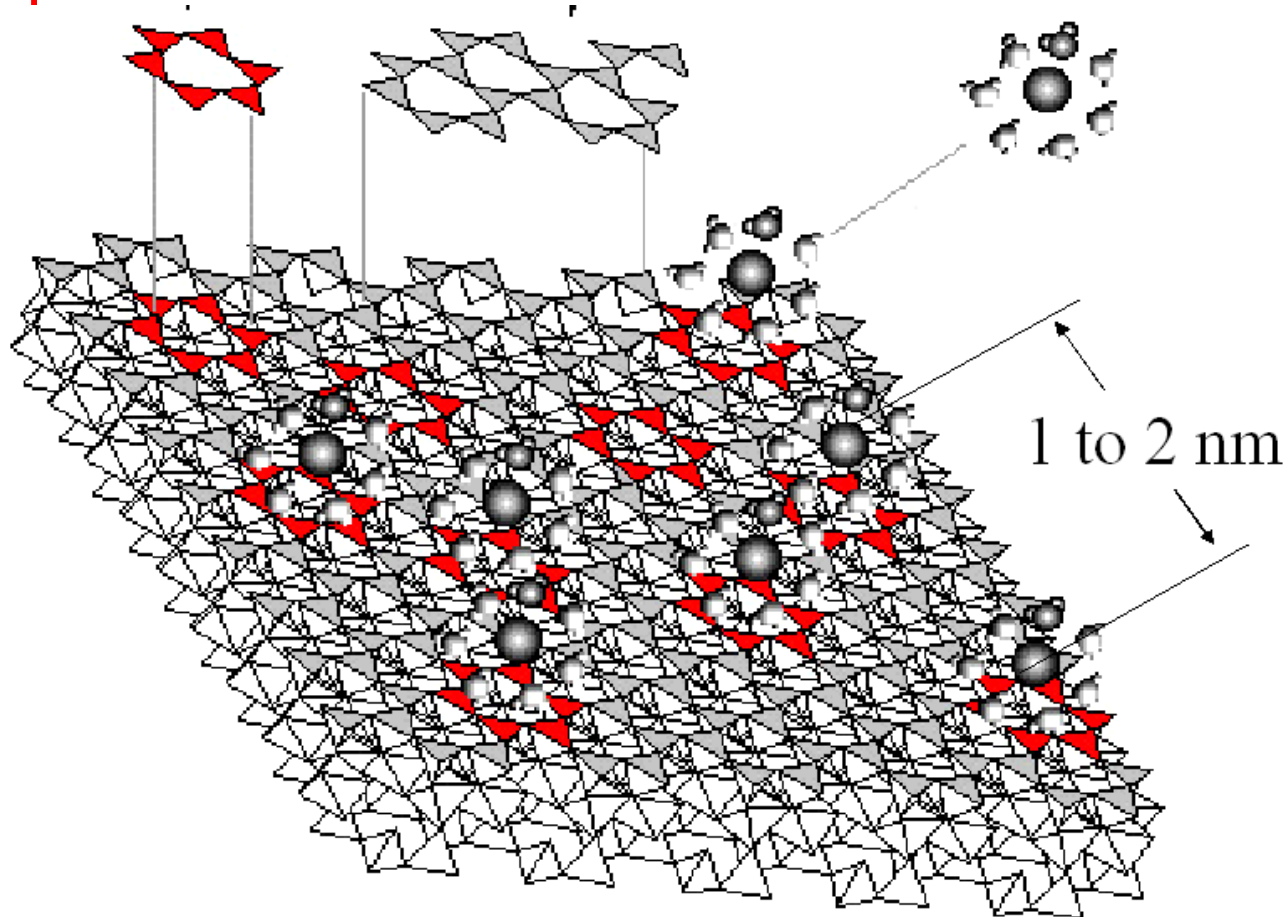
57 <b>La</b> 138.91	58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.36	63 <b>Eu</b> 151.96	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.93	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.93	70 <b>Yb</b> 173.04	71 <b>Lu</b> 174.97
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# Actinide series

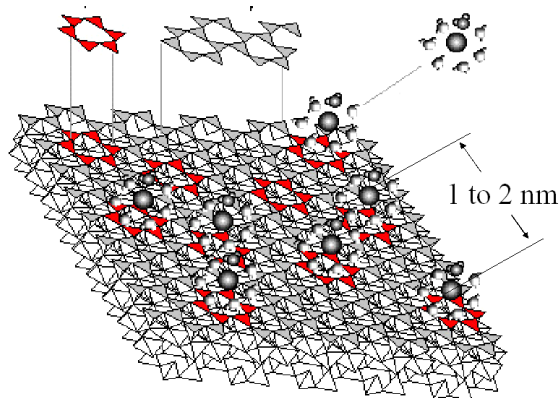
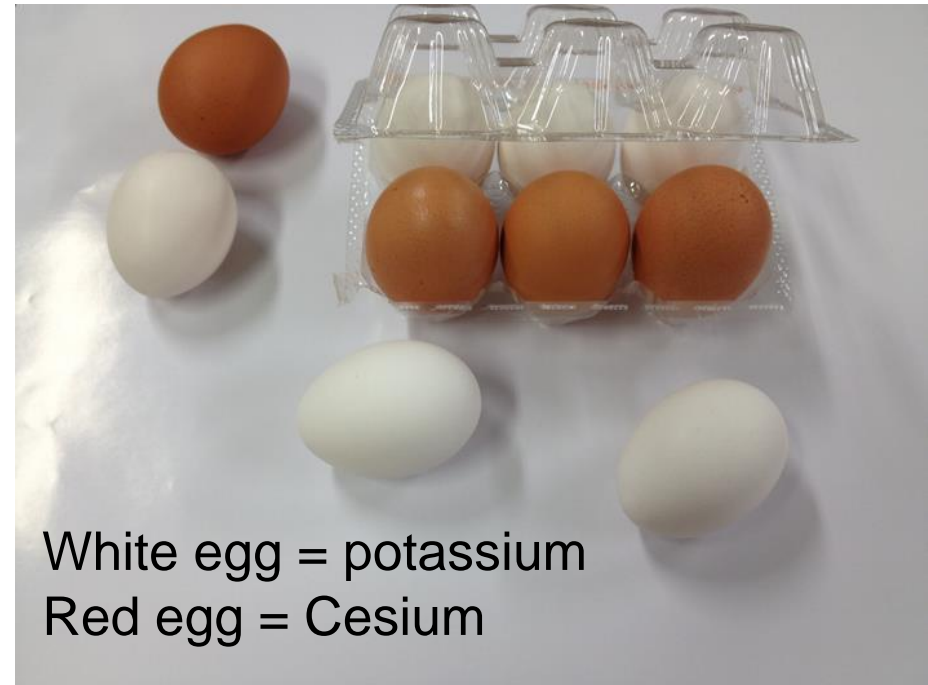
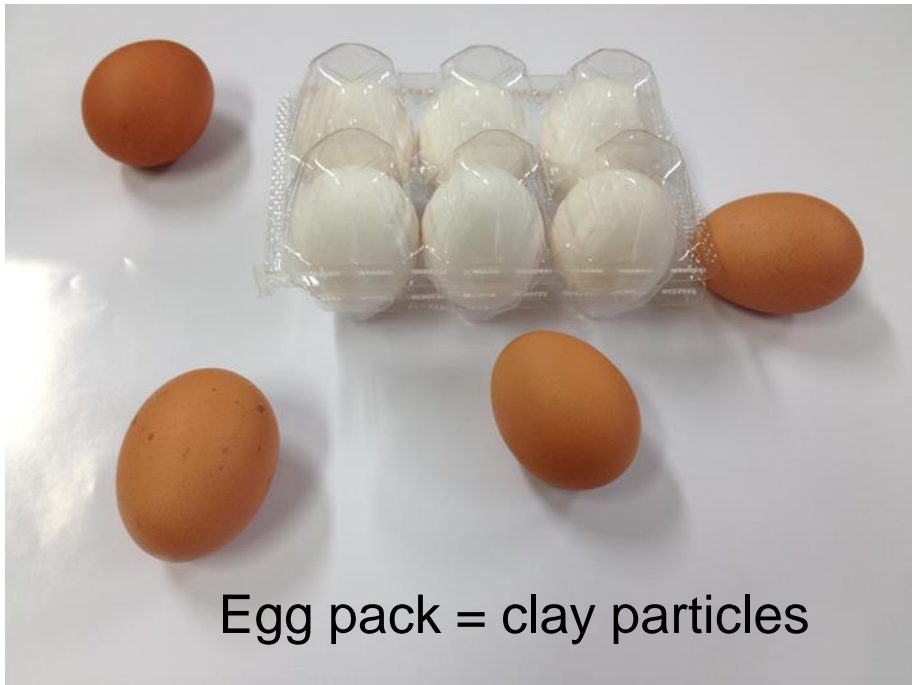
89 <b>Ac</b> (227)	90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> (237)	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (262)
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# Radioactive cesium falls into holes in the clay surface!

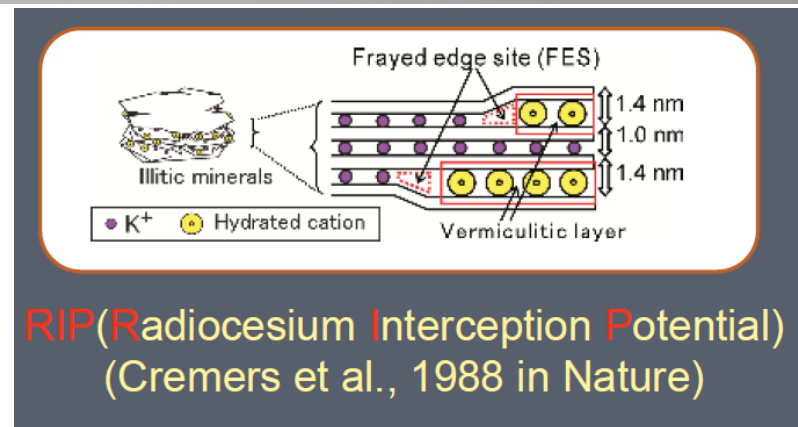
Hydrophilic Sites



# Radioactive cesium replaces potassium and is fixed in clay particles in soil



by Prof. C.T Johnston @Purdue Univ.



# Radiation dose measured on a slope in Iitate Village (2011.6.25)



2.5  $\mu\text{Sv/h}$

3.5  $\mu\text{Sv/h}$

7.0  $\mu\text{Sv/h}$





Stripping topsoil method



Soil puddling method



Deep plowing method

# 農林水産省

Official decontamination  
methods by Government

## MAFF

Ministry of Agriculture, Forestry and Fisheries

From August, 2012

# After the decontamination in Iitate



Decontamination work (2014.10)



“Temporal-temporal” storage space in a paddy

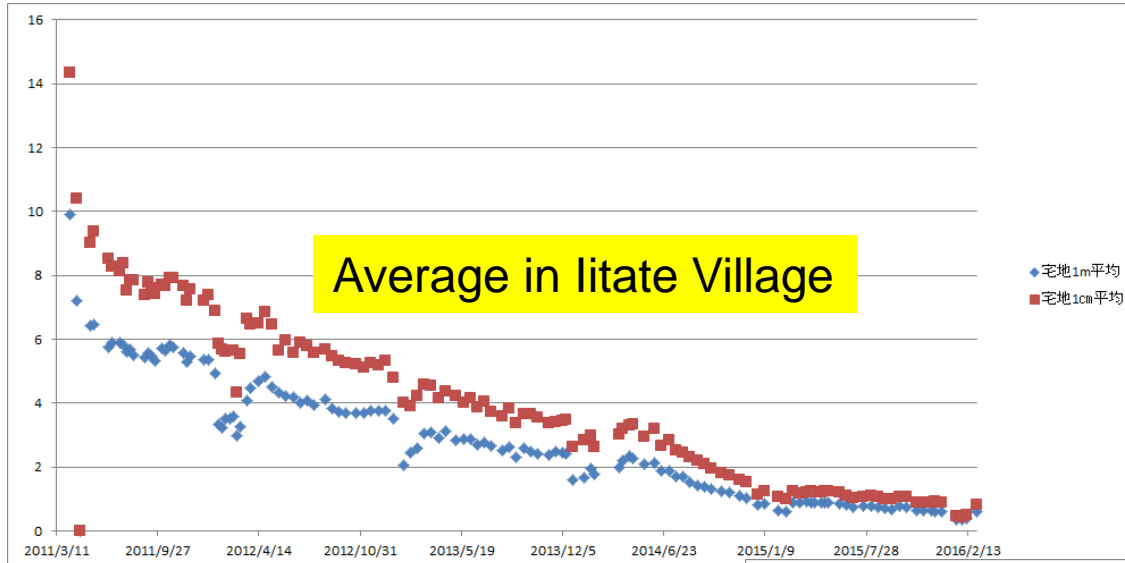


Soil dressing of farmland by sand (2015.3)



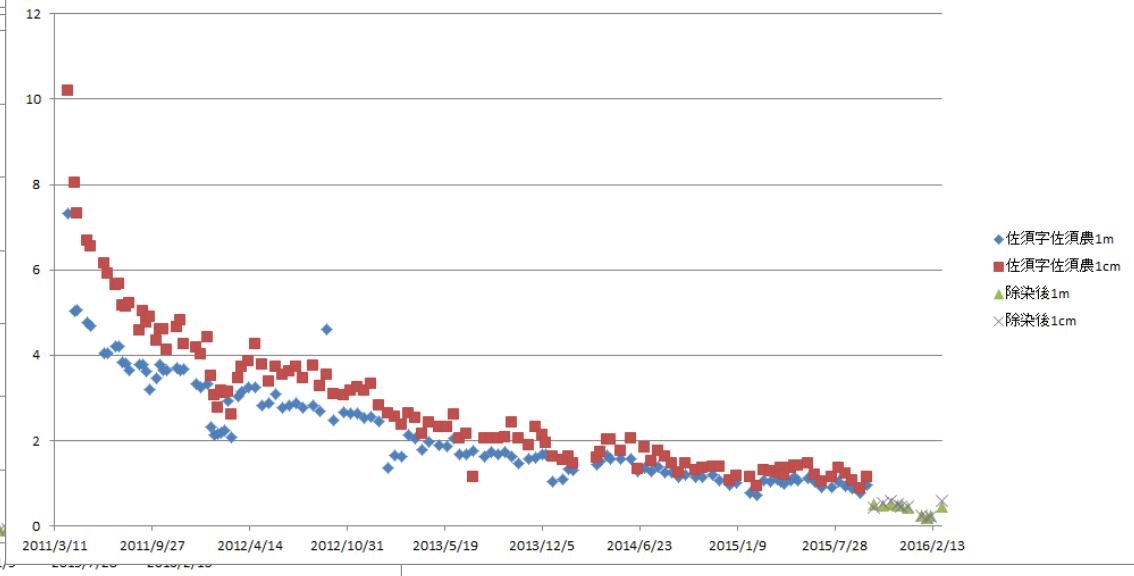
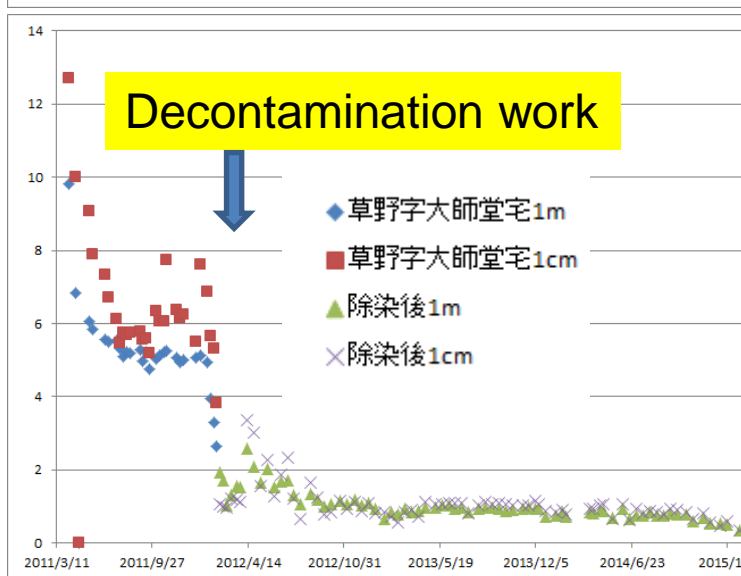
[Click to movie](#) 18

# Change of Radiation dose in Iitate Village



Source:

<http://www.fukushima-saisei.jp/mon/trendiitate/#00>



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



**Prof. Masaru *Mizoguchi***  
Dept. of Global Agricultural Science  
Univ. of Tokyo

# Empathy & Collaboration

## The Resurrection of Fukushima: Characteristics & Keywords

Goal: Recovery of the area  
 Collaboration  
 Independent Volunteers  
 Vitality from the varieties of participants  
 Knowledge, technics, work experience, network  
 Breadth of vision  
 Flexible handling  
 Detailed care

Power for Recovery  
 Experience, knowledge,  
 Tradition, culture, wisdom

**Villagers**

Collaboration against  
 Scattering

**Empathy  
 & Collaboration**

**Resurrection of Fukushima**

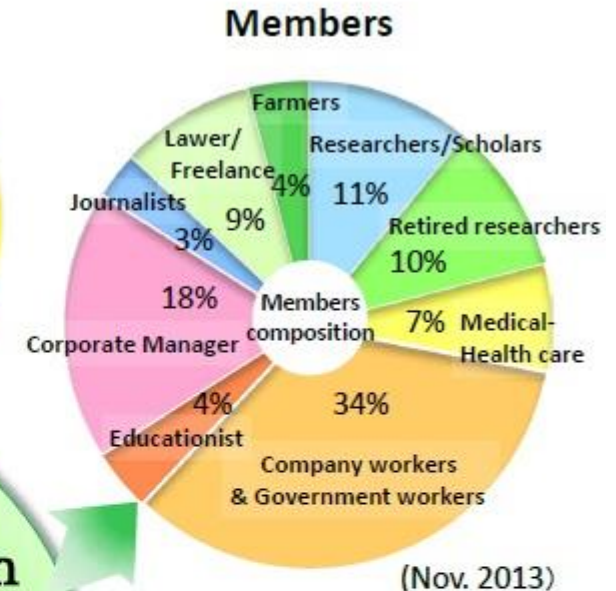


Non-Profit Organization

Specialists  
 Science & Technology

**Universities/  
 Research Institute**

Interdisciplinary  
 Collaboration



Public Service

**National  
 Prefectural  
 Local**

Overcome Sectionalism  
 & Bureaucratism



•[Message from the leader of "Resurrection of Fukushima"](#)

# Practices utilizing the properties of cesium and clay (2012)



Rotary weeder method  
(2012.4.1)

decontamination method by  
stripping frozen soil  
(2012.1.8)



# Made-method-2 (Komiya method)

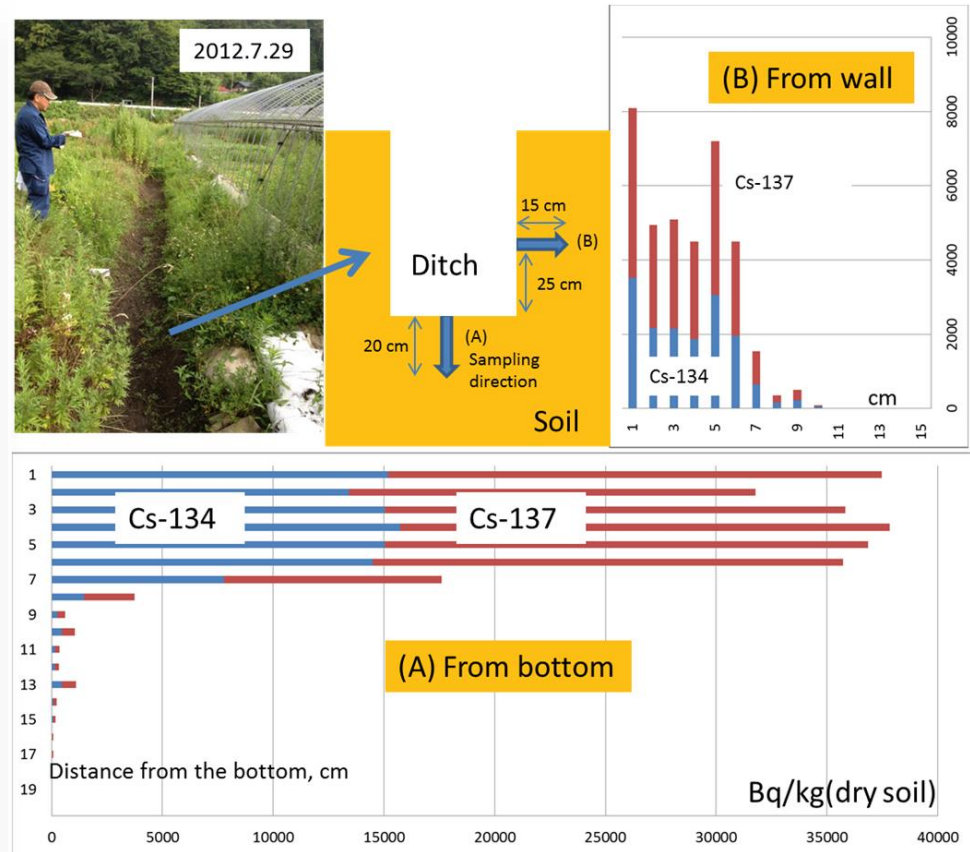
## Soil puddling + Deep plowing method (2013)



(2013.5.18)



# 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!



# 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 come out. Clay particles with radioactive cesium are also trapped in the sand by this principle.

# Made-method-1 (Sasu method)

## Stripping topsoil + Deep plowing method



Burial of contaminated soil

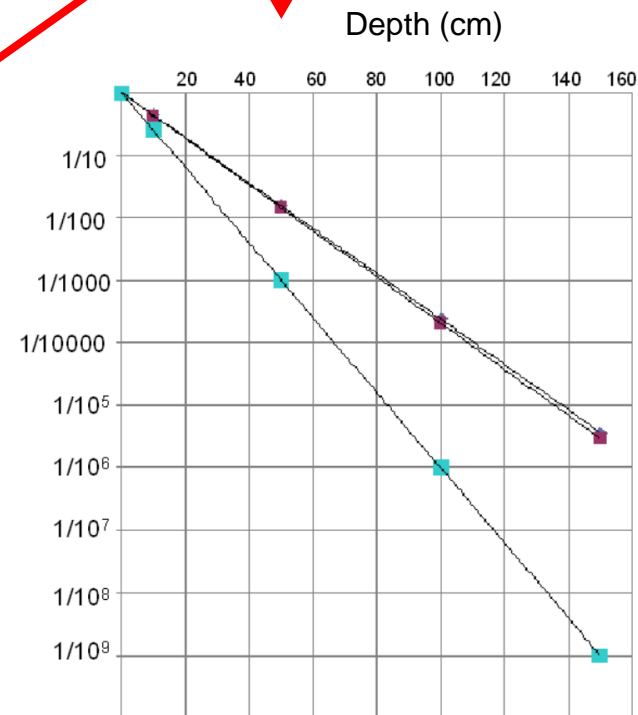
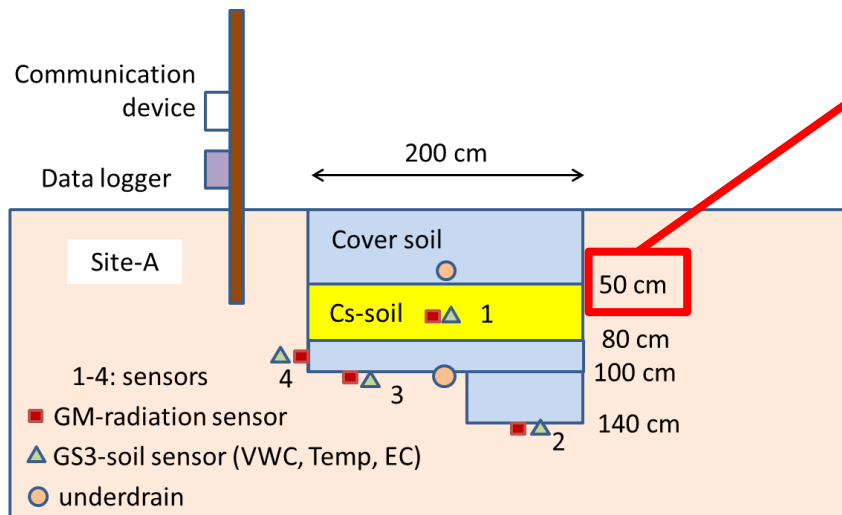
Compaction of soil

2012.12.1

# Contaminated soil should be buried in the bare hole!

Because

1. Cs is fixed to clay minerals such as weathered mica in soil
2. Radiation dose is 1/100 to 1/1000 just bury 50cm deep!



# Question?



Does NOT Cs leak out from the buried contaminated soil?

# Measurement of soil radiation

- Instrument “Choshaku-kun”
- 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
- 3-5 min to measure



# Buried work

2014/5/18

2015/11/15

# Measurement

15/3/21

16/3/20

16/11/6

17/3/12

17/12/9

18/3/11

19/3/10



溝口勝 @msrmz · 2017年3月12日

返信先: @msrmzさん

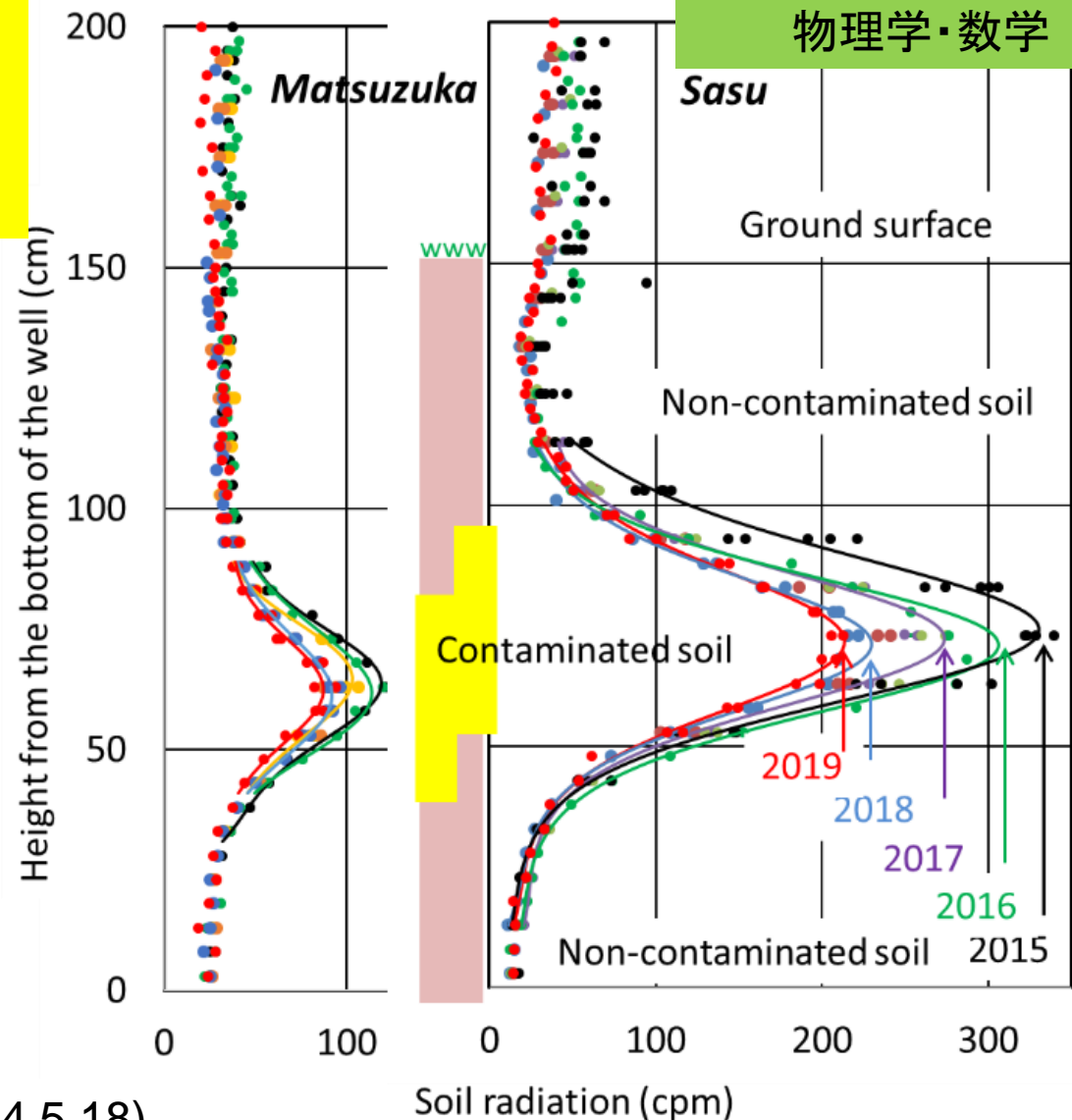
松塚の猛史さんの田んぼで測定。長尺くんを固定する新兵器の三脚を作って投入。



# Profiles of soil radiation level

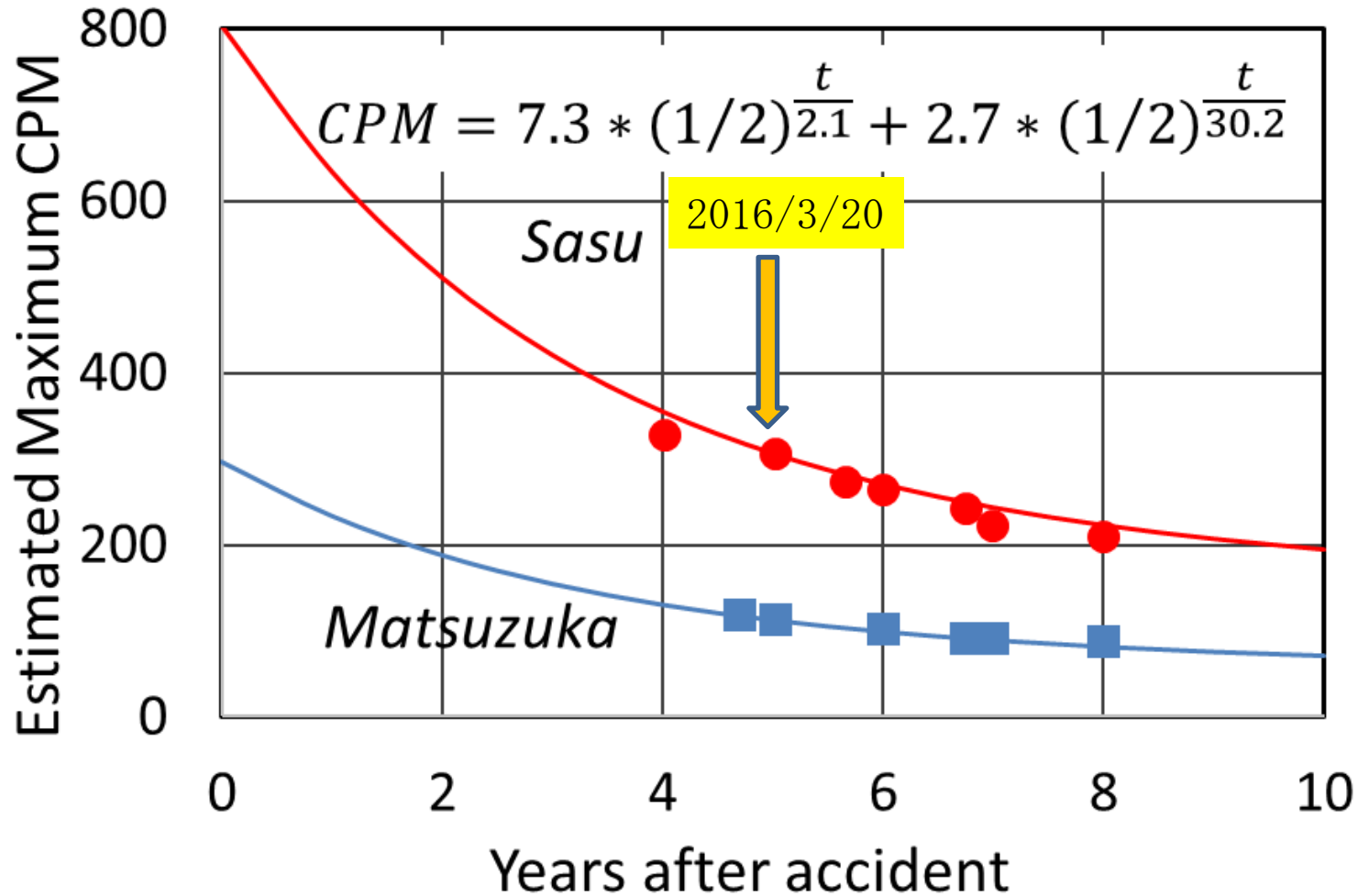


Burial of contaminated soil(2014.5.18)



- The peak depth of soil radiation has not changed
- The maximum of soil radiation levels are decaying naturally

# Estimation of soil radiation with theory



- The maximum of soil radiation is decaying, in line with theory.



# **Revitalizing Agriculture in Fukushima**

# Rice cultivation trial by NPO since 2012

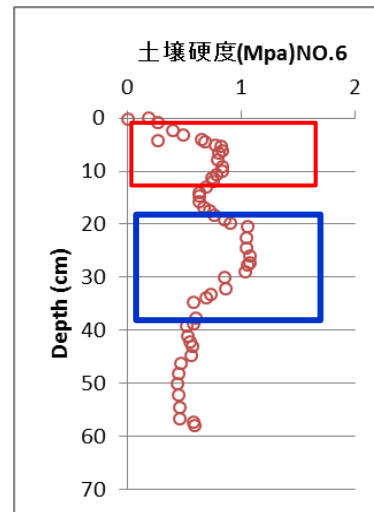
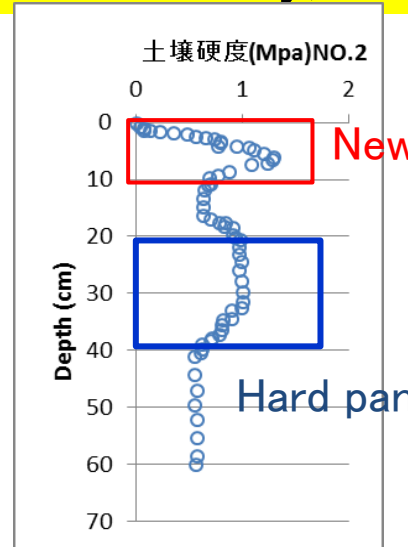


# Restoration of degraded agricultural soils

(physical, chemical, and microbial activity)

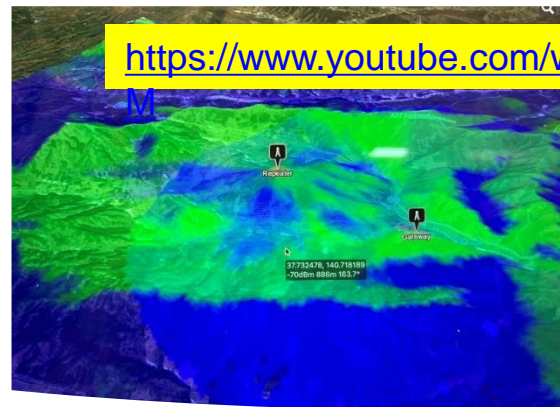


動画  
Movie



# Restoration of farmland fertility and prevention of animal damage

- Compost Making Using IoT Sensors
  - Restoring soil fertility lost during decontamination work
    - A raccoon dog gnawing on a wire  
<https://www.youtube.com/watch?v=egxkBRUIwuU>
- Animal Monitoring Using LoRa Communication Technology
  - Protect crops and fields from monkeys and wild boars



# Coexistence with Nature

Monitoring of bird and animal damage



音に驚いて逃げるイノシシ(動画)

Wild boar flees when startled by sound

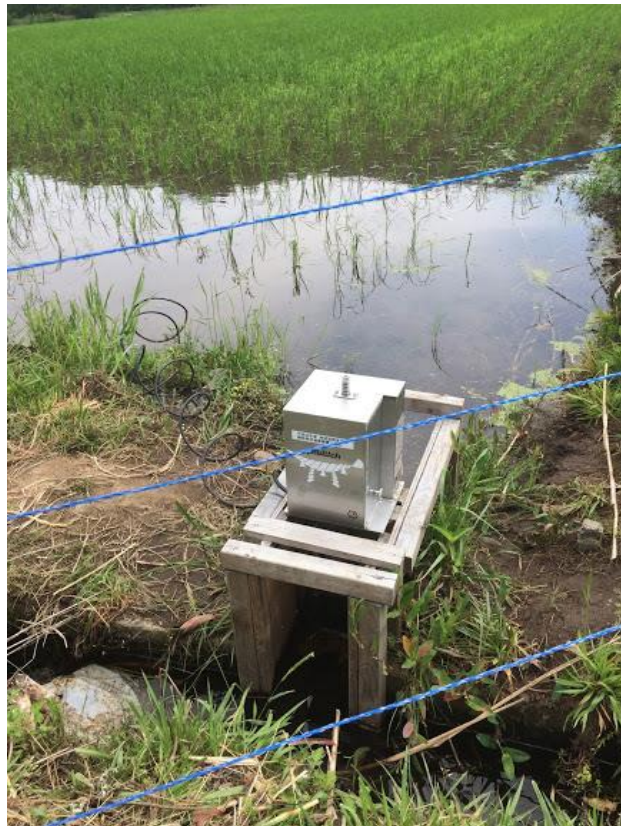


雪上の自分の足跡上を戻るサル(動画)

Monkey returning on his own footprints on snow

# ICT Agriculture practice in Fukushima

## Irrigation-water control in paddy field in Iitate Village, (2018)



1. Set Paditch

2. Add camera

3. Control gate

# Conquer the world with litate sake

虎捕山の麓から 飯館再生のために  
スマート農業のテクノロジーで育てた酒米から純米酒が誕生しました

Sake without heat



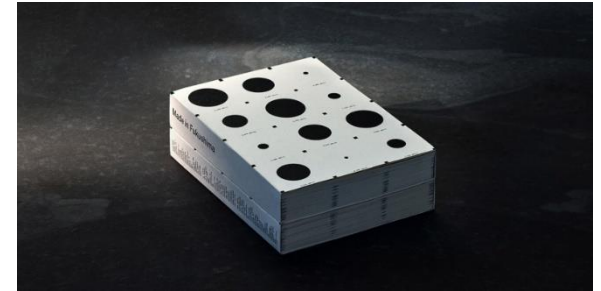
Sake with heat



フィールド WiFi カメラによる酒米水田の監視



## Cannes



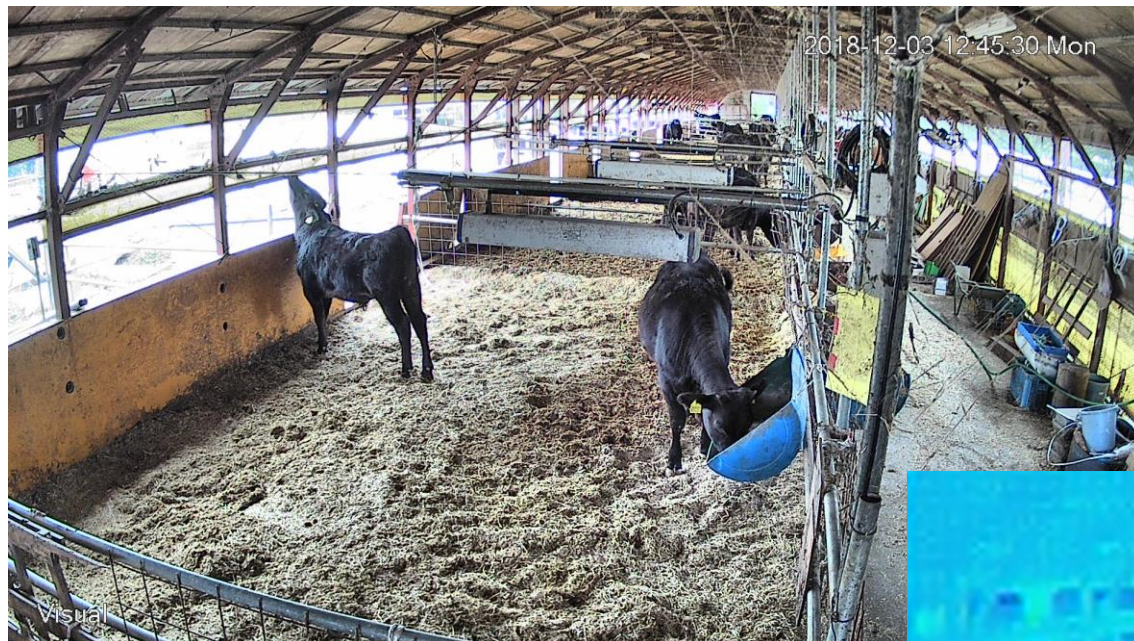
<https://www.madeinfukushima.com/>

2019/6/19



You can buy it at Takasakiya in front of the Faculty of Agriculture, UTokyo!

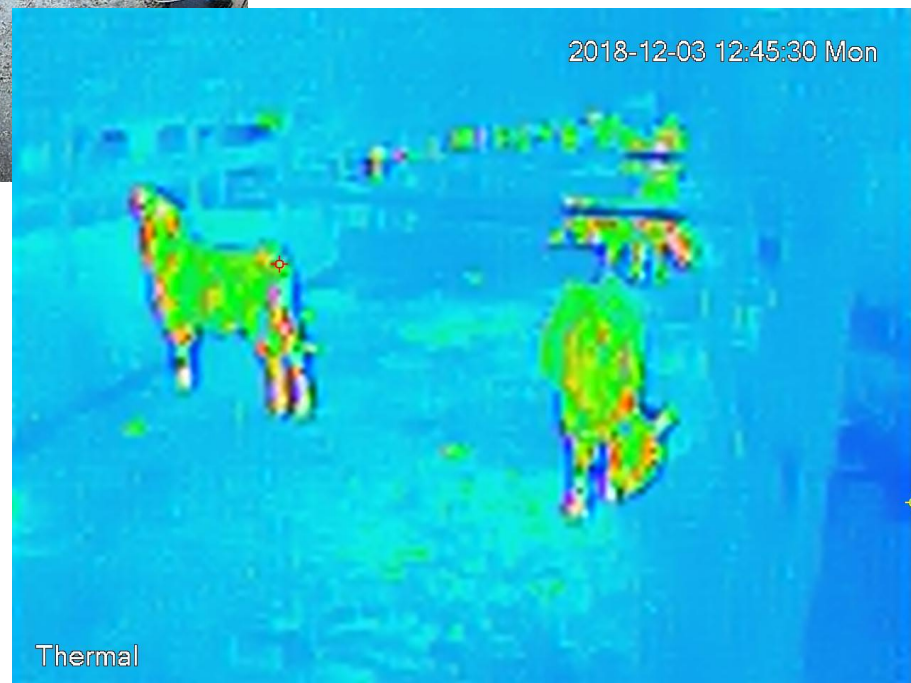
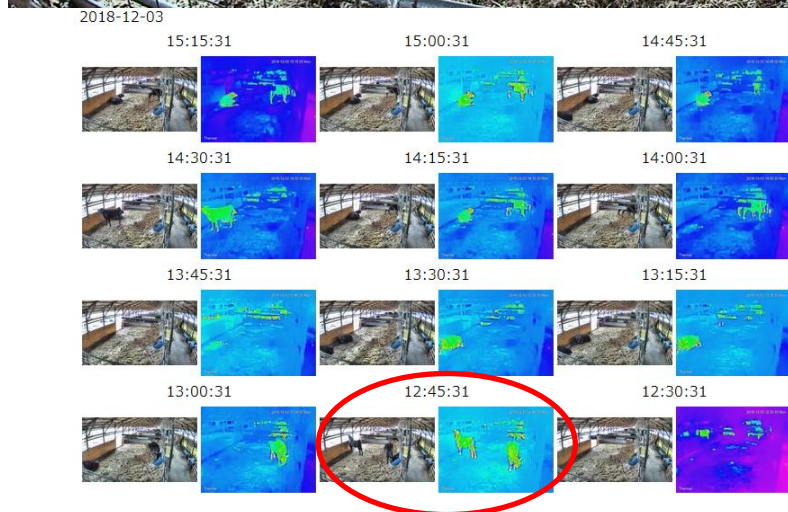
# Cattle (Wagyu) monitoring in litate village using image and thermal camera



Wagyu was brand of litate Village



Wagyu's revival will be a symbol of agricultural revival





# **Rural regeneration and youth education**

# litate Village field tours by soil scientists



Japanese Society of Soil Physics  
27 Oct. 2013



The 5th International Workshop of CAAM  
6-8 March 2016

# Madei Univ. (2018)



2018年10月6日-7日  
宮城大学、茨城大学、  
明治大学、四日市大学

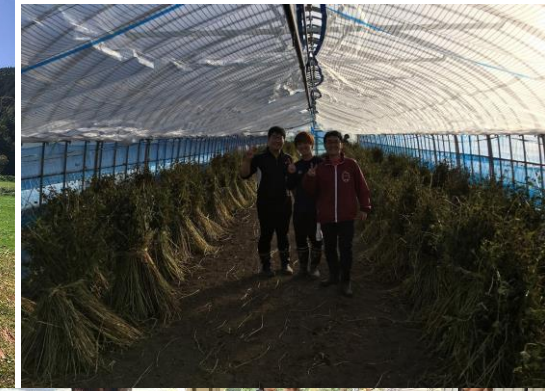


2018年10月14日-15日  
弘前大学、佐賀大学、三重大  
学、東京農工大学、明治大学



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宇都宮大学、京都大学、  
明治大学、東京大学

# Todai Mura Juku (Soba cultivation @ Hiso, 2019)



# Agricultural soil education for the general public



Soil Museum (2018.4.29)

Publication of  
Dr. Doroemon  
([Kindle版](#))



Japanese

English

Chinese



Tour for high school students  
([2019.9.14-15](#))

What are we to do with the contaminated soil?  
Stripping and burying the soil will protect you from radiation.

It's only soil on the surface, so should I strip it?

Instead of collecting and putting them in a bag, there is also a way to bury them deep in the ground.

Radiation dose when Burying Cesium-Contaminated Soil  
The Ministry of Agriculture, Forestry and Fisheries has recommended three methods of decontaminating agricultural land, according to the degree of radioactive cesium contamination. Stripping topsoil (if containing 10000 Bq / kg or more), muddy water removal (if containing 5000-10000 Bq / kg), and reversal tillage (if containing 5000 Bq / kg or less). However, the method used most frequently was stripping topsoil. The contaminated topsoil was collected by stripping away the top layer of soil and putting the topsoil into giant 1 m3 flexible container bags (flexi-con bags) used for packing bulk soil or similar material. Then, the filled flexi-con bags were transported and stored (4 to 5 tiers high) at temporary storage sites. At each site, other flexi-con bags filled with uncontaminated sand were placed along the sides of the bags containing contaminated soil to reduce the radiation dose (→p.23 Shielding). Such flexi-con bags were piled up in large quantities at the temporary storage sites, but they are gradually being removed to the intermediate storage sites.

On the other hand, reversal tillage (plowing to replace surface soil with subsoil) is a method in which the upper and lower soils are inverted using agricultural machinery and the contaminated soil is buried deep within the same sites. If this method was used according to the criteria by the Ministry of Agriculture, Forestry and Fisheries, the volume of contaminated soil in flexi-con bags could have been significantly reduced. However, it was rarely adopted due to the concerns that radioactive cesium remaining in the ground would move underground and contaminate the groundwater.

Dr. Doroemon actually buried the contaminated soil at a depth of 50-90 cm underground and put uncontaminated soil over it. Even now, we regularly measure the radiation dose at various depths, but we confirmed that the buried radioactive cesium does not move and that the radiation dose at ground level remains low (upper right figure).

Burying Experiment of Contaminated Soil

Does cesium contamination disappear by bagging it or burying it deep in soil?!

English

# 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)

# FPBL :

## Tips for Resilience Agriculture

- Quotations of Prof. Tokitaka Yokoi (1860-1927)
  - Agricultural science flourished, but agriculture destroyed
  - Those who stand on the earth will not fall, those who live on the earth will not starve, those who protect the earth will not perish (the earth = soil)
  - Ask the rice about the rice, ask the farmers about the agriculture
- What should the Faculty of Agriculture do now?
  - Strengthen learning to discover and solve issues on site
  - FPBL(Field and Project-Based Learning) is important

# Challenge to solve the problems in front of us

- What is the problem?
  - Find and set the right question
- How do we solve the problem?



Project-Z by Mizo



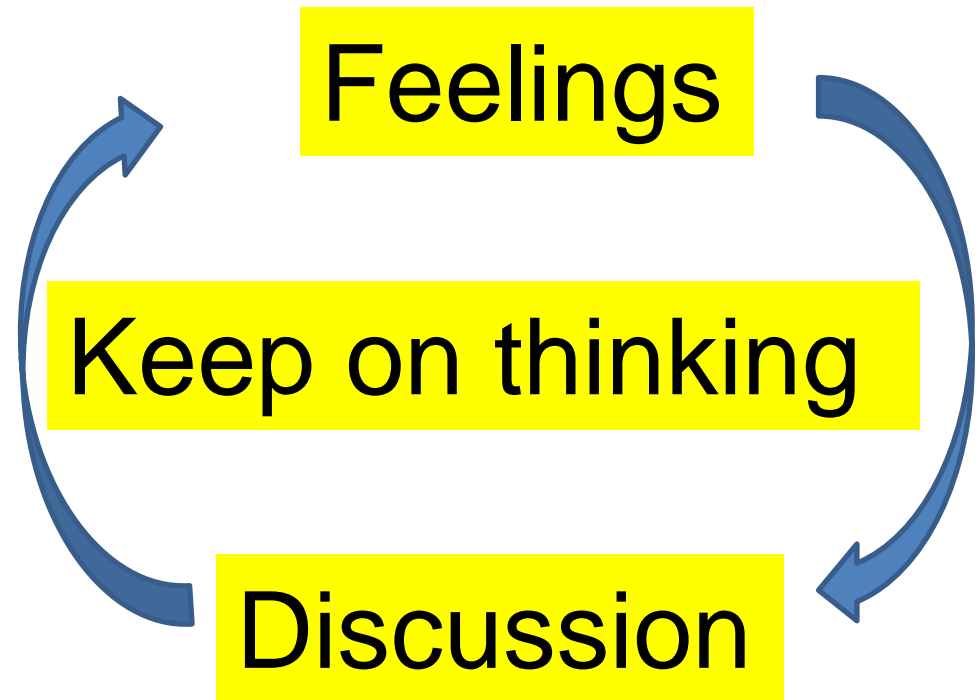


# Theory and Practice

- Notice the gap between theory and practice
- Understand the theory (Science)
  - Mathematics, physics, chemistry, biology, ecology,,,
  - Sociology, economics, political science,,,
- Know the practice (experience)
  - Field survey, interview, job training, internship,,,,

# Where does the idea come from?

- Lecture?
- Book?
- TV?
- Internet?
- Practice?



To see real fields by myself is most important!

# Let's watch movies and discuss!

- Made in Fukushima
  - <https://www.madeinfukushima.com/>
- **FUKUSHIMA REBORN**
  - <https://www.metergroup.com/environment-case-studies/fukushima-reborn/>
- The Rebirth of Fukushima
  - <http://www.iai.ga.a.u-tokyo.ac.jp/mizo/edrp/fukushima/media/The%20Rebirth%20of%20Fukushima-HD.mp4>



# Thank you for your attention

