Chernobyl - Fukushima LESSONS ARE LEARNT FROM NUCLEAR DISASTERS?

Chernobyl and Fukushima: similarities and differences about the accident process, the radioactivity release and the consequences





Cs-137 contamination around the Chernobyl NPP

Imanaka T. KURNS, Kyoto University April 9, 2019 European Parliament Brussels, Belgium

Self-introduction

- Born in Hiroshima in 1950
- Entered into Nuclear Engineering Course of Osaka University in 1969
- Started a researcher of Research Reactor Institute, Kyoto University in 1976
- Retired Kyoto University in 2016. Since then, a part-time researcher of the same institute



14:46 on March 11, 2011, a giant earthquake (M9.0) occurred at 180 km from Fukushima-1 NPP.

Three simple slogans at the time of reactor emergency in Japanese

- 1. TOMERU: stop fission chain reaction at the reactor core
- 2. HIYASU: cool residual heat in the reactor vessel
- 3. TOJIKOMERU: contain radioactivity inside the containment



15:36 March 12. Hydrogen explosion at #1

A vanished plan to construct coastal dyke against tsunami in 2008



Two years ago, at the criminal trial for three executives of TEPCO, it became uncovered that a plan was considered in 2008 against tsunami over 10 m, but it was crushed away by those executives.



11:01 March 14, Hydrogen explosion at #3

In case coolant water could not be sent to the reactor core



Structure of BWR







DRYWELL TORUS

^{11am on March 15th, 2011 Press conference by the prime minister and the cabinet secretary}



"Hydrogen explosion occurred also at #4 and the containment of #2 was ruptured"

I was convinced that Fukushima accident became like Chernobyl.

Evacuation instruction from the government

- 21:23 March 11. Evacuation within 3 km
- 05:44 March 12. Evacuation within 10 km
- 17:39 March 12: Evacuation within 20 km
- 11:00 March 15: Stay inside houses between 20-30km



Fukushima prefecture

Daily release of radionuclides into the atmosphere. $PBq=10^{15} Bq$



Based on the data by Katata et al, 2015 ₁₂

It was clear that serious contamination occurred around the Fukushima-1 NPP. However, strangely almost no information was released from the authorities!

We decided go to measure the contamination by ourselves!

First visit to Iitate village on March 28, 2011







Radiation survey team

Radiation Survey in Iitate Village on March 29th, 2011 Nagadoro-magata 30µSv/h



I have been working at a small research reactor of Kyoto University. Inside the reactor, places where dose rate exceed 20μ Sv/h, are "High radiation zone". Iitate villagers were living in such a radiation condition!

Radiation level map of Iitate village March 29, 2011



Measured with ALOKA-PDR-111

Evacuation of Iitate village was issued on April 22, more than 1 month later the contamination happened



浪江町 遺江町 傍遊困難区均 東京: 新製物完好除港信 双葉町 田村市 田村市 + 10 11 **超難指示解除** 川内村 川内村 建製指示影 小野町 措美町 源動指示解除 凡例 避難指示解除準備区域 20km 居住制限区域 広野町 - 保遗困難区域 いわき市

飯館村 居住制限区域

避難指示区域の概念図 平成25年8月8日~ 〇川侯町 区域見直し後

飯舘村 避難指示解除準

伊達市

相馬市

南相馬市

南相馬市 避難指示解除準備区域 (2012/4/16~)

Cs137 contamination map on the ground. Made from US NNSA aerial survey data,

Evacuation area

Total evacuated area: 1,150 km² 81,000 persons 17

Radiation survey in Iitate village 2011~2015



Temporal change of average dose rate in Iitate village



-Radiation level decreased to 1/20 during these seven years.

-Black dot line indicate theoretical decrease due to physical decay of radionuclides.

-The effect of decontamination seems to be about 2.

Transition of evacuation and evacuation preparing zones





April 22, 2011 Evacuation zone:1,150 km2 81,000 persons

April 1, 2017 Evacuation zone: 370 km2 24,000 persons Radiation survey around houses after decontamination in order to prepare lifting evacuation in spring of 2017

- May 20, 2016: 55 houses in MAEDA
- Oct 9, 2016: 125 houses in KAMI-IITOI
- Nov 24, 2016: 48 houses in WARABI-DAIRA
- Nov 24, 2016: 21 houses in KAYAKARINIWA

We measured 4 points around every house

- Front road
- Entrance
- Garden
- Back of main house







Summary of house survey in 2016

Settlement	No of – houses	Average dose rate, μ Sv/h				
		Front road	In front of Entrance	Garden	Back of main house	
Maeda	55	0.68	0.42	0.60	0.78	
Kami-Iitoi	125	0.48	0.37	0.51	0.68	
Warabi-Daira	48	0.99	0.79	1.01	1.13	
Kayakariniwa	21	0.86	0.65	0.93	1.09	

-Current (2019) radiation level around decontaminated houses is $0.4 - 0.8 \mu$ Sv/h. -Annual dose of people living such areas is estimated to be 2 - 4 mSv.

Current situation of Iitate village

- Before the accident: 1700 families 6200 persons
- April 22, 2011 designated as evacuation area
- $2014 \sim 2016$ Full-scale decontamination by the government
 - Cost: about 350 billion yen (about 24 billion Euro)
 - 2.3 million of flexible container bags
- March 31, 2017 Lifting of evacuation instruction (excluding one settlement of difficult-to return area)
- Currently about 10 % of residents returned, mainly old people



Before the accident



Decontamination (2012)



) Tentative storage(2016)

2.3 Million of FLECON BAGS remain in Iitate village after lifting evacuation.



Government promised to bring out these bags to the Interim Storage Site within 5 years.....²⁴

Forecast of radiation level for 50 years in cases; 1.0 µSv/h on Jan 1, 2019 0.5 µSv/h on Jan 1, 2019



Comparison between Chernobyl and Fukushima



Chernobyl: April 1986



Fukushima: March 2011

Two types of severe accident at NPP:
 Accident-1: Failure of fission chain reaction
 → power surge accident. *Chernobyl* Accident-2: Failure of core cooling
 → meltdown accident. *Fukushima*

Radioactivity release into the atmosphere

		Chernobyl				Fukushima-1	
	USSR 1986 [3]	Seo et al 1988 [8]	Chernobyl Forum 2005 [9]		NISA 2011 [10]	Stohl et al 2012 [11]	UNSCEAR 2014 [7]
¹³³ Xe	9,000	n.a.	6,500	į	11,000	15,300	7,300
¹³¹ I	760	2,600	1,760		160	n.a.	120
¹³² Te	640	3,100	1150		0.76	n.a.	29
¹³⁴ Cs	21	110	47		18	n.a.	9.0
¹³⁷ Cs	37	160	85		15	36.6	8.8
⁹⁰ Sr	8.1	20	10		0.14	n.a.	n.a.
⁹⁵ Zr	160	240	84		0.017	n.a.	n.a.
¹⁰³ Ru	150	470	168		7.5×10^{-6}	n.a.	n.a.
¹⁰⁶ Ru	60-	200	73		$2.1\times10^{\text{-6}}$	n.a.	n.a.
¹⁴⁰ Ba	300	520	240		3.2	n.a.	n.a.
¹⁴¹ Ce	130	310	84		0.018	n.a.	n.a.
²³⁹ Np	1,900	5,900	400		0.076	n.a.	n.a.
²³⁹ Pu	5.2	9.3	0.013		$3.2 imes 10^{-6}$	n.a.	n.a.

Table 1. Estimates of released radioactivity of major radionuclides into the atmosphere: Chernobyl and Gukushima-1. Unit:PBq.

n.a.; not assessed.

- Chernobyl: The reactor and the building were destroyed at a moment of the power surge. Radionulides similar composition to the reactor core were released.

- Fukushima: The reactor did not explode. Gaseous and volatile radionuclides were released escaping from melt-down cores.

Comparison of contaminated land area and population between Fukushima and Chernobyl

	Zone classification by ¹³⁷ Cs contamination level				
	> 37 kBq m⁻²		> 55	5 kBq m⁻²	
	Area, km²	Population, persons	Area, km²	Population, persons	
Fukushima	8,400	1,590,000	767	82,000	
Chernobyl	145,000	5,910,000	10,300	384,000	
Cher/Fuku ratio	17.2	3.7	13.4	4.7	

Decommissioning is more difficult for **Fukushima than Chernobyl**







Field inspection inside three melt-down reactors is just at the beginning stage in Fukushima. It is difficult to say how many years we need to stabilize the situation.

Although TEPCO proposed a road-map of decommissioning in 40-50 years, it is their optimistic desire.

~3亏機廃炉の工程衣 ※各号機とも最速で進んたと想定した場合の人ケシュール							
		2017 18 19 20 21 22 23 24 41~51年					
1	使用済み 核燃料 プール	準備作業 燃料取り出し					
授機	原子炉	デブリ取り出し 方法の検討 準備作業 取り出し					
2	使用済み 核燃料 プール	準備作業 燃料取り出し					
授機	原子炉	デブリ取り出し 準備作業 取り出し ??					
3	使用済み 核燃料 プール	準備作業 取り出し					
号機	原子炉	デブリ取り出し 準備作業 取り出し					

って松皮にのナロキ



Private opinion: It is clear misjudge that nuclear power plants were constructed on Japanese islands of frequent earthquake





Total energy supply in Japan



The most important question:

- Do we need to produce electricity even by using a technique people living within 30 km should be ready to evacuate?

Thanks for your attention!