

Evaluation of Internal Exposure of the Workers and the Residents Caused by the Fukushima Nuclear Accident



C. Takada¹, O. Kurihara^{1,3}, N. Tsujimura¹, K. Kanai¹, T. Nakagawa¹, H. Miyauchi², T. Murayama², Y. Maruo¹, T. Momose¹, and S. Furuta¹

¹ Nuclear Fuel Cycle Engineering Laboratories, Japan Atomic Energy Agency, 4-33 Muramatsu, Tokai-mura, Ibaraki-ken, 319-1194, Japan
² Nuclear Science Research Institute, Japan Atomic Energy Agency, 2-4 Shirakata-shirane, Tokai-mura, Ibaraki-ken, 319-1195, Japan
³ National Institute of Radiological Sciences, 4-9-1, Anagawa, Inage-ku, Chiba-shi, Chiba-ken, 263-8555 Japan



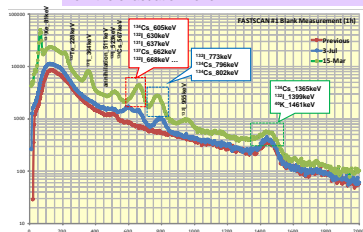
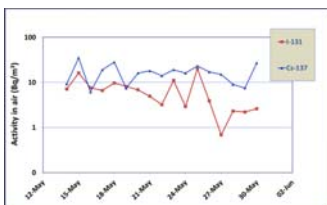
Abstract

The accident at the Fukushima Daiichi Nuclear Power Plant has resulted in many cases of internal exposure to radionuclides. JAEA staff have examined the workers and the residents by measurement with a various type of whole body counters. The committed effective dose was estimated using the intake scenarios according to the object of monitoring and expected level of exposure. In the examination of more than 500 workers who were in the plant at early stage of the accident or engaged in disaster-mitigation activities, ¹³¹I, ¹³²Te-¹³²I, ¹³⁴Cs and ¹³⁷Cs were detected and the maximum dose estimated based on the most severe scenario was 590 mSv. The monitoring for extended residents begun about 4 months after the accident. In this monitoring project, only ¹³⁴Cs and ¹³⁷Cs were detected instead of radioiodine.

1. INTRODUCTION and OBJECTIVES



A 9.0-magnitude earthquake and subsequent massive tsunami on March 11, 2011 deprived the Fukushima Daiichi Nuclear Power Plant of the ability to cool the cores of its reactors. The resultant loss of reactor integrity led to a series of releases of radioactive materials to the environment, the most serious of which occurred on March 15-16. During and after the initial confusion just after the disaster occurrence, hundreds of workers of the Tokyo Electric Power Co., Ltd. (TEPCO), the plant operator, initiated mitigation actions in an attempt to maintain control of the situation. Throughout the course of these actions, they were exposed to high external dose rates and to significant air concentrations of released radionuclides. Meanwhile, the Japanese government issued evacuation orders on March 12 for people living within 20 km of the plant and recommended those living within 30 km stay indoors to minimize any possible exposure. About 78,000 people were evacuated during the first days following the disaster, before the major radiological release, from the evacuation zone.



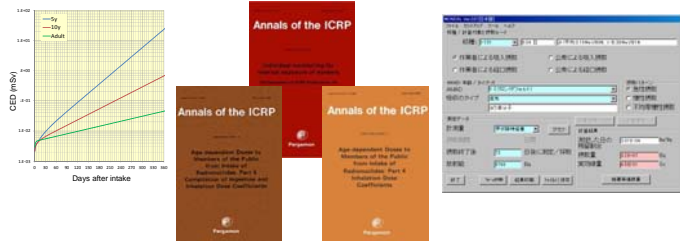
BG Spectrum of NaI-WBC at NCL

2. Material and Methods

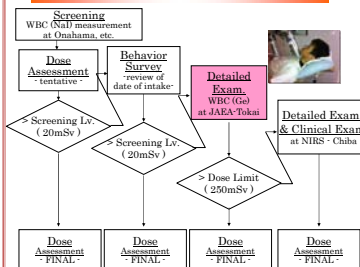
Whole Body Counters

Location	Type, Unit	Geometry and Exterior	Detector	Meas. time (min)	MDA* (Bq)	Remarks
Tokai	Fixed, 1	Chair	Canberra GC5021.p-type Ge (relative efficiency 50%) 2 sets	10	¹³¹ I: 30 ¹³⁴ Cs: 60 ¹³⁷ Cs: 60	Installed in a steel chamber
Tokai	Fixed, 1	Chair	Fuji Electric, NaI(8" φ × 4") 2 sets	3	¹³⁴ Cs: 340 ¹³⁷ Cs: 370	
Tokai	Fixed, 2	Standing	Canberra FASTSCAN, NaI (16" × 5" × 3") 2 sets	2	¹³⁴ Cs: 300 ¹³⁷ Cs: 300	
Onahama, etc	Vehicle, 2	2		—		
Western Fukushima	Vehicle, 1			2	—	
Chiba (NIRS)	Fixed, 1	Bed	NaI (size; no public) 4 sets	3	¹³⁴ Cs: 320 ¹³⁷ Cs: 570	

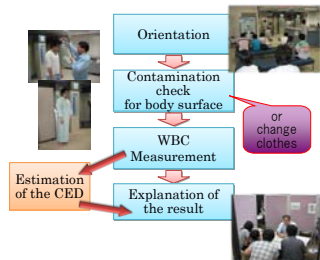
Dose Assessment Model



TEPCO Workers

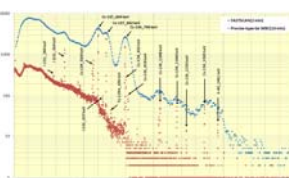


Fukushima Residents

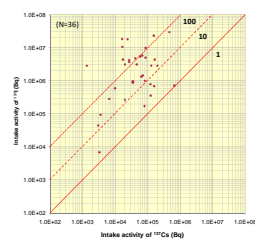
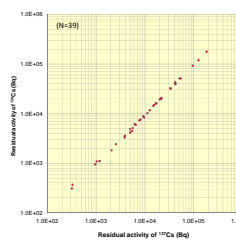


3. Results

TEPCO Workers



Segment (mSv)	TEPCO employee	Contractors	Total	TEPCO employee	Contractors	Total
Over 50 ~ less or equal to 100	38	26	64	0	0	0
Over 20 ~ less or equal to 50	11	7	18	0	1	1
Over 10 ~ less or equal to 20	0	1	1	0	1	1
Less or equal to 10	1	5	6	0	1	1
Total	50(*1)	39	89	0(*2)	3(*4)	3



Fukushima Residents

Table. Number of subjects examined from Jul. 11, 2011 to Jan. 31, 2012 by JAEA

Age	Male	Female	Total
< 8	1,209	1,150	2,389
8 - 12	1,451	1,394	2,845
13 - 17	772	793	1,565
> 17	756	2,372	3,128
Total	4,218	5,709	9,927

Table. The CED distribution of subjects examined from Jul. 11, 2011 to Jan. 31, 2012 by JAEA

Age	< 1 mSv	1 mSv	2 mSv	3 mSv
< 8	2,373	6	8	2
8 - 12	2,840	5	0	0
13 - 17	1,565	0	0	0
> 17	3,127	1	0	0
Total	9,905	12	8	2

4. Summary

The accident at the Fukushima Daiichi NPP resulted in a substantial release of radionuclide into the environment with the potential of internal contamination in large population. JAEA provided the whole body counting service for emergency operation workers and residents, for the latter of which the measurement is still continuing.

Fukushima-site Workers:

The examination in the workers revealed that over 300 workers showed very high levels of ¹³¹I and radioiodines with CEDs above 20 mSv, the highest being a CED of 590 mSv.

Fukushima Residents:

For the approximately 10,000 residents, some activity of radioiodines above MDA was detected in ~20% of subjects, but their estimated CEDs were in the order of mSv.

The WBC program helped for the residents allay anxiety about the internal contamination as a consequence of the accident.