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EFFECTS OF THE CHERNOBYL REACTOR ACCIDENT IN THE U. S. S. R. ON AKITA, NORTHERN JAPAN

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ABSTRACT

An investigation in Akita, Japan, was carried out to determine the results of radioactive fallout from the Chernobyl Atomic Reactor RBMK accident in the U. S. S. R. Strongly radioactive particles, rain water, dry fallout, airborne dust, and foodstuffs were examined by using a LBC counter and a multichannel analyzer with a Ge (Li) semiconductor detector. However, no highly radioactive substances could be found in the Akita University Inspection Area. The radioactivity of enviromental samples showed a distinct rise from May 4 to 6, 1986. Ten gamma-ray radioisotopes, ^{99}Mo, ^{103}Ru, ^{137}Ru, ^{131}I, ^{132}I, ^{132}Te, ^{134}Cs, ^{136}Cs, ^{137}Cs, and ^{140}La, were detected. In some samples, the maximum values were found from May 4 to 6 for ^{99}Mo, ^{103}Ru, ^{132}Te, and ^{140}La, and on May 8 to 9 for ^{134}Cs, ^{136}Cs, and ^{137}Cs, but around June 9, normal concentrations were resumed.

INTRODUCTION

Reuter's News Agency reported on April 29, 1986, that a reactor unit of 1,000 MW of the RBMK type in the Chernobyl Power Station, some 130 kilometers from the city of Kiev in the U. S. S. R., exploded on the 26th at approximately 6 : 23 a. m. Japanese time.[1] Soviet authorities officially announced that the fire in the reactor was extinguished on May 5 and that the reactor was shut down. A Special Committee on Radiation Safety Measures of the Japanese Cabinet[2] was immediately asked to quickly investigate the situation of radioactive fallout throughout Japan and to advise as to what action should be taken at the national level.

Japan, particularly in its northern part, has specific geographical and meteorological

condition features. It is situated in the northern temperate zone where accumulation of radioactive fallout[3] was high. The conditions resulting from the Chernobyl Reactor accident should be investigated to determine both pollution and stratospheric fallout.

This study was conducted to determine quantitatively the degree of environmental contamination from radioactive fallout due to the Chernobyl Reactor accident and the does from this fallout.

Materials and Methods

The materials analyzed were strong radioactive particles, rain water, dry fallout, airborne dust, and foodstuffs. A G. M. -survey meter was used for field examination at the Akita University Inspection Area where particles were collected. The rain water was collected on a sampling tray, approximately 1,965cm^2. Dry fallout, 32.5×42cm, was obtained with a sampling tray. Airborne dust was continuously collected by a high volume air sampler HVS-1000 (Shibata Co. Ltd., Tokyo) at a rate of 1,000 litres per minute on glass fiber filters GB-100R (0.6 μm, Toyo Co. Ltd., Tokyo). The leafy vegetables used were spinach, leek "Nira" (Allium odorum), greens "Aona" (Brassica rapa var. pervides), cabbage, "Aiko" (a kind of Chinese rape) and "Honna" (a kind of Chinese rape), all purchased from a market in Akita City. The seaweed of "Kuromo" (Papenfussiella), "Ishimozuku" (Nemacystus desipiens), and "Wakame" (Undaria pinatifida) were also collected from the Fishermen's Cooperative Association in Akita.

The beta and gamma emitting radioisotopes in several samples were detected through the method published by the Science and Technology Agency of Japan (1976). The measurements were conducted with a counter LBC-451 (ALOKA, Tokyo) with a tube FC-103C, and a multichannel analyzer (Canberra 8100) with a Ge (Li) semiconductor detector (Canberra 7229).

Results and Discussion

Figs. 1 through 3 show the rise and fall of radioactivity following the accident in rain water (Bq ml^{-1}), dry fallout (Bq m^{-2}), and airborne dust (Bq m^{-3}). The average amount of radioactivity in the former was 251.6 Bq ml^{-1} from January to March 1986. It increased rapidly by ten times to 2312.5 Bq ml^{-1} on May 2. The first peak value was 152, 588 Bq ml^{-1} on May 8, the second 48.026 Bq ml^{-1} on May 19.

The radioactivity of dry fallout on May 6 was 4,366 Bq km^{-2} and on May 8, 10,212 Bq km^{-2}, about 40 times that from January to March. The peak value was 10,767 Bq km^{-2} on May 19.

The airborne dust radioactivity ranged from 3.7 to 814 Bq m^{-3}, the highest value noted as 814 Bq m^{-3} on May 6. The activities of dry fallout and airborne dust showed a distinct increase on May 6 following the first increase in rain water on May 2.

Table 1 shows the concentrations of various radionuclide values of airborne dust on filter paper from May 2 to 4 and from 5 to 12. A 8.51 Bq m^{-3} of ^{131}I was detected in a

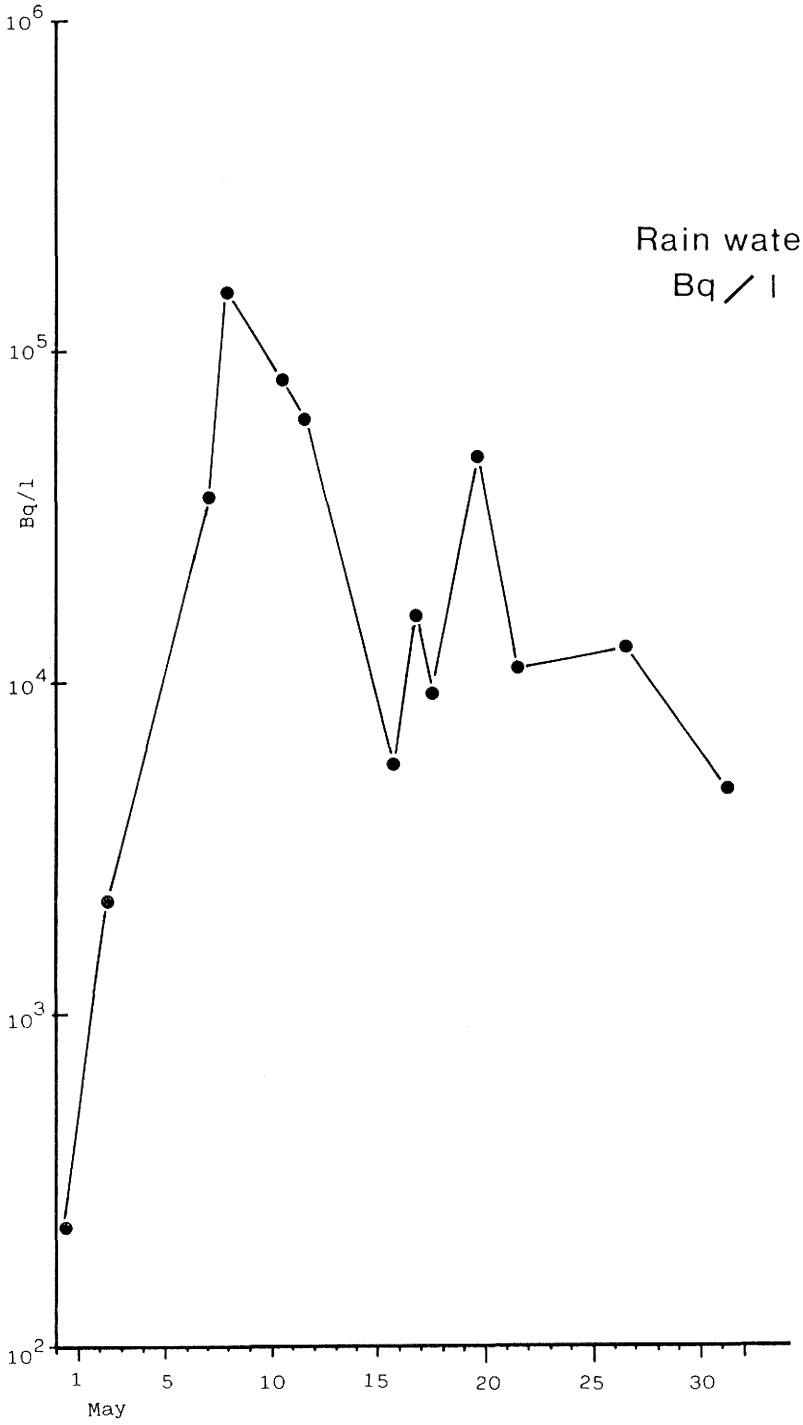

Fig. 1. Gross beta radioactivity in rain water at Akita.

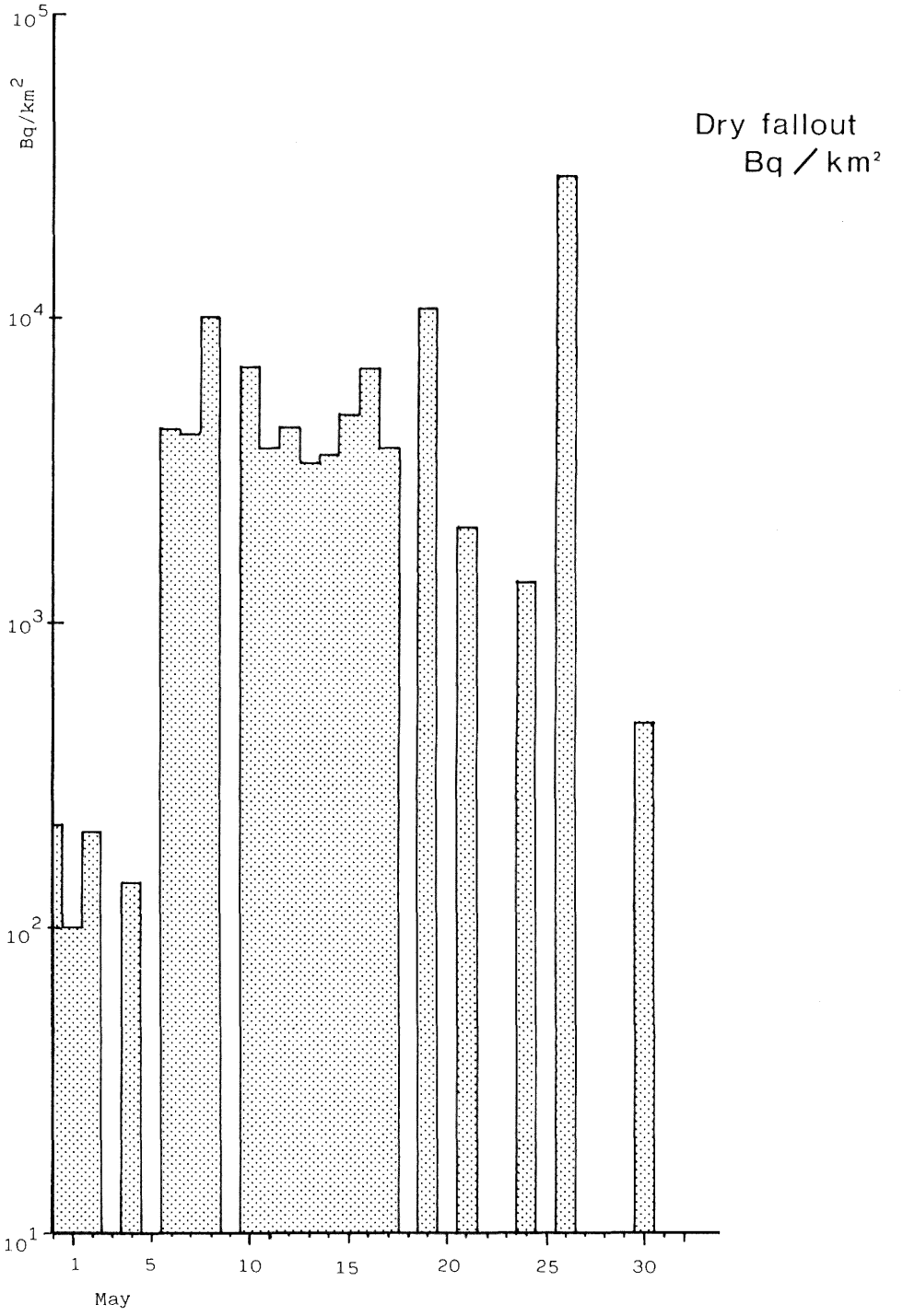

Fig. 2. Gross beta radioactivity in dry fallout at Akita.

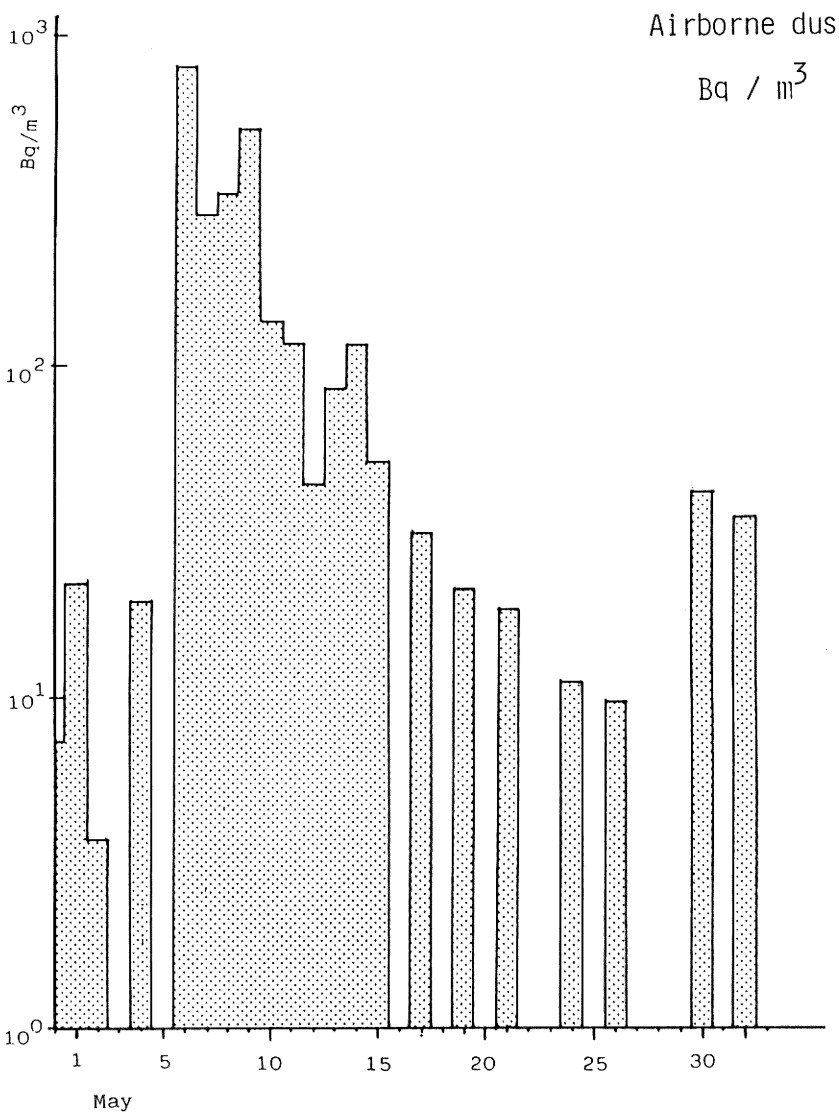

Fig. 3. Gross beta radioactivity in airborne dust at Akita.

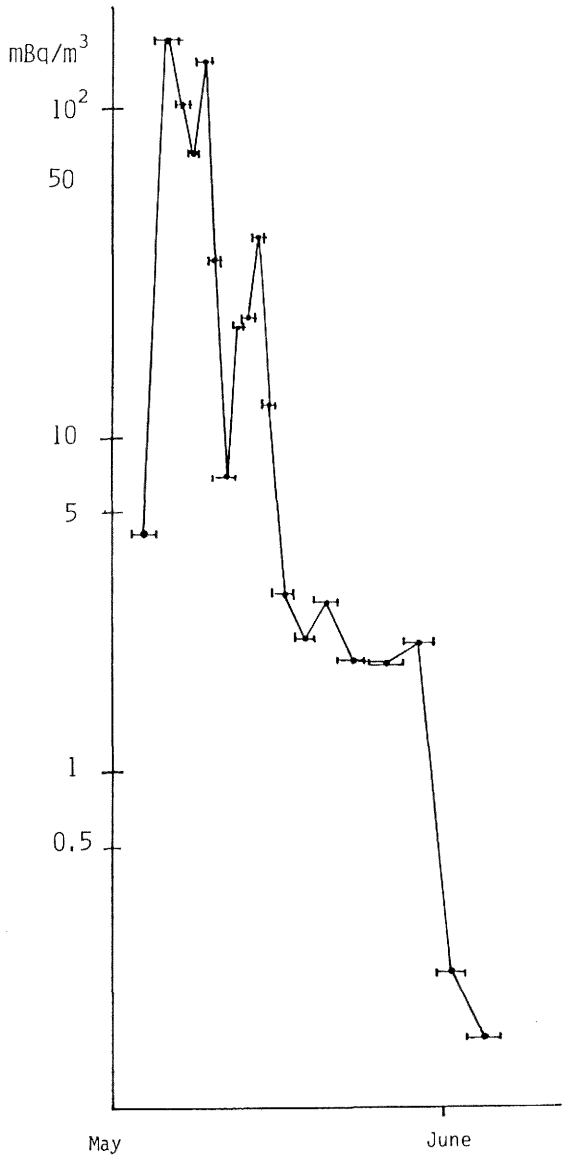

Fig. 4. ^{131}I concentration in airborne dust (glass fiber filter) versus time.

Table 1 Gamma-ray emitting radioisotopes in airborne dust at Akita

Date		Radioactivity mBq m^{-3}*								
		^{99}Mo	^{103}Ru	^{106}Ru	^{131}I	^{132}Te	^{134}Cs	^{136}Cs	^{137}Cs	^{140}La
May	2-4	0.28±0.06	0.72±0.07	nd	5.2 ±0.2	1.9 ±0.1	0.47±0.06	nd	0.78±0.10	nd
	4-6	6.2 ±0.1	43 ±0.4	19 ±4	160 ±1	53 ±0.3	17 ±0.4	4.3 ±0.1	27 ±1	5.6 ±0.09
	6-7	4.4 ±0.2	36 ±1	15 ±3	100 ±1	34 ±0.3	11 ±0.5	2.8 ±0.6	19 ±1	4.0 ±0.7
	7-8	3.5 ±0.2	42 ±1	20 ±6	66 ±1	34 ±0.5	141	3.1 ±0.4	22 ±1	4.7 ±0.4
	8-9	4.9 ±0.2	67 ±1	22 ±4	140 ±1	43 ±0.3	21 ±0.5	5.1 ±0.3	35 ±1	6.3 ±0.3
	9-10	1.3 ±0.1	25 ±0.5	10 ±3	35 ±0.5	13 ±0.2	7.4 ±0.4	1.7 ±0.4	13 ±1	2.0 ±0.2
	10-11	nd	0.91±0.13	nd	7.7 ±0.2	0.52±0.12	nd	nd	0.93±0.18	nd
	11-12	nd	5.1 ±0.1	3.7 ±1.3	22 ±0.3	1.6 ±0.1	1.6 ±0.1	0.40 ±0.10	2.5 ±0.2	1.6 ±0.1
	12-13	nd	6.9 ±0.2	nd	23 ±0.3	1.9 ±0.2	2.1 ±0.1	0.33 ±0.12	3.7 ±0.2	2.9 ±0.2
	13-14	nd	11 ±0.2	(3.6 ±2.6)	41 ±0.4	2.2 ±0.1	4.3 ±0.3	0.70 ±0.10	7.0 ±0.2	2.8 ±0.1
	14-15	nd	7.2 ±0.2	(1.9 ±1.3)	13 ±0.3	1.7 ±0.1	3.0 ±0.2	nd	4.7 ±0.2	1.8 ±0.2
	15-17	nd	3.2 ±0.1	1.7 ±0.5	3.7 ±0.1	0.40±0.05	1.0 ±0.1	nd	1.7 ±0.1	0.71±0.07
	17-19	nd	0.47±0.05	nd	2.5 ±0.1	nd	0.14±0.03	nd	0.21±0.04	nd
	19-21	nd	3.8 ±0.1	1.3 ±0.3	3.2 ±0.1	0.27±0.03	1.1 ±0.1	0.095±0.032	2.0 ±0.07	0.71±0.05
	21-24	nd	2.8 ±0.1	nd	2.2 ±0.1	(0.09±0.04)	0.72±0.10	nd	1.2 ±0.08	0.31±0.06
	24-27	nd	6.7 ±0.1	2.4 ±0.3	2.1 ±0.1	nd	0.93±0.06	nd	1.7 ±0.06	0.28±0.04
	27-30	nd	19 ±0.2	6.6 ±1.1	2.4 ±0.1	nd	2.4 ±0.1	0.34 ±0.06	4.5 ±0.1	0.41±0.05
May	30-June 2	nd	1.1 ±0.04	0.67±0.16	0.25 ±0.05	nd	0.13±0.03	nd	0.25±0.02	nd
June	2-5	nd	0.69±0.06	nd	0.16 ±0.05	nd	nd	nd	0.14±0.05	0.42±0.08
	5-12	nd	0.47±0.03	nd	0.094±0.018	nd	0.10±0.02	nd	0.20±0.02	nd

Particle size $< 10\mu m$

airborne dust fron May 2 to 4. Not much ^{131}I could generally be detected. A distinct increase occurred from May 4 to 6 and again from May 8 to 9, these values being 160 Bq m^{-3} and 140 Bq m^{-3}, respectively. The concentration decreased remarkably after the period from May 15 to 17 with a mean value of 3 Bq m^{-3}.

For the same samples, the maximum values obtained from May 4 to 6 for ^{99}Mo, ^{106}Ru, ^{132}Te, and ^{140}La, and from May 8 to 9 for ^{134}Cs, ^{136}Cs, ^{137}Cs, and ^{90}Sr as well as ^{89}Sr will be determined more accurately in the future. Table 2 shows the concentrations of various radionuclides in rain water from May 7 to June 9. ^{131}I, ^{103}Ru, and ^{132}Te were detected in the first rain water collected on May 7 following the accident. Maximum values of ^{131}I, ^{103}Ru, ^{137}Cs, and ^{134}Cs were on May 8, and second highest levels were on May 19. Concentrations resumed normal levels on June 9. The effects of ^{131}I in the rain water are summarized in Fig. 4.

Table 2 Concentration of ^{103}Ru, ^{134}Cs and ^{137}Cs in rain at sampling time

Date	Radioactivity, Bq L^{-1}				
	^{103}Ru	^{131}I	^{132}Te	^{134}Cs	^{137}Cs
May 6-7	7.8±1.9	75 ±4.8	7.8±1.5	3.4 ±0.8	3.4±0.6
7-8	32 ±3	180 ±6	29 ±2.4	7.2 ±0.7	16 ±0.7
9-10	25 ±3	96 ±4	15 ±1	9.2 ±0.6	21 ±0.6
10-11	11 ±3	57 ±4	nd	2.6 ±0.8	10 ±0.7
14-15	(0 ±1.7)	4.5±1.4	nd	(0.08±0.51)	1.4±0.4
15-16	4.6±1.3	17 ±2	nd	(1.2 ±0.8)	3.2±0.6
16-17	(0.5±1.4)	4.1±1.6	nd	(1.3 ±0.7)	2.2±0.6
17-19	15 ±2	52 ±3	nd	3.7 ±0.7	9.4±0.7
19-21	(1.1±2.0)	6.3±1.2	nd	1.5 ±0.7	3.6±0.5
21-26	6.2±0.6	8.4±0.6	nd	2.3 ±0.7	2.8±0.6
26-30	3.7±1.4	<4.8	nd	(0.45±0.49)	1.3±0.4
May 30-June 9	(0.9±1.1)	<3.8	nd	(1.4±0.8)	(0.92±0.54)

Table 3 shows the concentrations of various radionuclides in leafy vegetables. ^{131}I and ^{103}Ru in several kinds of vegetables were highest in spinach (Spinacia oleracea) and "Aiko" (Brassica rapa var. pervides). Special attention should be directed to their influence on the seaweed "Kuromo" (Papenfussiella), as presented in Table 4. The ^{131}I concentration of "Kkromo" on June 5 was 1,310 Bq Kg^{-1}, about 25 times that in spinach.[4] In Table 3, the level of ^{131}I (Maximum 68.8 Bq Kg^{-1}) can be seen as remaining constant over a long period of time. Normal concentration was resumed on June 13. The degree of decontamination of radionuclides by washing or boiling should be emphasized. The degree of decontamination of ^{131}I was 0.68 for seaweed and 0.42 for washed leafy vegetables.

Extensive measurement data has been reported in W. H. O. (1986) by 22 countries.[5] Due to insufficient data in this study, estimates of uptake and retention of radionuclides

in the human body were not considered. Many radionuclides produced by the reactor accident added to the external irradiation already present. What is most important in this regard is the magnitude of ^{131}I of short-lived radionuclides. Most internal exposure from contaminated food is due to contaminated fresh leaf vegetables and milk. As s temporary standard, the Science and Technology Agency of Japan[6] estimated that the per capita dosage of external irradiation for the entire nation was 1.3×10^{-5} Sv as a mean value during the period one year since May 1986. The dose from ingestion from 0 to 1-year-old infants was 1.4×10^{-7} Sv as a mean value and 3.1×10^{-7} Sv as a maximum value. Therefore, the per capita dose for the entire nation, including adults, was estimated to be less than this dose. This dose level corresponds approximately to 4.8×10^{-7} Sv of the estimated dose in the northern temperate zone. The present data shows no need for concern about the human health hazard due to the nuclear reactor accident at Chernobyl.

Table 3 Gamma-ray-emitting radioisotopes in leafy vegetables

Sample	Date	Radioactivity Bq (kg-fresh)$^{-1}$		
		^{103}Ru	^{131}I	^{137}Cs
Spinach	May 9	nd	51.0 ± 2.6	nd
	12	nd	24.5 ± 2.0	nd
	14	16.2 ±2.4	68.8 ± 4.4	8.10±2.09
	16	8.37±0.68	36.9 ± 0.9	4.74±0.67
	19	5.34±0.85	17.8 ± 1.2	3.82±0.95
	22	11.4 ±2.0	19.7 ± 3.2	nd
	26	8.14±1.43	10.7 ± 1.5	nd
	30	8.33±0.69	6.47± 0.74	2.76±0.67
	June 3	nd	nd	nd
	5	5.25±0.63	3.12± 0.64	2.31±0.61
	13	nd	nd	nd
(Nira)	May 7	nd	6.67± 0.74	nd
(Aona)	May 7	nd	20.1 ± 2.8	nd
Cabbage	May 9	nd	1.30± 0.40	nd
	19	nd	nd	nd
(Aona)	May 7	nd	34.6 ± 3.7	3.5 ±1.1
	9	5.75±1.58	51.7 ± 3.0	nd
	12	3.42±1.04	12.3 ± 2.1	nd
	14	6.54±1.53	19.5 ± 2.4	nd
(Honna)	May 7	nd	7.54± 1.54	nd

Table 4 Gamma-ray emitting radioisotopes in seaweed

Sample	Date	Radioactivity Bq (kg-fresh)$^{-1}$	
		^{103}Ru	^{131}I
(Kuromo)	June 5	7.43±1.94	1310. ±13
	10	5.88±1.37	586. ± 8
(Ishimozuku)	June 9	nd	23.1 ± 2.0
	12	nd	15.6 ± 0.7
	12	nd	18.0 ± 1.1
	12	nd	19.6 ± 0.9
	12	nd	17.0 ± 0.9
	25	nd	3.92±0.63
(Wakame)	June 5	nd	nd
	9	nd	6.25±0.82

References

1) Asahi Press (1986). Morning edition, *April* 29, 1986.
2) Special Committee on Radiation Safety Measures of the Japanese Cabinet (1986). The Soviet Chernobyl Atomic Reactor Accident. Report of the Science and Technology Agency of Japan, June 1986.
3) Takizawa, Y. (1973). Studies on mechanism of transfer of radioactive nuclides from the environment to the human body in the Niigata district, northern Japan. Acta Med. et Biol., 20, 147-61.
4) Hisamatsu, S., Takizawa, Y., and Abe, T. (1987). Reduction of ^{131}I content in leafy vegetables and seaweed by cooking. J. Radiat. Res., 28, 135-140.
5) W. H. O. (1986). Chernobyl Reactor Accident. Report of a Consultation, May 6.
6) Science and Technology Agency of Japan (1976). A Method for the Determination of Gross beta radioactivity. 1st ed., Nihon Bunseki Center, Tokyo; The Method of a Multichannel Analyzer with a Ge(Li) Semiconductor Detector, Nihon Bunseki Center, Tokyo.