RADIOACTIVITY LEVEL OF RESIDENTIAL AREAS AROUND XINJIANG NUCLEAR TESTING SITE AND ESTIMATED POPULATION DOSE

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ABSTRACT

Results are reported on a research for the radioactive level in the investigation region and the control region around the Xinjiang Nuclear Testing Site from 1982 to 1987. There are no significant differences on the land γ radiation level, nor in the radioactive level in the soil, food and water between the two regions. The distribution and transfer of ^{90}Sr, ^{137}Cs and Pu in various kinds of soil are also discussed. It is estimated that the effective dose equivalent of radiation undergone by the residents around the Testing Site is only 2.9% of that of natural radiation taken yearly by people in normal areas.

Keywords: Around Xinjiang nuclear testing site Radioactive level Radioactive dose Residents

I. INTRODUCTION

The environment may be polluted by the radioactive materials after nuclear explosions. People are paying special attention to see if our Nuclear Tests will seriously cause local radioactive pollution and do harm to the residents around the Testing Site. In order to get an overall understanding of the radioactive level and the dose commitment by the residents and to evaluate it scientifically, we undertook this research from 1982 to 1987.

II. REGIONS UNDER INVESTIGATION

The surroundings of the Testing Site refer to the natural villages and towns near the Center of the Site in all the directions in Xinjiang Province. Ten regions were chosen for investigation with a total population of 300000 from 120 kilometres southwest of the Testing Site to 400 kilometres northeast. There were five control regions with a total population of 200000, 847 kilometres northwest away. The natural circumstances, geological structure, lodging conditions and eating customs are almost the same in both the investigation and the control region.

III. INVESTIGATION ITEMS AND MEASUREMENT METHODS

The main purpose of our investigation is to measure the land γ exposure rate and the accumulative dose and to analyze the radioactive nuclides in the soil, food and

water.

1. Measurements of the land γ exposure rate and the accumulative dose

With the ^{226}Ra source scale metering instrument, we made on the spot measurements of the land γ exposure rate and the accumulated amount by using FD- 71 type Weilen machine and $CaSO_4$:Dy measure. The relative errors are less than 12.5% and 20% respectively.

2. Measurements of the total β in food and water

We took 1.00 g food ash and 2.0 litres of water as the origions and with KCl as the standard, we measured the β radioactivity. The relative error is below 5%.

3. Measurements of ^{40}K in food

We took 2.000 g food ash and measured ^{40}K with sodium tetra- phenylboron capacity method. The relative error is lower than 1%.

4. Measurements of the amount of ^{90}Sr, ^{137}Cs and Pu in the soil, food and water

We measured ^{90}Sr with a method of nitrate sedimentation and ^{90}Sr- ^{90}Y source scale meter, measured ^{137}Cs with A.M.P absorber, making the source with cesium chloroplatinate sedimentation and with ^{137}Cs source scale meter, and measured Pu with Kell- TOA reversed- phase partition chromatograph, electricity deposit making source α counting, and with Pu source scale meter. For the measurements of the above three nuclides, the relative error is less than 30%.

IV. RADIOACTIVE LEVEL AND DISCUSSION

1. Outer land γ irradiation level

1) The measurement of the land γ irradiation rate It is clearly known from Table 1 that there are no evident distinctions ($P>0.05$, P is the probability of the t test) in

Table 1

The dose rate of land γ radiation in the investigation and the control region (10^{-8} Gy/h)

Region	Investigation region				Control region			
	Number of survey spots	Range	Mean	Population weighted average	Number of survey spots	Range	Mean	Population weighted average
Outdoor	1000	5.0- 11.0	7.6	7.3	1275	5.5- 12.8	7.8	7.6
Indoor	1150	8.3- 16.8	12.1	11.6	1260	9.2- 16.5	12.1	11.9
Road	1065	4.8- 10.2	7.7	7.5	1255	4.5- 12.4	7.6	7.4

Ratio of investigation region and control region, $P>0.05$

the γ radiation level indoors, outdoors or on the roads between the investigation region and the control region. The γ radiation on the roads in both regions is slightly lower than the mean of that in Xinjiang regions[1] while the γ radiation indoors in both regions are 91.7% and 98.3% higher than that of the air absorption rate in the world[2]. The fact is closely related to the wood structure of the houses around the

Testing Site. Anyway, our nuclear tests have not yet caused serious and long- term radiopollution to its surroundings.

2) The Measurement of the accumulated dosage of land γ radiation We made measurements of the accumulated dose of the residents around the Testing Site with $CaSO_4$: Dy dose measure. There are no noticeable differences in the annual accumulated amount (indoors, outdoors and personal measure) between the investigation and the control region ($P>0.05$, see Table 2).

Table 2

The mean illuminated dose per year in the investigation and control regions*

Region	$CaSO_4$:Dy		Personal wearing
	Outdoor	Indoor	(mGy/a)
Investigation region	0.86	1.30	1.07
	(49)	(49)	(100)
Control region	0.97	1.27	1.18
	(51)	(51)	(105)

Ratio of the investigation and control regions, $P>0.05$

* The number in parentheses is the number of survey spots

2. Distribution and transfer of the level of ^{90}Sr, ^{137}Cs and Pu in soil

1) The level of ^{90}Sr, ^{137}Cs and Pu in soil The radioactive levels of ^{90}Sr, ^{137}Cs and Pu in the surface soil of the investigation and the control region are shown in Table 3. There are no apparent distinctions between the two regions. The levels of ^{137}Cs and Pu are somewhat similar to those in Zhejiang Province and Beijing[3,4].

Table 3

Level of ^{90}Sr, ^{137}Cs and Pu on soil (10cm deep)

Region	Number of survey spots	^{90}Sr (Bq/kg)	^{137}Cs (Bq/kg)	Pu ((10 ^{2}Bq/kg)
Investigatien region	96	5.4±2.5	17.9±10.7	44.6±9.5
Control region	41	5.2±0.5	17.9±3.9	47.0±7.6
Zhejiang province	24	-	15.0±11.0	-
Beijing	11	-	-	36.3

Table 4

^{90}Sr, ^{127}Cs and Pu accumulated subsidence (30cm deep) in westeland

Region	Number of survey spots	^{90}Sr (10^3Bq/m^2) (10^3Bq/m^2)	^{137}Cs 10^3Bq/m^2) (10^3Bq/m^2)	Pu (Bq/m^2) (Bq/m^2)
Investigation region	114	1.5±0.3	4.9±4.0	101.6±67.7
Control region	66	1.3±0.2	3.9±0.5	93.4±15.0
Region *A*	15	1.3±0.3	16.7±9.0*	321.7±86.0*

* $P<0.05$

The accumulated subsidences of ^{90}Sr, ^{137}Cs and Pu in soil of the investigation region are much the same as those of the control one, whereas the amount of ^{90}Sr, ^{137}Cs and

Pu in region *A*, 120 kilometres southwest from the center is higher than that in the control region (Table 4). This is one of the strongest windy areas, where the wind blows all the year round and makes the polluted dust flying and sinking, so it is possible to cause little local pollution.

2) The distribution and transfer of ^{90}Sr, ^{137}Cs and Pu in soil We know clearly from Table 5 that the amount of ^{90}Sr, ^{137}Cs and Pu (10cm deep) in sticky loess varies greatly from those in tide soil, saline soil and sand soil ($P<0.05$), but no obvious differences can be seen from among the latter three kinds of soil ($P>0.05$). The main cause may be related to the destruction of vegetation. It was reported that the well- vegetated places, full of humus, were useful to the retention of ^{137}Cs sediment. We found that it was the sticky loess that was most well- vegetated with much black humus[3].

Table 5

The distribution of the amount of ^{90}Sr, ^{137}Cs and Pu in different types of soil with different depth

Soil type	Depth (cm)	Number of samples	^{90}Sr (Bq/kg)	(%)	^{137}Cs (Bq/kg)	(%)	Pu (Bq/kg)	(%)
	0- 10	5	17.6	77.2	64.1	82.0	54.3	74.9
Sticky	11- 20	5	3.3	14.5	9.6	12.3	15.6	21.5
loess*	21- 30	5	1.9	8.3	4.5	5.7	2.6	3.6
	Total	15	22.8	100.0	78.2	100.0	72.5	100.0
	0- 10	11	4.2	46.7	16.5	54.3	41.7	62.4
Tide	11- 20	11	3.0	33.3	9.3	30.6	19.0	28.5
soil	21- 30	11	1.8	20.0	4.6	15.1	6.0	9.1
	Total	33	9.0	100.0	30.4	100.0	66.7	100.0
	0- 10	27	4.2	45.2	15.9	47.9	39.6	56.6
Saline	11- 20	27	3.3	33.5	11.0	33.0	21.0	30.0
soil	21- 30	27	1.8	19.3	6.3	19.0	9.5	13.5
	Total	81	9.3	100.0	33.2	100.0	70.1	100.0
Windy	0- 10	17	4.5	46.4	10.1	51.3	35.6	44.2
and	11- 20	17	3.4	35.0	6.1	31.0	27.4	34.0
sand	21- 30	17	1.8	18.6	3.5	17.7	17.6	21.8
soil	Total	51	9.7	100.0	19.7	100.0	80,6	100.0

* $P<0.05$; Comparison of the rest three type soil, $P>0.05$

The amount of ^{90}Sr, ^{137}Cs and Pu in various kinds of soil decreases with the depth. The speed of transfer differs not so greatly in tide soil, saline soil and sand soil, but a bit slower in the sticky soil loess (Table 5). However, the transfer of ^{90}Sr in the above soil tends to go a little faster than that of ^{137}Cs. Some authors suggested that the subsidence of ^{90}Sr, ^{137}Cs should be correlated with the soil seepage which affects the distribution of the nuclides in varied depth. Furthermore, since the maintenance of ^{137}Cs in the soil is higher than that of ^{90}Sr, the maintenance of leakage and the replacement of the accumulated total of ^{90}Sr and nuclide in the soil is largely

Table 6

Concentration of gross β and ^{40}K in staple foods (Bq/kg)

Samples	Number of samples	Investigation region Gross β	^{40}K	Number of samples	Control region Grossβ	^{40}K
Flour	16	74.4±12.4	58.8±12.7	6	50.8±4.5	64.8±2,1
Corn meal	6	102.8±0.3	77.0±16.1	4	96.6±8.7	85.5±1.0
Rice	14	23.2±3.6	18.0±1.1	6	22.0±1.8	15.9±0.8
Chise	18	169.1±30.2	137.7±19.5	6	179.2±36.7	144.1±9.1
Chinese cabbage	18	43.9±16.5	36.7±15.5	6	67.4±10.0	62.6±10.0
Apium	18	101.0±21.0	82.9±23.8	6	100.8±27.9	95.3±5.1
Eggplant	18	68.3±11.9	56.4±13.0	6	81.6±20.2	76.0±2.3
Canavalis ensifomis	18	76.8±12.2	64.4±10.5	6	82.6±9.9	61.5±7.8
Carrot	18	89.1±24.3	77.5±19.7	6	91.0±2.3	74.9±7.9
Hami melon	18	52.2±19.3	46.8±11.1	6	45.1±2.6	35.7±3.5
Apple	18	34.4±8.1	29.4±5.3	6	47.6±6.8	38.3±5.6
Pear	18	34.3±7.1	29.5±5.1	6	35.6±2.7	30.5±4.5
Fish	6	74.3±21.4	56.9±14.9	4	84.3±5.9	–
Pork	6	27.2±5.1	22.7±3.1	8	26.6±2.1	21.5±2.1
Mutton	6	69.3±11.1	62.0±6.7	4	61.8±8.1	62.7±3.1
Egg	18	38.3±4.0	35.6±5.1	6	29.6±6.7	23.5±4.1
Milk	18	36.2±6.1	31.8±5.8	6	52.8±13.0	41.5±2.3

Table 7

Levels of ^{90}Sr, ^{137}Cs and Pu in staple foods

Samples	Number of samples	Investigation region ^{90}Sr (10^{-2}Bq/kg)	^{137}Cs (10^{-2}Bq/kg)	Pu (10^{-3}Bq/kg)	Number of samples	Control region ^{90}Sr (10^{-2}Bq/kg)	^{137}Cs (10^{-2}Bq/kg)	Pu (10^{-3}Bq/kg)
Flour	16	16.7±9.2	5.2±1.4	2.0±0.5	6	17.6±11.7	5.8±1.9	2.0±0.5
Corn meal	6	6.2±0.8	6.6±0.8	2.5±0.8	4	5.0±0.2	5.2±0.1	2.1±0.7
Rice	14	3.0±2.5	1.8±0.6	0.7±0.1	6	2.8±0.7	1.5±0.7	0.7±0.8
Chise	18	30.4±14.2	9.4±7.3	7.2±2.0	6	28.1±16.9	8.3±1.8	7.3±1.2
Chinese cabbage	18	18.6±8.5	4.3±1.1	13.6±1.6	6	17.9±3.5	4.5±0.3	11.4±1.2
Apium	18	37.1±18.5	7.3±3.1	8.2±3.0	6	43.7±21.4	9.0±1.7	6.8±0.8
Eggplant	18	5.6±2.6	2.2±1.2	2.6±1.1	6	5.4±1.2	1.5±0.8	2.2±0.8
Canavalis ensifomis	18	18.6±4.7	2.6±1.2	2.2±0.8	6	20.9±10.3	1.5±0.5	2.2±1.0
Carrot	18	19.8±7.9	3.1±1.8	4.7±1.5	6	17.1±5.7	4.5±3.1	4.6±0.4
Hami melon	18	5.4±2.3	1.2±0.7	1.8±0.9	6	4.1±1.4	1.2±0.6	2.2±1.0
Apple	18	5.0±2.6	1.8±1.3	1.8±0.5	6	6.4±1.8	2.3±0.5	1.6±0.4
Pear	18	4.1±2.5	1.2±0.7	1.4±0.3	6	5.0±0.5	1.0±0.5	1.8±0.6
Fish	6	22.5±4.6	16.6±8.5	9.1±1.9	4	24.2±1.6	24.8±0.8	8.1±2.3
Pork	6	6.6±1.5	10.7±5.8	5.1±1.9	8	8.0±1.6	11.8±0.1	7.7±1.1
Mutton	6	7.0±1.5	31.8±12.9	7.8±0.2	4	7.3±1.5	27.4±0.2	5.6±0.2
Egg	18	9.6±5.2	3.4±1.6	3.1±1.1	6	6.6±0.9	3.0±0.7	3.4±1.0
Milk	18	5.4±2.4	3.1±1.2	2.4±0.7	6	4.8±2.1	2.9±1.6	2.2±0.4

Notes: Ratio of investigation region and control region, $P>0.05$

associated with the soil nature[5]. It was reported that the transfer of Pu is faster than that of ^{137}Cs but slower than that of ^{90}Sr[6]. However, we did not find any evidences in our investigation.

3. The total β , ^{40}K, ^{90}Sr, ^{137}Cs and Pu in biological samples

The average concentration of radionuclides in biological samples in the two regions is shown in Table 6,7. We can see that there are no obvious contrasts in the total β , ^{40}K, ^{90}Sr,^{137}Cs and Pu ($P>0.05$). Our findings are consistent with the results reported[7,8].

4. The total β , ^{90}Sr, ^{137}Cs and Pu in surface water and ground water

Differences on the total β , ^{90}Sr, ^{137}Cs and Pu in surface water and ground water between the two regions are not evident ($P>0.05$, see Table 8). It suggests that the residential areas around the Nuclear Testing Site in Xinjiang have not yet been polluted by the radioactive materials produced by the tests.

Table 8

The radioactive level of surface water and ground water in the investigation and the control region* (Bq/L)

	Investigation region* *		Control region* *	
Radionuclides	Surface water	Ground water	Surface water	Ground water
Gross β	0.69±0.2 (14)	0.47±0.16 (12)	0.60±0.20 (12)	0.49±0.18 (8)
^{90}Sr ($\times 10^{-3}$)	13.7±5.8 (14)	7.6±6.4 (12)	11.2±2.8 (12)	8.3±4.4 (8)
^{137}Cs ($\times 10^{-3}$)	1.3±0.5 (14)	0.6±0.2 (12)	1.2±0.3 (12)	0.6±0.1 (8)
Pu ($\times 10^{-4}$)	2.7±1.7 (14)	1.2±0.5 (12)	2.5±1.7 (12)	1.4±0.7 (8)

* $P>0.05$; * * The data in parentheses are the number of the samples

V. THE ESTIMATED POPULATION DOSE

The effective dose equivalent of the residents is estimated at 1546.2 μ Sv (the collective effective dose equivalent is 471.3 man · Sv), which is resulted from internal irradiation (^{90}Sr, ^{137}Cs and Pu) and external irradiation (^{137}Cs, ^{95}Zr, ^{103}Ru, ^{106}Ru, ^{140}Ba, ^{141}Ce and ^{144}Ce) caused by the globe sediments from the beginning of the atmospherical nuclear testing to 1983. Our estimation is made by resorting to the analysis of the accumulated subsidence of ^{90}Sr (1.5×10^{3} Bq/m^2), ^{137}Cs (4.9×10^{3} Bq/m^2) and Pu (1.2×10^{2} Bq/m^2) in the soil around the Nuclear Testing Site according to the report[9], in which the parameter derived from relevant formulae given by the UNSCEAR report 1982[2]. We adopted the calculation of the total equivalent weight of the nuclear explosions in the atmosphere in other countries and the globe subsidence model. The equivalent weight of our nuclear tests is only 3.8% of that of the world total explosions. Since the valid equivalent weight of the residents around the Testing Site is only 58.8 μ Sv (collective effective dose equivalent is 17.9 man · Sv), and is 2.9% of the effective dose equivalent of the natural annual radiation in normal areas we believe from the viewpoint of radioactive hygience that such little additional dose can not cause ill

effect on the health of the local residents.

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