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Environmental Radioactivity at Ko-ri Nuclear Power Plant Site December 1970-November 1972

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Abstract

The present report concerns measurement of environmental radioactivity in the Ko-ri nuclear power plant site area. Gross beta measurements have been performed on soil, water, pine needle, and fallout samples collected during the period of December 1970-November 1972.

Radioactivities of Strontium-90 and Cesium-137 have been measured by radiochemical analyses on samples of vegetables and marine products collected in 1972.

Apparent seasonal variations and overall decrease by the year was also observed from the results of soil, pine needle, and fallout sample measurements respectively.

요 약

고리에 위치한 원자력발전소 건설부지의 환경방사능의 측정보고이며 1970년 12월부터 1972년 11월 사이에 일광, 월내, 신암, 좌천, 소상 고리등 여섯개 지역에서 채취한 토양, 물, 솔잎, 낙진시료에 대하여 전방사능을 측정하였고 1972년에 채집한 채소류, 해산물 시료에 대하여 Sr-90 Cs-137의 방사능을 측정하였다. 각 시료의 측정치를 보면 그값은 계절적인 변화와 연차적인 감소현상을 나타내 주고 있다.

1. Introduction

Measurements of environmental radioactivity in Ko-ri area, Kyungsan-Namdo, Korea have been started in anticipation of the construction of 600 Mega Watts nuclear power plant.

The measuring was started in June of 1969 and is still going on current. In this report the completed measurements during the period of December 1970 November 1972 are stated.

In this work, soil, water, pine needle, fallout and some of terrestrial foods and marine products were collected in December of 1970, and February, June, September, October and December of 1971, and March, May, August and November of 1972. Sampling sites were fixed at six places; Il-kwang, Wol-nae, Shin-am, Chua-chun, So-sang and Ko-ri. The sampling sites are shown in a map of Tong-nae Kun area in page 4.

The examinations were made mainly on the gross beta activity measurement, and radiochemical analyses of Sr-90 and Cs-137 were made only on the terrestrial foods and marine products.

2. Sample Collection, Preparation and Activity Measurement

(1) Gross Beta Activity

(a) Soil

Samples were taken from the sites of Il-kwang, Wol-nae, Shin-am, Chua-chun, So-sang and Ko-ri in December of 1970 and February, June, September, October and December of 1971 and March, May, August and November of 1972.

The samples are dried in an oven and sifted through 9 mesh standard sieve. An aliquot of sample is tranferred to the tared stainless steel counting planchet and weighed for a counting sample.

(b) Water

Well water samples were taken from the sites of Shin-am and Kil-chun, stream water samples from the sites of Pak-ryon and Hyo-am stream and sea water samples from the seashore of Ko-ri site. The sampling dates of the above samples were the same as that of soil samples. One of snow samples was taken from Ko-ri site in February of 1971. Precipitation samples were taken from Ko-ri site in June, July, August and Septamber of 1971 and in each month of 1972 except December.

500ml. of sample water containing 5ml. of concentrated nitric acid is evaporated to near dryness and transferred to the stainless steel counting planchet. Residue and liquor are evaporated under infra-red lamp. The sea water is evaporated under quartz lamp, and an aliquot of sea minerals were transferred to the stainless steel counting planchet and weighed for a counting sample.

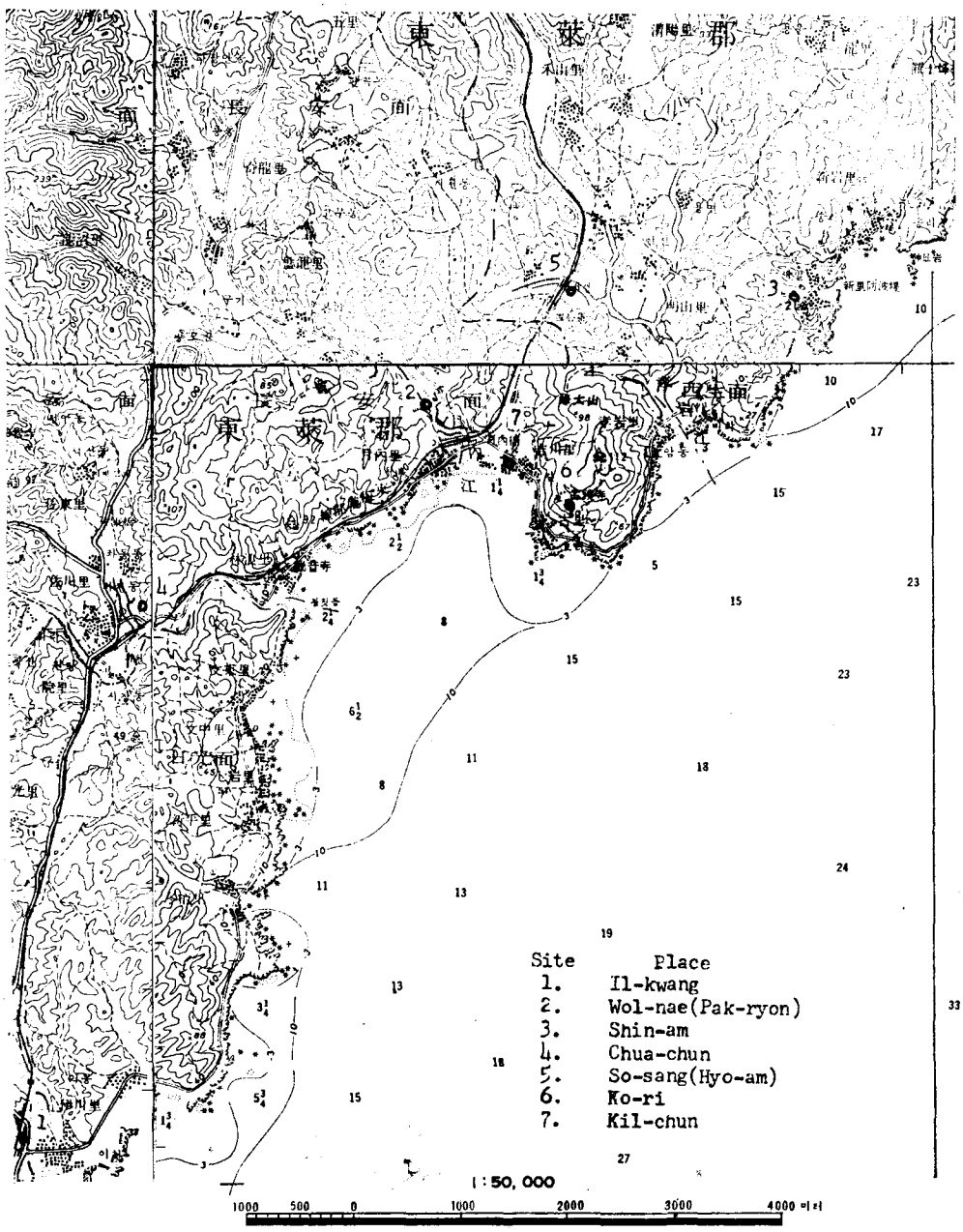
(c) Pine Needle

Sampling sites and dates were the same as that of soil samples. The samples were ashed at 450 to 500°C in an electrically heated muffle furnace. The ashing process is accelerated by feeding in about one liter of oxygen per minute to the furnace, and ashing requires slightly over one hour for completion. After cooling, an aliquot of ash was transferred to the stainless steel counting planchet and weighed for a counting sample.

(d) Fallout

Fallout samples, by using Gummed Acetate Paper, were collected from the sites of Ko-ri and Kil-chun. Each paper is exposed for 10 days. The exposed films are stripped off and folded with the gummed sides together into a size suitable for mailing. The collections were made irregularly because of some difficulties. Among the 13 samples from the Ko-ri site, 9 samples were collected during the period of December, 1970-March, 1971, and 3 samples were collected during the period of September-November, 1971 and one sample was collected in June, 1971. From the Kil-chun site, 5 samples were collected during the period of December, 1970-February, 1971 and 2 samples were collected in August and November of 1971. In 1972, monthly sampling were made at the Ko-ri, and Kil-chun sites but several samplings were failed at the Kil-chun site.

The sample preparation method is the same method of the pine needle sample. The blank samples were prepared with unexposed paper. The background count rates were determined from the blank sample. There is some loss of volatile fission products in the ashing process. The volatility loss depends upon the age of the material, since the volatile elements are chiefly iodine and ruthenium, but the overall losses are less than 20%.



(f) Terrestrial Foods and Marine Products

One sample of mackerel was collected in March of 1972 at Ko-ri site. Four samples each of sea eel and green laver were collected in March, May, August and November of 1972 at Ko-ri site. One sample each of shell fish and laver were collected in December of 1970 at Ko-ri site. Two samples of dulse were collected in March and May of 1972. Three samples of spinach were collected in December of 1970, May and November of 1972 at Wol-nae, So-sang and Ko-ri sites. Two samples of cabbage was collected in August and November of 1972 at Ko-ri site. Four samples of barley were collected in December of 1970 and February of 1971 at Wol-nae, Il-kwang, Shin-am sites. A bamboo leaf sample was collected in December of 1970 at Wol-nae site.

The sample preparation method is the same method as that of pine needle sample.

(g) Radioactivity Measurement

Gross beta activity of the samples were counted in a low background beta counting system, LOW BETA II, Beckman. The background count rate of used counting system is less than one count per minute for 1/2 inches stainless steel counting planchet. The detection efficiency of the counting system calibrated using Thallium-204 standard is about 45% for 1/2 inches planchet.

Radioactivity was calculated using following equation.

$$\text{Gross Beta Activity} = \frac{(S-B) \pm \sigma}{A \cdot E \cdot 2.22} pCi$$

S: Count rate of sample plus background

B: Count rate of background

A: Volume of sample

E: Counting efficiency

σ: Combined standard deviation of S and B.

The results were expessed in following units.

Soil: pico curies per gram soil

Water: 10^{-3}·pico curies per cc water

Pine needle: pico curies per gram ash

Fallout: pico curies per square feet per 10 days

Others: pico curies per gram ash

(2) Strontium-90 and Cesium-137 Activities

Terrestrial foodstuffs and marine products samples collected in 1972 at Ko-ri site were assaied for Strontium-90 Cesium-137 radioactivities.

(a) Radiochemical Analyses

Samples were dried in an oven and placed in a muffle furnace regulated at 450°C until ashing was complete.

An aliquote of ash was taken for radiochemical analyses of Strontium-90 and Cesium-137.

(b) Radioactinity Measurement

Radioactivities were counted in a low background beta counter. The counter has ca. one c. p. m. of background count rate and ca. 45% of detection efficiency for Yttrium-90, and ca. 1.5 c. p. m. of background count rate and ca. 35% detection efficiency for Cesium-137. Calculations were made by following equations.

$$\text{Sr-90 Activity} = (A_y - B) \frac{F_t \times F_e \times 10^4}{R_{sr} \times R_y \times 2.22} pCi$$

Where A_y: Sample count in c. p. m.

B: Background count in c. p. m.

F_e: Efficiency factor of counter

F_t: Correction factor for decay of Y-90 from separation to mid-point of counting period

R_{sr}, R_y: Respective Sr and Y yield in %

$$\text{Cs-137 Activity} = (A - B) \frac{F \times 10^2}{R \times 2.22} pCi$$

Where A: Sample count in c. p. m.

B: Background count in c. p. m.

F: Efficiency factor of counter

R: Chemical recovery of Cs in %

3. Results and Discussions

The collection of valid samples is equal of importance to accurate analysis in carrying out a program for evaluating contamination of man and his environment. The purpose of environmental sampling and analysis is to obtain numerical data which can be interpreted as a basis for possible action. From the results, we found that the environmental radioactivity in Ko-ri area shows normal pattern. The pronounced seasonal fluctuations were appeared clearly and over-all decrease by the year was also observed.

(1) Gross Beta Activities

(a) Soil

The results obtained were tabulated in Table 1. The results showed clear seasonal variation of fallout radioactivity, Spring Peak, and some differences according to the sites. The Shin-am area shows rather high activities than other sites.

(b) Water

Table 1. Gross beta activities in soil (Dec. 1970-Nov. 1972)

(Unit: pCi/g·Soil)

Site	Il-kwang	Wol-nae	Sgin-am	Chua-chun	So-sang	Ko-ri	Mean
Dec.		32.28	38.26		29.43	38.09	34.51
Feb.	28.50	23.94	28.85	9.30		32.75	24.68
June	49.08	35.33	52.05	16.76	30.99	44.37	38.09
Sept.	27.33	19.53	47.55	28.30	24.80	17.60	27.52
Oct.	23.54	22.10	32.87	28.56	22.61	27.28	26.16
Dec.	23.08	19.69	34.59	23.19	15.69	15.67	21.99
Mean	30.33	25.48	39.03	21.22	24.70	29.29	
March	7.93	18.18	36.45	12.24	14.18	34.13	20.52
May	21.94	24.32	37.46	27.32	17.43	26.86	25.89
Aug.	15.60	21.10	24.40	24.50	12.70	21.90	20.03
Nov.	14.72	23.62	29.52	25.59	17.40	18.84	21.62
Mean	15.05	21.81	31.96	22.41	15.43	25.43	

Table 2. Gross beta activities in water samples (Dec. 1970-Nov. 1972)

Site	Shin-am*	Kil-chun*	Pak-ryon**	Hyo-am**	Snow	Sea water
Dec.	1.68	1.50	0.88	0.56	—	521.54
Feb.	0.50	6.38	0.40	0.60	2.40	167.40
June	0.44	2.80	2.12	1.02	—	284.31
Sept.	1.96	2.78	0.70	3.06	—	389.51
Oct.	1.38	3.56	1.18	1.88	—	506.89
Dec.	4.52	4.16	3.36	3.76	—	348.48
Mean	1.75	3.53	1.44	1.81	2.40	369.69
March	1.10	7.00	0.70	3.10	—	275.90
May	0.80	4.80	2.20	3.80	—	96.90
Aug.	0.60	1.40	2.40	3.00	—	164.10
Nov.	1.10	8.20	1.30	1.00	—	295.60
Mean	0.90	5.35	1.65	2.72	—	208.10

* Well-water
** Stream-water

The results obtained were tabulated in Table 2. No clear differences were shown between well and stream water. The seasonal variations were also not clear.

(c) Pine Needle

The results obtained were tabulated in Table 3. The clear seasonal variations were shown as in soil determinations. Comparing with the soil results no similar tendencies were found on the same sites. The Chua-chun site gives the highest activities and the Ilk-wang site gived the lowest value in mean

(d) Fallout

The results obtained were tabulated in Table 4. The seasonal variations were found. No special phenomena were observed.

(e) Precipitation

The results obtained were tabulated in Table 5. The clear seasonal variations were observed.

(f) Terrestrial Foods and Marine Products

The results obtained were tabulated in

Table 3. Gross beta activities in pine needle (Dec. 1970-Nov. 1972)

(Unit: PCi/g·Ash)

Site	Il-kwang	Wol-nae	Shin-am	Chua-chun	So-sang	Ko-ri	Mean
Dec.		189.5	266.7		225.2	620.9	325.6
Feb.	152.6	294.7	418.4	639.7		348.0	370.7
June	296.0	442.8	532.6	772.0	217.5	731.5	498.7
Sept.	322.3	391.7	329.5	458.2	488.7	383.9	395.7
Oct.	217.5	277.3	363.3	578.5	209.7	351.2	332.9
Nov.	196.6	159.4	202.4	397.9	248.4	267.9	245.4
Mean	237.1	292.6	352.2	569.3	277.9	450.6	
March	166.97	364.96	406.96	706.09	169.52	371.68	364.36
May	236.43	415.73	411.31	793.79	224.59	412.84	415.78
Aug.	164.6	236.0	183.1	244.2	199.6	531.3	259.8
Nov.	174.68	265.88	280.16	678.07	397.14	289.88	347.64
Mean	185.67	320.64	320.38	605.54	247.71	401.43	

Table 4. Gross beta activities in Fallout(Dec. 1970-Nov. 1972)

(Unit: pCi/ft²—10d.)

Ko-ri Site		Kil-chun Site	
Collection Date	Activities	Collection Date	Activities
23—31 Dec. 1970	7.33	23—31 Dec. 1970	7.69
1—11 Jan. 1971	13.51	1—11 Jan. 1971	11.32
21—31 Jan. 1971	24.08	21—31 Jan. 1971	18.24
1—11 Feb. 1971	37.30	1—11 Feb. 1971	13.70
20—28 Feb. 1971	73.50	20—28 Feb. 1971	75.80
2—12 Mar. 1971	49.10		
21—31 Mar. 1971	124.40		
1—10 Apr. 1971	89.30		
12—21 Apr. 1971	110.90		
10—20 June. 1971	192.70		
10—20 Sept. 1971	44.01	10—20 Sept. 1971	27.68
6—16 Oct. 1971	16.44		
10—20 Nov. 1971	18.89		
Mean	61.65		
10—20 Jan. 1972	40.08		
11—20 Feb. 1972	18.90		
11—21 Mar. 1972	26.65	11—21 Mar. 1972	36.36
11—21 Apr. 1972	110.04	11—21 Apr. 1972	891.59
11—21 May 1972	127.10	11—21 May 1972	123.97
11—21 June 1972	18.70	11—21 June 1972	27.10
11—21 July 1972	62.10	11—21 July 1972	75.60
11—21 Aug. 1972	25.77	11—21 Aug. 1972	16.04
11—21 Sept. 1972	9.57	11—21 Sept. 1972	19.15
11—21 Oct. 1972	8.24	11—21 Oct. 1972	19.58
11—21 Nov. 1972	11.70	11—21 Nov. 1972	11.00
Mean	**41.62**		**135.60**

Table 5. Gross beta activities in precipitation at Ko-ri site (June 1971-Nov. 1972)

(Unit:pCi/l)

Collection Date	Activities	Collection Date	Activities
—	—	5 Jan. 1972	5.21
—	—	31 Jan. 1972	6.00
—	—	5—6 Feb. 1972	8.90
—	—	23 Feb. 1972	6.60
—	—	30 Mar. 1972	16.60
—	—	30 Apr. 1972	19.00
—	—	26 May 1972	2.80
10—11 June 1971	3.66	13 June 1972	3.40
22 July 1971	5.14	4—5 July 1972	3.80
5 Aug. 1971	2.18	9 Aug. 1972	1.60
1 Sept. 1971	3.26	14 Sept. 1972	4.50
—	—	3 Oct. 1972	1.00
—	—	2—3 Nov. 1972	0.20
Mean			6.12

Table 6. Gross beta activities in vegetables, cereals and marine products (Dec. 1970-Nov. 1972)

(Unit: pCi/g·Ash)

Products	Collection Date	Activities	Site
Mackerel	Mar. 1972	228.10	Ko-ri
// bone	Mar. 1972	371.10	Ko-ri
Halfbeak bone	Mar. 1972	51.90	Ko-ri
Sea eel	Mar. 1972	47.60	Ko-ri
// bone	Mar. 1972	45.50	Ko-ri
Sea eel	May 1972	80.60	Ko-ri
Sea eel	Aug. 1972	58.60	Ko-ri
Sea eel	Nov. 1972	104.50	Ko-ri
Stieg mushell	May 1972	13.80	Ko-ri
Shell fish	Dec. 1970	61.93	Ko-ri
Laver	Dec. 1970	82.66	Ko-ri
Green laver	Mar. 1972	116.36	Ko ri
Green laver	May 1972	30.10	Ko-ri
Green laver	Aug. 1972	34.80	Ko-ri
Green laver	Nov. 1972	70.30	Ko-ri
Dulse	Mar. 1972	147.50	Ko-ri
Dulse	May	97.80	Ko-ri
Spinach	Dec. 1970	33.53	Wol-nae
Spinach	Dec. 1970	234.47	So-sang
Spinach	May 1972	213·00	Ko-ri
Cabbage	Aug. 1972	183.12	Ko-ri
Barley	Dec. 1970	286.98	Wol-nae
Barley	Feb. 1971	220.90	Il-kwang
Barley	Feb. 1971	138.20	
Barley	Feb. 1971	125.60	Wol-nae
Bamboo leaf	Dec. 1970	152.92	Wol-nae

Table 7. Sr-90, Cs-137 activities in vegetables and marine products at Ko-ri site
(Mar. 1972- Nov. 1972)

Products	Collection Date	pCi^{90}Sr/g—Ca	pCi^{137} Cs/g—K
Mackerel	Mar. 1972	3.42	—
// bone	Mar. 1972	0.46	40.94
Halfbeak bone	Mar. 1972	1.05	2.34
Sea eel bone	Mar. 1972	0.58	2.11
Sea eel	May 1972	0.19	3.35
Sea eel	Aug. 1972	10.38	10.04
Sea eel	Nov. 1972	2.35	1.61
Mean		4.30	5.01
Stieg mushell	May 1972	2.07	113.06
Stieg mushell	Nov. 1972	14.49	1.66
Mean		8.28	57.36
Green laver	Mar. 1972	4.11	524.28
Green laver	May 1972	3.04	—
Green laver	Aug. 1972	23.85	1.94
Green laver	Nov. 1972	2.96	0.91
Mean		8.49	175.78
Dulse	Mar. 1972	5.21	115.27
Dulse	May 1972	1.20	2.43
Mean		3.21	58.85
Spinach	May 1972	68.59	1.06
Spinach	Nov. 1972	55.34	1.85
Mean		61.96	1.46
Cabbage	Aug. 1972	105.69	
Cabbage	Nov. 1972	44.54	8.71
Mean		75.12	4.56

Table 6. No special features were found but spinach from the Wol-nae site gives very low value as compared with the So-sang site. The gross beta activity in terrestrial foods and marine products decline year after year.

(2) Strontium-90 and Cesium-137 Activities

Terrestrial foods and marine products collected in 1972 at Ko-ri site were radiochemically assaied for Strontium-90 and Cesium-137, The results obtained were Tabulated in Table 7. Strontium-90 levels in spinach and cabbage samples showed clear seasonal effect of fallout radioactivity. From the results, we found some irregularity of fallout nuclide deposition.

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References

1) A. Aarkrog and J. Lippert, Environmental Radioactivity in Denmark in 1968, Risoe Report No. 201, Danish Atomic Energy Commission, Research Establishment Risoe, (1969)

2) K.R. Yang, J. of Nuclear Science (Korea) Vol 9 No. 1, Part 1, (1969)

3) Manual of Standard Procedures, HASL, AEC NYO-4700, (1967)