

〈Technical Report〉

Environmental Radioactivity Prior to the Kori Nuclear Power Plant Operation

Chan Kirl Pak and Kyung Rin Yang

Korea Atomic Energy Research Institute Radioanalytical Division, Seoul, Korea

(Received January 12, 1978)

Abstract

The present paper deals with the measurement of the environmental radioactivity at the Kori nuclear power plant site area for the period of six years from December 1970 to December 1976.

Gross alpha activity was measured in samples of airborne particulate. Gross beta measurement was performed on soil, water, airborne particulate, pine needle, precipitation, fallout (gummed acetate paper) and various foodstuffs.

Radioactivities of strontium-90 and cesium-137 were determined by means of radiochemical analyses in samples of spinach, cabbage, barley, rice in terrestrial food, sea eel, shell fish, dulse, green laver in marine product and milk, and of fallout (column). Furthermore, tritium was also analyzed in water sample of well, stream and sea by electrical enrichment.

요 약

1970년 12월에서 1976년 12월 사이의 6년간 고리 원자력발전소 주변 환경에서 채취한 시료에 대하여 환경방사능을 측정조사하였다.

1976년에 채취한 공기미진에서 전알파 방사능과 1970년 12월에서 1976년 12월 사이에 채취한 시료인 토양, 물, 공기미진, 낙진, 솔잎, 빗물과 여러 식품시료에 대하여 전베타 방사능을 측정하였다. 시금치, 배추, 보리, 쌀, 뱀장어, 조기, 미역, 파래 및 우유 중에 함유된 스트론튬-90 및 세슘-137 방사능은 방사화학적으로 분석하여 측정하였고 정수, 하천수, 바닷물 중의 트리튬도 전해법으로 농축하여 그 방사능을 측정하였다.

I. Introduction

The procedures and techniques employed in a preoperational survey of the radiological environment of the Kori Nuclear Power Plant near Kori, Kyungnam Province, Korea and the results obtained from December 1970 to December 1976 will be summarized here.

The survey has been conducted for the Korea Electric Co. (KECO), by the Korea Atomic Energy Research Institute (KAERI), Seoul Korea. The data collected prior to routine operation of the reactor, scheduled to begin in 1977, provide basic information on the levels of radioactivity present in the environment and the kinds of variation to which these levels are subject. This information should provide a sound basis

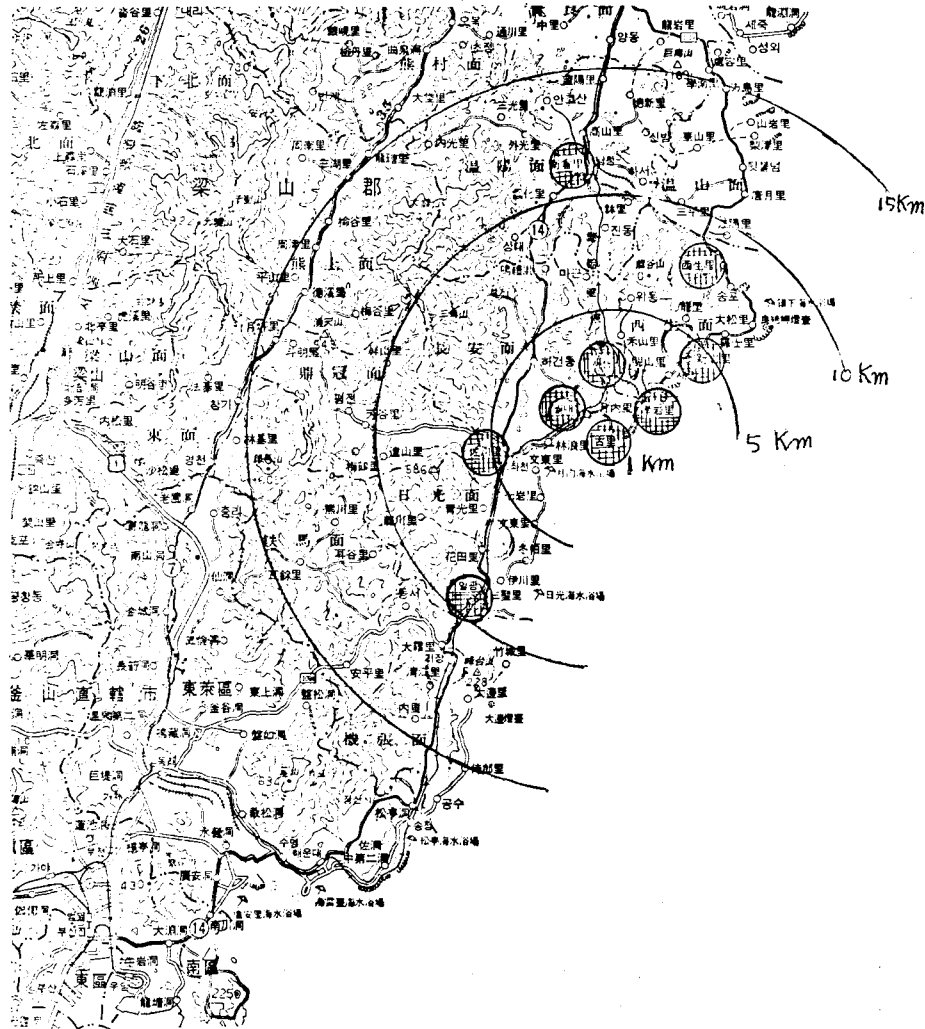


Fig. 1. Sampling Sites

for an evaluation of the impact of reactor operation on the radiological environment.

All samples have been analyzed for gross alpha activity and gross beta activity. In addition, radiochemical procedures have been employed to provide a measure of the levels of specific radionuclides present in the environment. Particular emphasis here is on ^3H , ^{90}Sr and ^{137}Cs . The sampling sites are shown in a map of Tong-nae kun area (Fig. 1).

II. Environmental monitoring

The employed procedures of sampling, analysing and counting are same as those mentioned in References No. 1. 2. 3. 4. 5 and 6.

(1) Gross alpha activity

(a) Airborne particulate

Alpha determination for airborne particulate was started in 1976. Air sample was collected on 10cm diameter filter paper,

Whatman #40, at a volumetric flow rate of approximately 20ft³/min. for 10 hrs with the high volume air sampler, Staplex, Type TFIA.

Samples were collected each quarter basis from four sampling stations; Hyoam, On-site, Wolnae and Site boundary. The counting system used was alpha-beta-gamma proportional counter, Model PC-3, Indianapolis. The background count rate of the counting system was 0.2 cpm in mean value at 2 inch planchet.

(2) Gross beta activity

(a) Airborne particulate

Sample collection and preparation were the same as alpha measurement. The prepared sample was counted in a low background beta counter, Low Beta II, Beckman, having the background ca. 1 cpm at 1 inch planchet.

(b) Soil, pine needle

Sample was taken from the sites of Ilkwang, Chuachun, Wolnae, Kori, Suhseng and Shinam from December 1970 to December 1976. Another sample was taken at Namchang in March 1975.

The surface soil sample was collected in each quarter. Each sample was collected from an unvegetated area by digging up the soil in a one square foot area to a depth of approximately 10cm.

(c) Water

Water sample was collected essentially from well, stream and sea water sources from December 1970 to December 1976. Well water sample was taken from the sites of Kilchun, Shinam, and Wolnae, stream water from Wolnae, Hyoam and Namchang, and sea water from the seashore of Kori site.

(d) Precipitation

Precipitation sample was collected directly from rainfall at Kori and Kilchun area in 10 quart polyethylene pails from June 1971 to December 1976.

(e) Fallout

Fallout sample using gummed acetate paper was collected at the site of Kilchun from December 1970 to December 1974, and of Kori from December 1970 to December 1976. Each paper was exposed for 10 days.

(f) Terrestrial foods and marine products

In the present paper, spinach, cabbage, barley and rice were used for the measurements of the level of gross beta activity in terrestrial foodstuffs. Spinach was collected in 1970 and 1972 at Wolnae, Suhseng and Kori sites. Cabbage was collected from 1972 to 1976 at Kori site. Barley was from 1970 to 1976 at Wolnae, Ilkwang and Kori sites, Rice was from 1973 to 1976 at Kilchun.

Gross beta activities in marine products were also determined on dulse, green laver, shell fish and sea eel. Dulse was collected at Kori coast from 1972 to 1975. Green laver was also collected from the same site as dulse from 1972 to 1973. Shell fish was collected from December 1972 to December 1976 from Kori coast and sea eel was from March 1972 to December 1976.

(3) Tritium in water

The collection of water sample for tritium determination was essentially the same as those of other water samples.

Tritium in liquid cannot be easily determined quantitatively by any kind of non-destructive analysis because its beta radiation energy is so weak that most of beta energy is absorbed in the sample. Specific activity of tritiated samples is so low that sufficient activity could not be introduced

into the counting equipment to give statistically adequate counts. For water sample, electrolysis is the most popular method of enrichment. The electrolysis was performed in the cell. The activity of enriched water sample in a polyethylene vial containing scintillator solution was determined by liquid scintillation counter, Liquid scintillation counting system LS-100, Beckman.

The counting efficiency for liquid scintillation counter caused by each type of sample quenching was determined by the quenching correction curve of external standard-channel ratio method.

(4) Strontium-90 and cesium-137

(a) Milk

The levels of strontium-90 and cesium-137 in milk sample collected at Ilkwang area in 1976 were determined by means of radiochemical method.

Strontium-90 in milk sample was separated from calcium using fuming nitric acid and purified radiochemically. After secular equilibrium was completed, the radioactivity of yttrium-90 was counted with above low background beta counting system.

The cesium-137 in milk sample was separated from solution with ammonium phosphomolybdate and purified as the cobaltinitrate complex and then purified cesium was finally precipitated as a cesium platonic chloride. The radioactivity of cesium-137 was counted with the same counter.

(b) Fallout

Fallout sample was collected in ion exchange column collector. Ion exchange column was exposed for monthly intervals from January 1975 to December 1976 at Kori area. Column sample was also determined only for strontium-90 by radiochemical me-

thod.

(c) Terrestrial foods and marine products

Strontium-90 and cesium-137 activities in terrestrial foods and marine products were also analyzed by radiochemical method for the same sample as used for gross beta activity measurements.

III. Results and discussion

(1) Gross alpha activity

(a) Airborne particulate

Table 1 shows the result of gross alpha activities in air samples in 1976. The mean value for the year was 0.21×10^{-2} pCi/m³-air. The levels were not significantly different from sites and seasons.

(2) Gross beta activity

(a) Airborne particulate

Table 2 shows the beta activities in air particulate. Sample collected in October 1976 was higher levels than the other sampling dates.

(b) Soil

Table 3 and 4 contain the gross beta activities in 7 soil sampling sites from December 1970 to December 1976.

Gross beta activity of Shinam site was somewhat higher than the other sites and 39.18 pCi/gr-soil of Shinam in 1971 was the highest in mean value, and among the sampling sites the highest mean value through 7 years was 45.09 pCi/gr-soil in March 1976.

(c) Pine needle

Gross beta activities obtained from pine needle was presented in Table 5 and 6.

As shown in Table 5 and 6, the gross beta activities of Chuachun site was somewhat higher than that of other sites for 7 years in an average.

(d) Water

The obtained values were summerized in table 7 and 8. Comparing the mean levels for the 7 years, we notice that the stream water activities were a little lower than the well water activities in all locations and seasons. Sea water activities were 521. 54×10^{-3} pCi/cc in 1970, 339.32×10^{-3} pCi/cc in 1971, 208.13×10^{-3} pCi/cc in 1972, 180.53×10^{-3} pCi/cc in 1973, 156.81×10^{-3} pCi/cc in 1974, 446.49×10^{-3} pCi/cc in 1975 and 294.34×10^{-3} pCi/cc in 1976.

(e) Precipitation

Table 9, 10, and 11 shows the results for the fallout activities in precipitation. The mean of the activities in precipitation was 3.56×10^{-3} pCi/cc in 1971, 6.12×10^{-3} pCi/cc in 1972, 42.50×10^{-3} pCi/cc in 1973, 5.83×10^{-3} pCi/cc in 1974, 117.67×10^{-3} pCi/cc in 1975 and 7.37×10^{-3} pCi/cc in 1976.

The activities in 1974 and 1975 were much higher than others, because of high activities of 1, May, 20, May, 18, July in 1974 and 15, November and 30, November in 1975.

(f) Fallout

Activities in fallout collected from the gummed acetate paper were tabulated in Table 12, 13 and 14. Comparing the activities collected from Kori with Kilchun, the mean levels were approximately equal each year except for 1971 and 1972. The annual average levels in Kori were as follows; 7.33 in 1970, 99.18 in 1971, 40.81 in 1972, 6.76 in 1973, 22.51 in 1974, 13.77 in 1975 and 20.31 pCi/ft²-10d in 1976.

(g) Terrestrial foods and marine products

The results obtained in terrestrial foods were as follows; spinach in Table 15, cabbage in Table 16, barley in Table 17, and rice in Table 18, Measurements of

gross beta activities in marine products were as follows: sea eel in Table 19, shell fish in Table 20, dulse in Table 21 and green laver in Table 22, respectively. No special characteristics were found in the terrestrial samples of spinach, cabbage, barley and rice, and in such marine samples as sea eel, shell fish, dulse and green laver. But gross beta activities in the terrestrial samples were shown generally higher levels than that of marine samples.

(3) Tritium in water

Table 23 shows the results of the tritium determination in well, stream and sea water. As shown in table 23, the tritium content of well water was higher than that of stream water, mean value of well water was 2.38 at Wolnae and 1.63 at Shinam, while stream was 1.06 at Paekryn and 0.68 pCi/cc at Hyoam. Tritium content in sea water was about 100 pCi/cc.

(4) Strontium-90 and cesium-137

(1) Milk

Table 1. Gross alpha activities in air samples
10⁻² pCi/m³.air

Sampling Dates	Hyoam	On-Site	Wolnae	Site-Boundary
Jul. 1976	0.24	0.26	0.19	0.16
Oct. 1976	0.19	0.13	0.16	0.18
Dec. 1976	0.27	0.27	0.24	0.23

Table 2. Gross beta activities in air samples
10⁻² pCi/m³.air

Sampling Dates	Hyoam	On-Site	Wolnae	Site-Boundary
Jul. 1976	1.14	0.57	2.13	1.54
Oct. 1976	17.77	47.91	54.01	6.94
Dec. 1976	3.94	11.80	10.74	15.45

Table 3. Gross beta activities in soils

pCi/g-Soil

Dates \ Sites		Sites					
		Ilkwang	Chuachun	Wolnae	Kori	Suhseng	Shinam
Dec.	1970	—	—	32.28	38.09	29.43	38.26
Feb.	1971	28.50	9.30	23.94	32.75	—	28.85
Jun.	1971	49.08	16.76	35.33	44.37	30.99	52.05
Sep.	1971	27.33	28.30	19.53	17.60	24.80	47.55
Oct.	1971	23.54	28.56	22.10	27.28	22.61	32.87
Dec.	1971	23.08	23.19	19.69	15.67	15.69	34.59
Mar.	1972	7.93	12.24	18.18	34.13	14.13	36.45
May.	1972	21.94	27.32	24.32	26.86	17.43	37.46
Aug.	1972	15.60	24.50	21.10	21.90	12.70	24.40
Nov.	1972	14.72	25.59	23.62	18.84	17.40	29.52
May.	1973	5.33	18.03	18.42	10.77	12.13	26.08
Jul.	1973	23.66	16.67	50.94	35.86	18.05	33.9
Sep.	1973	9.67	19.82	17.90	10.28	12.88	27.49
Nov.	1973	2.05	2.55	2.15	1.25	2.15	3.60

Table 4. Gross beta activities in soils

pCi/g-Soil

Dates \ Sites		Sites						
		Ilkwang	Chuachun	Wolnae	Kori	Suhseng	Shinam	Namchang
May.	1974	33.22	31.62	18.27	17.40	21.18	38.59	—
Jul.	1974	21.52	26.56	18.64	22.02	20.73	22.78	—
Oct.	1974	12.51	17.00	25.78	35.64	13.89	41.55	—
Mar.	1975	16.08	25.09	16.64	18.90	24.28	27.30	23.79
Jun.	1975	22.57	20.52	19.90	27.27	32.06	30.42	36.95
Sep.	1975	29.05	31.18	19.20	24.42	21.21	37.85	30.14
Nov.	1975	21.08	14.35	28.57	39.86	41.37	52.55	38.40
Mar.	1976	38.59	26.58	57.10	69.86	24.51	37.30	61.72
Jun.	1976	33.70	29.18	20.58	29.68	24.23	44.97	30.28
Sep.	1976	24.19	22.90	27.97	20.71	22.67	24.23	25.01
Dec.	1976	22.79	11.40	27.50	22.50	17.68	29.33	29.99

Table 5. Gross beta activities in pine needles

pCi/g-Ash

Dates \ Sites		Sites					
		Ilkwang	Chuachun	Wolnae	Kori	Suhseng	Shinam
Dec.	1970	—	—	189.5	620.9	225.2	266.7
Feb.	1971	152.6	639.7	294.7	348.0	—	418.4
Jun.	1971	296.0	772.0	442.8	731.5	217.5	532.6
Sep.	1971	322.3	458.2	791.7	383.9	488.7	329.5
Oct.	1971	217.5	578.5	277.3	351.2	209.7	363.3
Nov.	1971	196.6	397.9	159.4	267.9	248.4	202.4
Mar.	1972	166.97	706.09	364.96	371.68	169.52	406.96

May.	1972	236.43	793.79	415.73	412.84	224.59	411.31
Aug.	1972	164.60	244.2	236.00	531.30	199.60	183.10
Nov.	1972	174.68	678.07	265.88	289.88	397.14	280.16
May.	1973	210.72	308.20	244.20	143.31	135.49	131.62
Jul.	1973	358.95	609.40	1097.91	479.71	341.76	548.83
Sep.	1973	180.55	411.47	200.78	359.96	251.30	237.06
Nov.	1973	291.50	329.50	134.50	278.50	93.70	280.00

Table 6. Gross beta activities in pine needles

pCi/g-Ash

Sites		Ilkwang	Chuachun	Wolnae	Kori	Suhseng	Shinam	Namchang
Dates								
May.	1974	—	476.76	223.76	358.45	299.44	255.79	—
Jul.	1974	253.85	342.91	271.75	341.11	210.00	196.32	—
Oct.	1974	369.99	142.76	254.49	347.28	224.31	198.00	—
Mar.	1975	311.65	205.64	345.16	488.39	315.76	244.73	376.23
Jun.	1975	524.16	396.57	213.60	356.48	142.21	194.64	380.10
Sep.	1975	366.00	293.23	259.05	319.10	159.63	227.42	130.45
Nov.	1975	280.10	406.70	379.95	397.12	212.76	277.13	200.44
Mar.	1976	175.29	278.60	140.93	251.90	191.95	131.83	187.34
Jun.	1976	276.08	177.56	281.91	448.21	190.50	443.83	140.09
Sep.	1976	348.96	267.63	228.08	407.11	153.92	138.83	318.48
Dec.	1976	275.67	281.85	245.56	425.16	370.52	225.58	252.77

Table 7. Gross beta activities in water samples

10⁻³ pCi/cc

Dates		Wolnae Stream	Kilchun Well	Hyoam Stream	Shinam Well	Sea Water
Sites						
Dec.	1970	0.88	1.50	0.56	1.63	521.54
Feb.	1971	0.40	6.38	0.60	0.50	167.40
Jun.	1971	2.12	2.80	1.02	0.44	284.31
Sep.	1971	0.70	2.78	3.06	1.96	389.51
Oct.	1971	1.18	3.56	1.88	1.38	506.89
Dec.	1971	3.36	4.16	3.76	4.53	348.48
Mar.	1972	0.70	7.00	3.10	1.10	275.90
May.	1972	2.20	4.80	3.80	0.80	96.90
Aug.	1972	2.40	1.40	3.00	0.60	164.10
Nov.	1972	1.30	8.20	1.00	1.10	295.60

Table 8. Gross beta activities in water samples

10⁻³pCi/cc

Sites		Wolnae Well	Wolnae Stream	Kilchun Well	Hyoam Stream	Shinam Well	Namchang Stream	Sea Water
Dates								
May.	1973	—	5.04	4.24	4.96	3.52	—	275.92
Jul.	1973	—	5.80	3.56	1.18	12.58	—	154.41
Sep.	1973	—	1.10	4.28	0.92	1.88	—	113.88

Nov.	1973	—	0.45	6.35	0.70	1.00	—	177.90
May.	1974	—	2.89	1.80	5.17	—	—	185.22
Jul.	1974	—	1.17	3.65	2.95	2.36	—	192.65
Oct.	1974	—	31.51	4.84	1.96	—	—	92.56
Mar.	1975	1.76	8.14	—	2.64	0.88	3.30	555.06
Jun.	1975	8.52	6.14	—	3.17	9.02	1.49	152.30
Sep.	1975	6.64	3.07	—	1.98	3.27	2.68	333.37
Nov.	1975	7.93	4.56	—	2.48	4.36	7.04	745.23
Mar.	1976	16.10	13.08	—	4.06	10.31	14.17	214.55
Jun.	1976	7.10	11.96	—	5.43	6.82	3.20	276.49
Sep.	1976	10.85	8.21	—	4.03	6.81	2.97	366.98
Dec.	1976	16.13	2.50	—	3.62	10.01	2.78	319.32

Table 9. Gross beta activities in precipitation
10⁻³ pCi/cc

Dates	Sites		Kori
10-11	Jun.	1971	3.66
22	Jul.	1971	5.14
5	Aug.	1971	2.18
1	Sep.	1971	3.26
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
13	Jun.	1972	3.40
4-5	Jul.	1972	3.80
9	Aug.	1972	1.60
14	Sep.	1972	4.50
3	Oct.	1972	1.00
2-3	Nov.	1972	0.20
21	Jan.	1973	2.18
22	Jan.	1973	18.33
1	May.	1973	102.92
20	May.	1973	275.92
4	Jun.	1973	6.80
6	Jun.	1973	0.18
30	Jun.	1973	1.58
18	Jul.	1973	136.48
30	Jul.	1973	1.88
27	Aug.	1973	2.00
6	Sep.	1973	0.46

9	Sep.	1973	0.65
13	Oct.	1973	3.05
9	May.	1974	3.88
6	Jul.	1974	9.30
26	Jul.	1974	4.49
1	Oct.	1974	2.61
7	Oct.	1974	8.08
2	Dec.	1974	6.60
4	Jan.	1975	12.34
1	May.	1975	1.78
21	May.	1975	6.57
20	Jun.	1975	2.97
16	Sep.	1975	6.05
6	Nov.	1975	36.78
15	Nov.	1975	129.65
30	Nov.	1975	745.23
26	Mar.	1976	10.31
21	Jun.	1976	3.48
19	Sep.	1976	3.06
16	Dec.	1976	12.61

Table 12. Gross beta activities in fallout
PCi/ft²-10 d

Dates	Sites		Kori	Kilchun
23-31	Dec.	1970	7.33	7.69
1-11	Jan.	1971	13.51	11.32
21-31	Jan.	1971	24.08	18.24
1-11	Feb.	1971	37.30	13.70
20-28	Feb.	1971	73.50	75.80
2-12	Mar.	1971	49.10	—
21-31	Mar.	1971	124.40	—

1-10 Apr. 1971	89.30	—	10-20 Jun. 1974	76.05	76.35
12-21 Apr. 1971	110.90	—	10-20 Jul. 1974	32.06	31.33
10-20 Jun. 1971	192.70	—	10-20 Aug. 1974	9.70	8.25
10-20 Sep. 1971	440.01	27.68	10-20 Sep. 1974	8.03	8.88
1-16 Oct. 1971	16.44	—	10-20 Oct. 1974	7.44	12.41
10-20 Nov. 1971	18.89	—	10-20 Nov. 1974	15.08	45.98
10-20 Jan. 1972	40.08	—	10-20 Dec. 1974	12.88	4.19
11-20 Feb. 1972	18.90	—			
11-21 Mar. 1972	26.65	36.36			
11-21 Apr. 1972	110.4	891.59			
11-21 May. 1972	127.10	123.97			
11-21 Jun. 1972	18.70	27.10			
11-21 Jul. 1972	62.10	75.60			
11-21 Aug. 1972	25.77	16.04			
11-21 Sep. 1972	9.57	19.15			
11-21 Oct. 1972	8.24	19.58			
11-21 Nov. 1972	1.70	11.00			
11-21 May. 1973	8.79	4.10			
11-21 Jul. 1973	7.27	8.81			
11-21 Aug. 1973	13.22	13.17			
11-21 Sep. 1973	2.35	2.68			
11-21 Oct. 1973	6.86	6.05			
11-21 Nov. 1973	2.70	2.89			
11-21 Dec. 1973	6.15	5.87			
11-21 Jan. 1974	14.33	—			
20-31 May. 1974	27.06	6.52			

Table 14. Gross beta activities in fallout
PCi/ft²-10 d

Dates		Sites	
			Kori
10-20	Jan. 1975		23.77
10-20	Jun. 1975		12.57
10-20	Aug. 1975		6.83
10-20	Oct. 1975		9.72
11-11	Nov. 1975		15.94
1-10	Apr. 1976		46.34
15-25	Apr. 1976		27.20
10-20	May. 1976		30.88
10-20	Jun. 1976		11.65
10-20	Aug. 1976		4.45
20-30	Sep. 1976		4.51
20-30	Oct. 1976		23.14
10-20	Nov. 1976		14.85

Table 15. Gross beta, Sr-90 & Cs-137 activities in spinach

Dates		Activities		
		Gross beta pCi/g-ash	Sr-90 pCi/g-Ca	Cs-137 pCi/g-K
Dec.	1970, Wolnae	33.53	—	—
Dec.	1970, Suhseng	234.47	—	—
May.	1972, Kori	213.00	68.59	1.06
Nov.	1972, Kori	—	55.34	1.85

Table 16. Gross beta, Sr-90 & Cs-137 activities in cabbare

Dates		Activities		
		Gross beta pCi/g-ash	Sr-90 pCi/g-Ca	Cs-137 pCi/g-K
Aug.	1972, Kori	183.12	105.69	—
Nov.	1972, "	—	44.54	8.71
Jul.	1973, "	173.90	361.00	2.82
Sep.	1973, "	15.06	1.29	1.36
Nov.	1973, "	12.66	260.52	3.82
Jun.	1975, "	215.22	—	—
Nov.	1975, "	150.51	15.00	1.42
Jun.	1976, "	240.86	83.47	17.68

Table 17. Gross beta, Sr-90 & Cs-137 activities in barley

Activities		Gross beta pCi/g-ash	Sr-90 pCi/p-Ca	Cs-137 pci/g-K
Dates				
Dec.	1970, Wolnae	286.98	—	—
Feb.	1971, Ilkwang	220.90	—	—
Feb.	1971, Wolnae	125.60	—	—
Feb.	1972, Wolnae	138.20	—	—
Jul.	1973, "	174.50	21.84	5.40
Jul.	1974, "	202.81	—	—
Jun.	1975, Kori	196.47	274.8	2.55
Jun.	1976, "	180.69	173.08	3.61

Table 18. Gross beta, Sr-137 activities in rice

Activities		Gross beta pCi/g-ash	Sr-90 pCi/g-Ca	Cs-137 pCi/g-K
Dates				
Nov.	1973, Kilchun	15.38	533.98	15.58
Oct.	1974, "	262.07	159.00	75.33
Oct.	1975, "	74.55	110.17	6.91
Sep.	1976, "	216.83	178.30	6.15

Table 19. Gross beta, Sr-90 and Cs-137 activities in sea eel

Activities		Gross beta pCi/g-ash	Sr-90 pCi/g-Ca	Cs-137 pCi/g-K
Dates				
Mar.	1972, Kori	47.60	0.19	3.35
May.	1972, "	80.60	—	—
Aug.	1972, "	58.60	10.38	10.04
Nov.	1972, "	104.50	2.35	1.61
May.	1973, "	28.43	0.20	0.37
Jul.	1973, "	75.73	1.32	0.30
Sep.	1973, "	89.05	3.17	3.13
Nov.	1973, "	10.97	0.84	1.92
May.	1974, "	100.67	1.54	1.00
Jul.	1974, "	110.53	0.33	2.70
Oct.	1974, "	122.92	1.92	1.72
Mar.	1975, "	60.08	0.69	1.33
Jun.	1975, "	38.08	2.65	2.99
Oct.	1975, "	22.75	1.18	1.90
Nov.	1975, "	54.21	0.61	4.53
Apr.	1976, "	94.25	1.52	8.87
Jun.	1967, "	123.90	5.17	3.33
Sep.	1976, "	79.47	4.68	6.41
Dec.	1976, "	123.50	0.06	8.25
Mar.	1977, "	90.02	5.26	26.87

Table 20. Gross beta, Sr-90 and Cs-137 activities in shell fish

Activities		Gross beta pCi/g-ash	Sr-90 pCi/g-Ca	Cs-137 pCi/g-K
Dates				
Dec.	1970, Kori	61.93	—	—
Jul.	1937, "	60.71	6.72	0.24
Sep.	1973, "	98.96	1.55	16.00
Nov.	1973, "	12.32	5.86	3.09
May.	1974, "	109.30	3.14	1.57
Jul.	1974, "	101.12	2.17	0.92
Oct.	1974, "	140.70	10.00	1.02
Mar.	1975, "	114.61	5.62	1.68
Jun.	1976, "	93.53	1.08	1.50
Oct.	1975, "	23.09	8.38	1.66
Nov.	1975, "	119.47	1.21	1.45
Apr.	1976, "	142.81	5.43	9.09
Jun.	1976, "	122.04	1.505	4.35
Sep.	1976, "	85.25	20.51	4.87
Dec.	1976, "	129.06	8.15	1.27

Table 21. Gross beta, Sr-90 & Cs-137 activities in dulse

Activities		Gross beta pCi/g-ash	Sr-90 pCi/g-Ca	Cs-137 pCi/g-K
Dates				
Mar.	1972, Kori	147.50	5.21	115.27
May.	1972, "	97.80	1.20	2.43
May.	1973, "	—	2.56	—
Jul.	1973, "	85.51	1.64	0.80
May.	1974, "	99.10	—	—
May.	1975, "	174.01	1.07	2.73

Table 22. Gross beta, Sr-90 and Cs-137 activities in green laver

Activities		Gross beta pCi/g-ash	Sr-90 pCi/g-Ca	Cs-137 pCi/g-K
Dates				
Mar.	1972, Kori	116.36	4.11	524.28
May.	1972, "	34.80	3.04	—
Aug.	1972, "	—	23.85	1.94
Nov.	1972, "	70.30	2.96	0.91
Sep.	1973, "	59.82	5.68	0.56
Nov.	1973, "	1.70	33.90	2.00

Table 23. Tritium in water samples

Sampling Dates	pCi/ml-water					
	Well Water Wolnae	Well Water Shinam	Sea Water	Stream Paekryn	Stream Hyoam	Stream Namchang
Mar. 1976	5.49	0.77	174.68	—	—	—

Jun.	1976	1.04	2.94	123.52	—	—	—
Sep.	1976	0.415	0.563	0.530	1.078	0.407	0.473
Dec.	1976	2.57	2.23	102.36	1.05	0.96	1.54

Table 25. Strontium-90 activities in fallout (column) mCi/Km²

Dates	Kori	Dates	Kori
Jan. 1975	0.017	Feb. 1976	0.088
Feb. 1975	0.016	Mar. 1976	0.138
Mar. 1975	0.021	Apr. 1976	0.210
Apr. 1975	0.020	May. 1976	0.070
May. 1975	0.028	Jun. 1976	0.133
Jun. 1975	0.023	Jul. 1976	0.076
Jul. 1975	0.050	Aug. 1976	0.076
Aug. 1975	0.054	Sep. 1976	0.149
Sep. 1975	0.039	Oct. 1976	0.720
Oct. 1975	0.035	Nov. 1976	0.060
Nov. 1975	0.035	Dec. 1976	0.090
Jan. 1976	0.104		

Table 24. Sr-90 & Cs-137 activities in Milk

Milk (Ilkwang)	Sr-90	Cs-137
Mar. 1976	4.26	12.80
Jun. 1976	6.44	9.19
Sep. 1976	2.98	9.74
Dec. 1976	20.53	6.32

Table 24 contains the strontium-90 and cesium-137 activities in milk collected from Ilkwang area. ¹³⁷Cs/⁹⁰Sr ratio was 3.00 in March, 1.43 in June, and 3.27 in September 1976, but 0.31 in December 1976 was quite contrary to that of previous month.

(2) Fallout

The results of strontium-90 obtained in fallout by resin column were tabulated in Table 25. The fluctuation of result obtained was the lowest, 0.016 mCi/km² in February 1975 and the highest, 0.720 mCi/km² in October 1976. The mean value of the strontium-90 in fallout was 0.075 in 1974, 0.042 in 1975 and 0.160 mCi/km² in 1976.

(3) Terrestrial foods and marine products

(a) Terrestrial foods

Table 11, 12, 13 and 14 show the calculation of strontium-90 and cesium-137 in spinach, cabbage, barley and rice. The strontium-90 levels were generally much higher than cesium levels in all kinds of sample.

(b) Marine products

The 19, 20, 21 and 22 show the strontium-90 and cesium-137 contents in sea eel, shell fish, dulse and green laver.

Strontium-90 and cesium-137 activities in marine products were variable even in a single sample taken at the same sampling date and sampling sites. There are no such patterns which strontium-90 higher than cesium-137 levels as terrestrial foods. Strontium-90 and cesium-137 activities of marine products were generally much lower than that of terrestrial foods.

Acknowledgment

This work was financed by the Korea Electric Company. We are indebted to Mr. Koo Je Hyoo for his help in sample preparation and measurements.

References

1. A. Aarlgrog and J. Leppert, Environmental Radioactivity in Denmark in 1975, Risoe Report No. 345, Danish Atomic Energy Commission, Research Establishment Risoe, (1976)
2. A. Manual of radioactivity procedures, NCRP Report No. 28, National Council on Radiation Protection and Measurements, (1961)

3. K.R. Yang, *J. of Nuclear Science*, Vol. 9, No. 1, part 1, (1969)
 4. *Manual Standard Procedures*, HASL-300, Health and Safety, Laboratory, U.S. Energy Research & Development Administration, (1972)
 5. *Methods of Radiochemical Analysis*, WHO Technical Report Series, No. 173 (1959)
 6. *Tritium measurement techniques*, NCRP Report No. 47, National Council on Radiation Protection and Measurements, (1976)
-