Transactions of the Korean Nuclear Society Autumn Meeting
Pyeongchang, Korea, October 30-31, 2014

Importance of Environmental Radiation Measurements in Radiation Safety Report

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1. Introduction

Recently, the use of radiations in health and industry is increasing steadily [1]. This is the reason why the new construction rate of a medical radiation facility is increasing in this country. One of the typical examples is the Korea Heavy-ion Medical Accelerator (KHIMA) facility in Busan led by Korea Institute of Radiological and Medical Sciences (KIRAMS). Thus, the importance of the environmental radiation measurements is emphasized for the general public before it is operated.

Meanwhile the dose rate limit for a public place is 1mSv/yr, UNSCEAR has estimated the annual natural background dose rate of 2.4 mSv/yr in worldwide average. Actually, the typical range varies from 1 to 10 mSv/yr [2]. Thus, the back ground radiation measurement is necessary in pre-construction phase for the new heavy-ion medical accelerator facility. Moreover, this information is useful for the environmental control of the continuing operation of the radiation facility and the final decommissioning phase. Besides, a big nuclear power plant site is located within the range of about 4 km from our accelerator facility. This fact is enough to draw attention of artificial radionuclide. Thus, the pre-background measurements will be very useful for the future estimation of the effects done only by the KHIMA facility. In this study, we report the partial results of our pre-background measurements.

2. Methods and Results

2.1 Measurement points & sampling sites

We performed effective dose rate measurements and collected soil samples on the ground surface in surrounding areas of the facility on May 22, 2014.

Figure 1 shows the measurement spots on the floor plan of the KHIMA building. Table I shows the GPS values of the sampling positions. Eight spots were selected on the surroundings of the accelerator hall. Beneath areas of the accelerator hall are not yet selected because the preparation of the ground floor is not ready yet. After the preparation of the basement of the ground floor is ready, we have a plan to collect the soil samples there. Number 1 is at the entrance and the others are inside the facility. We will not expand our measurement to the nearby residence area because we believe that the environmental effect of our facility will be very limited.

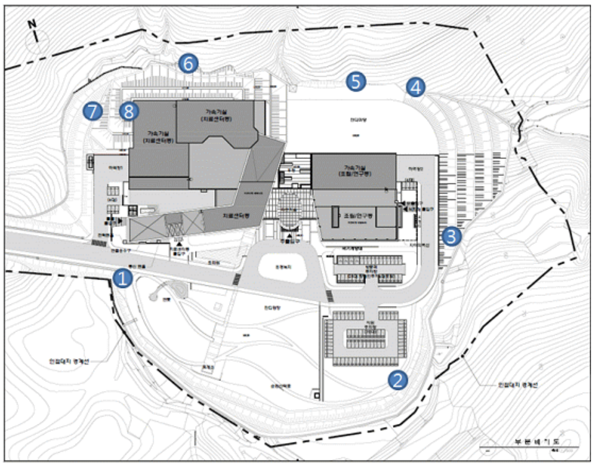

Fig. 1. Positions of the sampling spots

Table I: GPS values of the sampling points

Sample No.	Latitude	Longitude
1	35°19'17.65"N	129°14'50.53"E
2	35°19'15.05"N	129°14'55.47"E
3	35°19'17.35"N	129°14'57.79"E
4	35°19'20.33"N	129°14'57.56"E
5	35°19'20.69"N	129°14'56.57"E
6	35°19'21.79"N	129°14'52.99"E
7	35°19'21.28"N	129°14'49.72"E
8	35°19'21.15"N	129°14'50.63"E

2.2 Background radiation measurement on the ground

The gamma dose rate on the ground was measured with two portable FH40G survey meters. The exact specifications of the survey meters are shown in Table II.

Table II: Specifications of gamma survey meter

	FH-40G	FH-40G-L10
Energy range	36keV~1.3MeV 10nSv/hr~1Sv/hr	30keV~4.4MeV 10nSv/hr ~100mSv/hr
Calibration factor (300uSv/hr)	1.10	1.07
Calibration date	2014.4.11	2014.4.14

The range of gamma dose rate on ground varies from 118 to 219 nSv/hr, which is 1.5 times higher than the public annual dose limit (114.2 nSv/hr) defined by the Korean Radiation Protection law [3]. Figure 2 shows the gamma dose rate distribution in different measurement spots.

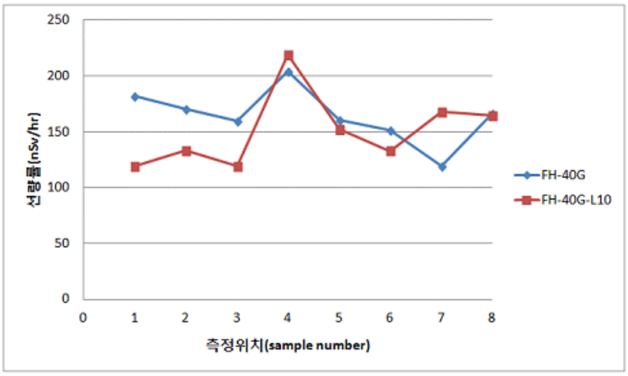

Fig. 2. Gamma dose rate distribution in different spots

2.3 Background radiation measurement in soil

Surface soil samples were collected at the chosen surfaces, each about 2 kg per sample within 5 m radius and the depth of about 0 ~ 5 cm. Pre-preparation of the soil sample for the measurement of radioactive isotopes was followed by the definition of ISO 18589-2. After preprocessing, soil sample of about 1kg was filled in Marinelli beaker(1,000 ml) [4]. Measurement time was about 80,000 sec with two HPGe semiconductor detectors whose specifications are shown in Table III. Table IV shows the measurement information of soil samples.

Table III: Specifications of HPGe semiconductor detectors

	GR1520	GC2518
Relative efficiency	15 %	25 %
Resolution	1.33 MeV~2.0 keV	1.33 MeV~2.0 keV
Uncertainty	6 %	5.7 %
Calibration date	2013.07.12	2013.07.12

Table IV: Measurement information of soil samples

Sample No.	Sampling date	Mass(g)	Measured date
1	2014-05-22, 13:55	1257.47	2014-06-03, 17:41
2	2014-05-22, 14:08	1190.38	2014-06-03, 17:45
3	2014-05-22, 14:13	1291.29	2014-06-05, 15:10
4	2014-05-22, 14:25	1075.43	2014-06-05, 15:15
5	2014-05-22, 14:31	1179.36	2014-06-06, 13:42
6	2014-05-22, 14:40	1025.36	2014-06-06, 13:47
7	2014-05-22, 14:49	999.83	2014-06-07, 20:31
8	2014-05-22, 15:06	1158.19	2014-06-07, 20:35

If the measured value is below MDA value, it is designated as MDA.

^{137}Cs were detected in all samples of about 0.18 ~ 1.50Bq/kg-dry, except for the sample number 8. The detection of this artificial isotope was assumed due to the past nuclear bomb experiments in North Korea/Russia and the long time effect of Fukushima accident in Japan.

^{60}Co was detected at sample number 3, about 0.50Bq/kg-dry. ^{54}Mn was detected in all samples, 0.47 ~ 1.52Bq/kg-dry except sample number 2. The detection of ^{60}Co and ^{54}Mn can be explained by the nearby Kori nuclear power plant [5]. Table V shows the measurement results in detail. Typical natural radionuclide ^{40}K was also detected in all samples, about 417 ~ 938 Bq/kg-dry which lies in the range reported by the Korea Institute of Nuclear Safety [6,7].

3. Conclusions

Although Korea radiation safety act (104) requires background radiation measurement only for a nuclear power plant facilities (i.e. nuclear reactor, nuclear fuel cycling facility, independent spent fuel storage installation, radioactive waste disposal building) [3], we also measured the background environmental radiation for the KHIMA facility because we believe that our facility can, somewhat, produce radioactive isotopes and this information will be useful for the future decommissioning.

Effective dose rate on the ground was about 1.5 times higher than the annual dose limit for a public area, 1mSv/yr.

For the artificial radioactive isotopes, we observed ^{137}Cs, ^{60}Co, and ^{54}Mn. ^{137}Cs is unusual because this can frequently be observed in the area of the nuclear bomb experiments. Thus, we carefully guess that it is due to the North Korea or Russian nuclear bomb experiments or the long time effect of Fukushima accident in Japan. ^{60}Co and ^{54}Mn can be due to the nearby Kori nuclear power plant. Thus, our facility is already affected by the other nearby or far away facilities and our measurements prove to be very useful for the relative estimation of the effect done only by the KHIMA facility.

ACKNOWLEDGEMENTS

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (No. 2014029534).

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Table V: Results of Background radiation measurement in soil

Nuclide	Half life	Sample 1		Sample 2		Sample 3		Sample 4		Sample 5		Sample 6		Sample 7		Sample 8	
		Activity(Bq/kg-dry) (Uncertainty)	MDA (Bq/kg)	Activity(Bq/kg-dry) (Uncertainty)	MDA (Bq/kg)	Activity(Bq/kg-dry) (Uncertainty)	MDA (Bq/kg)	Activity(Bq/kg-dry) (Uncertainty)	MDA (Bq/kg)	Activity(Bq/kg-dry) (Uncertainty)	MDA (Bq/kg)	Activity(Bq/kg-dry) (Uncertainty)	MDA (Bq/kg)	Activity(Bq/kg-dry) (Uncertainty)	MDA (Bq/kg)	Activity(Bq/kg-dry) (Uncertainty)	MDA (Bq/kg)
Be-7	53.44 d	16.30456 (1.355124E-03)	-	12.24042 (9.984700E-04)	-	14.01279 (1.187141E-03)	-	10.51452 (1.101251E-03)	-	30.69803 (1.544614E-03)	-	**35.82879** (1.619362E-03)	-	11.63729 (1.383376E-03)	-	21.75921 (1.467847E-03)	-
K-40	1.27E9 y	614.13190 (1.214799E-02)	4.79	513.59880 (1.055404E-02)	6.08	729.84090 (1.423818E-02)	4.43	793.53520 (1.600697E-02)	7.49	823.75610 (1.605766E-02)	5.31	**937.72050** (1.879968E-02)	7.78	417.68120 (8.780368E-03)	5.53	847.89620 (1.700635E-02)	7.61
Mn-54	312.5 d	0.58842 (6.189977E-05)	-	**< MDA*** (8.625428E-05)	0.28	0.60363 (6.215921E-05)	-	0.83831 (5.342989E-05)	0.34	0.69142 (7.035185E-05)	-	0.87469 (5.624219E-05)	0.35	0.47333 (5.914958E-05)	-	**1.51536** (6.590370E-05)	0.34
Co-60	5.27 y	-	-	-	-	0.49668 (1.287678E-04)	0.41	-	-	**< MDA*** (1.597608E-04)	0.52	-	-	-	-	-	-
Zr-95	63.98 d	-	-	-	-	-	-	0.78481 (9.394518E-05)	-	0.78452 (1.255909E-04)	-	0.61254 (1.003154E-04)	-	-	-	**1.54505** (1.213804E-04)	-
Sb-122	2.73 d	-	-	4.60650 (2.409675E-03)	-	20.04257 (5.413356E-03)	-	18.41139 (3.780525E-03)	-	19.67090 (6.517788E-03)	-	-	-	-	-	**70.89524** (1.021996E-02)	-
Sb-126	12.4 d	0.71515 (9.563008E-05)	-	0.43471 (6.326950E-05)	-	0.82966 (1.135539E-04)	-	0.73482 (9.356252E-05)	-	1.09859 (1.417887E-04)	-	0.58252 (9.557261E-05)	-	0.94663 (1.283475E-04)	-	**1.32683** (1.764038E-04)	-
Cs-137	30.0 y	0.63755 (6.289057E-05)	0.29	0.21931 (3.719517E-05)	-	0.73172 (6.762429E-05)	0.31	0.42280 (4.885323E-05)	-	0.75430 (7.580820E-05)	0.37	0.18544 (4.563734E-05)	-	**1.49427** (8.617208E-05)	0.32	-	-
Bi-211	2.14 m	-	-	-	-	-	-	5.50209 (1.143283E-03)	-	-	-	5.35230 (1.180792E-03)	-	-	-	**6.53033** (1.334763E-03)	-
Bi-212	60.55 m	18.67181 (8.919486E-04)	-	15.07754 (7.819661E-04)	-	23.41238 (1.158072E-03)	-	28.76426 (1.069618E-03)	-	24.25444 (1.186006E-03)	-	27.38813 (1.122814E-03)	-	18.73281 (9.652869E-04)	-	**53.13027** (1.030298E-03)	-
Pb-212	10.64 h	23.86567 (3.930252E-04)	-	23.55246 (3.065948E-04)	-	41.97434 (5.357455E-04)	-	40.34064 (4.980758E-04)	-	22.29898 (4.538225E-04)	-	43.0328 (5.311034E-04)	-	31.39742 (4.419870E-04)	-	**80.58892** (8.798031E-04)	-
Bi-214	19.9 m	22.62337 (3.818665E-04)	0.91	15.03776 (2.744788E-04)	-	25.89208 (4.204181E-04)	0.99	27.35979 (3.923445E-04)	-	29.19656 (4.724473E-04)	1.00	27.23029 (4.208846E-04)	-	22.42827 (4.246610E-04)	1.04	**42.74020** (5.127621E-04)	-
Pb-214	26.8 m	22.45296 (3.248294E-04)	0.94	17.55763 (2.177624E-04)	-	29.46038 (3.715399E-04)	0.97	29.71704 (3.792466E-04)	-	28.51122 (4.045661E-04)	1.08	30.86794 (3.991621E-04)	-	25.68126 (3.539789E-04)	1.02	47.52035 (5.431786E-04)	-
Rn-219	3.96 s	3.56978 (5.805422E-04)	-	1.71034 (7.889443E-04)	-	4.08847 (6.525121E-04)	-	2.17782 (4.613870E-04)	-	5.11388 (7.046471E-04)	-	2.60697 (1.028168E-03)	-	4.04218 (6.330651E-04)	-	3.75941 (1.272262E-03)	-
Ra-226	1600 y	-	-	-	-	-	-		-	84.12763 (3.609464E-03)	-	-	-	-	-	-	-
Ac-228	6.13 h	32.11418 (3.816273E-04)	-	25.67725 (3.461567E-04)	-	40.71807 (4.064091E-04)	-	43.35238 (3.982933E-04)	-	39.92885 (4.674417E-04)	-	46.43836 (4.704221E-04)	-	31.81183 (4.430920E-04)	-	86.30300 (6.446281E-04)	-
Th-231	25.52 h	2.90830 (1.931060E-04)	-	8.15890 (5.423614E-04)	-	4.08180 (3.504959E-04)	-	13.11601 (7.143757E-04)	-	3.40243 (2.339151E-04)	-	15.75796 (7.769898E-04)	-	6.02028 (4.428268E-04)	-	21.83365 (8.788326E-04)	-
Pa-234	6.70 h	-	-	1.51106 (2.695784E-04)	-	0.54414 (8.058321E-05)	-	2.09226 (1.533212E-04)	-	1.15682 (1.695050E-04)	-	3.33176 (3.882538E-04)	-	-	-	3.68902 (1.845448E-04)	-
Pa-234M	1.17 m	46.81908 (2.277478E-02)	-	-	-	63.23374 (2.397467E-02)	-	46.15681 (1.310819E-02)	-	-	-	37.60111 (1.250162E-02)	-	85.37330 (2.191750E-02)	-	34.09559 (1.595875E-02)	-
U-235	7.03E8 y	3.29008 (2.465588E-04)	-	2.95220 (1.599025E-04)	-	4.66790 (2.015679E-04)	-	5.00297 (2.016363E-04)	-	-	-	4.83571 (2.045630E-04)	-	4.59232 (2.011812E-04)	-	7.17032 (2.373267E-04)	-

*MDA : Minimum Detectable Activity