Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2018

Radioactivity Measurement of Medical Radioactive Waste for Self-disposal

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1. Introduction

Unsealed radioactive source, which are mainly used in medical institutions' laboratories and nuclear medicine departments, generate various types of radioactive waste due to their use characteristics. Most of them are contaminated with radionuclides with short half-lives, so they are characterized by a sufficiently safe level of radioactivity when stored for a certain period of time.

In 1992, the International Atomic Energy Agency (IAEA) proposed limits for individual dose (10 uSv / y) and collective dose (1 man-Sv / y) for nearby residents on its disposal basis. In addition, the standard concentration of self-disposal was presented through RS-G-1.7 "Application of the Concepts of Exclusion, Exemption and Clearance". In order to apply this, there is inconvenience that dose assessment or concentration of radionuclides should be measured. Therefore, in most countries including Korea, the storage period of radioactive waste is determined and implemented. In order to derive such international practices as international standards, it is necessary to set the appropriate storage period for the radioactive waste for medical use up to the concentration level of the IAEA's disposal, to measure and analyze the radioactive contamination of the radioactive waste generated after use at the medical institution, We want to estimate the date of disposal.

2. Materials and Methods

The Cyclotron RI Production Facility, Nuclear Medicine Department, and Thyroid Therapy Isolation Ward, which produce and distribute radioactive isotopes at the Korea Institute of Radiological and Medical Sciences, are major uses of medical radioisotopes.

In this study, 73 bundles of 32 kinds of wastes were collected for five radionuclides of F-18, Tc-99m, I-123, I-131 and Tl-201. Radiation and radioactivity were measured using a high purity germanium (HPGe) semiconductor detector gamma ray spectrometer (MCA) and a portable survey meter (proportional counter).

2.1 Procedures for radioactive waste collection and surface radiation dose rate measurement

Check the schedule of the nuclear medicine department, collect it immediately after the waste is generated, and transport it to the measuring room using the radioactive waste carrier. The collected radioactive wastes shall be kept in the shielding by nuclear species. Place the sample on the support jack at a height of 10 cm from the laboratory test table and level it like the radiation meter. Install shielding wall during measurement to prevent unnecessary radiation exposure. Measurements were repeatedly measured at a distance of 10 cm and 1 m from the sample using two Survey meter (Thermo Scientific, FH 40 G: energy measurement range: 36 keV to 1.3 MeV, dose measurement range: 0.01 μSv / h to 1 Sv / h). When the surface radiation dose rate is reduced to the natural radiation dose rate, it goes to the radioactivity measurement step according to the gamma ray spectrometer (MCA) measurement procedure.

2.2 Radioactivity measurement procedure

For the measurement of radioactivity using a gamma-ray spectrometer, the weights of each sample were measured three times using an electronic balance (Model AJH-2200E-D, Vibra, Japan) and the samples were classified according to the following procedure . The same 20 ml vials as the standard source were measured without pretreatment, and paper cups, gloves, etc. were collected in 90 mm U8 containers. Syringes of various sizes were collected in a 1 liter Marinelli container and measured after pretreatment as follows. 1,000 g of a measurement sample and distilled water were put into a marinelie container and weighed with an electronic balance. A 1 liter Marinelie container was run on a stirrer (Sseriker: Vision scientific Co. Ltd, Korea) for 6 hours at 65 RPM to homogeneously mix the radioactivity. A 1-liter Marinelli container uniformly mixed in a stirrer was measured using a gamma ray spectrometer, and the measurement was made when the dead time was less than 3%.

3. Results

Table I shows the results of surface radiation dose rate measurements at 10 cm and 1 m distance for five radionuclides of F-18, Tc-99m, I-123, I-131 and Tl-201.

Table Ⅱ - Ⅴ shows the actual radioactivity of radioactive waste in the natural radiation dose rate status of each radionuclide.

Table I: Surface dose rates using survey meter.

Nuclide	Number of waste type	Number of measurements	Surface dose rate (10 cm)		Surface dose rate (1 m)	
			Mean (μSv/h)	Max (μSv/h)	Mean (μSv/h)	Max (μSv/h)
^{18}F	6	185	46.37	180	1.02	3
^{99m}Tc	8	200	19.42	145	0.52	2.1
^{123}I	6	89	22.58	200	0.58	3.3
^{131}I	4	72	5.38	20	0.54	2
^{201}Tl	8	279	5.5	50	0.26	1.5

Table II: Radioactivity measurements of ^{18}F.

Waste type	Average elapsed time (Day)	Radioactivity (Bq/g)		
		Mean	Max	STD
3 ml syringe	0.23	915	1241	153.7
3 way	1.12	16.6	95.8	20.4
5 ml syringe	1.11	88.6	317	90.3
Needle	0.92	6.1	6.1	0

Table III: Radioactivity measurements of ^{99m}Tc.

Waste type	Average elapsed time (Day)	Radioactivity (Bq/g)		
		Mean	Max	STD
1 ml syringe	3.09	2980.5	6181.3	1416.5
Soft needle	3.70	2.4	3.7	0.8
3 ml syringe	3.23	1.4	2.2	0.4
Needle	4.02	587.2	1041.6	214.2
Cotton swap	0.26	56033	130000	31360

Table IV: Radioactivity measurements of ^{123}I.

Waste type	Average elapsed time (Day)	Radioactivity (Bq/g)		
		Mean	Max	STD
Cotton swap	11.51	5.7	10.5	2.3
1 ml syringe	7.85	1177	3617.1	1445.8
Vial	9.41	1472.1	2910	677.8

Table V: Radioactivity measurements of ^{201}Tl.

Waste type	Average elapsed time (Day)	Radioactivity (Bq/g)		
		Mean	Max	STD
Cotton swap	6.17	88.7	185	51.6
10 ml syringe	8.19	577.9	1502.6	497.4
3 way	14.82	1946.1	11000	2494.4
3 ml syringe	23.07	2848	7556.6	2474.1
Vial	45.77	1130.3	2652.6	605.4

The permissible concentration of self-disposal of F-18 is 10 Bq / g, the permissible concentration of Tc-99m, I-123 and Tl-201 is 100 Bq / g. Table II - V shows that the average radioactivity measured by each type of radioactive waste is 2-100 times larger than the allowable.

4. Conclusions

When radioactive waste samples with natural radiation dose rate status are analyzed by nuclide analysis, the radioactivity exceeding the allowable concentration limit of self-disposal is detected.

However, the results show that the actual disposable date is shorter than the allowable self-disposition date calculated using the theoretical half-life. In the future, we will make clear and detailed deregulation procedures and standardize the self-disposal procedure of medical radioactive waste to contribute to the simplification of the complicated measurement and verification procedures by Nuclear Safety Commission Notice No. 2014-003 on self-disposal of radioactive waste

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