Vertical Distribution of ^{90}Sr Activities in the Soils of Jeju Island, Korea

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1. Introduction

Since the atomic weapons tests in the fifties and early sixties of the last century and the nuclear power plant accidents (Chernobyl in 1986, Fukushima in 2011), also anthropogenic fission and activation products are dispersed in nature [1]. They included such radionuclides as ^{134}Cs, ^{137}Cs, ^{131}I and ^{90}Sr. Due to their relatively long half-lifes of 28.5 and 30.17 yr, the fission products ^{90}Sr and ^{137}Cs which are of relevance from the radiation protection point of view, can still be detected in environmental samples.

For the determination of ^{90}Sr in environmental samples numerous methods such as fuming nitric acid procedure, ion exchange, or extraction techniques using Sr Specific resin from Eichrom Technologies have been described [2-4]. In this paper we present soil sample data of vertical distribution of ^{90}Sr activities from selected areas in Jeju Island, Korea.

2. Materials and methods

2.1 Reagents and equipment

All chemicals used are of analytical grade, and the pure water is obtained with a Gradient A10 (Millipore, USA). The carrier solution $Sr(NO_3)_2$ is prepared by weighing from the corresponding salt. Reagents used for the digestion of the moss samples were 37% analytical grade HCl (Merck, Germany) and 65% analytical grade HNO_3 (Merck, Germany). Sr-Spec resin(particle size: 100 ㎛ to 150 ㎛) was obtained from Eichrom Industries, Inc. A standard solution of ^{90}Sr/^{90}Y, provided by KRISS (Korea Research Institute of Standards and Science; Certification No. 1107-00441-001), was used for calibrating the counting efficiency of ^{90}Sr and ^{90}Y as a function of quenching. Separation of ^{90}Sr and ^{90}Y was carried out with extraction chromatography utilizing a Sr-Spec column. Ultima Gold LLT (Perkin Elmer Instrument) scintillation cocktail was mixed with the sample solution in a 20 mL low-potassium glass vial. Quantulus 1220 (Perkin Elmer Instrument) was used for the measurement of radiostrontium by liquid scintillation counting (LSC).

2.2 Collection of the samples

This study took place at Jeju Island (Korea), ca. 1,400 km southeast of the Fukushima Daiichi nuclear power plant. Annual rainfall of Jeju Island ranges between 1,000 mm and 1,800 mm, with an average of 1,460 mm. The altitude of Mt. Halla (center place of Jeju Island) is 1,950 m. The samples were collected from 4 locations in 2013 (Fig. 1, Table 1). Sampling area and locations are presented in Table 1.

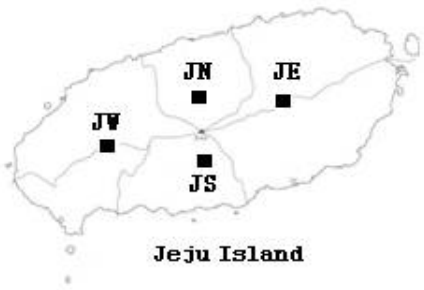

Fig. 1. Sampling sites of Jeju island.

Our soil samples stem from the eastern part (Sanbangsan, 424 m), northern part (Gwaneumsa, 548 m), the western part (Dolohreum, 692 m), the southern part (Miaksan, 472 m) and the of the Mt. Halla in Jeju island. With a tube an approximately 10 ~ 20 cm deep bore was drilled into the soil. The obtained 4 samples were divided into layers. Before measurement the samples were air dried.

Table 1. Geographical information of the sampled locations

Location	Geo code	Altitude (m)	Sampled date
JE (Sanbangsan)	33°26'8.1"N 126°41'19.2"E	424	2013-06-05
JN (Gwaneumsa)	33°25'27.8"N 126°33'24.2"E	548	2013-07-11
JW (Dolohreum)	33°24'18.4"N 126°27'59.6"E	692	2013-07-18
JS (Miaksan)	33°18'14.0"N 126°33'33.0"E	472	2013-08-08

2.3 Determination of ^{90}Sr in soil

All samples were dried in an oven at a temperature of 105°C for 24 h. The samples were powdered and homogenized in the laboratory. The 100 g soil samples were ashed at 550 °C in an electric furnace. Soil ashes were dissolved in 1 L of 9 M HCl and 1.0 mL of 10.0 mg/mL Sr carrier was added. After stirring for 5 h, the sample solution was filtered; the beaker and filter were

washed with a few milliliters of 9 M HCl and 500 mL hot water. Iron precipitate was removed from the alkaline solution (> pH 10) by conc. NH_3. A few milliliters of HCl (< pH 1) and 40 g of oxalic acid ware added to the solution. Strontium oxalate was precipitated from the alkaline solution (> pH 4) by conc. NH_3. The precipitate was filtered through a GF/C filter paper. The precipitate was dissolved in ca. 30 mL 8 M HNO_3. Subsequently ^{90}Sr was purified on Sr-Spec resin. The flow rate for all procedures was kept at 1 mL/min. The fractions were mixed with the cocktail Ultima Gold LLT scintillation cocktail and measured by LSC on a Quantulus1220 (Wallac, Finland, now Perkin Elmer). The stripped solution was evaporated by heating on a hot plate at 100°C. The lower limit of detection (LLD) of ^{90}Sr was calculated according to [5]. It was 1.1 Bq kg^{-1} for soil samples (counting times and chemical recovery as with ash samples, sample mass: 100 g of dried soil).

3. Results and discussion

The ^{90}Sr activity concentrations of each sample are shown in Table. 2. The ^{90}Sr vertical concentrations in the investigated soil samples were 18.24 ± 0.42 ~ 2.77 ± 0.22 Bq kg^{-1} in eastern part (JE; Sanbangsan, 424 m), 18.27 ± 0.28 ~ 1.69 ± 0.11 Bq kg^{-1} in northern part (JN; Gwaneumsa, 548 m), 45.27 ± 2.60 ~ 3.76 ± 0.19 Bq kg^{-1} in the western part (JW; Dolohreum, 692 m) and 8.70 ± 0.59 ~ 1.09 ± 0.14 Bq kg^{-1} in the southern part (JS; Miaksan, 472 m) of the Mt. Halla in Jeju island, respectively.

Table 2. Activity concentrations of ^{90}Sr in Jeju island soil samples with depth

Site	Depth (cm)	Sr-90 Activity (Bq kg^{-1} -dry)	MDA
JE	1-2	18.24 ± 0.42	0.33
	3-4	14.51 ± 1.24	2.18
	4-6	7.72 ± 0.51	0.80
	6-8	7.39 ± 0.56	0.93
	8-10	2.77 ± 0.22	0.39
JN	1-2	18.27 ± 0.28	0.21
	3-4	13.48 ± 0.24	0.20
	4-6	6.22 ± 0.19	0.24
	6-8	7.51 ± 0.17	0.18
	8-10	1.69 ± 0.11	0.21
JW	1-2	13.46 ± 0.67	0.91
	3-4	45.27 ± 2.60	3.83
	4-6	7.86 ± 1.11	2.30
	6-8	4.56 ± 0.29	0.45
	8-10	3.76 ± 0.19	0.26
JS	1-2	8.70 ± 0.59	0.94
	3-4	1.09 ± 0.14	0.29
	4-6	3.64 ± 0.20	0.29
	6-8	< MDA	2.14
	8-10	1.46 ± 0.41	0.96

Activities of ^{90}Sr show the highest value at the surface soil and decrease with depth (Fig. 2).

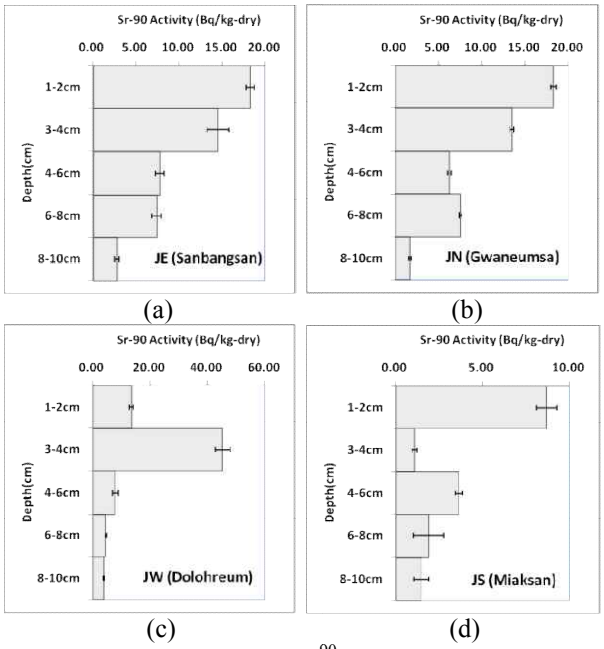

Fig. 2 Vertical distribution of ^{90}Sr activities in the soils from Jeju island: (a) JE, (b) JN, (c) JW and (d) JS sites.

4. Summary

Vertical distributions of ^{90}Sr activities are studied for the soils of four areas, Jeju island, Korea. Activities of ^{90}Sr show the highest value at the surface soil and decrease with depth.

REFERENCES

[1] Kim, C.K., Byun, J.I., Chae, J.S., Choi, H.Y., Choi, S.W., Kim, D.J., Kim, Y.J., Lee, D.M., Park, W.J., Yim, S.A., Yun, J.Y., 2012. Radiological impact in Korea following the Fukushima nuclear accident. *J. Environ. Radioact.*111, 70–82.

[2] Pimpl, M., 1995. Strontium-89/strontium-90 determination in soils and sediments using crown ethers for calcium/strontium separation. *J. Radioanal. Nucl. Chem.* 194 (2), 311-318.

[3] Grahek, Z., Eškinja, I., Ko_sutić, K., Lulić, S., Kvastek, K., 1999. Isolation of radioactive strontium from natural samples: a semi-automatic procedure. *J. Radioanal. Nucl. Chem.* 241 (3), 617-626.

[4] Jakopič, R., Benedik, L., 2005. Trace studies on Sr resin and determination of 90Sr in environmental samples. *Acta Chim. Slov.* 52, 297-302.

[5] Seymour, R., Sergent, F., Knight, K., Kyker, B., 1992. Impact of sensitivity and throughput on optimum selection of a low-back-ground alpha/beta gross counting system. *Radioact. Radiochem.* 3, 14-28.