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Daily intake of major and trace elements in residents of Gomel oblast, Belarus

Susumu Ko[1], Kunio Shiraishi[1], Sarata Kumar Sahoo[1], Larisa Shevchuk[2], Valery E. Shevchuk[2], Pavlo V. Zamostyan[3]

[1]Research Center for Radiation Emergency Medicine, National Institute of Radiological Sciences
[2]Gomel branch of Scientific Research Institute of Radiation Medicine & Endocrinology
[3]Research Center for Radiation Medicine of Academy of Medical Science of Ukraine

Abstract Gomel oblast in Belarus is one of the areas most seriously affected by the Chernobyl nuclear power plant accident. While food contamination by radionuclides has been well studied after the accident, no reports describing intakes of stable elements could be found. This paper describes a preliminary investigation on elements intakes. Diets of adults and children in the region were analyzed by ICP-AES and ICP-MS. The daily intakes of elements for Belarusian children were estimated as follows: Ba (1.6mg); Ca (0.44g); Cd (12μg); Co (20μg); Cs (3.3μg); Cu (0.90mg); Fe (29mg); K (2.2g); Mg (0.17g); Mn (2.4mg); Na (2.1g); P (0.65g); Rb (0.83mg); Sr (1.5mg); Th (0.50μg); U (0.36μg); and Zn (5.0mg.) Although a deficiency in Zn intake was found, the intakes of radionuclides such as ^{232}Th and ^{238}U were below levels of other regions.

Key words: Chernobyl, Belarus, dietary intake, ICP-AES, ICP-MS, elements, radionuclides

Introduction

The Chernobyl nuclear power plant accident in 1986 caused serious effects on the global environment and health condition of local residents. Since then, many researchers have studied relationships between exposure to the radioactive substances released from the accident and human health [1]. Unfortunately, there are no reports on stable element intake for the area. For the sake of detailed discussion about the effects of the radiation exposure derived from the accident, some factors which have not related to the accident, such as local food habits and influence of economic situation on eating habits, need to be clarified and taken into account.

Gomel oblast (Gomel province) in Belarus Republic is one of the areas most seriously damaged by the nuclear accident. Because the socio-economic situation of this country has not been stable especially after the breakup of the former Soviet Union, base data are limited [2].

In this paper, concentrations of radioactive and stable elements in the diets of local adults and children were preliminarily determined and daily intakes were estimated.

Experimental

Whole diet samples were collected in Gomel oblast with the duplicate portion method (Fig. 1). Samples for adults (n=4) were collected at Gomel City, and samples for children (n=19) were taken at various locations over a wide area. The samples were heated in a muffle furnace at a final temperature of 400°C to get ash. For ICP-MS and ICP-AES analyses, the ash was digested with a microwave oven (Ethos plus, Milestone s.r.l, Bergamo, Italy) using HNO_3, $HClO_4$ and HF to get a solution in 5% HNO_3 media. Acid reagents were ultra pure grade (Tama pure AA-100, Tama chemical, Kawasaki. Japan). In order to check the error caused by inhomogeneity and chemical procedures, three portions for each ash sample were digested. Details of the digestion method have been given elsewhere [3]. Standard reference materials (SRM 1575 pine needles and SRM 1577a bovine liver, NIST, Gaithersburg, MD) were treated in the same way as the diet samples in order to estimate the precision and accuracy of results. The ICP-MS analysis was done using a HP4500 (Hewlett Packard Co., Ltd., Rockville, MD). Standard solutions were prepared by diluting mixed stock solution (XSTC-13, SPEX Industries, Edison, NJ) and a calibration was made. As internal standard, rhodium was added to the sample

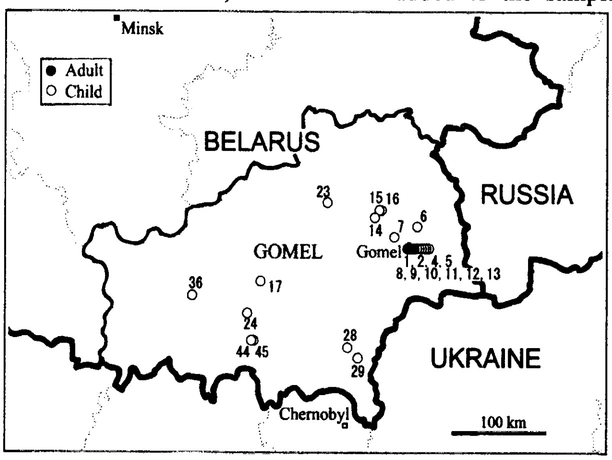

Fig. 1 Location where diet samples were collected in Gomel oblast

corresponding author : Susumu Ko
Research Center for Radiation Emergency Medicine, National Institute of Radiological Sciences, 4-9-1 Anagawa, Inage-ku, Chiba 263-8555, Japan

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solutions to get 1 ppb to compensate for the fluctuation of instrument parameters. ICP-AES analysis was done with an IRIS AP Model (Thermo Jarrell Ash, Franklin, MA), using 1ppm of Y as internal standard. Standard solutions were prepared from stock solutions. Daily intake of each element was estimated from the results of the analysis and total dietary intake of each case.

Results and discussion

Data display

The errors between the results and the certificated values for standard reference materials were within 10%. Mostly, the errors among three analyses of the same samples were less than 5%, and the repeatabilities of ICP-AES and ICP-MS analyses were within 2-3% and 10%, respectively.

Estimated daily dietary intakes of elements are summarized in Table 1. Although the number of samples for adults was limited to only four, the greatest daily intake of each element among the analyzed samples was for adults in most cases, mainly due to the differences in makeup of meals although total dietary intakes were almost at the same level. Hereafter, discussion is mainly made on results of children's samples.

Distributions of the results were not the same type. Typically, distributions were close to a log-normal distribution, but some elements had other patterns. For that reason, a non parametric method would be suitable to deal with such data. Between every two elements, Spearman's rank correlation coefficient was calculated. Most sets showed good correlations with the exception that Co and Fe had poor correlations against other elements. Very good correlations ($r>0.9$) were found between Ca-K, Ca-P, Ca-Rb, K-Mg, Mg-P, Mg-Rb and P-Rb. It is suggested that these elements have common origin in the diet because the behaviors of Rb are thought to be similar to K, another alkaline metal.

Comparison of present results with world values

Because the results did not have a normal distribution, the median should be suitable as a nonparametric representative value of each element. Table 2 compares the current results with some reference data [4-10]. In the table, ratios of the results to model values for daily balance of elements in Reference man (ICRP, 1974 [10]) are included. For children, these ratios were calculated by comparing the results with 50% of the model values, according to energy expenditure.

Daily intakes of most of the analyzed elements (Ca, Cs, Cu, K, Mg, Mn, Na, P, Rb and Sr) were almost the same or slightly lower than the reference values. The intake of Ba for children was 1.63 mg/day per capita (for adults was 3.73 mg) and this was several times higher than other data. The intake of Cd, which is known as toxic element, was less than 20% of the Reference man. The intake of Co for children was 20.1μg/day per capita and this was one order of magnitude lower than the Reference man, but it was several times higher than the values of Co intake in other regions [10]. The Fe intake was about 3 times higher than other data. Some Fe could have been included from tools and vessels used during food processing.

Table 1 *Daily intakes of seventeen elements in Belarusian

Sample No.	Ba (mg)	Ca (g)	Cd (μg)	Co (μg)	Cs (μg)	Cu (mg)	Fe (mg)	K (g)	Mg (mg)	Mn (mg)	Na (g)	P (g)	Rb (mg)	Sr (mg)	Th (μg)	U (μg)	Zn (mg)
Adult																	
1	6.37	1.79	3.4	47.1	4.60	11.14	83	3.69	320	5.80	3.15	1.11	2.14	7.08	3.15	2.14	18.9
2	2.13	1.70	30.7	24.9	5.98	0.95	21	3.48	260	2.86	3.06	1.60	1.37	3.98	0.93	0.88	7.2
4	3.67	0.83	13.4	70.3	4.03	1.21	58	2.88	219	3.58	2.27	0.96	1.19	1.69	4.44	1.46	8.8
5	3.79	0.85	9.3	50.5	5.37	1.33	50	3.40	232	3.27	2.31	1.01	1.36	1.74	5.39	1.56	6.6
Child																	
6	1.15	0.89	16.7	31.1	3.97	1.18	28	2.35	158	2.09	1.40	0.96	0.80	2.52	0.68	1.93	5.0
7	2.28	1.10	23.9	20.1	3.66	1.79	36	3.36	276	3.12	3.54	1.28	1.48	4.36	0.70	0.71	8.5
8	1.02	0.41	10.6	11.3	3.18	0.50	17	2.27	170	1.79	1.89	0.64	0.90	1.90	0.51	0.36	4.0
9	2.07	0.83	11.6	18.1	5.04	1.10	25	3.22	205	2.39	3.00	0.96	1.24	2.30	0.68	1.24	6.2
10	1.37	0.44	6.5	11.4	2.11	0.90	22	1.56	167	2.28	1.72	0.65	0.85	1.73	0.50	0.40	4.1
11	2.45	0.72	21.1	18.7	3.19	0.93	22	2.48	229	2.65	2.12	1.02	1.21	1.13	0.63	0.75	5.0
12	1.87	0.44	4.9	20.9	3.09	0.92	21	2.37	187	2.37	2.16	0.62	0.82	2.23	0.65	0.35	3.7
13	1.87	0.68	15.3	8.2	4.17	0.64	13	2.33	164	1.69	1.81	0.78	0.98	1.47	0.17	0.37	5.2
14	2.94	0.30	5.0	12.6	5.61	0.97	35	1.90	130	2.71	2.18	0.49	0.74	1.51	0.39	0.22	6.1
15	4.43	0.66	77.4	33.2	3.93	1.26	35	2.04	193	3.30	2.54	1.02	1.18	1.45	0.35	0.64	10.5
16	2.09	0.34	5.0	18.6	2.28	0.73	32	2.16	168	2.72	2.30	0.54	0.70	2.52	0.56	0.36	4.5
17	1.09	0.14	8.7	22.5	2.91	0.71	28	1.43	100	1.74	1.38	0.37	0.61	0.60	0.30	0.15	4.1
23	1.63	0.90	29.7	35.1	5.06	1.24	105	3.05	280	3.30	2.59	1.08	2.00	1.72	0.37	0.24	5.8
24	0.58	0.19	13.5	26.3	1.97	0.44	37	1.52	107	2.33	1.54	0.38	0.58	0.37	0.55	0.24	2.5
28	2.11	0.72	55.7	20.8	5.07	1.05	32	2.42	258	3.07	2.37	1.06	1.13	4.65	1.09	2.05	11.7
29	1.33	0.34	75.3	16.0	3.29	0.82	37	1.84	151	3.65	2.09	0.67	0.71	1.27	0.31	0.24	7.1
36	0.72	0.31	2.8	12.0	2.19	0.47	20	1.62	107	1.50	1.83	0.48	0.68	0.66	0.26	0.45	3.7
44	0.32	0.12	6.7	22.7	1.38	0.24	20	1.19	84	1.37	0.94	0.27	0.38	0.40	0.27	0.16	0.8
45	0.19	0.10	3.0	37.6	3.58	0.45	31	0.98	60	1.42	0.71	0.23	0.43	0.20	0.30	0.15	1.9

* Mean of three analyses

Table 2 Comparison of current results and reference data

Element	Child				Adult				Reference man[10]
	Current results			Russia[4]	Current results			Other region	
	Median	(*ratio)	Range		Median	(**ratio)	Range		
Ba (mg)	1.63	(4.3)	0.19-4.43		3.73	(5.0)	2.13-6.37	0.36[5]	0.75
Ca (g)	0.44	(0.8)	0.10-1.10	0.68	1.28	(1.2)	0.83-1.79	0.56[5], 0.57[6]	1.1
Cd (μg)	11.6	(0.2)	2.8-77.4		11.4	(0.1)	3.4-30.8	18-33[7]	150
Co (μg)	20.1	(0.1)	8.2-37.6	6.85	48.8	(0.2)	24.9-70.3	25.7[6]	300
Cs (μg)	3.29	(0.7)	1.38-5.61	5.9	4.99	(0.5)	4.03-5.98	7.22[6], 10.2[8]	10
Cu (mg)	0.90	(0.5)	0.24-1.79		1.27	(0.4)	0.95-11.14	1.3[5], 0.7-1.6[7]	3.5
Fe (mg)	28.5	(3.7)	13.1-105.3	9	53.9	(3.4)	21.3-83.3	9.15[6]	16
K (g)	2.16	(1.3)	0.98-3.36	2.18	3.44	(1.0)	2.88-3.69	1.9[5], 1.28[6]	3.3
Mg (mg)	167	(1.0)	60-280	227	246	(0.7)	219-320	200[5], 370[6]	340
Mn (mg)	2.37	(1.3)	1.37-3.65	3.7	3.43	(0.9)	2.86-5.80	3.4[5], 3[6]	3.7
Na (g)	2.09	(1.0)	0.71-3.54	3.241	2.69	(0.6)	2.27-3.15	4.5[5], 2.52[6]	4.4
P (g)	0.648	(0.9)	0.23-1.28		1.06	(0.8)	0.96-1.60	0.92[5]	1.4
Rb (mg)	0.83	(0.8)	0.38-2.00	3.18	1.37	(0.6)	1.19-2.15	1.34[6]	2.2
Sr (mg)	1.51	(1.6)	0.20-4.65	<52.4	2.86	(1.5)	1.69-7.08	2.3[5], 1.18[8]	1.9
^{232}Th (μg)	0.50	(0.3)	0.17-1.09		3.80	(1.3)	0.93-5.39	0.99[8], 0.41[9]	3
^{238}U (μg)	0.358	(0.4)	0.150-2.051		1.508	(0.8)	0.875-2.136	0.66[8], 0.71[9]	1.9
Zn (mg)	4.97	(0.8)	0.77-11.74	9.28	8.00	(0.6)	6.60-18.87	7.1[5], 7.55[6]	13

* Ratio to half of the Reference man ** Ratio to the Reference man

The daily intakes of Zn for children and adults were 4.97 and 8.00 mg, respectively. They were slightly lower than the Reference man. On the other hand, it has been reported that Zn deficiencies occurred in the diets of children and adolescents in Chernobyl disaster territories in Russia close to Gomel oblast, although their values were higher than our result [4]. According to their discussion, also in Gomel oblast, children would be deficient in Zn.

The intakes of ^{232}Th and ^{238}U were below the levels of other regions [8-10]. No evidence could be found that higher amounts of such radioactive elements were included in the diets of the region.

The results should be interpreted as showing that children of this region take adequate amounts of elements with some exceptions, although recommended or standard values for children have not yet been established.

Since reports on intakes of elements in Belarus have not been found, the results of this study should provide base data. It is required that the number of samples and the sampling area will be increased for further discussion and fixed conclusion.

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