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RADIOACTIVE CONTAMINATION OF FOOD IN WARSAW FOUR YEARS AFTER THE CHERNOBYL NUCLEAR DISASTER

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Gamma spectroscopy measurements of food were carried out to determine radiocesium levels in dietary in the Warsaw region. Four years after the Chernobyl disaster the annual intakes of ^{134}Cs, ^{137}Cs and ^{40}K are 280, 1180 and 31370 Bq respectively. The effective dose equivalent commitment after radiocesium intake with food is approximately equal to 3 μSv from ^{134}Cs and 9 μSv from ^{137}Cs. This equals 0.5% of the annual dose from natural radiation sources.

INTRODUCTION

The natural environment we live in contains diverse natural radioactive elements in soil, water, air and building materials. With the development of nuclear power plants, industry and scientific research, detonations of nuclear devices, and radiation leaks, increasing amounts of radioactive substances find their way into the human environment [3]. Exposure to radionuclides released into the environment as a result of human activity is seen as comparable to exposure to natural radionuclides [4]. In estimates of irradiation a distinction is made between external and internal exposure. One way radioactive substances enter organisms is through the alimentary tract. Studies of radionuclides content in food help to estimate their role in internal exposition.

MATERIAL AND METHODS

Studies of gamma-radioactive radionuclides in daily dietary commenced in October 1989. Meal samples were collected at the canteen of the Central Clinic of the Military Medical Academy in Warsaw, one of the largest of its kind in Warsaw, serving meals for several thousand people. Daily meal servings were collected from the canteen twice weekly. The daily diet was homogenized, weighed, and its volume determined. 450 ml samples of the homogenate were transferred into Marinelli beaker and measured with a PTG spectrometer

equipped with a germanium detector (18% yield). Analyses were performed with a VARRO 16-thousand-channel amplitude analyser manufactured by SILENA with 2.04 keV resolution (for 1332 keV spectral line of ^{60}Co) [7]. The detector was placed inside of a shielding hous (100 mm Pb + 2 mm Cu).

Energy and efficiency calibration was done with QCY-48 standard source with 12 defined energy lines of various intensity. The standard was prepared from an Amersham standard solution and attested by ORIPI-Świerk.

The time of sample measurement was such as to keep the error of measurement of the ^{40}K peak (1460 keV) below 10% at confidence level 1.96 [7]. Depending on the specific activity of sample, this time ranged from 10^4 to 10^5 s.

The body burden of absorbed radionuclides was determined by integrating retention functions [3]. Calculations were performed numerically with the Monte Carlo method. The effective dose equivalent commitment (EDEC) [1, 6] was determined using body burden-to-dose conversion coefficients [8]. The following coefficients were assumed: 1.38×10^{-4} $\mu Sv\ Bq^{-1}d^{-1}$ for ^{137}Cs and ^{137}mBa, 8.78×10^{-5} $\mu Sv\ Bq^{-1}d^{-1}$ for ^{134}Cs, and 1.08×10^{-4} $\mu Sv\ Bq^{-1}d^{-1}$ for ^{40}K. The average monthly intake was calculated as the product of arithmetical means of daily intakes and number of days in the month. The annual intake was estimated by extrapolating the monthly figures for October-May on the May-September period.

RESULTS AND DISCUSSION

Figures for the average daily intake of ^{134}Cs, ^{137}Cs and ^{40}K in the period from October 1989 to April 1990 are given in Table 1. The lowest ^{137}Cs content was in October 1989 (1.7 Bq d^{-1}) and the highest in March 1990 (5.1 Bq d^{-1}). The content of ^{134}Cs oscillated around the detectability level. It seems the observed variance of mean specific activity of the dietary depends on the composition of meals. Cesium content may be relatively lower the more meat and milk products the meals contain [5]. One must also bear in mind here that the consumed products may come from agricultural areas with different degrees of radiocesium decomposition.

Table 1. Mean daily intake of ^{134}Cs, ^{137}Cs and ^{40}K with daily diet

Month	Mean daily intake (Bq d^{-1})		
	^{134}Cs	^{137}Cs	^{40}K
October	0.5 ± 0.5	1.7 ± 0.4	100.7 ± 9.5
November	0.5 ± 0.4	2.7 ± 0.4	92.6 ± 9.8
December	1.5 ± 1.4	3.4 ± 0.6	75.7 ± 6.8
January	0.5 ± 0.2	3.2 ± 0.2	49.1 ± 3.4
February	1.0 ± 0.7	3.8 ± 0.7	73.7 ± 4.2
March	0.8 ± 0.5	5.1 ± 0.7	116.2 ± 11.8
April	0.5 ± 0.3	2.9 ± 0.4	95.9 ± 8.4

Also observed were changes in ^{40}K content which decreased in the period from october to January (from 100 to 49 Bq d^{-1}) to rise again in April and May (to about 100 Bq d^{-1}). This may be due to changes in the diet composition in winter (less fruit and vegetables), differences in meal preparation, and discontinuation of slaughter animals grazing. The observed oscillations of mean monthly contents of cesium and potassium in food are in agreement with the earlier findings of Pietrzak-Flis et al. [5].

Table 2. Annual intake of cesium and potassium radionuclides through the alimentary tract, annual limits on intake, and intake in terms of per cent of limits

	^{134}Cs	^{137}Cs	^{40}K
Annual intake (Bq $year^{-1}$)	280 ± 130	1180 ± 350	31370 ± 7800
Annual intake limit (Bq)	3×10^4	4×10^4	1×10^5
Annual intake (per cent of limit)	1	3	30

The mean annual intake of the investigated radio-nuclides is presented in Table 2, the values being referred to the admissible annual limits on intake (ALI) [1, 3, 10]. We assumed that for members of the public* [1]. In order to get a picture of the radiation hazard, the absorbed activity of the studied radionuclides was represented as ALI percentages. The annual intake of cesium isotopes was found to be 280 Bq for ^{134}Cs and 1180 Bq for ^{137}Cs; for ^{40}K was 31370 Bq. These values and correspond to 1% ALI for ^{134}Cs, 3% for ^{137}Cs, and 30% for ^{40}K. Table 3 shows the body burden of radionuclides accumulated in organs and tissues, and the dose absorbed after the intake of the analyzed radionuclides expressed in terms of EDEC. Aceording to our estimates, the annual volue for EDEC after the intake of the radionuchides in question will be 114 μSv, of which 12 μVs will be due to cesium isotopes introduced into the environment. The estimated doses and intakes are in agreement with values of Deszczak's "pessimistic hypothesis" concerning the radiation hazard after July 1989 [2].

Table 3. Body burden and effective dose equivalent commitment (EDEC) from May 1989 to April 1990

	^{134}Cs	^{137}Cs	^{40}K
Body burden (Bq)	67	280	2600
EDEC (μSv)	3	9	102

* The value one-hundredth of ALI for occupationaly exposed people is assessed.

Assuming that exposure to natural radiation sources is 2.4 μSv per year per person [9], we estimate that exposition to cesium isotopes absorbed through the alimentary tract in the fourth year after the Chernobyl nuclear disaster amounts to 0.5% of this magnitude.

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SKAŻENIA PROMIENIOTWÓRCZE ŻYWNOŚCI W WARSZAWIE, W CZWARTYM ROKU PO AWARII W CZERNOBYLSKIEJ ELEKTROWNI JĄDROWEJ

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Streszczenie

W pracy określono zawartość radionuklidów ^{134}Cs, ^{137}Cs i ^{40}K w pożywieniu całodobowym w okresie od maja 1989 do kwietnia 1990 r. Oszacowano aktywność wchłoniętą w ciągu roku ^{134}Cs na 280 Bq, ^{137}Cs na 1180 Bq oraz ^{40}K na 31370 Bq. Stanowi to odpowiednio 1%, 3% i 30% rocznego limitu wchłonięcia* dla osób z populacji. Roczny efektywny równoważnik dawki obciążającej** oszacowano dla ^{134}Cs na 3 μSv, dla ^{137}Cs na 9 μSv dla ^{40}K na 102 μSv.

* — roczny limit wchłonięcia (ang. effective dose-equivalent commitment),

** — efektywny równoważnik dawki obciążającej (ang. effective dose-equivalent commitment.