RADIOLOGICAL IMPACT OF THE REACTOR ACCIDENT AT CHERNOBYL ON THE HUNGARIAN POPULATION

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ABSTRACT

The accident of the Chernobyl nuclear power plant at the end of April 1986 has resulted in the release of radioactive substances in considerable amounts. The meteorological conditions that prevailed at the time of the accident and during the subsequent days facilitated dispersion of the airborne pollution and contamination of the environment over almost the whole continent. The first contaminated air masses appeared over the territory of Hungary from north-east during the night from 29 to 30 April. A second, somewhat smaller and a third, somewhat higher contamination occurred from the south - south-east direction on the 3rd of May and between the 6th and 8th of May, respectively. In determination of the magnitude of the environmental contamination and assessment of its radiological significance as well as in elaboration of recommendations on the measures which were believed to be necessary for the protection of the public, surveillance systems and institutes of several national authorities and organizations have participated, including also the Radiological Controlling and Data Providing Network of the Ministry of Health. Results of radioactivity and radiation measurements, assessment of the situation developed and recommendations on protection of the population made by this system are summarized in this paper.

1. CONTAMINATION OF THE DOMESTIC ENVIRONMENT

Arrival of radioactively contaminated air masses was first detected in the northern and north-western regions of the country during the night from 29 to 30 April. A somewhat less pronounced second contamination occurred on the 3-4 May and a more significant third one on the 6-8 May from the direction of south and south-east.

With the aid of gamma spectrometry analysis, typical fission products were found in the aerosol samples, such as Zr/Nb-95, Mo-99, Ru-103, I-131, Te/I-132, Cs-134 and 137, Ba/La-140, Ce-141 and 144.

These airborne radionuclides settled down on the ground surface by either dry or wet deposition influenced by the local meteorological conditions and, in particular, by rainfall patterns. The site specific increments in dose rates of environmental radiation measured outdoors at 123 selected points of the country in the early post-accident period have given a reasonable good information on the geographical distribution of the surface contamination over the whole Hungary.

According to these measurements, the region of Budapest was one of the most heavily contaminated areas of the country. Thus, the results obtained in Budapest on the levels of radioactive contamination of the environment and food-stuffs could be taken as

representative values for the most contaminated parts of our country.

Time integrated radionuclide composition of the aerosol in Budapest can be seen in Table I.

Table I. Radionuclide composition of the aerosol and fallout in the region of Budapest

Sample	Radionuclides						
	Mo-99	Ru-103	I-131	I-132	Cs-134	Cs-137	La-140
Aerosol 29 April-8 May $Bq.d.m^{-3}$	1.28	13.95	11.20	16.25	1.89	3.48	0.72
Fallout 29 April-9 May $Bq.m^{-3}$	1.09	16.11	3.55+	10.19+	2.28	4.71	2.55

+About 5/6 fraction of the radioiodine isotopes has been lost due to evaporation and incineration of the fallout samples.

In addition to the radioactive iodine absorbed to the airborne particulates (aerosol), about 1.5-2.5 times as much radioiodine was present in the atmosphere in vapour form. Accordingly, the maximum I-131 activities that could be inhaled in the region of Budapest by infants, children, adolescents and adults between 29 April and 8 May were about 150, 400, 750 and 1000 Bq, respectively, in case they spent all the time outdoors, and considerably lower if a significant fraction of time was spent indoors. Assuming that, in reality, at least 3/4-2/3 part of the day is spent indoors, the committed dose equivalent for the thyroid was about 100-150 uSv, and the committed effective dose equivalent about 3-4.5 uSv, at most.

The radioactive contamination of the atmosphere was washed out almost completely by a widespread rainfall during the night from 8 to 9 May. The radionuclide composition of the fallout can also be seen in Table I. This composition changed rapidly in the subsequent days and weeks depending on the half-life of each radionuclide. Gamma-emitting radionuclides deposited on ground surface were primarily responsible for the increase in the environmental dose rate observed in the early post-accident period.

The outdoor gamma dose rate in Budapest reached a maximum of 430 $nGy.h^{-1}$ on 1 May. This was about 4.5 times higher than the average background level during the preceding years. From the 2nd of May, it started to decrease rapidly. The country-wide average of environmental dose rate of 86.8 ± 10 $nGy.h^{-1}$ measured outdoors in the years of 1983-85 increased to 106.4 ± 22 $nGy.h^{-1}$ in 1986. No significant increase was detected in the indoor dose rates. The per caput increment in annual effective dose equivalent received by the Hungarian population from external sources in 1986 was estimated to be about 25 uSv.

2. CONTAMINATION OF WATER AND FOOD-STUFFS

Activity concentrations of radionuclides in surface and underground water resources remained so low throughout the whole post-accident period that contribution of drinking water to the exposure of the population was considered to be negligible.

During the first days of May, the same radionuclides could be detected in samples of grass and vegetables as in air and soil samples. Maximum concentration of I-131 of about 10 $kBq.kg^{-1}$ wet weight was measured in grass samples on 1-2 May. Concentration of Cs-137 in grass samples went up to 2-2.5 $kBq.kg^{-1}$ wet weight at the beginning of the month. These concentrations decreased fast to about 0.05-0.15 $kBq.kg^{-1}$ till the end of May. Radioactive contamination of vegetables was lower than that of grass by a factor of 2-3, at least, and was mainly attributable to surface contamination that could be partially removed by repeated and careful wash in running water. No contamination was found on vegetables grown in green-houses or under plastic tent. Relatively low and readily removable radioactive contamination was on the surface of fruit, such as cherry and strawberry.

Based on these contamination data, state farms and agricultural cooperatives were requested by the Government to discontinue grazing of animals, and the population was adviced to wash all leafy vegetables (lettuce, sorrel, spinach) carefully prior to consumption.

Grazing of farm animals in the early post-accident period resulted in a rapid increase in concentrations of I-131, Cs-134 and Cs-137 in fresh milk. Maximum concentration of I-131 was found to be about 1.5 $kBq.l^{-1}$ in the first days of May, and that of Cs-137 around 50 $Bq.l^{-1}$ between 5 and 15 May. Concentrations of these radionuclides remained significantly lower in milk collected from differently contaminated areas, but blended and put on market by the dairy industry. The maximum concentration of I-131 in milk marketed in Budapest was less than 200 $Bq.l^{-1}$ and that of Cs-137 less than 50 $Bq.l^{-1}$ all the time. Milk with a particularly high contamination level was withdrawn and either converted into milk products of a longer shelf-life or used for animal feeding.

No particularly high concentration of I-131 was detected in meat of animals, such as pig and cow, except in their thyroid glands, during the second half of May and the first half of June. Concentration of Cs-137 was 25-60 $Bq.kg^{-1}$ in beef and 10-70 $Bq.kg^{-1}$ in pork during the same time period. A rather slow decrease in Cs-137 concentration of meat could be observed thereafter.

Average concentrations of Cs-137 in cereals, such as wheat and rye, produced in various regions of the country in 1986 were about the same and fell within the range of 10-80 $Bq.kg^{-1}$. Radiocaesium was detected in much lower concentrations in crops, milk and meat products of the subsequent year in spite of the fact that the upper 5 cm layer of soil still contained about 50-60 $Bq.kg^{-1}$ Cs-137.

3. RADIONUCLIDES IN THE HUMAN BODY

Monitoring of 35 adults and 4 children during the first half of May, who had spent the days of radioactive contamination of the environment in various regions of the country, revealed that the maximum detectable content of I-131 in their thyroid glands was 0.4 kBq and that in their bodies was 0.93 kBq. Some other radionuclides, including Mo-99, Ru-103 and Cs-137 were just de-

tectable in a few cases.

From May 1986 to September 1987, additional 160 persons of both sexes and different ages have been examined in regard to the Cs-137 content of their bodies. Of these, 23 were adolescents of 12-17 years old. The results of these studies are given below.

Table II. Results of personal monitoring for whole-body content of Cs-137

Parameters	adults		adolescents	
	males	females	males	females
Number of persons	69	68	15	8
Number of measurements	142	144	16	11
Average Cs-137 content, Bq	1024	638	963	779
Average body-weight, kg	77.5	62.2	60.9	55.2
Average Cs-137 concentration, $Bq.kg^{-1}$	13.2	10.3	15.8	14.1

In 1986, the average body content of Cs-137 in both sexes increased steadily from about 530 Bq to 570 Bq. This increase became much faster at the beginning of 1987 resulting in a maximum of about 1050 Bq in July and followed by a rather steep decrease afterwards, reaching a level of somewhat less than 700 Bq in September.

A loose correlation could also be established between the body content of Cs-137 and its daily excretion rate in the urine. According to our measurements, 1000 Bq body content corresponds to an average excretion rate of 8.5 $Bq.l^{-1}$ of Cs-137.

Average concentration of Cs-137 was found to be about 2.7 $Bq.kg^{-1}$ in embryonic tissue, 4.25 $Bq.kg^{-1}$ in placental tissue, and 8.75 $Bq.kg^{-1}$ in the body of adult females in the period of June 1986 to April 1987. These data seem to suggest a discrimination ratio of 1:3 between embryonic and adult tissues and 1.2 between placental and adult female tissues.

4. INCREMENT IN EXPOSURE OF THE POPULATION

On the basis of the preceding data, the national average increment in the annual exposure rate of individual members of the Hungarian population in 1986 might have been about 100 uSv effective dose equivalent, somewhat higher for children and somewhat lower for adults. The maximum increments in the most heavily contaminated areas might have been about 2-4 times higher.

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