Monitoring of post-Chernobyl contamination in the Czech Republic

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Abstract. The results of monitoring of radiation situation in the period 1986-1994 are presented together with the estimation of doses to the Czech population due to Chernobyl accident.

1. Introduction

Large scale monitoring program [1] was implemented in the then Czechoslovakia immediately after the first passage of contaminated air masses from Chernobyl over the territory of the country on 30 April 1986 [2]. Likewise in other countries the first institutions that detected the increase of radioactivity in the air were nuclear power plants during their routine monitoring, then laboratories of hygienic service, hydrometeorologic service and some research institutes started the measurements. On the basis of the Chernobyl experience the Czechoslovak government decided in July 1986 to set up the Czechoslovak Radiation Monitoring Network (RMN) to provide competent authorities with timely information on any changes in radiation situation and that enable them to take appropriate protective measures and to inform the public. Up to the present the data on the activity of radionuclides and on dose rates in the environment are collected and evaluated by the Centre of Czech RMN working in National Radiation Protection Institute in Prague (former Centre of Radiation Hygiene of National Institute of Public Health), monitoring being performed according to monitoring plan set up by the Centre.

2. Methods

In 1986 several thousands of samples were measured to obtain representative values of radionuclide content in all parts of environment and to find out possible extreme values. In following years about one thousand samples (aerosols, fallout, milk and other foodstuff, etc.) were measured annually. All samples were measured by gamma spectrometry using mainly well shielded HPGe detectors. Radiochemical separation followed by alpha and beta spectrometry was used for determination of transuranium radionuclides and ^{90}Sr content in some samples. Additional measurement of surface contamination were performed by means of in-situ and airborne gamma spectrometry. The extensive databases exist about the contamination of environment, food chain and people. The aim of the monitoring in the first days after the accident was in particular the protection of population. Realistic estimation of the average dose and new experimental data on the transfer of different radionuclides in the environment are also important results of long-term monitoring. The average values of radionuclide content in environmental samples and values of doses up to the end of 1992 are valid for the former Czechoslovakia as a whole, since 1993 only the results from the Czech republic were evaluated.

3. Results and discussion

3.1 Activity concentrations in the air

Over the territory of Czechoslovakia three passages of markedly contaminated air masses were observed i.e. on April 30, from May 3 to May 4 and on May 7, 1986 (Figure 1). Activity concentration of radionuclides during those passages differs often even by an order of magnitude depending on locality. The first and the third passage was recorded in all 10 stations which monitored radioactivity in the atmosphere over the Czechoslovak territory. The second passage was not recorded in stations east of 19°E. Up to 20 radionuclides was identified in the aerosol filters in the first days after the accident [1]. The time course of activity concentration of ^{137}Cs and ^{134}Cs up to the end of 1994 is in Figure 2 [3]. Information on particle size distribution was obtained using sampling with cascade impactor [4], from which origin of particles (evaporation, dispersion of fuel) was deduced .

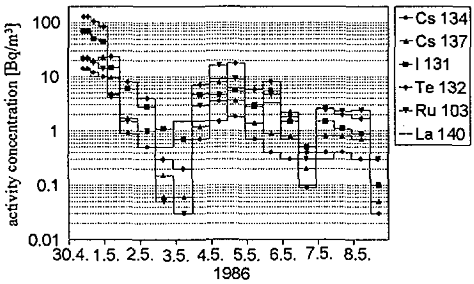

Figure 1 Time course of activity concentration of six most important radionuclides in the air in Prague in the first days after the accident

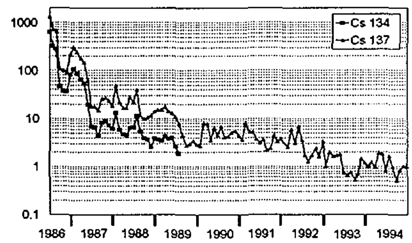

Figure 2 Time course of monthly averages of activity concentration of ^{137}Cs and ^{134}Cs in the air in Prague

3.2 Concentration of radionuclides in the soil [2, 4, 6]

For the evaluation of fall-out and soil contamination a nationwide survey was organized between June 16 and 18, 1986. Altogether 1300 bare soil samples were collected on sites not shielded by buildings, shrubs and trees, with no grass surface, preferably on agricultural land not tilled since April 26, 1986, with the slope less than 3° , principally not on sandy soil. Results of measurements are listed in Table 1 and for ^{137}Cs displayed in Figure 3. The arithmetic mean of ^{137}Cs deposition in the Czech Republic calculated from the lognormal distribution is 6.5 kBq/m^2. Maximum value of ^{137}Cs deposition found was 95 kBq/m^2 . Some soil samples have been remeasured in 1987 and 1988 to find out radionuclides of minor presence. Mean deposition of ^{110m}Ag (70 Bq/m^2) and ^{125}Sb (140 Bq/m^2) were estimated on the basis of correlation with ^{137}Cs and that of ^{106}Ru (1350 Bq/m^2) on the basis of correlation with ^{103}Ru. Arithmetic means in Table 1 could be underestimated by about 20% as the dry deposition by impaction and interception on the surface of the vegetation was not included.

Table 1. Summary of deposition of individual radionuclides on the Czechoslovak territory as estimated from lognormal distribution of surface activities (reference date June 16, 1986)

Radionuclide	Most Probable Value [Bq/m^2]	Median [Bq/m^2]	Arithmetic Mean [Bq/m^2]	Geometric Standard Deviation
^{137}Cs	600	2190	4200	3.1
^{134}Cs	200	930	1980	3.5
^{103}Ru	490	1560	2800	2.9
^{140}La	0.014 to 1.4	5.18 to 49	101.4 to 294	11.4 to 6.6
^{95}Zr	0.021 to 1.1	7.88 to 20	48.6 to 87	11.4 to 5.5
^{95}Nb	2.92 to 14.5	35.4 to 97	123.3 to 252	4.9 to 3.8
^{141}Ce	3.71 to 7.9	20.63 to 44	48.5 to 103	3.7
^{131}I	9.20 to 14.3	82.74 to 108	248.1 to 295	4.4 to 4.1

3.3 Food contamination [2, 3, 7, 8]

Data about radionuclide content in milk came either from five nationwide surveys which included all large dairies in Czechoslovakia or from regular milk sampling performed from the

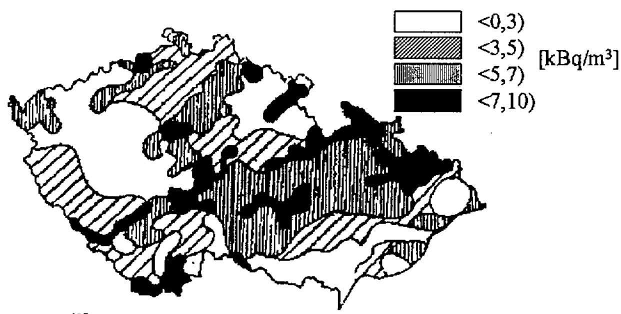

Figure 3 Distribution of ^{137}Cs deposition in soil over the territory of the Czech Republic

beginning of May, 1986 till middle of June, 1986 daily in most of 130 dairies, then weekly, later monthly on a smaller scale covering especially the biggest dairies. The most important radionuclides were ^{131}I, ^{134}Cs and ^{137}Cs. The samples of meat and other important foodstuff have been measured since the accident, too. Time course of specific activity of ^{137}Cs in milk, beef and pork is in Figure 4.

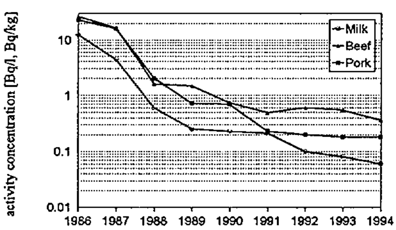

Figure 4 Annual average activity concentrations of ^{137}Cs in milk, beef and pork

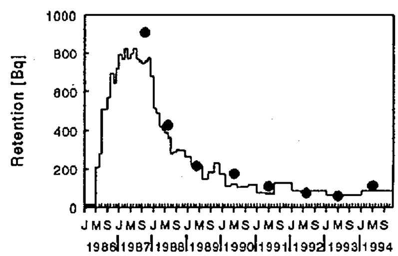

Figure 5 Time course of retention of ^{137}Cs in the Czech population (• nation wide survey by means of mesurement of ^{137}Cs in urine)

3.4 Internal contamination of people [5, 6, 9]

After the Chernobyl accident long term study of the internal contamination has been started. The group of about 30 persons living in Prague has been repeatedly measured by whole body counter. The measurements started on May 1, 1986 and were repeated monthly, later on in longer intervals. From 1993 measurements are performed once a year. Within a short period after the accident internal contamination by ^{131}I, ^{132}Te+^{132}I, ^{103}Ru, ^{137}Cs and ^{134}Cs was measurable. Since the second half of June, 1986 only ^{137}Cs and ^{134}Cs were measurable, since1990 only ^{137}Cs has been measurable. The time course of the ^{137}Cs retention in the refence group in years 1986-1994 is in Fig. 5. In addition to it, as an indirect method, the measurement of cesium daily excretion rate by urine was used, too. Nationwide surveys, that enable to gain information on internal contamination from the whole territory have been performed once a year since 1987. The results are included in Figure 5.

3.5 Doses [3, 6, 9]

The external dose was calculated both for contribution from the radioactive cloud and from the ground deposition. Occupancy factors were taken into account for the calculation of shielding correction. The calculation of effective dose equivalent commitments was as much as possible based on the data from whole body counting. For evaluation of contribution of short lived radionuclides and for assessment of inhalation dose also supplemental information about radionuclide content in air and most important types of foodstuff was used. The assessment of the effective dose equivalent commitments and effective doses during the period 1986-1994 is given for both the external and the internal exposure in Table 2.

Table 2 Summary of doses [μSv] to the Czech population due to Chernobyl accident

	1986	1987	1988	1989	1990	1991	1992	1993	1994
Internal	213	41	9.5	7.5	4.1	3.4	2.9	2.2	4
^{103}Ru	2	-	-	-	-	-	-	-	-
^{131}I	159	-	-	-	-	-	-	-	-
$^{132}Te+^{132}I$	16	-	-	-	-	-	-	-	-
^{134}Cs	14	14	2.5	1.5	0.6	0.5	0.2	0.1	-
^{137}Cs	22	27	7	6	3.5	2.9	2.6	2.1	4
External	49	31	23	17	14	11.8	10.1	7.9	5.3
Total	262	72	32.5	24.5	18.1	15.2	13	10.1	9.3

4. Conclusions

Immediately after the first reports about the Chernobyl accident the Governmental Commission for Radiation Accidents was activated and started to coordinate all the following activities. All the data concerning radiation situation were summed up and interpreted in terms of the actual and the potential radiation hazards by the Centre of RMN. The main shortcoming of the response of the authorities was the delay of the first official information of the public and the limited will to release fully open information afterwards. On the other hand no substantial technical countermeasures were needed. Even the most conservative estimates of doses to population were substantially bellow the internationally recognized intervention levels. The only exception was the administration of stable iodine to shepherds in mountain region of Slovakia since the activity of ^{131}I in sheep milk they consumed was in some cases several tens of kBq/l. There were, however, a few countermeasures not directly affecting the everyday life of people. Feeding cattle with stored fodder was recommended instead of fresh grass. Milk was daily sampled and measured in all dairies with the intention to discard from direct consumption deliveries exceeding 1000 Bq/l of ^{131}I. The use of fresh milk for production of baby formulae was temporarily stopped and then milk from selected farms from the areas less exposed to fallout was used.

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