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Second Brief Report About Some Consequences for the Lithuanian SSR of the Accident at the Chernobyl AEhS [Atomic Power Station]

1986
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[signatures at the bottom of the title page]

General Information About the Radioactivity of the Air in Vilnius and Some Other Locations of the Republic Between the Second Half of May to August 1986

The study of the material collected by the Department of Radioactive Material has shown that the initial cloud of radioactive substances released into the atmosphere during the accident at the Chernobyl AEhS [Atomic Power Station] reached our republic on 26-27 April 1986. The first signs of the decay products were detected in Vilnius and the station of our institute in the village of Preila in samples collected between 0900 26 April and 0900 27 April. An increase in gamma radiation in the vicinity of the Ignalina AEhS was observed beginning 2300 29 April.

The central part of the cloud passed west of Vilnius, which is illustrated by the increase in the concentrations of radioactivity in the direction of Alytus and Preila and the decrease in the direction of the northern and eastern regions of the republic.

The research of gamma spectra of samples of atmospheric aerosols at the end of April and the first days of May indicated the presence in the air of a large quantity of short-lived and long-lived radionuclides: isotopes of iodine, tellurium, ruthenium, cesium, rhodium, barium, lanthanum, cerium, zirconium, niobium, cobalt, and many others. Further research also led to the discovery of quite dangerous beta emitters (strontium-90 and others).

A considerable portion of the atmospheric radioactivity in our republic in the first days after the accident was caused by the decay of iodine-131 (with a half-life of 8.08 days). On 30 April its concentration in Vilnius exceeded the current Soviet standards for the population by approximately 20 times (the total concentration of aerosol and the gaseous component of iodine-131 during the second half of 30 April reached ~100 Bk/m^3 against a standard of 5 Bk/m^3). In the village of Preila the concentration reached 250 Bk/m^3 on 27 April (the average for the day), which exceeded the level safe for the population by 50 times and was above the standard established for people working with radioactive substances (155) Bk/m^3. It should be noted that at this same time the population was subjected to a relatively intense radiation effect from a large number of other radionuclides. This undoubtedly led to an even more considerable surpassing of safe standards. In addition, large concentrations of so-called "hot" particles were detected during the first days after the accident in air samples in Vilnius, which in our view present a considerable danger and are not yet taken into account by the safety rules (standards). We will dwell on the issue of "hot" particles in more detail later.

Since the beginning of May the concentrations of radioactive nuclides in Vilnius and other locations in the republic have dropped rapidly. The isotope composition of the emitters has also changed. The contribution to the total radioactivity of the nuclides with relatively long half-lives (cesium-137 with a half-life of about 30 years, cesium-134, 2.05 years) has increased with time, with a practically complete absence of iodine-131.

However, at times individual repeated "surges" in the radioactivity of the air have been observed (for example, 8-10 May, 23-26 May, 6-9 June, 19-20 June, etc.). The repeated appearance in the atmosphere of short-lived ruthenium-103 (with a half-life of 39.4 days) indicates continuing discharges from the reactor that suffered the accident.

The contamination of the air with radioactive substances usually increased with a shift of direction from Chernobyl. There were apparently two variants here:

1. Repeated discharges occurred from the reactor.
2. An airstream came permeated with aerosols and lifted by the wind from previously strongly contaminated surfaces.

In our opinion, one can judge the first reason for the increase of radioactivity in Vilnius from the growth of the ratio between short-lived ruthenium-103 and the long-lived isotopes, cesium-137 and -134. In the second case these ratios remain low with the overall increase in the radioactivity of the air.

It should be noted that many samples of atmospheric aerosols collected in Vilnius during the second half of August already showed a practically complete absence of artificial radionuclides. However, notable traces of beta- and gamma-emitters were still present in many environmental objects (mushrooms, some berries, grass, honey, etc.). We will cite examples of the latest measurements in samples taken in Varena Rayon on 11 September:

1) White mushrooms - 150 Bk/kg
2) Chanterelles - 200 Bk/kg
3) Viper's bugloss - 310 Bk/kg

in beta activity (the safe level is 18,500 Bk/kg).

In heather - 740 Bk/kg, blueberries - 480 Bk/kg, moss - 830 Bk/kg. Almost half the activity in these objects resulted from isotopes of cesium, but rhodium-103 and other nuclides were also present.

Although the concentrations of these nuclides in food products are lower than safe standards it ought to be borne in mind that they accumulate in the body (for example, the period to excrete half of the strontium-90 from the body is in the neighborhood of five years). The pace of the development of nuclear technology and the use of radioactive nuclides is constantly accelerating, so evidently in the future there will be a rapid accumulation of radioactive substances in the biosphere. Several specialists claim that the body loses resistance to infectious and other diseases even under the influence of weak doses of radiation on cell membranes, not to mention the genetic and oncological consequences. Accordingly, it is desirable to avoid even relatively small amounts of radioactive substances reaching the body.

One can judge the fall of the level of contamination of atmospheric air in Vilnius beginning with the second half of May until the end of August from the data of table 1. Here is shown the time dependence of the two radionuclides that are dominant right now, ruthenium-103 and cesium-137.

Date	Ruthenium-103	Cesium-137	Date	Ruthenium-103	Cesium-137
19-20 May 1986	66	54	18-19 June	50	35
20-21	94	42	19-20	2332	136
21-22	56	33	25-26	9	3
23-26	628	122	26-27	11	5
26-27	80	43	27-30	6	3
27-28	90	43	30 June- 1 July	5	7
28-29	93	43	1-3	6	6
29-30	79	20	2-3	6	5
30 May - 2 June	44	10	3-4	8	3
2-3	85	14	4-7	8	4
3-4	38	15	7-8	7	6
4-5	30	14	8-9	3	0
6-9	122	17	9-10	4	2
9-10	41	17	10-11	8	3
11-12	82	22	11-14	6	3
12-13	50	18	15-16	2	2
13-16	56	23	16-17	9	7
16-17	46	18	17-18	9	1
17-18	20	15	18-21	10	1
22-23 July	14	1	21-22	12	1
23-24	14	2	5-6 August	26	6
24-25	39	14	6-7	4	1
25-28	6	0	7-8	11	1
28-29	10	1	8-11	8	1
29-30	13	1	11-12	10	0
30-31	10	0	12-13	5	0
31 July - 1 August	8	1	13-14	2	0
1-4	7	1	14-15	3	0
4-5	14	2	18-19	0	1
			19-20	5	1
			20-21	0	1
			21-22	0	0

All the concentrations cited in table 1 are considerably lower than the standards permitted by health regulations.

The concentrations of radioactive radionuclides are low in rainwater.

Even in the first rain which fell in Vilnius after the accident (12 May) only relatively small concentrations of iodine-131 and traces of some other radionuclides were observed.

"Hot" particles

Atmospheric "hot" particles are conglomerates of radioactive atoms located in aerosols the size of a micron. One such particle might contain many millions of radioactive nuclei. Such aerosols enter respiratory passages and the lungs with air. Thus internal sources of dangerous long-term effects on the human body arise. With time these sources can become the cause of cancers.

We exposed two nuclear emulsions of the type A-2 in contact with FPP-15 filters containing atmospheric aerosols in order to research the possibility of the presence of alpha- and beta- "hot" particles in the air after the accident in Chernobyl.

No "hot" alpha particles were detected.

However, the very high concentration of "hot" beta particles established causes some alarm. "Hot" beta particles with rings 0.37-22.2 micrometers in diameter were observed on the plates. In a sample collected between 25 and 28 April 1986 the concentration of these particles was in the neighborhood of $0.6m^{-3}$. This corresponds to approximately 10 particles striking a person's lungs per day. On 28-29 April the concentration of particles in the air of Vilnius was so high that the complete blackening of the plates did not permit qualitative estimates to be conducted. On 29-30 April the concentration was 130 m^{-3} (approximately 2,000 particles striking the lungs of an adult per day). The second maximum concentration of "hot" beta particles was noted on 30 April between 0842 and 1435. At this time the concentration was in the neighborhood of 600 particles per cubic meter of air (10,000 particles per day in the lungs). Then there was a rapid decline in concentrations.

It should be noted that the exposure of filters in a nuclear emulsion was only began on 24 May (that is, almost a month after the accident), hence part of the radioactive nuclei had already disintegrated by this time. It can be assumed that in the first days after the accident the actual content of the "hot" beta particles was considerably higher than cited above.

Research was also conducted of the distribution of "hot" particles by the sizes of their rings. A shift of the maximum number of particles was observed with time in the direction of smaller sizes in the samples studied. This circumstance can be explained by the slower fallout of small particles from the zone of vertical displacement of the cloud (the center was at an altitude in the neighborhood of 300m?) or the fractionation of particles during the migration of the cloud from the source to Vilnius.

A microscope inspection of nuclear emulsions is very labor-intensive work and therefore final results will only be obtained in several months. However, a conclusion can already be drawn about the great importance of the use of respirators and the population being in closed buildings when such a cloud is passing over.

We also made attempts at a gamma spectroscopy study of the "hot" particles detected on environmental objects in several regions of the republic. On 16 May a radiation meter detected individual points with increased radioactivity on about 400 m^2 of land surface in the village of Leipalingis of Veisiejai Rayon. More detailed research showed that the reason for such fluctuations in radioactivity were individual microscopic particles with very high specific radioactivity which had adhered to various objects. The results of the identification of their radionuclide composition and the radioactivity of the individual nuclides are presented in table 2.

Table 2. The Parameters of "Hot" Particles Taken in the Village of Leipalingis (Veisiejai Rayon of the Lithuanian SSR)

Nº	Name of the object containing the particle	Radionuclide	Half-life in days	Radiant energy, keV	Yield per decay, %	Activity as of 23 May, Bk
1	2	3	4	5	6	7
1.	Glass	Ru-103 Ru-106>Ru-106 [SIC]	39.3 368	497 622	90 9.76	6300 610
2.	Clump of turf	Ru-103 Ru-106> Rh-106	39.3 368	497 622	90 9.76	6200 300
3.	Cane	Ru-103 Ru-106> Rh-106 Nb-95	39.3 368 35	497 622 766	90 9.76 99.8	520 50 130
4.	Blade of grass	Ce-141 Ce-144 Zr-95 Nb-95	32.5 284.3 64.1 35	145 133 757 724 766	47.0 10.8 55.4 43.7 99.8	140 290 23 23

The fact that different particles contain different radionuclides and that only daughter niobium-95 was observed in a single particle without parental zirconium-95 indicates that they could have been formed only when the cloud in which these elements were present at high temperature (more than 2500^{o} C) in gaseous form cooled in the atmosphere. Similar particles were subsequently detected in the clothing of a person who had worked in a field in the village of Leipalingis before and after the [May Day and Victory Day] holidays. Swedish researchers also reported the detection of such particles with the same radionuclides.

Thus it can be supposed that between 27 April and 10 May the cloud spread with large concentrations of radionuclides throughout practically the entire territory of the republic, beginning with the southern rayons. There were gaseous and uranium-235 fission products associated with aerosols, and products of the interaction of neutrons with other substances in the air, and also coats of dust from materials of the reactor with large massic activity emitting beta and gamma rays. The level of gamma radiation in the air at this time changed from values above 100 mkR/ch to close to background by the end of the week. In view of the lack of rain the radionuclides first fell on the earth's surface and vegetation, mainly in dead zones in the form of dry fallout, but continues to fall to the present time with the rain.

Separate measurements showed the presence of radionuclides in berries and mushrooms collected in September. Radionuclides in such objects can be measured using only gamma spectrometers with appropriate protection from external radiation or using radiochemical methods. The Republic health and epidemic center is acting absolutely incorrectly in advertising in the press that one can decide the edibility of berries and mushrooms in a moment with the aid of an ordinary radiation meter. It is much more correct to refrain from consuming them. This can be numbered among the measures reducing the likelihood of the manifestation of the consequences of those small additional doses of radiation to which every resident of the republic is being subjected in one way or another. And the subsequent actually limited time in the air; the cleaning of clothing, shoes, and premises of dust; and the careful use of food products, since not all radionuclides have decayed and continue to be present in our environment.

Some Features of the Contamination of the Earth's Surface and Food With Radioactive Substances

At the request of the Civil Defense Staff of the Lithuanian SSR, in cooperation with a number of other organizations of the republic the Department of Atmospheric Radioactivity of the Institute has also participated in research of the isotope composition of local fallout of the products of fission ("hot spots") in the area of Orija and Reketija Lakes of Kapsukas Rayon, near the city of Raudone, and other places. Soil samples (the distribution of radionuclides by depth), vegetation, water, and other environmental objects were studied. A typical gamma spectrum allowing one to determine the isotope composition of radionuclides is shown in figure 1. Considerable quantities of the following radionuclides were detected when studying samples: cerium-141 (half-life: 32.51 days), cerium -144 with promethium-144 (284.3 days and 17.3 million, respectively), ruthenium-103 (39.4 days), barium-140 with lanthanum-140 (12.8 and 1.68 days, respectively), zirconium-95 with niobium-95 (65.5 and 35.58 days, respectively), cesium-134 (2.05 years), and cesium-137 (29.9 years). It was established that the majority of the radionuclides are in the top one centimeter layer of soil and also in vegetation cover. At the instruction of the Civil Defense Staff sources with high levels of radionuclides were sealed off and it was forbidden to use these sectors as pasture. The Institute suggests that in the future the migration patterns of the radionuclides in these places with an increased level of radiation be studied.

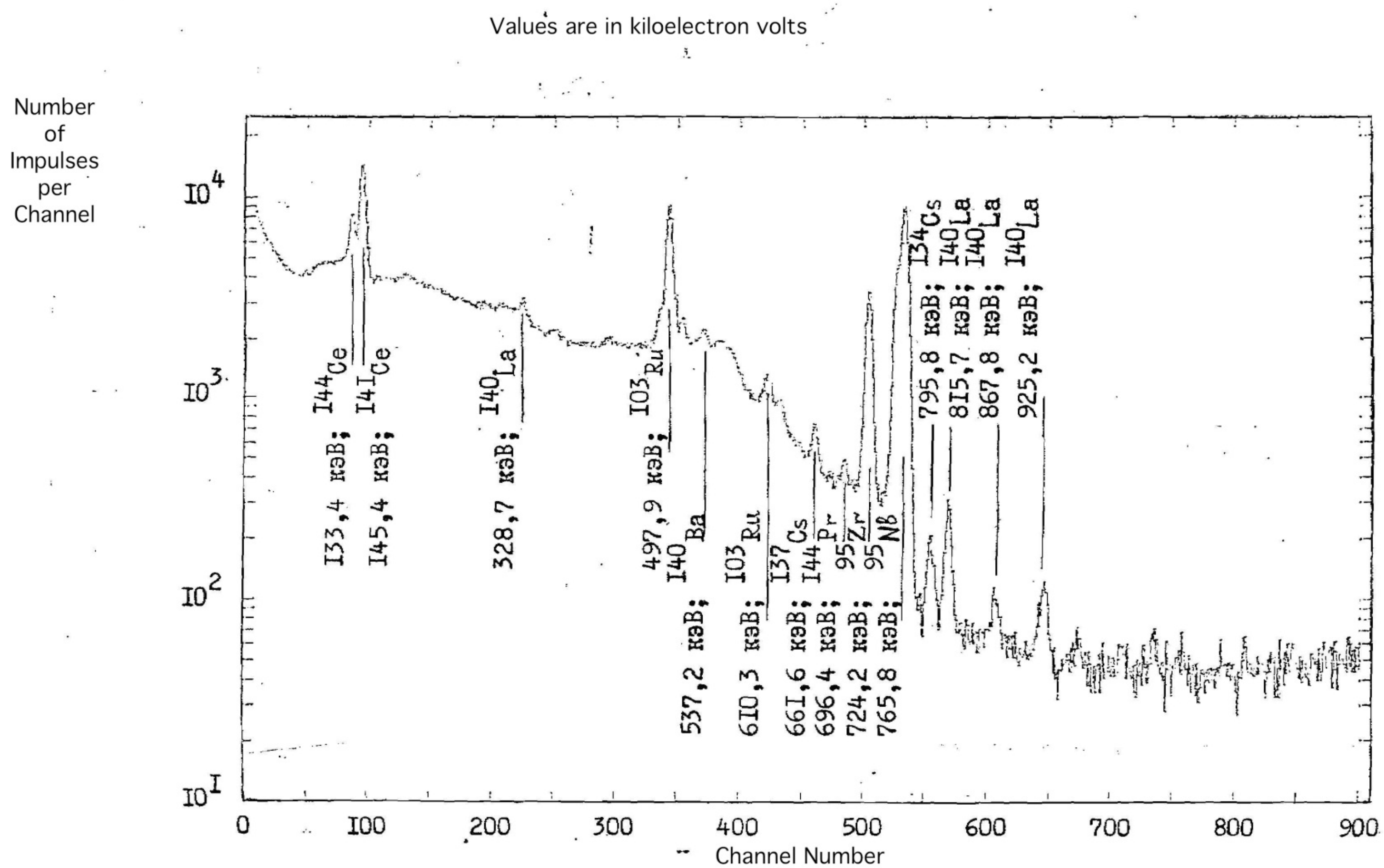


Figure 1. The Spectrum of Gamma Radiation Collected on 8 June 1986 in the Region of a "Hot Spot" Near Lake Orija

As a public service, the spectra of gamma radiation of various food products (more than 1,000 samples) were measured in the Lithuanian SSR Academy of Sciences' Institute of Physics during June, July, and August 1986 in order to estimate the concentration of radionuclides in various food products (in this case the radionuclides are the source of more dangerous internal irradiation of an individual). The samples were mainly supplied by the radiology departments of the republic SEhS [Health Inspection Service] and the Republic Veterinary Laboratory. In addition, at the instruction of the Lithuanian SSR Ministry of Health, the Littorgbakaley [Lithuanian Grocery Trade] of the Lithuanian SSR Ministry of Trade supplied samples of food products coming into our republic from the Ukrainian, Belorussian, Georgian SSR's, and other republics. In some cases the data obtained about concentrations of radionuclides served as the basis for making decisions about the inadvisability of selling food products to the population and also about the possibility of purchasing various berries and fruits from other republics.

On the basis of a request from the Commercial and Industrial Chamber of the Lithuanian SSR careful monitoring is being conducted of exhibits representing our republic at the 1986 international fair in Vienna.

Numerous measurements of the gamma spectra of mushrooms and wild berries were made on the basis of a request from the Lithuanian SSR Ministry of Forest Management and the Forestry Industry, the Lithuanian SSR Environmental Protection Committee, and the Republic SEhS radiological departments, and the Republic Veterinary Laboratory.

Table 3 cites some data about the content of cesium-137 in some food products. In view of the large concentrations of radioactive substances in the tea which has come to our republic from the Georgian SSR (figure 2) experiments were conducted about the transference of radionuclides from tea leaves to water. It was demonstrated that it is mainly cesium-137 is entering the water. In the process its concentration in one glass of tea can reach 100 Bk and more.

Such cooperation with a whole series of ministries and departments was necessary in view of the lack of corresponding abilities to measure radioactivity in a number of the special departmental laboratories of the Lithuanian SSR.

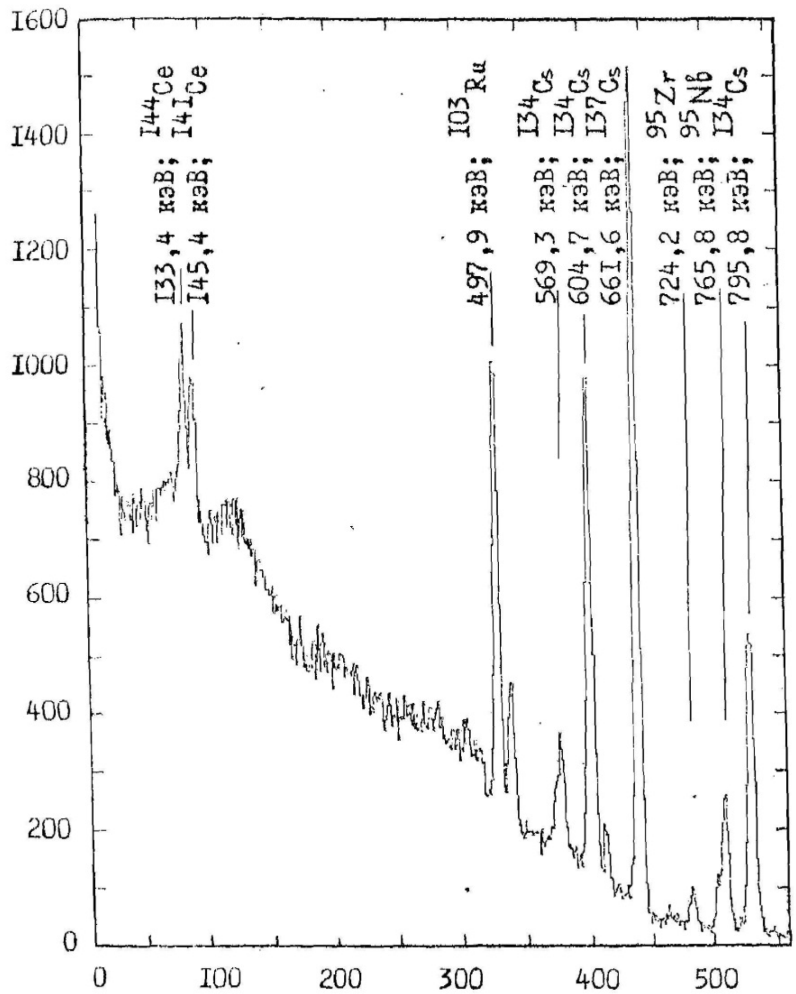
Table 3. Specific Activity of Some Food Products Recorded in July and August 1986

Name of the food	Place collected or processed	Specific activity of Cs-137
Milk	Lithuanian SSR	no more than 25 Bk/l
Beef	"	50-90 Bk/kg
Pork	"	20-40 Bk/kg
Honey	"	traces
Mushrooms	"	no more than 1500 Bk/kg
		no more than 100 Bk/kg
Cranberries	"	no more than 600 Bk/kg
		no more than 50 Bk/kg
	Belorussian SSR	no more than 50 Bk/kg
		380-825 Bk/kg
Mountain cranberries	Lithuanian SSR	
Whortleberries	"	380-20,600 Bk/kg
Ground whortleberries with	Ukrainian SSR	no more than 2,535 Bk/kg
sugar*		63-1,875 Bk/l
Georgian tea	Georgian SSR	
Azerbaijani tea	Azerbaijan SSR	
Baby formula	Belorussian SSR	

* a "hot particle" was detected containing a radionuclide of Cs-137 with an activity of 4,000 Bk in 10 g of ground whortleberries.

Values are in kiloelectron volts

Number of Impulses per Channel



Channel Number

Figure 2. The Spectrum of Gamma Radiation of the Georgian Tea "Ekstra" Recorded with the Aid of Ge (Li) Semiconductor Detector on 19 September 1986

The Study of Concentrations of Radionuclides in Atmospheric Air and the Fallout in the Region of the Ignalina AEhS

Measurements of the concentrations of individual radionuclides were conducted in the surface air and in the fallout in the region of the Ignalina AEhS. Air samples were taken every other day and fallout [samples] every month. The level of gamma radiation was continuously recorded at two places, the village of Vosilishkes where the discharge of the Ignalina AEhS have been recorded during a northwesterly wind, and the village of Tilze, where the gamma radiation of radionuclides coming with the south wind has been recorded.

The maximum values of the level of gamma radiation, as shown in the previous report, were noted on 30 April and reached values of up to 50 mkR/ch. A cloud with radionuclides appeared in the region of the Ignalina AEhS at 2300 29 April. In a publication of Swedish researchers ([Nietje], v. 321, p. 152, 1986) it pointed out that that the cloud reached the station in Stud[s]vik, 75 km north of Stockholm, at 1200 27 April and that the level of gamma radiation in surface air reached 100 mkR/ch. This data confirms the assumption expressed in the first report that the cloud with the radionuclides released into the atmosphere after the accident at the Chernobyl AEhS reached the region of the Ignalina AEhS in a circuitous way after the end of the influence of the high-pressure system along the southern periphery of which it was released in a westerly direction. The direct path of the cloud evidently touched the southern regions of the republic and it can be supposed that the level of gamma radiation there was more than 100 mkR/ch and that the maximum values were reached in the morning hours of 27 April, that is, a day after the accident.

The main emitters (up to 90% of the gamma radiation) in the cloud which reached the Ignalina AEhS were tellurium-132 (half-life = 2.9 days) in equilibrium with iodine-132 (half-life = 2.3 hours) and iodine-132 (half-life = 8.9 days), the concentrations of which in the air on the night of 30 April were 40 and 8 Bk/m^3, respectively. Ruthenium-103 (half-life - 39.3 days) - 2 Bk/m^3, cesium-134 - 0.3 Bk/m^3, cesium-136 - 0.25 Bk/m^3, barium-140 (half-life = 12.8 days) - 0.3 Bk/m^3 in equilibrium with lanthanum-140 (half-life = 40 hours) - 2.10^{-3} Bk/m^3, cesium-137 (half-life = 30.1 years) - 0.5 Bk/m^3, zirconium-95 (half-life - 64.1 days) with daughter niobium-95 (35 days) - 0.02 Bk/m^3 were also detected in a sample taken between 0100 and 0600 on 30 April. The concentrations of pure beta emitters strontium-90 and strontium-89 were 0.03 Bk/m^3 and 0.02 Bk/m^3, respectively.

Subsequently, a gradual reduction in the concentrations of radionuclides in the air was observed until 8 May; the concentrations of tellurium-132 with iodine-132 fell by an order of magnitude from sample to sample and was no longer detected after 6 May. In samples from 8 to 10 May an increase in concentrations of radionuclides was observed and here the dominant gamma radiation was ruthenium-103 - 5 Bk/m^3. The sample for 21-23 May was the last in which traces of iodine-131 were still detected. At the end of May and the beginning of July [SIC] only isotopes of ruthenium, cesium, cerium, and zirconium-95 with niobium-95 were being detected in the air. Their concentrations were gradually compared to the concentrations of beryllium-7 formed under the influence of cosmic rays and remained measurable until the end of August. Increases of their concentrations could be noted in the periods 1-3 June and 22-25 July, but without a change of the radionuclide composition.

Dry fallout during the period from 26 April to 6 May and monthly fallout with rain were collected to determine the radionuclides reaching the earth's surface. During the period from 30 April to 7 May the dry fallout of individual radionuclides can be estimated by the [following] values: iodine-131 - 260 Bk/m^2; ruthenium-103 - 7.0 Bk/m^2; cesium-137 - 10.0 Bk/m^2; cesium-136 - 7.0 Bk/m^2; ruthenium-106 - 3.0 Bk/m^2; and cesium-134 - 2.0 Bk/m^2. During the period before 20 May [the following] had already fallen with precipitation: ruthenium-106 - 203 Bk/m^2; ruthenium-103 - 850 Bk/m^2; iodine-131 - 120 Bk/m^2; zirconium-95 - 160 Bk/m^2; niobium-95 - 107 Bk/m^2; cesium-137 - 21 Bk/m^2; and cesium-134 - 10 Bk/m^2.

The further study of monthly samples of fallout showed that the fallout gradually dropped during June, July, and August but nevertheless in the last fallout sample taken on 21 August it was: ruthenium-106 - 80 Bk/m^2; ruthenium -103 - 10 Bk/m^2; cesium-137 - 11 Bk/m^2; and cesium-137 - 7 Bk/m^2.

Some Conclusions

1. In the event of an accident at an AEhS or other potential source of radioactive contamination an immediate forecast of the trajectory of the plume distribution and an instant warning to the population about necessary precautionary measures (respirators, sealing up buildings, minimal exposure outside buildings) are needed. It is inadvisable to wait for the results from local measurements since the processing of the results, the transmission of the information, the warning of the population, and the adoption of measures might lead to an absolutely unnecessary and dangerous irradiation of people. It ought to be kept in mind that a small additional irradiation of the population might lead to considerable deaths after several years.

2. The development of rapid methods of detecting "hot" particles in the air is necessary.

3. The development of simplified but sufficiently accurate rapid methods of measuring the contamination of food products and other environmental objects with radioactive substances is necessary. The methods of determining the concentrations of radionuclides used in a number of departmental laboratories at the present time have great shortcomings: they are insufficiently accurate, quite labor-intensive, lengthy, part of the nuclides being measured are lost during preparation of the samples, etc.

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