

So-called "underground" explosions led not only to the appearance of "fresh" fission products in the air, but also to increased concentrations of some other isotopes, such as Zn95, Ru103, and Ce141, above the usual level.

A retrospective estimate of the radiation circumstances in the Semipalatinsk region (1965-1989) would not be complete without calculating the contribution of the parameters of the radioactive cloud to the dose equivalent of the population from the underground nuclear explosions conducted with soil excavation.

At the beginning of the 1960s "The program for industrial use of underground nuclear explosions in the National Economy" was elaborated and worked out in the USSR. In the same period an analogous program under the title "Plausher" was elaborated and worked out in the USA. A number of underground nuclear explosions with consequent soil excavation was made in both countries for these programs until 1970. The data on the yield and other parameters of this explosions are shown in the table 1.6.

Table 1.6. Some parameters of underground nuclear explosions with soil excavation

Country	Title of explosion	Date of explosion	Capacity (kilotonnes)	Depth of explosion (metres per 1 kt)	Size of a crater		Altitude of a cloud (km)	Part of the radioactive substances behind the embankment (%)
					Radius (m)	Depth (m)		
USA	Jungl-1	1.29.1951	1.2	4.9	40.0	16.0	2.0	40
	Tunom-Ess	3.23.1955	1.2	19.5	44.5	27.4	2.4	35
	Neptun	10.14.1958	0.15	53.5	0.5	10.7	1.2	0.3-0.5
	Dni-Boy	03.05.1962	0.42	50.0	33.5	19.3	0.3	7.7
	Sedan	07.06.1962	100.0	50.0	183.0	97.0	4.0	7.3
USSR	1004	01.15.1965	224.0	41.0	205.0	100.0	4.5	21.5
	1003	10.08.1965	?	47.0	53.5	31.0	0.3	4.5
	Telkem-1	October, 1968	?	51.0	35.0	21.0	0.3	?

Besides these explosions simultaneous explosions of 5 line-situated cartridges of small yield were made in 1968 in the USA under the project "Buggy". The aim of these explosions (or "experiments") was to investigate the possibility of constructing the channels by excavating soil by nuclear explosion. A similar experiment was also carried out in the USSR in 1968 under the title "Telkem-2". All of these explosions were of the so-called "experimental" type. Reportedly, the population of the USA was not exposed to ionizing radiation from these explosions. But in the USSR the explosions were made near populated areas, of the Beskaragaiski district of the Semipalatinsk region. From the point of view of radiation safety the principal danger of underground nuclear explosions with soil excavation is the possibility of radiation exposure due to: 1. formation of radioactive clouds and their coming to populated areas, and 2. contamination of the environment by radioactive substances and their consequent intake.

Therefore, the levels of contamination and the doses of exposure depend on the amount of radioactive substances released into the atmosphere.

Whether the amount of radiation exposure is significant or not, depends on the parameters of the cloud. The "cloud" dose could be the principal dose constituting the total dose, if the altitude of the cloud is not high. According to K.I.Gordin (1967), the dose of radiation exposure from the cloud can be calculated by the following formula:

$$D_{\text{cloud}}/D_{\text{fall}} = 1.08e^{(2-4.7 \lg hn)} (K+7.6) 10^2$$

where hn — the altitude of the cloud (km)

R — the distance from the hypocentre (km)

Calculations made according to this formula showed that if the altitude of the cloud was less than 3 km, the principal part to the dose would derive from the cloud itself. But if the altitude was more than 3 km, the principal part of the dose formation would derive from the radioactive fallout.

It was determined that the basic source of internal irradiation of the population after underground explosions with soil excavation depended on the parameters of air contamination by highly toxic and easily biologically accessible radionuclides (Sr-89, I-131, I-133, I-135, Ba-140, Mo-99, Ag-111, Ru-106, Te-132 and others). The principal period of