Introduction: immediate consequences of ChNPP 1986 accident

Oleg Nasvit[1)], Yuriy Skaletskyy[2)]

1) LLC “AFRY Ukraine”

2) State Institution "Marzieiev Institute for Public Health of the National Academy of Medical Sciences of Ukraine"

ICRP Webinar **Lessons for radiological protection from the Chornobyl and Fukushima Daiichi NPPs accidents**

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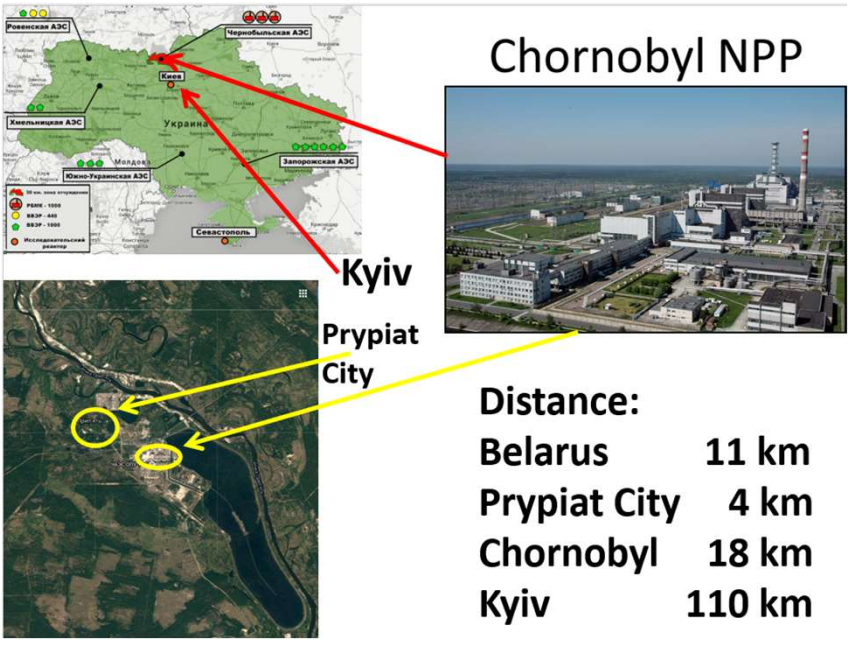
Chornobyl NPP location



Location

Just to remind the location of the Chornobyl NPP accident. It is in the Northern part of Ukraine, 110 km from Kyiv, 18 km from Chornobyl and 4 km from the Prypiat City, 11 km from the border of Belarus.

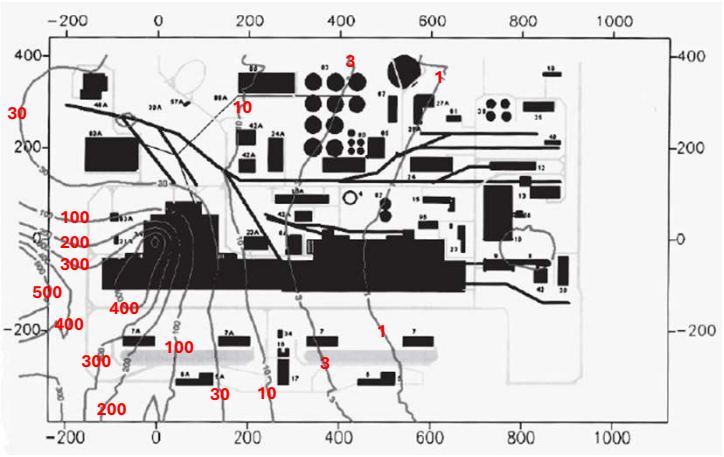
Features of the Chornobyl accident and the situation at that time that shaped the consequences

- The Soviet Union was a kind of totalitarian state, everything was top-down prescripted.
- The Soviet Union experienced a number of nuclear and radiological accidents on the industrial and military objects and managed to keep them secret.
- Long time of emissions, changes in wind directions and weather conditions during the emissions period.
- Long time for the party and state leadership to realize the scale of the accident.
- Use of the army for emergency and recovery works.
- Ability of the centralized power to mobilize huge resources.

Accident

- Two explosions destroyed Unit #4 reactor building at 1:23 on April, 26, 1986 (Saturday)
- Huge amount of radioactivity was released to the environment

Doses and effect on first responders and staff



Radiation conditions on the ChNPP industrial site on the first day after the accident.
Gamma-radiation dose rates in cSv/h

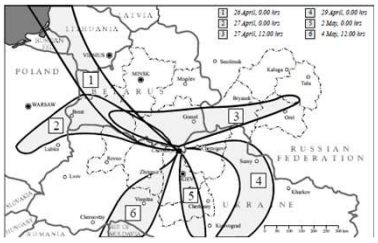
- Of about the 600 persons present during the night 490 were suspected to have ARS.
- From the beginning for 237 persons the ARS was diagnosed, but later ARS was proved for 134 persons.
- Their doses were from less than 2,1 Gy up to 16 Gy.
- 27 of them died within 14 weeks after the accident
- The skin doses from beta exposures evaluated for eight patients with ARS ranged from 10 to 30 times the whole-body doses from external irradiation.

Explosions destroyed Unit #4 reactor building, all the barriers were destroyed. Hot fragments of reactor structures, graphite linings, and fuel assemblies were thrown out the reactor core onto the roofs of nearby buildings and caused 30 fires.

Fire-fighters who came were equipped to deal with the regular fire.

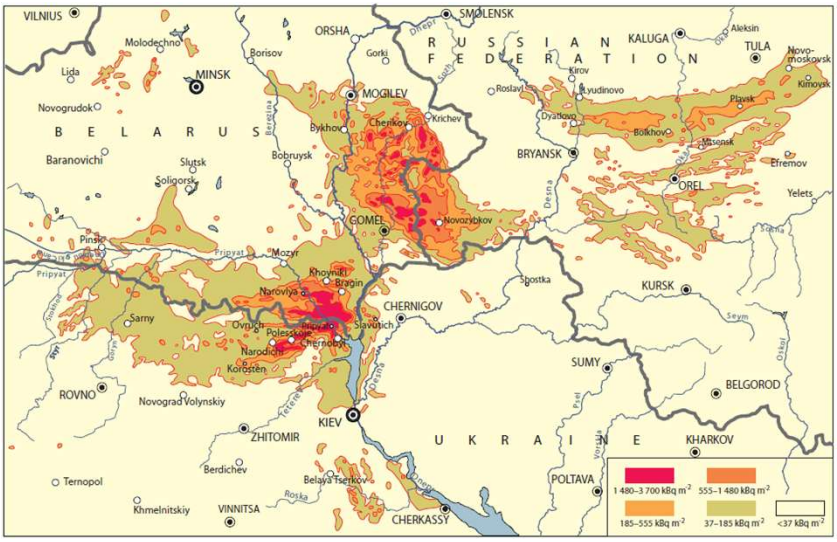
The highest doses were received by the approximately 600 emergency workers (including fire-fighters) who were on the site of the Chornobyl power plant during the night of the accident. The most important exposures were due to external irradiation – gamma-irradiation of the whole body and beta-irradiation of the skin. Doses of gamma-irradiation of the whole body of the 134 persons for whom Acute Radiation Sikness was diagnosed was in the range of less than 2.1 to 16 Gy.

Release of radionuclides and contamination field formation



Plume formation by meteorological conditions for instantaneous releases on dates and times (GMT) indicated

The releases of ^{131}I and ^{137}Cs are estimated to have been 1,760 and 85 PBq, respectively.
Three main areas of the former Soviet Union (in total. 150.000 km^2 with more than 5 million inhabitants) later on were classified as contaminated areas.



Map of ^{137}Cs deposition levels in Belarus, the Russian Federation and Ukraine as of December 1989

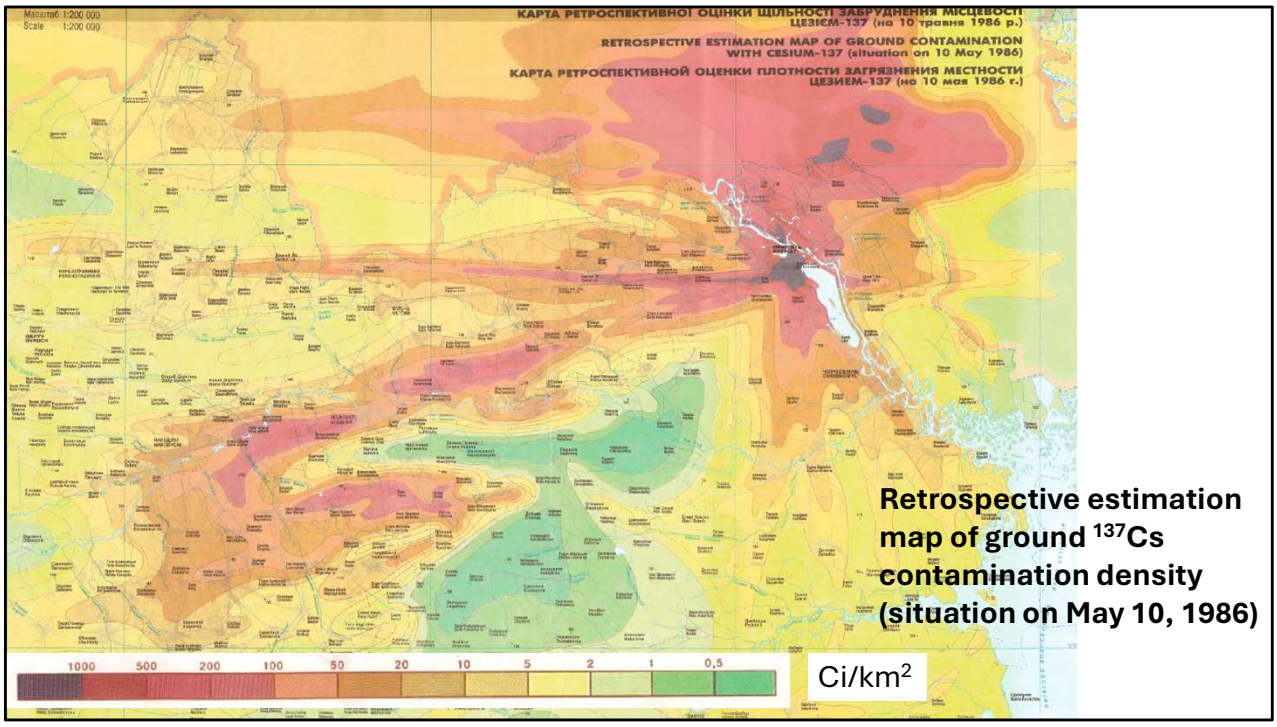
The radionuclide releases from the damaged reactor continued for about 10-day period after the explosion and the graphite fire with varying release rates, radionuclides composition and fuel particles contribution.

Early release after explosion was dominated by noble gases and volatile radionuclides, especially iodine and caesium isotopes. Later phases included less volatile material and fuel particles. Rainfall created major hotspots.

On the larger distances from the radiological point of view, ^{131}I and ^{137}Cs were the most important radionuclides to consider, because they are responsible for most of the radiation exposure received by the general population. The releases of ^{131}I and ^{137}Cs are estimated to have been 1,760 and 85 PBq, respectively (1 PBq = 10^{15} Bq).

Three main areas of the former Soviet Union (in total. 150.000 km^2 with more than 5 million inhabitants) later on were classified as contaminated areas. Outside of the former Soviet Union, other large areas of Europe were also subjected to deposition of radioactive material (45,000 km^2 had ^{l37}Cs deposition levels ranging from 37 to 200 kBq/m^2).

In the vicinity of the ChNPP industrial site the levels of ^{137}Cs and ^{90}Sr contamination density reached 40 MBq/m^2 or more than 1000 Ci/km^2.



Retrospective estimation map of ground ^{137}Cs contamination density (situation on May 10, 1986)

Retrospective estimation map of ground ^{137}Cs contamination density (situation on May 10, 1986)

You can see the complicated picture of ^{137}Cs contamination, the narrow western plume with high levels of contamination. It enriched in fuel particles.

Evacuation decisions

- Evacuation decisions were made based on data on the radiation dose rate at the location.
- By the evening of April 26, the radiation dose rate in the city of Prypiat had increased from 0.14–0.60 mSv/h to 4–5.4 mSv/h, and a decision was made to evacuate urgently. But the final decision was made in Moscow. Evacuation vehicles were waiting at the nearby locations for about 12 hours. After the decision was made, the evacuation of about 50,000 people was carried out on April 27, well organized during a 3-hour period starting at 2:00 p.m.
- From April 27 to May 2, the population was evacuated from areas where the dose rate was 0.2 mSv/h or more (normalized to May 10). This is a 10-km zone plus areas behind it in the direction of the western plume. On May 2, the Governmental Commission made decision to evacuate population from the 30-km zone plus the territory outside it, where the dose rate was 0.05 mSv/h and more (normalized to May 10). The evacuation was carried out mainly during May. The last two settlements were evacuated from this territory in August 1986. In total, about 116 thousand people were evacuated.

On May 12 the decision was made on the individual dose limit of 100 mSv during the first year after the accident for general population. The further evacuation should comply with this decision.

Doses to evacuees

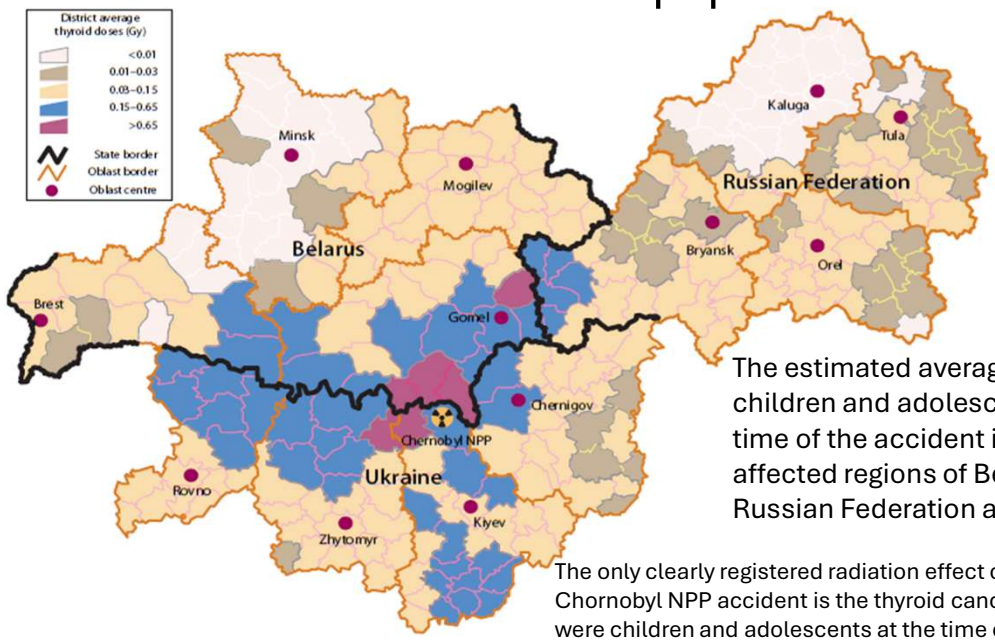
- The average effective dose of evacuees from the city of Prypiat, which was accumulated by the time of evacuation, was 10.1 mSv (with a maximum of up to 75 mSv). The average effective dose of the population, which was evacuated with a significant delay from settlements in the 30-km zone, was 15.9 mSv. The maximum dose in this group was 214 mSv. Due to insufficient assessment of the radiation situation on the evacuation routes, the doses of the population of the city of Prypiat, which were received during the evacuation, were within 11-19 mSv.
- The effective radiation doses of people evacuated from the Chornobyl accident area in the spring and summer of 1986 were estimated at an average of 33 mSv, and the highest doses reached several hundred mSv.
- Delayed informing the population about possible dangers and measures to prevent them and an imperfect regulatory framework for iodine prophylaxis led to significant dose loads on the thyroid gland of residents of the 30-kilometer zone, in some cases up to 5 Gy. And this resulted almost entirely from drinking fresh milk containing ^{131}I in the first few weeks following the accident.

Doses and effects on population

Average individual doses to residents in different regions	Group	Time period	Number (thousands)	Thyroid dose (mGy)	Effective dose (mSv)
	Evacuees	First year	≈115	≈500	≈50
	"Contaminated areas" in Belarus. Russian Federation and Ukraine	First year for thyroid dose	6400	≈100	≈13
	Belarus. Russian Federation and Ukraine	1986-2005 for effective dose	98 000	≈20	≈2
	Rest of Europe		500 000	≈1	≈0.4
Ranges of individual doses	Absorbed doses to the thyroids of evacuees ranged from <5 mGy to >5 Gy, with several hundred evacuees receiving doses in excess of 5 Gy Absorbed doses to the rest of the population of Belarus, Russian Federation and Ukraine (98 million) varied over a wide range, with most receiving thyroid doses <50 mGy and about 1 % doses >200 mGy				

- The average thyroid dose to the evacuees is estimated to have been about 500 mGy (with individual values ranging from less than 50 mGy to more than 5.000 mGy). For the more than six million residents of the contaminated areas of the former Soviet Union (i.e. those with ^{137}Cs levels greater than 37 kBq/m^2) who were not evacuated, the average thyroid dose was about 100 mGy, while for about 0.7% of them, the thyroid doses were more than 1.000 mGy. The average thyroid dose to pre-school children was some 2 to 4 times greater than the population average.

Doses and effects on population



The estimated average thyroid doses to children and adolescents living at the time of the accident in the most affected regions of Belarus, the Russian Federation and Ukraine

The only clearly registered radiation effect on population due to Chornobyl NPP accident is the thyroid cancer among those who were children and adolescents at the time of accident.

A map of the average thyroid dose to population is presented on the slide.

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Using of army

- From the very beginning some military units had individual dose limits 0.25 Sv per work in the zone of accident and 0.1 Sv for one-time exposure, but some had limits for the time of nuclear conflict – 0.5 Sv and even 1 Sv for the “special work” conditions.
- This led to doses over 0.4 Sv for 17 people. In total 44 persons had recorded doses of more than 0.4 Sv. Analysis showed that only one of these cases might be considered as justified.
- Dose limitation was the only principle of radiation protection which was used in military units' activities in the zone of accident. Justification and optimization usually were not considered.

Thank you for your attention