Information on the need to carefully monitor the radioecological situation in the Chernobyl Exclusion Zone

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For limited use

Following the accident at Unit 4 of the Chernobyl Nuclear Power Plant, 188,959,000,000,000 Bq [~189 TBq] of radioactivity were released into the atmosphere, most of which was localised within a 30-kilometer zone. Overall, radionuclide fallout within the zone is characterised by a patchy structure. The following long-lived radionuclides were detected in the release products: Cs134, Nb95, Ru103, Zn95, Ce144, Ru106, Cs137, Sr90, Pu238, Pu239, and Pu240.

Currently, according to expert estimates, the 30-kilometer zone contains 3,330,000,000,000–3,885,000,000,000 Bq [3.33-3.85 TBq] of strontium, 94,350,000,000 Bq [94.35 GBq] of caesium, and an estimated 14,800,000,000,000 Bq [14.8 TBq] of plutonium. Areas with gamma-radiation levels exceeding 100 µSv/hr, containing 4,514,000,000,000,000 Bq [4,514 TBq] of radioactivity, cover an area of 4,700 hectares.

The significant risk of radionuclide release from the 30-kilometer zone of the Chernobyl Nuclear Power Plant is determined not only by the high level of contamination but also by the presence of areas susceptible to wind and water erosion of the top layer of the most contaminated soils.

Within the 30-km zone, with a total land area of 266,000 hectares, approximately 30,000 hectares are occupied by cropland and other lands exposed to wind and water, containing up to 1,110,000,000,000,000 Bq [1,100 TBq] in an unstable state. Of this, 11,500 hectares are sandy and dune areas, the top layer of which (1–5 cm) is estimated to contain up to 370,000,000,000,000 Bq [370 TBq].

The most dangerous zone in terms of wind transport is the five-kilometre zone, which covers 8,000 hectares and contains more than 50% of the activity from the accidental release.

Forested, meadow, and marshy areas within the 30-km zone occupy more than 98,000 hectares and contain 60–80% of the total radionuclide mass. In terms of water and wind transport, they can be considered relatively safe, largely due to the high permeability of the underlying sandy soils, which prevents active surface runoff. Outside the 30-km zone of the Chernobyl Nuclear Power Plant, there are isolated areas with elevated levels of contamination by long-lived radionuclides (Polessky, Olevsk, Ovruch, and other districts).

As a result of decontamination measures carried out within the 30-km zone, some of the contamination has been localized at 14 radioactive waste disposal sites (RWDS), where approximately 430,000 m^3 of waste with gamma-radiation levels ranging from 10 µSv/hr to 2,500,000 µSv/hr or more, with a total activity of 55,500,000,000,000,000 Bq [55,500 TBq], is stored.

Currently, only three disposal sites (Podlesny, Burakovka, and the Chernobyl Nuclear Power Plant's Phase III) can be considered provisionally equipped with surface and geo-filtration protection. The remaining RWDS require additional engineering or relocation.

The most suitable location for group (long-term, permanent) repositories may be the Chistogalovsko-Lelevskaya Ridge, characterized by the presence of deep groundwater. A mandatory requirement for the construction of a waste disposal facility is the installation of radionuclide migration monitoring systems, including monitoring wells.

Repositories located directly in the decontaminated areas around Unit 4, in the construction base area, and within the 5-km zone of the Chernobyl Nuclear Power Plant (CNPP) must be monitored to determine whether to rebury the waste they contain.

According to preliminary estimates, the Chernobyl Nuclear Power Plant cooling pond contains between 3,848,000,000,000 and 3,885,000,000,000 Bq [3,848-3,885 TBq] of radioactive contamination.

Although its current condition does not raise concerns, long-term measures to decontaminate the bottom sediments must be developed and implemented.
Biocenoses *[a community of interacting living organisms—including plants, animals, fungi, and microorganisms—that inhabit a specific environment at the same time]* within the 30-km zone have undergone changes depending on their radiation resistance and the density of radioactive contamination. In the 5-km zone, pine forests have been completely destroyed over an area of 300–400 hectares, and partially contaminated over an area of over 1,000 hectares.

The population of soil-forming organisms has decreased, and morphoses of conifers and angiosperms are observed. In most of the zone, the consequences of evacuation (cessation of soil cultivation, removal of people and domestic animals), hydraulic engineering measures, and engineering and decontamination work have had a much greater impact on ecosystems.

An assessment of the removal of radioactive substances by animals and birds beyond the 30-km zone shows that it is small (37,000,000,000 Bq/year) [37 GBq/year] and poses no danger.

The removal of radioactive contamination beyond the Chernobyl Nuclear Power Plant zone leads to an increased influx of radionuclides into water bodies. Due to the decay of short-lived radionuclides and self-purification processes in the Kiev and Kaniv reservoirs, the total beta activity of the water decreased from 370 Bq/L in early May 1986 to 7.4-14.8 Bq/L in the fall of 1987. The radiological situation in these reservoirs is currently largely determined by long-lived radionuclides, cesium-137 and strontium-90. Their concentrations in the Dnieper Cascade reservoirs during the spring and fall of 1987 were characterized by weak temporal variability.

Meanwhile, downstream from the Kiev to the Kakhovka Reservoir, the concentration of cesium-137 changed from 1.147 to 0.019 Bq/L, and the concentration of strontium-90 from 0.740 to 0.407 Bq/L.

The Academy of Sciences of the Ukrainian SSR prepared a forecast of the radiological state of the Dnieper reservoir cascade during the spring high water of 1988, based on mathematical modelling of the development of major, minor, and moderate floods.

According to the forecast, the following maximum reservoir contamination levels are expected during the 1988 high-water period, depending on the year's water content: cesium-137 from 1.887 to 7.77 Bq/L in the Kiev Reservoir; up to 0.215 Bq/L in the Kakhovka Reservoir; strontium-90 from 1.147 to 4.070 Bq/L in the Kiev Reservoir; up to 0.555 Bq/L in the Kakhovka Reservoir. These values will be refined in February–March 1988 as information on the hydrometeorological factors responsible for flood formation becomes available.

A long-term forecast of the radiological state of the reservoirs up to 1993 showed that, against a background of intra-annual variability in strontium and caesium concentrations, a slow decline in their average values would occur. Approximately during 1988–1989, a slight increase in radionuclide concentrations could be observed, and only in 1990 would a slow decline will begin. High floods during this five-year period, due to the intensive flushing of radionuclides from the Chernobyl Nuclear Power Plant zone, could lead to strontium and caesium concentrations in the cascade's reservoirs exceeding the 1987 level.

Due to the presence of localized zones of intense sediment contamination in the Dnieper Reservoir cascade, and particularly in the Kiev Reservoir, it is necessary to develop long-term measures for their large-scale decontamination. The problem of increasing the sustainability of drinking water supplies for residential and economic facilities in the republics through the preferential use of protected groundwater also requires a solution.

Careful monitoring of the radioecological situation in irrigated lands in southern Ukraine is necessary, given the predicted long-term release of strontium-90 and cesium-137 into the soil and agricultural products in these areas. The estimated additional collective dose for a population of 30 million people associated with water consumption and irrigation from the Dnieper River could be 0.13 million person-Sv, or 4 mSv per person.

With a strontium content of 8.14 Bq/L in the water intake, 3.626 Bq/L were detected in rice paddy water, with a soil activity of 6.29 Bq/kg, indicating a tendency for radionuclides to concentrate in the soil. Cabbage grown under irrigation in the Irpen River floodplain, with a radioactive caesium content of 0.777 Bq/L in the water, concentrated this radionuclide to 370 Bq/kg, which is within the MAC limit for the first year of the accident.

Currently, specialists from the Academy of Sciences of the Ukrainian SSR and the Ministry of Water Resources of the Ukrainian SSR are working to select spring storage and accumulation regimes for reservoirs that will reduce pollution levels during the irrigation season.

The runoff of radionuclides into the Kiev Reservoir and the location of the Dnieper Cascade reservoir downstream plays an important role in protecting water resources. To retain these radionuclides, work was carried out in 1986 to embank the Pripyat River basin with earthen and rock-and-earth dams, and to block existing canals and small rivers with filter dams.

A total of 131 temporary damming hydraulic structures were built, with a service life ending in May 1987. Some of these were reconstructed and reinforced before the 1987 flood.

Analysis of available data shows that these structures primarily performed their water protection role in the summer and fall of 1986. However, during the 1987 flood, the effectiveness of most of these structures proved comparatively low. For example, on the right bank of the Pripyat River, they retained only 1,850,000,000,000-3,700,000,000,000 Bq [1.85-3.70 TBq].

This was apparently due to the slow progression of the flood and minor runoff. At the same time, the reservoirs formed by the dams, flood adjacent areas, which facilitates the dissolution and migration of caesium, strontium, and, to some extent, ruthenium radionuclides.
For these reasons, by Government Commission Decision No. 416 of August 15, 1987, most dams were to be completely dismantled. Twelve dams on rivers with the most contaminated basins (Braginka, Sakhan, Ilya) and in backwaters near the Chernobyl Nuclear Power Plant, in front of which the bulk of the radioactivity (up to 74,000,000,000,000 Bq [74 TBq]) had accumulated, were left in operation.

In light of the above, it is proposed that the remaining dams located north of the cooling pond, in the floodplains of the Pripyat and Braginka rivers, undergo a major overhaul before the 1988 flood. They must be converted into permanent structures, including regulated catchment areas capable of withstanding floods of any intensity. The radioactive sludge accumulated in front of the dams should be removed to disposal sites.

Since the majority of radionuclides are located within the 30-km zone and pose a potential hazard to adjacent areas, appropriate decontamination measures must be implemented.
The need for these measures is also dictated by the socio-political aspects of this problem: the alienation of territory in a region with a high population density and the long-term existence of a potential source of increased danger for adjacent territories. Passive behaviour, both in the recovery of lost territories and in eliminating the potential danger, could be used by certain Western circles to discredit the country before the international community.
In this regard, the task of eliminating the consequences of the Chernobyl accident as completely as possible can be classified as a national priority.

A strategy for comprehensive, phased decontamination of the territory within the zone, combined with biological and chemical remediation of residual activity, is proposed. Biological and chemical reclamation measures should be aimed at creating a managed, highly productive forestry complex within the zone, which should ultimately support the development of forestry and perennial grass seed production.

Active, targeted afforestation of the area, combined with mechanical decontamination and increasing the biomass of swamps, meadows, and other unforested areas, will allow a significant portion of the area to be gradually returned to economic use while maintaining the principle of maximum safety for adjacent territories of the republic and carrying out decontamination work with minimal damage to the ecology of the region, with less stringent radiation requirements than for agricultural use.

Maximum afforestation (70–80%) of the area will create a protective belt to conserve the existing emissions from the Chernobyl Nuclear Power Plant, whose impact on the environment will continue. Forests are a source of oxygen in the air and an optimal regulator of water resources, helping to smooth out flood peaks on rivers and actively replenish groundwater resources. Thus, the 30-kilometer zone, once a potentially hazardous area with little economic value in the past, can be transformed into a profitable natural and economic complex, crucial for stabilizing the environmental situation in the Kiev industrial and urban agglomeration.

To achieve this strategic objective, it is proposed to designate areas for priority decontamination measures, areas for partial or periodic decontamination, research and production sites, and three areas designated as absolute nature reserves.

Thus, temporarily alienated lands will be returned to the country's overall system of natural resource management on a new basis of scientific and technological progress.

An analysis of the technical and economic aspects associated with solving this problem shows that decontamination and reclamation work can be highly intensive.
For this, an organization of 3,000-4,000 people, working under radiation doses that do not exceed the limits established for nuclear power plant personnel, would be sufficient. Total costs could amount to approximately 50 million roubles per year for ten years.

The task of decontaminating the zone and preparing it for economic use must be accomplished through a number of measures, the most important of which is the establishment of an emergency response centre in Ukraine for the purpose of:
- mitigation of accidents at nuclear power facilities;
- decommissioning of spent power units;
- development and application of specialized equipment for mechanization and automation in high-radiation environments.

Scientific and technical support for the work should include:
- establishment of research and development units and pilot production at the Emergency Technical Centre (ETC);
- participation of the ETC in the Progress Scientific and Technical Complex to ensure a temporary level of mechanization and automation of work with the ultimate goal of reducing the collective dose during emergency recovery operations in the zone;
– the establishment of a permanent working group within the Academy of Sciences of the Ukrainian SSR to address issues related to the strategy for emergency response and recovery operations.

The Academy of Sciences of the Ukrainian SSR is devoting considerable attention to the condition of the damaged Unit IV of the Chernobyl Nuclear Power Plant.

As calculations and diagnostic studies conducted by the Kurchatov Institute of Atomic Energy, the Nuclear Research Institute of the Academy of Sciences of the Ukrainian SSR, and others have shown, up to 95% of the original amount of nuclear fuel remains within the Shelter.

The presence of such a large quantity of nuclear fuel in an unknown state and location does not exclude the possibility of a self-sustaining chain reaction (SSCR). Several systems have been created to monitor the condition of the facility and influence it, of which the "Shater" information and diagnostic complex, developed by the Institute of Nuclear Research of the Ukrainian Academy of Sciences, is particularly noteworthy. It contains more than 150 sensors measuring temperature, heat flux, neutron and gamma radiation, and vibration, installed through special tunnels near the reactor shaft and above the collapsed area. The use of a computer to accumulate information allows for the prediction of the facility's condition using software methods.

Systematic measurements of neutron fluxes have shown their instability, albeit at a low level. This indicates, in particular, the presence of certain processes associated with changes in neutron multiplication conditions.
A correlation between changes in neutron fluctuations and temperature changes has been observed.
A preliminary analysis has shown that, as a result of the accident, the core disintegrated into a number of separate sections, displaced from their original position, primarily toward the lower part of the reactor shaft and partially ejected upward, into the area of the spent fuel pool.

The measurements and analysis conducted show that there are a number of unresolved issues with the damaged Unit IV:
- the distribution of the remaining fuel, its condition, and the subcriticality of the facility have not been determined;
- there is no effective system for suppressing a self-sustaining chain reaction;
- the guaranteed service life of the metal structures exposed to prolonged, intense radiation exposure has not been determined.

This indicates a lack of safety guarantees for the operation of the Shelter facility and requires constant monitoring of the unit's condition and the resolution of a number of scientific and technical issues.
The optimal solution for Unit IV is the unloading and disposal of the fuel, provided that special mechanisms and methods are developed based on a study
of the fuel's localization.

Radioactive contamination of vast areas of the republic does not pose an immediate danger to the population, but it does have a negative impact on their normal living conditions. Along with the process of self-burial of nuclides and the spontaneous cleansing of nature from radiation, processes of their concentration in various biological chains occur, which intensifies the negative impact on the human body.

The possibility of significant radionuclide washout due to extreme flooding cannot be ruled out.
This is particularly alarming, as data on the immunological status of individuals exposed to radiation, including residents of Kiev, re-obtained a year after the accident, indicate changes in the ultrastructure and function of cells responsible for protecting the body from malignant growth and viral infections.

It is worth noting that the USSR Ministry of Atomic Energy, despite the relevant decisions of the CPSU Central Committee, is raising the issue of constructing Units 5 and 6 of the Chernobyl Nuclear Power Plant during the 12th Five-Year Plan. Moreover, a project for the construction of Chernobyl Nuclear Power Plant No. 2 is already being developed, which essentially ignores critical economic, environmental, and social considerations. This will inevitably lead to significant, irrational expenditures of material, financial, and human resources associated with the rotational work schedule for construction and operational work under conditions of elevated radiation contamination levels.

Furthermore, it will cause intensive radionuclide release beyond the 30-km Chernobyl zone, creating a serious threat of additional radionuclide contamination of the Dnieper River basin, whose water is used by 35 million people and 65% of the republic's industrial enterprises.
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