Information on the condition and problems of water bodies in the 30-kilometer exclusion zone

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Secret

Regarding the condition and problems of water bodies within a 30-kilometer zone

The KGB Directorate of the Ukrainian SSR for the city of Kiev and Kiev Region, given the increased public attention to the consequences of the Chernobyl Nuclear Power Plant accident, as well as the negative environmental consequences that may arise from the runoff of radioactive substances into the Dnieper River basin during flooding, continues to monitor the condition of water bodies within a 30-kilometer zone and assess the effectiveness of water protection measures implemented on the recommendations of the USSR State Hydrometeorological Committee, the USSR Academy of Sciences, the USSR Ministry of Water Resources, and other interested agencies.

Using the operational and official resources of the Combine Production Association, the Special Design Bureau of the Institute of Cybernetics of the Academy of Sciences of the Ukrainian SSR, the Ukrainian State Hydrometeorological Committee, and the Ukrgiprovodkhoz Institute of the Ministry of Agriculture of the Ukrainian SSR, which participated in developing a forecast for the radiological state of the Dnieper Cascade of Reservoirs during the spring floods, a study of the current situation was conducted.

An analysis of the materials revealed that the calculations were based on data on flooding during the 1931 (1% probability per 100 years) and 1970 (5% probability per 100 years) floods.

According to the current estimate, the radionuclide contents on the soil surface in the zone of the most extensive flooding (1% probability, flooded area of 933 km^2) amount to 370,000,000,000,000 Bq [370 TBq] of cesium-137 and 740,000,000,000,000 Bq [740 TBq] of strontium-90.

A forecast developed by specialists for radionuclide leaching from the soil surface during snowmelt and their migration in watersheds in the right- and left-bank floodplains around the Chernobyl Nuclear Power Plant (96x96 km) was prepared taking into account coefficients (adjusted at the Institute of Geochemistry and Mineral Physics of the Ukrainian Academy of Sciences based on the 1987–1988 floods) for the retention of part of the runoff by water protection structures.

According to the data obtained, the total radioactive waste from snowmelt from the Pripyat River was:

	Cs-137 (Bq)	Sr-90 (Bq)
1987	12,580,000,000,000 [12.58 TBq]	7,400,000,000,000 [7.4 TBq]
1988	5,365,000,000,000 [5.365 TBq]	3,330,000,000,000 [3.33 TBq]

The distribution ratio of caesium in the Pripyat River runoff in solution and suspended matter during the 1987 flood was equivalent (1:1).

During the 1988 flood, it was 1.6:1. Most strontium is carried away in solution.

The predicted radionuclide migration in watersheds under conditions of the most extreme flooding, taking into account correction factors, is 36,260,000,000,000 Bq [36.36 TBq] for cesium-137 and 34,040,000,000,000 Bq [34.04 TBq] for strontium-90.

Under the same conditions, the activity loss in watersheds from the flooded right- and left-bank floodplains, taking into account higher correction factors, is predicted to be 3,700,000,000,000 Bq [3.7 TBq] for cesium-137 and 3,700,000,000,000 Bq [3.7 TBq] for strontium-90.

Furthermore, according to experts, with a 1% flood probability, the release of radionuclides from the bottom sediments of the Pripyat Backwater and the Semikhodsky will amount to 18,500,000,000,000 Bq [18.5 TBq].

When assessing the total discharge of contaminants from the Pripyat River, it is taken into account that at least half of the release of nuclides will be formed by the distant trace of the contamination zone upstream of the city of Mozyr.

According to the above forecasts, the concentration of strontium-90 at the peak of the most intense flooding could reach 2.22 Bq/L. By the end of the flood, the activity will decrease to 1.11 Bq/L (according to radiation safety standards (NRB-76), the permissible concentration of strontium-90 in water should not exceed 14.8 Bq/L).
According to experts, even with the most likely spring floods involving inundation of the left- and right-bank floodplains, the caesium removal in bottom sediments from the contaminated area will not exceed the permissible limit (18.5 Bq/L).

A special focus of research was the radioactive contamination of the Kiev Reservoir. According to existing estimates, the primary source of contamination was the deposition of radioactive aerosols on the reservoir surface and their sorption in bottom sediments.

The balance of bottom sediment contamination is determined by the influx of radioactive suspended matter and its removal through physicochemical and biological processes, as well as the discharge of some contaminated suspended sediment through the hydroelectric dam. The main areas of bottom sediment contamination are in zones of stable silt accumulation.

According to experts, the hydrodynamics of flows in the reservoir determine the gradual spreading of radioactive caesium contamination and its diffusion into the bottom. Furthermore, autochthonous processes (death of biomass and microorganisms, their sedimentation on the reservoir bottom) are significant for the binding and deposition of dissolved caesium on the reservoir bottom.

The conducted studies allowed us to draw the following conclusions:
1. Currently, cesium-137 amount in the bottom sediments of the Dnieper Cascade reservoirs amount to more than 203,500,000,000,000 Bq [203.5 TBq], 65% of which are concentrated in the Kiev Reservoir.

2. As a result of natural sediment accumulation processes, it is predicted that within 5-10 years, significant areas of contaminated sediments may be covered with a layer of other material.
3. Up to 85% of the suspended sediment of all incoming contaminated material is retained by the Kiev Reservoir from the hydroelectric cascade. A significant portion of the cesium-137 is bound by finely dispersed and hydrodynamically mobile sludge accumulation products. However, given the vast areas of contamination and the diffusion of radionuclides into the bottom sediment layer (to a depth of 4–5 cm within 5 years), large-scale decontamination measures using existing methods and means are technically impossible.

Natural lithodynamic and biological sludge accumulation processes are recognised as the most effective factors for improving the radioecological situation in the Dnieper Cascade reservoirs.

Experts propose the following as priority technical solutions to slow the migration of active material and facilitate the reliable localisation of accumulated radioactive sediments:
- in stagnant and low-flow reservoirs of the Pripyat River floodplain, the closest, most contaminated zone of the nuclear power plant, conduct engineering work to maximise the retention of sludge deposits;
- implement large-scale anti-erosion measures in the contaminated zone;
- consider the need to wash out the quarries used to trap sediments created in 1986-1987;
- accelerate the implementation of the underwater sand quarry project at the Kiev Hydroelectric Power Station, which will allow its use as a settling basin with greater depths in the pre-dam section;
- study the possibility of regulating the migration of contaminated sediments into the reservoir cascade using a variable water release method;
- develop a comprehensive program to study the situation in the reservoirs of the Dnieper Cascade.

These and other measures to localise accumulated radioactive material will be effective only if objective information is available about the pathways of nuclide influx, the most potentially dangerous sources are identified, and they are contained by engineering structures.

Experts also note the significant content of radioactive substances in the water, silt, sediment, and sedimentary materials of the Pripyat River basin's reservoirs — the Semikhodovsky Starok and the Pripyat Backwater.

The surface area of the "backwater" is 0.82 km^2, and that of the "old man" is 0.21 km^2, with an average depth of 3 to 24 meters. The amount of radioactive cesium-137 is estimated at 25,900,000,000,000 Bq [25.9 TBq] in the "backwater" and 3,700,000,000,000 Bq [3.7 TBq] in the "old man."

The qualitative composition of the radioactive spectrum is represented by cesium-137, cerium-144, ruthenium-106, and zirconium-95.
“Zaton”:
cerium-144 (147,630,000,000,000 Bq/km^2 [147.63 TBq/km^2]),
cesium-134 (10,360,000,000,000 Bq/km^2 [10.36 TBq/km^2]),

cesium-137 (27,380,000,000,000 Bq/km^2 [27.38 TBq/km^2]),
zirconium-95 (7,030,000,000,000 Bq/km^2 [7.03 TBq/km^2),
ruthenium-106 (59,200,000,000,000 Bq/km^2 [59.2 TBq/km^2]).

"Old Man":

cerium-144 (11,470,000,000,000 Bq/km^2 [11.47 TBq/km^2]),
cesium-134 (1,850,000,000,000 Bq/km^2 [1.85 TBq/km^2]),
cesium-137 (4,440,000,000,000 Bq/km^2 [4.44 TBq/km^2]),
zirconium-95 (740,000,000,000 Bq/km^2 [0.74 TBq/km^2]),
ruthenium-106 (8,880,000,000,000 Bq/km2 [8.88 TBq/km^2]).

Given this spectrum and volume of activity, the condition of the water protection structures is particularly important.

As of February 1, 1989, 13 dams had been constructed within the 30-kilometer zone on the Sakhai, Ilya, and Braginka rivers, and seven dams within the five-kilometre exclusion zone (the Pripyat backwater, the Semikhodovsky Starik (old man), the Goluboy Ruchey, the Yuzhnaya and Severnaya dams, and two other dams).

The Chernobyl section of the water protection structures monitors the condition of the dams and dikes. A reserve of over 1 million cubic meters of crushed stone has been created for repair and restoration work.

According to experts, the Semikhodovsky Starik dam is in good condition. It was reconstructed in 1988, the sand fill was reinforced, and a filter cut was created. A permanent rack post needs to be installed on the dam.

The Pripyat Backwater dam was built in February-March 1987; the dam body was reinforced with crushed stone and concrete slabs, and drainage slots were installed.

In recent months, erosion of the right bank and a shallow, blind section of the dam near its junction with the road was discovered upstream. Specialists from the Ukrgiprovodkhoz Institute have urgently developed a project to strengthen the embankment. The emergency stockpile of crushed stone (3,500 m^3) must be restored in the dam area.

According to experts, the water protection structures within a 30-kilometer zone are in good condition, and their destruction during the peak flood period is considered unlikely.

However, the successful completion of the task of minimising the negative consequences of the spring floods should be greatly facilitated by:

– organising systematic monitoring of the dams, including with the participation of special teams equipped with the appropriate technical equipment;

– completing dam reconstruction and bank stabilisation work.

The implementation of these and other measures is generally carried out in accordance with the developed schedules.

In view of the above, we have taken additional measures to ensure reliable operational control over the development of the situation.

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